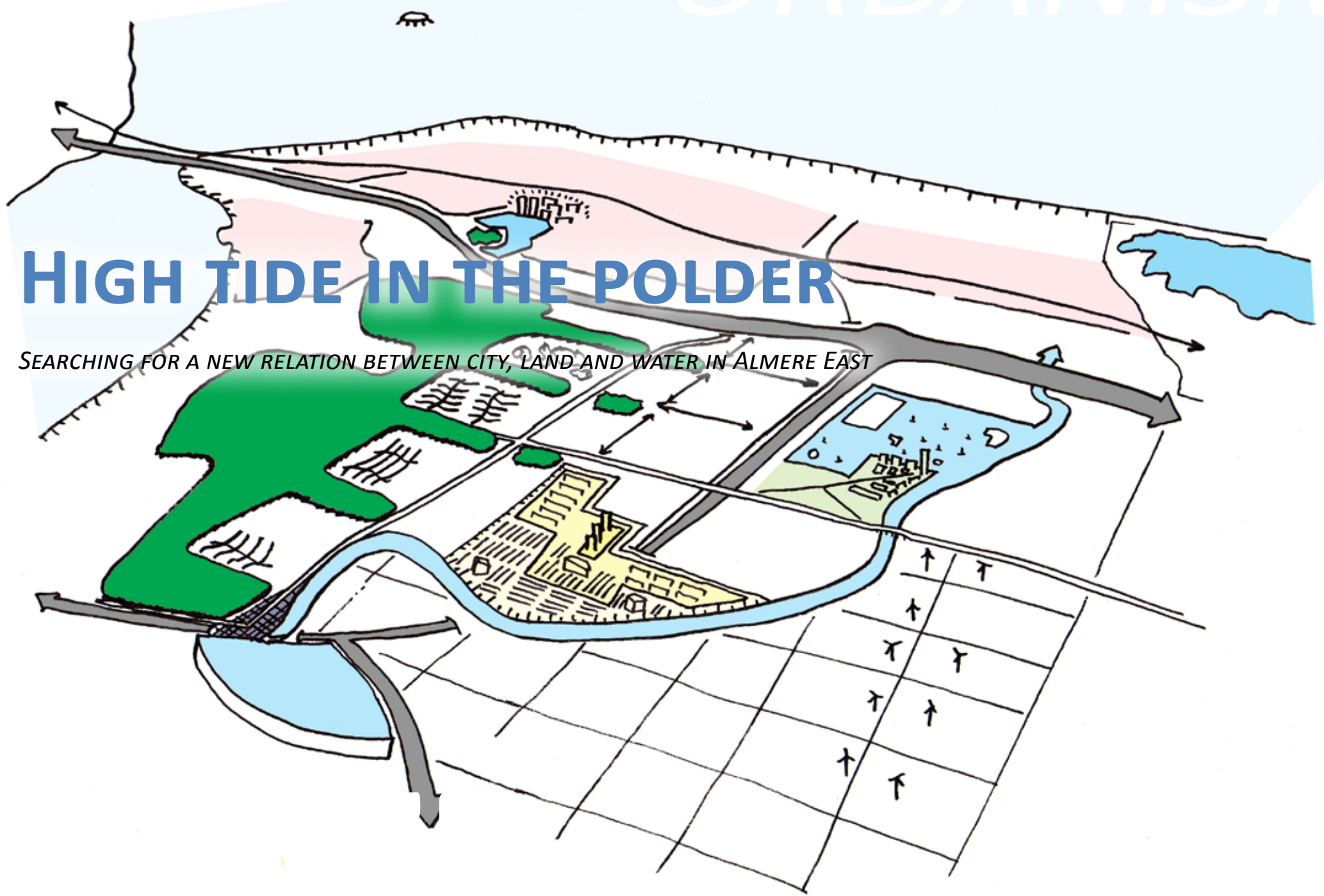


HIGH TIDE IN THE POLDER

SEARCHING FOR A NEW RELATION BETWEEN CITY, LAND AND WATER IN ALMERE EAST



COLOPHON

Graduation project:

High tide in the polder, searching for a new relation between city, land and water in Almere East

Keywords:

Masterplan, Almere East, Urban design, Water management, Urban engineering

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PREFACE

Before you lies my thesis as the end result of a year of research and design on water urbanism. The year started with a fairly general fascination for water in the broadest way. With the Dutch culture of waterbuilders, the present day pragmatic reality and the uncertain future climate change in mind I started a quest in the world of water.

Along this journey I found stepping stones in the form of interesting people at Urbanism, then in Civil Engineering and later on at Dura Vermeer. Circumstances at the Faculty of Architecture enabled me to choose and follow this path in my own way, which was a very learning experience. This brought me to my main mentor Fransje who helped me consistently throughout the year with defining the project and staying focused and introducing me to Harry de Brauw and Dura Vermeer. My second mentor Willem has guided me with sharp questions about urban quality and experience. And Marjolijn, my third mentor, guided me on the integration of urban design and civil engineering and showed me everyday practice on living and experiencing water. And Chris has helped me with inspiring conversations and interesting information.

I want to thank all my mentors for this learning and inspiring year this has been. I want to thank also Harry de Brauw for the joyful and successful cooperation throughout both our graduation projects. And the numerous people who helped me by sharp discussions and remarks or inspiring images or stories, at the faculty, the atelier, at DVBD, at conferences or at home, thank you!

Peter Minnema - 23 January 2009

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An aerial photograph of a rural landscape. The foreground and middle ground are dominated by large, rectangular green agricultural fields. A dirt road or path runs diagonally across the lower-left portion of the image. In the center-right, there is a small cluster of buildings, possibly a farm or a small village, surrounded by trees. Several white wind turbines are scattered across the landscape, particularly in the middle and background. The sky is clear and blue.

URBANISM

CHAPTER 1

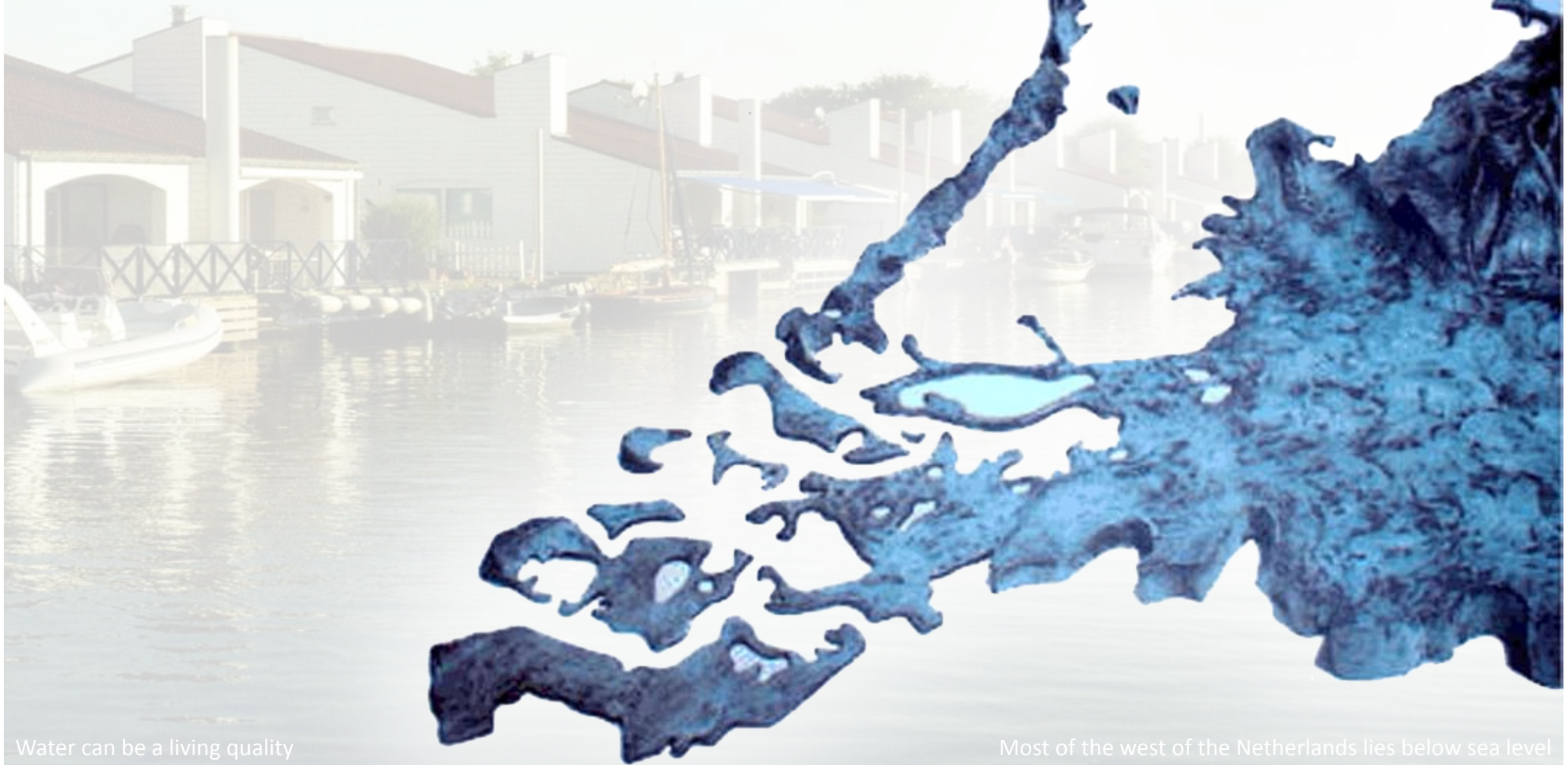
INTRODUCTION

WATER

SOCIETY

“The **aim** of my graduation project is to make a **masterplan** for an urban expansion in a low polder based on **water management** criteria in a way that it generates **quality** in living conditions in a **robust** water network.”

Peter Minnema, March 2008



Water can be a living quality

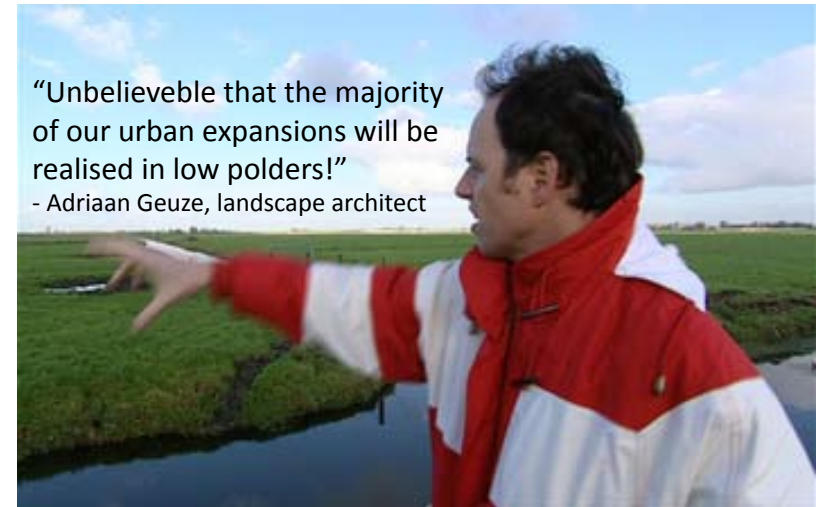
Most of the west of the Netherlands lies below sea level

1.1. THE ASSIGNMENT

The spatial claim in the Netherlands is increasing, more and more functions, such as living, industry, recreation, transport and water all have to find their place on a small area. People are demanding increasingly more space and are living more individual.

This spatial claim is concentrated in the Randstad area, the economic and densely populated heart of the Netherlands. The Randstad area is, for most part, lying under sea level. With a carefully balanced systems of dykes, canals and pumping stations this is kept dry. But a further urbanization of the Randstad will stress these water systems to the limit. Especially when this assignment is realised in very low lying polders more than six metres under sea level. And finally climate change, which will dramatically change the context of our water systems.

It seems an impossible task, but this thesis will show how urbanization can help in making a robust water network and quality in living, precisely in one of the lowest polders we have...



“Unbelievable that the majority of our urban expansions will be realised in low polders!”
- Adriaan Geuze, landscape architect



“Water management is the oldest characteristic of Dutch culture”
- Prince Willem-Alexander, World Water Forum



“We need to raise the dykes to deal with climate change”
- Cees Veerman, deltacommission

1.2. THE DUTCH AND WATER

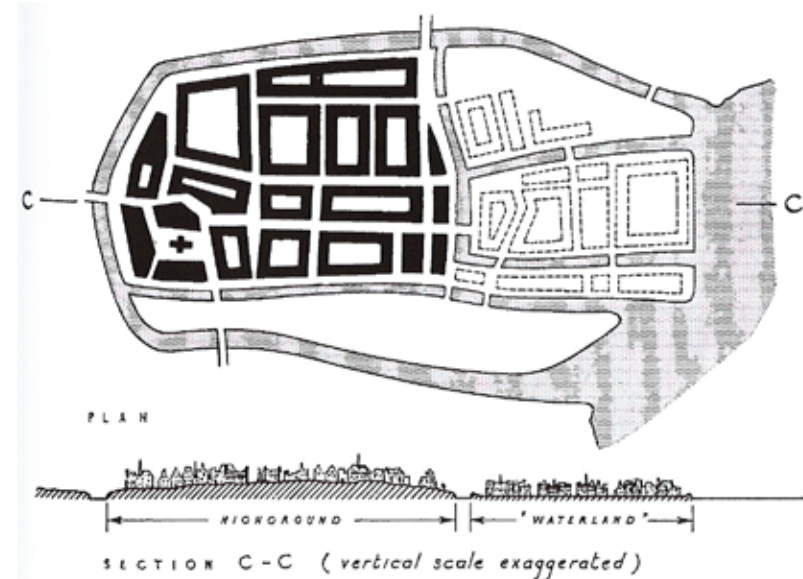
In Roman Times the Netherlands were for more than half covered by peat, impassable and inaccessible (de Wit, 2005). Only in the neighbourhood of peat streams the soil had the capacity to carry settlements and to take up farming. At about the year 800 the first arable farms began here. Not until the end of the early Middle Ages, from the tenth century, people started to cultivate the peat. This was the start of a great cultivation process which transformed the Dutch territory from a water rich swamp like Delta into a coherent structure of city, land and water.

The occupation history of this waterland has always been characterized by a equivocal position regarding water (Hooimeijer 2005). Besides all the problems the position between land and water also presented benefits for the development of the first modern trading nation in the world. Fertile land and rich fishing grounds but also good connections to sea relatively safe behind the dunes.

The Dutch lowland is reclaimed from water: swamp, lakes and ponds, sea. This resulted in numerous polders with all their own characteristics: borders, orientation and width of the drainage grid, differences in ground and water level height and in vegetation (de Wit, 2005).

The different polderlandscapes - peat cultivation, land reclamation and dyke encirclements - produced different types of cities. All these cities knew the need for a strict control of the city map, taking in account the size of the urban expansion for the current need, but also the expected need in the following centuries. Then

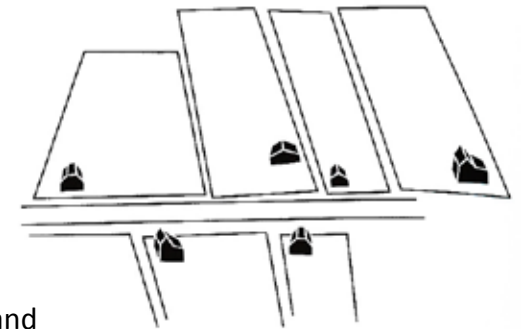
Planned urban expansion in 'waterland'



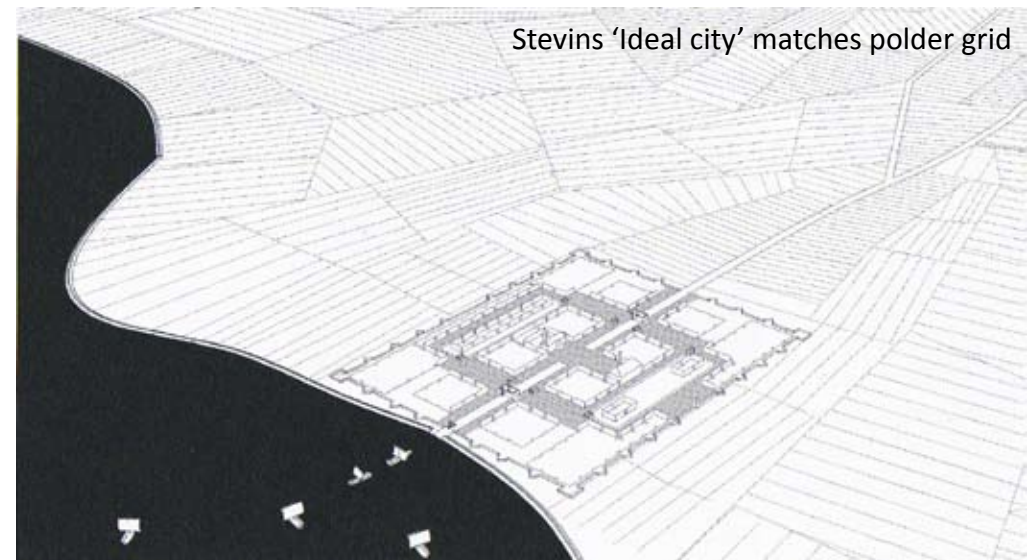
a technical plan had to ensure that the water could be drained and controlled and the water in the city canals had a constant level. Next the reclaimed land had to be raised to acquire the desired protection level, had to be consolidated and prepared for building. These city expansions are characterized by their strict and formal control of the city map in contrast with the higher centres where most cities were founded on.

After the successful cultivation of peat land the technology of windmills came available and larger lakes could be reclaimed. This cleared the way to design a city without high ground and positioned freely in the (designed) landscape. This produced an unprecedented rationality and coherence in city map, landscape plots and drainage systems. After the successful reclamation of the Haarlemmermeer in the middle of the 19th century the Dutch discovered that space, even when it had large dimensions and a difficult character, was basically makable in name of society (van der Woude, 1998).

The design of the Dutch polder and the cities within was based on water management and economical dimensions. These designs can be typed as Dutch Renaissance, with as perfect example Simon Stevins 'Ideal city'.



Coherent polder design of city and land



Stevins 'Ideal city' matches polder grid

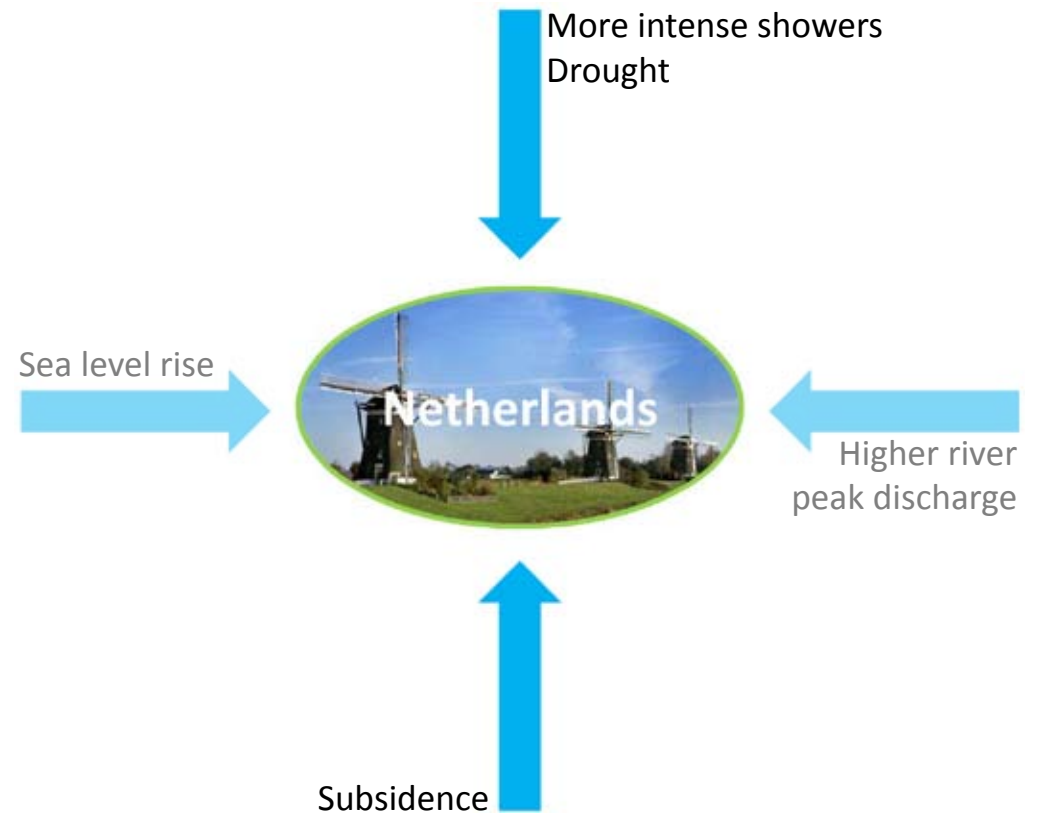
1.3. DOOMS AND DREAMS OF WATER

Water in the Netherlands comes from the left, the right, above and beneath. In the west we have the sea, in the east the big rivers, above the rainfall and beneath the seepage. But water systems are dynamic and due to climate change we have to deal with the urgency of doom scenarios (Tjallingii, 2008).

Our western border is formed by the North Sea, which often flooded parts of the Netherlands in history. With an expected sea level rise of 9-88 cm in the next decades, safety from sea floods is an important theme now and in the future.

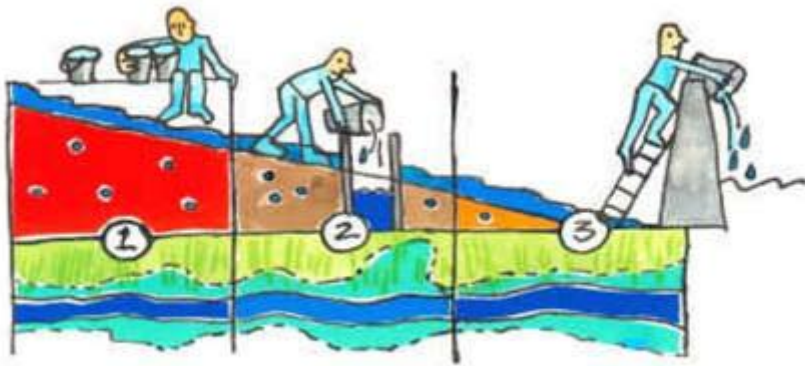
The rivers Rijn and Maas enter our country from the east and south. The discharge of these rivers varies from time to time, making it hard to control the risks of flooding or drought. Due to climate change, maxima and minima in river discharges will be more extreme. National policy now focuses on giving space to rivers and thus creating buffers and increased flexibility in water levels (Rijkswaterstaat, 2000).

Due to climate change there will be more dry periods and a need for more freshwater storage. On the other hand there will be more heavy showers. This calls for a policy focused on creating flexibility in water levels, in new and old city parts and landscapes. Furthermore there is the drop in land level in most parts of Holland. This is caused by drainage, subsidence and geological toppling (Wolters-Noordhoff Atlasproducties, 2007). Realizing this dynamic condition with future developments will be essential in avoiding unwanted situations, like flooding and (salt) seepage.



For low lying polders such as the Zuidplaspolder, the Haarlemmermeer and the Flevopolder, the water coming from above and beneath is most relevant as these polders have to be pumped dry. Storage capacity in the polder is essential as buffer for extreme situations. The urgency to deal with water safety risks from rivers and sea is context sensitive.

There is a lively public debate about water management. Local, regional and national authority's are thinking of ways to deal with climate change. Also our flood policy has changed since the water logging and near-floods in the mid '90s. According to the national 'Water Policy in the 21st Century' (WB21) we have to give more room to water and do not shift problems to the surrounding. This agreement is between the Interprovincial Consultation, Union of Waterboards and the Association of Dutch Municipalities. This policy introduces a safety chain in the form of three main strategies - retaining, storing and drain away - and proposes to use all strategies (Oosterberg, 2006).



WB21 Strategy of retaining, storing and drain away.

Dutch spatial planning also introduced the Watertest, to check if (an urban) development adversely effects the water system. Compensation of these effects at least is mandatory, water positive development is preferably (Ministerie van Verkeer en Waterstaat, 2001).

But not only necessities as spatial scarcity and changing climate force us to innovative solutions: living with water also results in exciting and attractive new living environments and extends the existing typology in 'dry Vinex-building'. We can connect our dooms with dreams and use the creative energy of **dreams** for sustainable urban water design (Tjallingii, 2008).

Awareness is also a goal of living with water, as we now take a lot of things for granted. For instance, less than a century ago, obtaining drinking water involved a lot of effort. Due to technological advancements we do not see and understand these life cycles anymore. With the current 'dooms' at hand we need to make people conscious of efforts for water purification and drainage.

That the consumer feels the **attraction** of living on the water is shown by the climbing prices on the existing market of the approximately 10.000 houseboats and floating homes (Singelenberg, 2008). They rose tremendously in the last years, a development which is also caused by the restrictive policy of municipalities in the last decade. However, many new forms of living with water are still unfamiliar with the consumer.

Probably water-living only occurs in the middle and higher segments of the market (Singelenberg, 2008). But the possibilities in the cheaper segment have to be studied. To provide an alternative for the regular housing demand, housing for all layers of the population have to be realised in a water living district (Bouwen met water, 2007).

AND

MODERN

REVOLUTION



ALMERE

CHAPTER 2

ALMERE

NEWTOWN

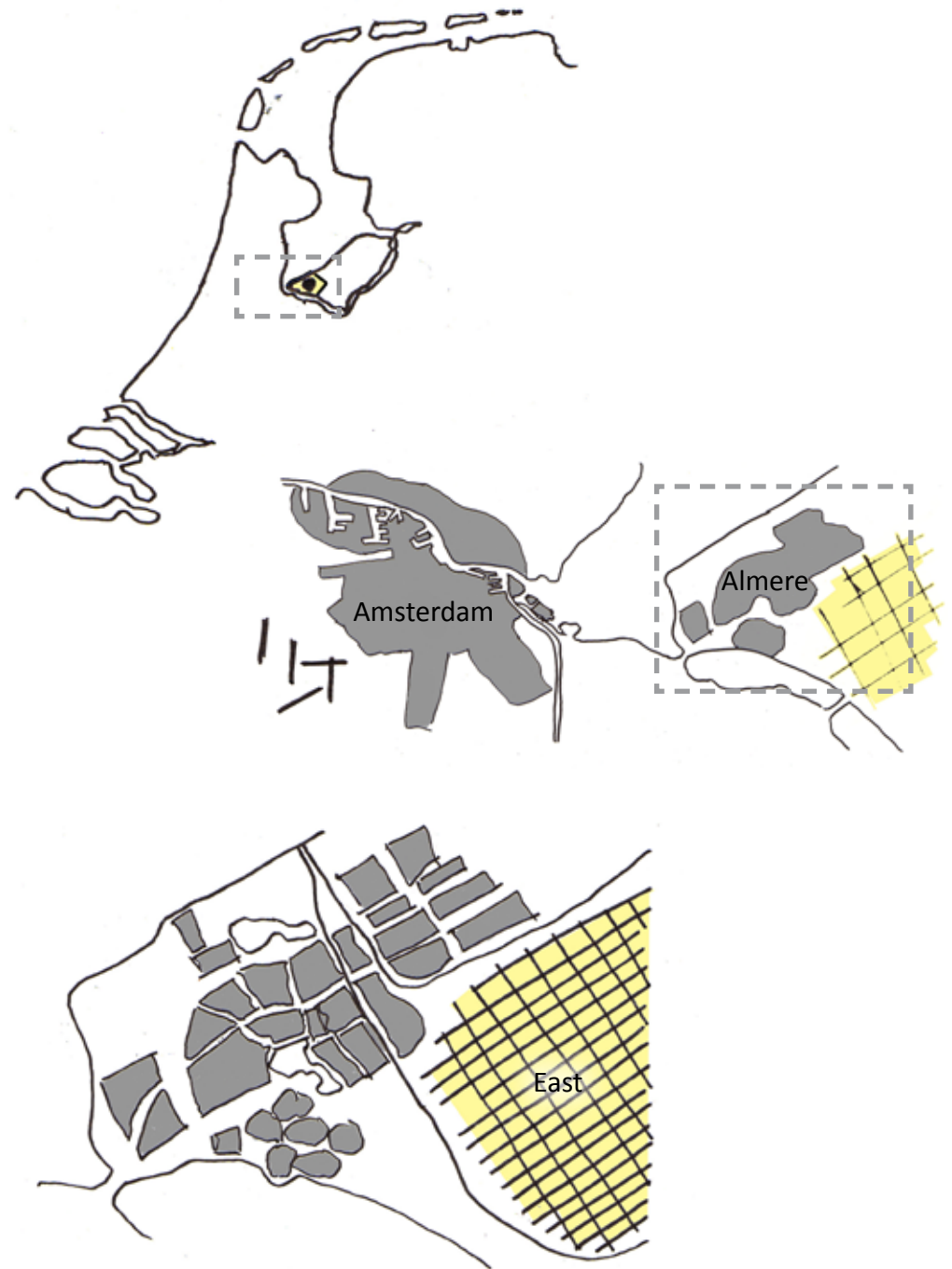
2.1. ALMERE, FLEVOLAND, NL

Almere is one of the youngest cities in the Netherlands with 33 years of existence since the first inhabitants moved in their homes. The city lies completely under sea level in the biggest land reclamation polder ever created. In 2009 the city has about 185.000 inhabitants and still is the fastest growing city in the Netherlands.

The location of Almere close to Amsterdam, the suburban Gooi area and Utrecht explains a lot of it's success as an centre of growth. It still functions as an overspill town where a great part of the housing demand of these cities is resolved.

Almere lies in the province of Flevoland, which capital is Lelystad, the northeast neighbour. This province consists mostly of farmland with a few service towns and two cities, Lelystad and Almere. The latter is far out the largest city and is counted to the North Wing Randstad. This is a conglomeration with Amsterdam, Airport Schiphol and surrounding cities from an economic point of view.

Almere itself is positioned in middle of the southwest corner of the polder. It consists of different districts with their own centre and one covering main centre in Almere Stad (= City).

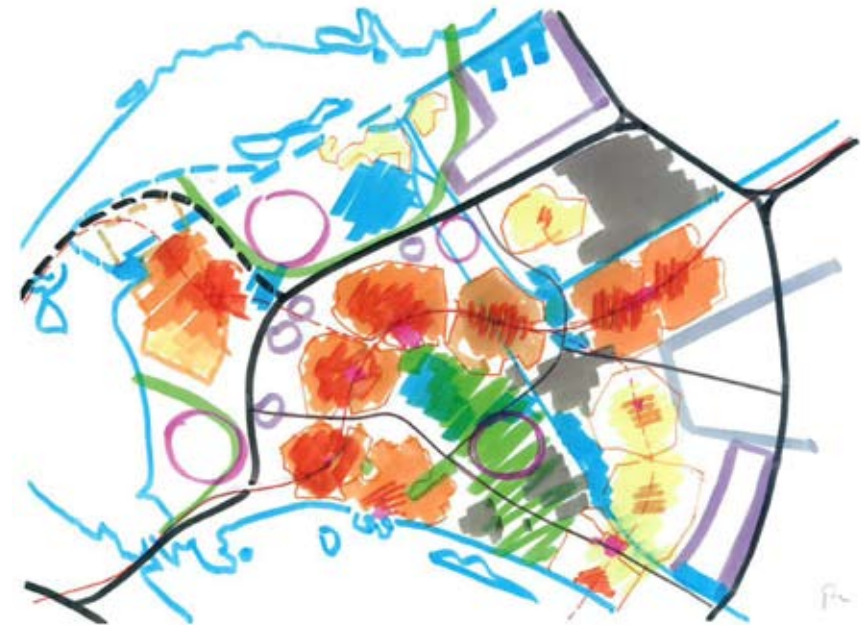


2.2. BIRTH OF A NEW TOWN

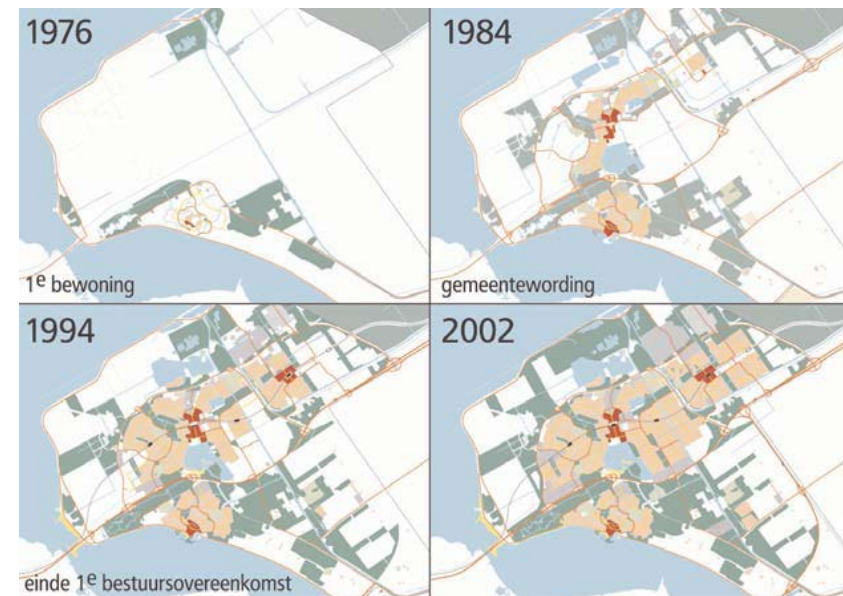
In the Second Memorandum on spatial planning (1966) the national government decided the develop 'Southwestcity', the later Almere. The plan was a well accessible living-working city of approximately 125.000 to 250.000 inhabitants to deal with the suburbanisation around Amsterdam and the Gooi in varied living environments. The city would be an overspill town for living and working in the region as well being a magnet for people and investments outside the region (Projectbureau Toekomst Almere, 2003). As a result of specific financial agreements with the national government, great pre-investments in infrastructure, green and water could be done. The urbanisation of Almere could therefore be done within a robust framework and in five different 'town centres'.

With an urban area of about 125 km², this city was in dimensions and structure similar with the Gooi. The town centres were organised with a central regional capital of about 100.000 inhabitants (Almere Stad) and around this four smaller centres, every with its own character (Have, Buiten, Pampus and East). In 1976 construction started with Almere Haven, in 1980 with Almere Stad and in 1984 with Almere Buiten.

Primarily low-rise building and wide green spaces made it an attractive alternative for inhabitants of the narrow, dated city renewal districts and anonymous flat districts of that time. The multinuclear plan gave the possibility to build correspondingly with the current social and economical demands and in the desired speed.



Sketch polynuclear structure - Teun Koolhaas



Chronological development of Almere

2.3. CRITICISM

One of the big common criticism is that the city is monotonous and has no identity. This image has been confirmed by the election of the city in the Volkskrant in 2007 as ugliest city in the Netherlands.

These critiques can, for most part, be explained by the fact that the city is built in a very short time. This makes the city and the houses monotonous and creates a monocultural landscape. This landscape has never been (partly) demolished or destroyed by outdated, outfashioning or war, as many older cities have experienced. This is something which will take a time. Another important reason for this monotony is the ignorance of underlying historical layers. The polder is often seen as a white sheet of paper, but also Almere has a lot of historical artifacts, although nobody knows.



Another point of criticism is often heard in professional circles: the lack of conflicts in the urban system. This avoidance of conflicts when designing systems is often a ground rule in technical design. But when this is consistently carried through, as in Almere, one ends up with a city characterized by some as 'lifeless', without an 'urban vibe'. De Bois, Buurmans and Josselin de Jong (2007)

analyzed this phenomenon and stated that: "Almere consists of freestanding districts with little mutual connection and little variation in internal buildup." This refers to a certain spatial incoherence.

Loes van Wolferen (2006), part of the Almere Atelier, concluded that the in-between spatial relation of the city parts, districts and neighbourhoods is poor. This is the result of the consequent hierarchy in infrastructure and the drastic separation of traffic types. The connection between the a district and an adjacent

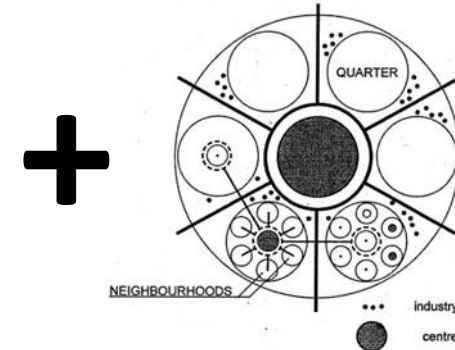
district is for cars always indirect, because this traffic is taken care of through the avenue-system. This makes the orientation in the city poor, because when moving through the city one always have to go back to the avenue-system. Additional problem is that the avenues don't have any variation in their layout. When every avenue would have its own identity, perhaps through context, it would be easier for citizens and visitors to orientate themselves in the city. Spatially seen this variation also lacks in building typology and density.

At the same time the inhabitants are quite happy with their living situation and their neighbourhood. The citizens appreciation for their house (an 8) and their living environment is high (90%), but at the same time there is a high tendency to move: 50% of the citizens thinks about moving within the next two years and half of them considers a dwelling outside Almere (Lichter, 2007). According to social researcher Pieter Hooimeijer this is a shocking in a way that such a willingness to move is unprecedented in the Netherlands.

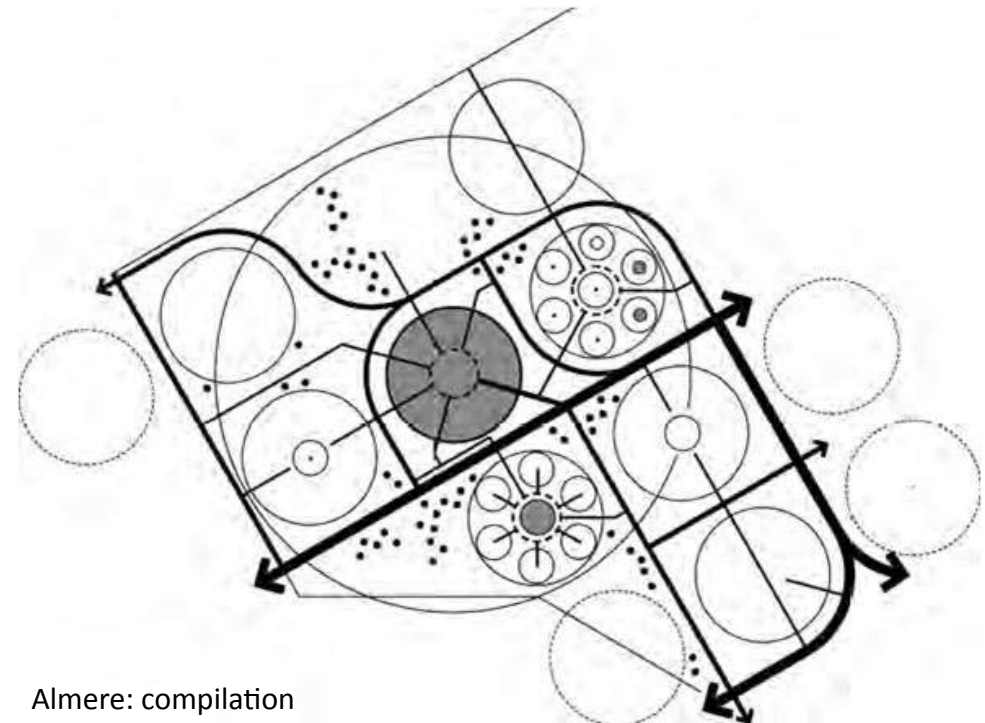
Arnold Reijndorp (2006) sees the migration from old to new urban expansions inside Almere blamed to the fact that the new seems fashionable and the old outdated. This implicates that the housing market in Almere is strongly affected by trends.



Garden city



Segmented city



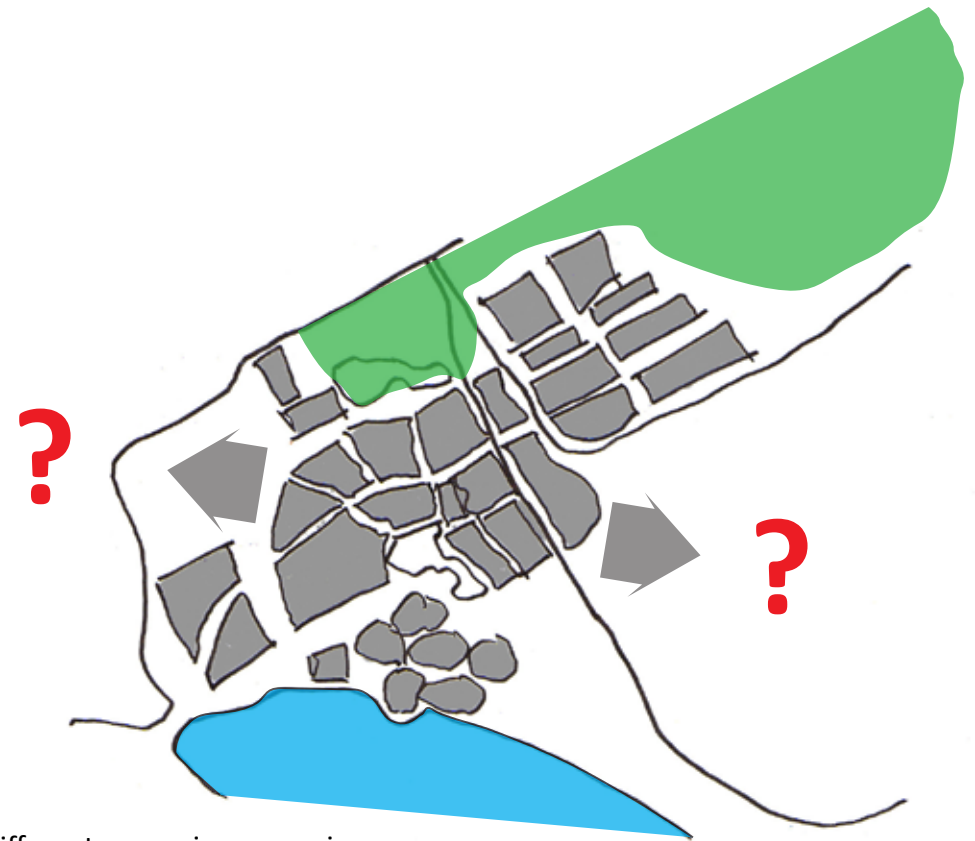
Almere: compilation

2.4. FUTURE ASSIGNMENT

The original assignment will be completed in 2010, with the completion of Almere Poort (first phase). Almere will then have 250.000 inhabitants. But the national government, the Northern Randstad and the city council have taken up the new assignment to grow to 400.000 inhabitants in 2030. The development potentials for this mission are researched on two fronts, the west and east. The city is bordered by nature reserves in the north and the Gooimeer lake in the south.

The west has the potential for a highly urban and marine development focussed on the IJmeer and Amsterdam. The area in the polder is called Almere Pampus, but plans with this name mostly refer to an area beyond the dykes, in the IJmeer and Markermeer lake. Developments here can greatly improve the quality of the IJmeer/Markermeer lake, which is lamentably poor. It can also create alternatives for the traffic bottlenecks there are now. The presented plans are numerous and some are very inspiring, like the Markeroog proposal from West 8 and the Atelier IJmeer proposal from Teun Koolhaas and Ellen Marcusse.

The eastern development has potentials in large-scale development of green living- and working environments. The strong grid gives starting points for urban design. Some ideas have been developed which are inspiring, as the plan of MVRDV. In the north-east a big nature reserve will be developed. The area has also a lot of possibilities in terms of water, for this is the lowest part of the polder and the soil is sensitive for subsidence.



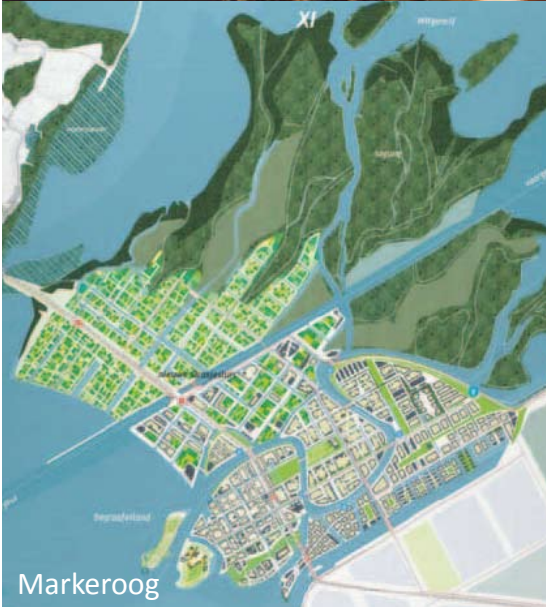
Different expansion scenarios

ALMERE

Almere Pampus



Almere East



Markerroog



Atelier IJmeer

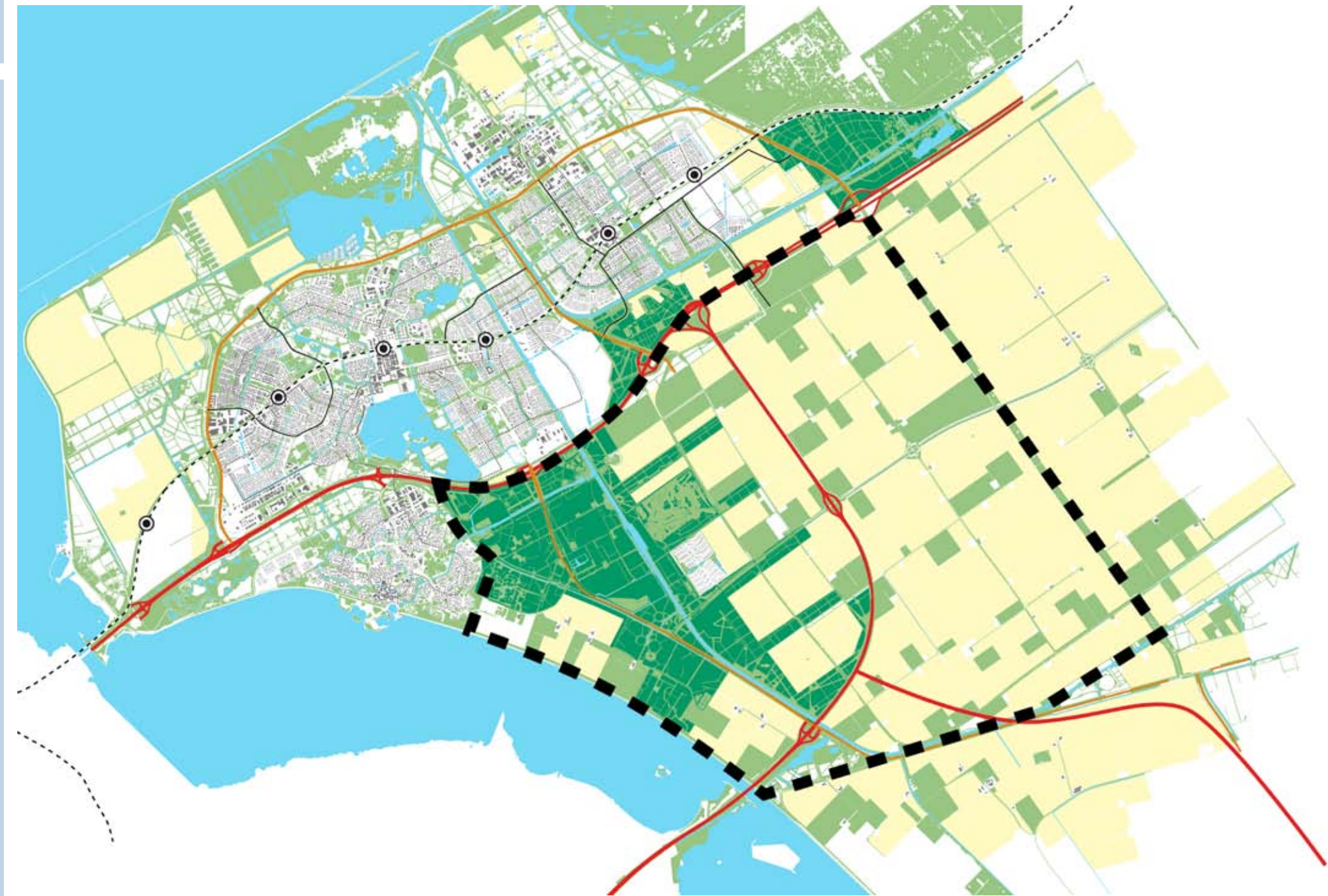


MVRDV

NEW TOWN

AND

MODERN



FLEVOLAND

2.5. ALMERE'S EASTERN HORIZON

The vast area beyond the eastern border of Almere is cultivated into a technical optimized system for farming. Soil is divided in the largest farming slots in Holland with in between a functional-hierarchical system of roads and waterways.

This is an area which is, without doubt, optimized for one goal: farming. But now it faces a problem: a dropping land level, due to subsidence and geological toppling (Wolters-Noordhoff Atlasproducties, 2007). While this part of the recent reclaimed land is already the lowest place in the polder with -6,20 meters, it will subside in the future with about 30 cm. The water board Zuiderzeeland, responsible for safety and quality of water in Flevoland rings the alarm bell (see inset). The water board sees subsidence and the increasing water assignment as the challenge in 2050, especially in the Almere-East area (Waterschap Zuiderzeeland et al., 2008).

However this area is suitable for a function change, from industrial green to a red-blue environment, where living-with-water experiments can be held. But adding new functions will need an integrated and thorough idea of water management in this changed situation. This makes water now and in the future a very relevant issue in this area.

APPROACH



CHAPTER 3
STRATEGY

STRATEGY

WATTD PRINCIPLE

3.1. ROLE OF THE URBAN DESIGNER

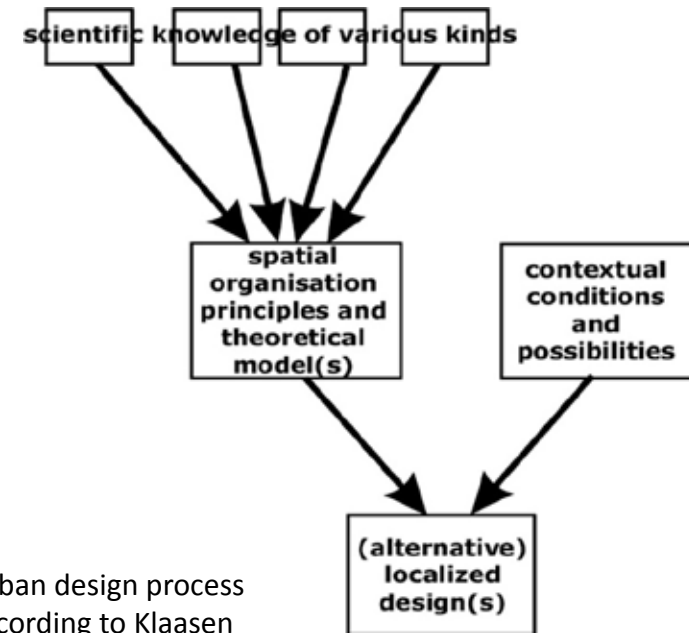
The relationship between research and design is complicated within the Faculty of Architecture, as seen in the enormous stock-taking of opinions, understandings and views in the book *Ways to Study Urban, Architectural and Technical Design* (de Jong and van der Voordt, 2005).

According to Edward Hulsbergen (2007) the debate is troubled by the fact that an important share of the urban design work consists of integrating – including neutralising opposites – elsewhere postulated and researched (sectoral, specialistic, disciplinary) knowledge and views.

Klaasen (2004) sees the academic architecture as a practical science with practical-scientific research, in distinction with fundamental and empirical sciences particularly conducted in other disciplines.

Arthur Veen (Inaugural Lecture, 1976) concludes furthermore that practical science is a task-oriented combination of two or more (empirical) sciences: “A conglomeration of disciplines stuck together by an extrascientific function”. In this way academic architecture can be compared to medical science: If we ignore the task of healing, medical science decomposes into biology, chemistry, psychology etc.

In the same way academic urban design can be decomposed into civil engineering, landscape architecture, sociology, material knowledge etc. But only when the task of integrating is left out, which can be considered as the basic role of the urban designer.



Urban design process according to Klaasen



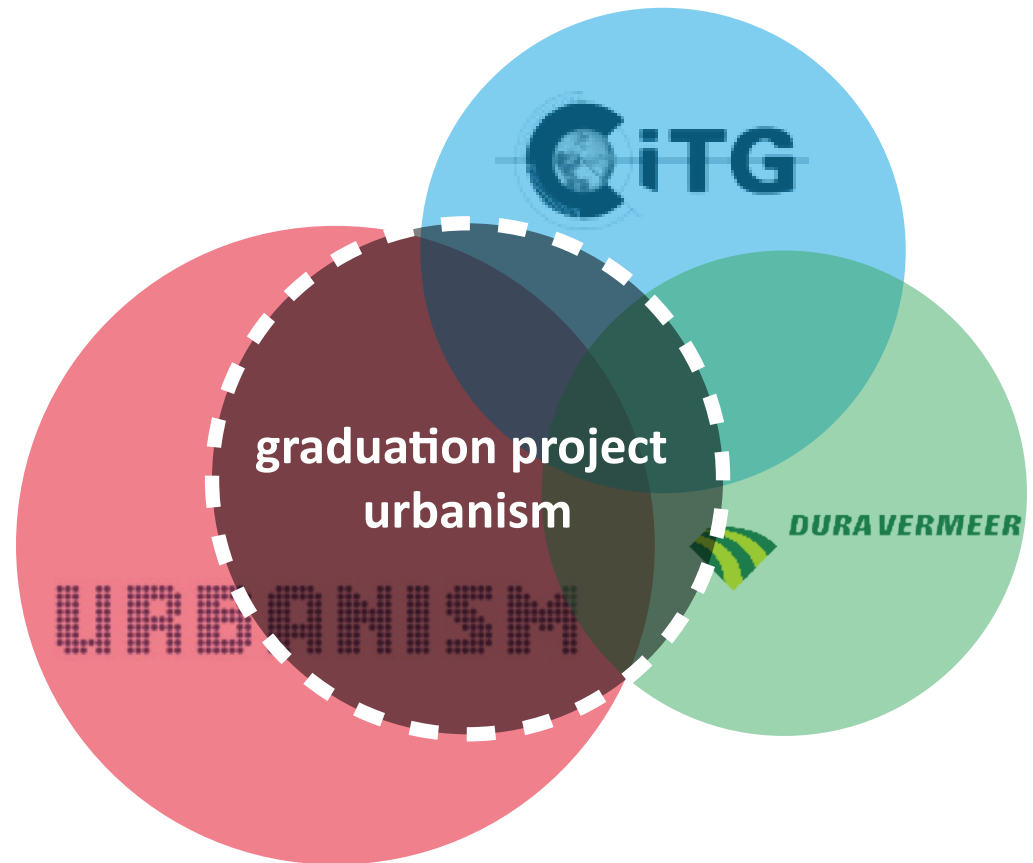
Example of integrated urban design: Amsterdam ring of canals

URBAN ENGINEERING

This project takes place on the edge of the disciplines of urbanism and civil engineering. Some aspects of analysis and the creating of a concept are done in cooperation with people of the civil engineering discipline. Harry de Brauw is a civil engineering student who has the subject of creating a new urban water system for Almere East. Until now we have cooperated in morphological analysis as well as developing guiding principles. This cooperation will continue and expanded to the design process.

The design of the city map and public domain is unthinkable without a strong relation with and the necessary knowledge of civil engineering and landscape architecture (Heeling et al., 2002). It is essential for the urban designer that he has the know-how of the possibilities to treat the ground surface, alter the underground infrastructure, make waterproof constructions, realising crossings on different levels, planting trees and landscape elements. The urban designer doesn't have to be a fully skilled civil engineer however he has to know how to communicate with other disciplines and have understanding of the possibilities and limitations of civil engineering.

Frans van de Ven (2007) sees the differences between the disciplines of Civil Engineering and Urban design in the fundamental contrast in culture and education resulting in difficult communication between both groups. Civil engineers are educated in the tradition of analysis, structuring, schematizing and reducing until a soluble problem arises. Urban designers use another strategy: they analyze the problems and structure them, but they don't reduce. They first make a problem more complex, by including other aspects. And after this they look for a pretty,



fitting solution.

Nowadays there is attention for other forms of coastal defence, river hydraulic engineering and water management in polders. At the same time water will keep its attraction in giving meaning to urban and rural areas. Urban design, landscape and civil engineering are (again) condemned to each other (Hooimeijer et al., 2005). This especially means new assignments, new chances and possibilities for the spatial design of city and country.

Workshop Almere East organized by Deltares

In May 2008 Harry de Brauw and myself attended a workshop with people from the Municipality of Almere and the Water board Zuiderzeeland about Almere East. The goal of this workshop was to develop plans in consultation between urban designers and experts on water, soil and sustainable techniques and methods. Concurrent engineering was used to development of usable propositions for the spatial planning of Almere East. Every of the three produced variants had a coherent package of measures.

Concurrent engineering is an applied design method by which the team works, simultaneously, on a design for on site development (Hoogvliet, 2008). Goal of this design method is:

- Shorten the development process;
- Raise the quality;
- Lowering costs;
- Take all aspects of the life cycle in account.

This means working in a multidisciplinary team, with all expertise involved early in the project. And this gives possibilities to combine realization and maintenance

Presentation municipality personal graduation plans

In December 2008 we presented our plans to a group experts from the Municipality and the Water board. In the following discussion the experts pointed out their view of the area and about our plans. They found it interesting how we cooperated in the project while keeping each our own discipline in mind. This way of working is what they now try to implement between the municipality and the water board in developing urban plans.



Workshop room

PRACTICE

This graduation project is supported by the company Dura Vermeer Business Developments BV. They offered guidance, information and a workplace to conduct this research and to develop this design. Both parties benefit from this graduation project by the information and research conducted on deep polders and water urbanism. Also the realistic approach in the company adds a dimension to the graduation project.

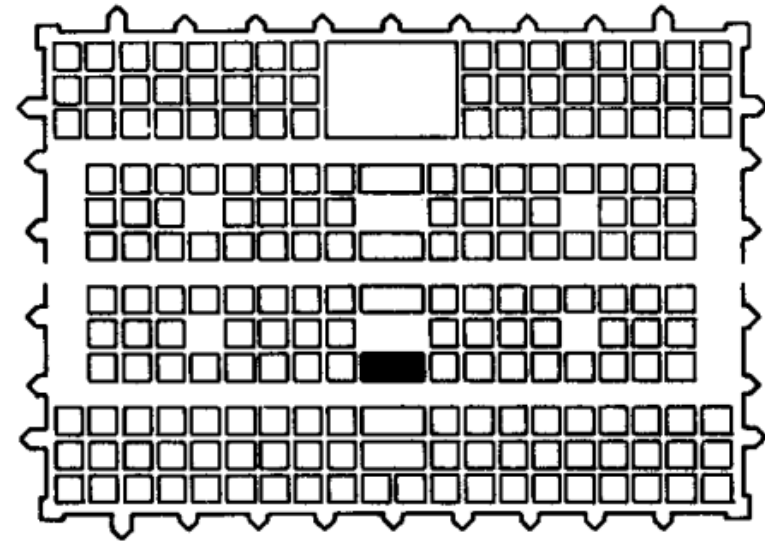
Dura Vermeer also gave me the possibility to attend different workshops, give presentations and interview people involved in Almere.

IMAGINE OVER NETWORK BY DURA VERMEER.
www.beteropjeplek.nl



3.2. DESIGN PRINCIPLES OF WATER IN URBAN DESIGN

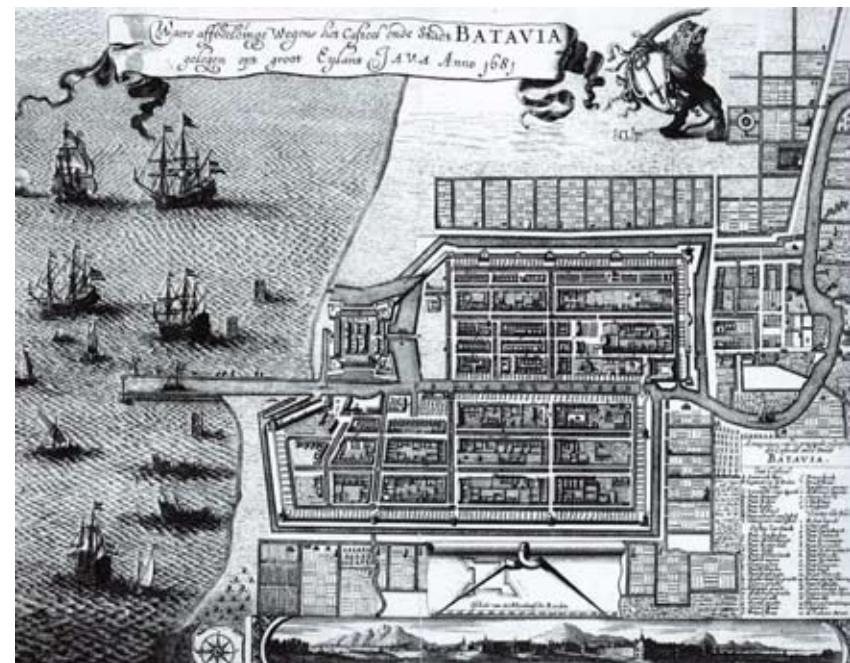
In developing a strategy for the expansion of the New Town Almere, research to the relationship between water management and city design is important. The first article is about the main recommendations of an analysis of New Towns ranging from the 17th till the 20th century on their water management decisions. The second article is about water as a tool in the urban design of large scale plans. Subject of study are the plans for Meerstad, Groningen and Warande, Lelystad. The last article is about the polder as testing ground for new ways of living with water in the same studied plans.



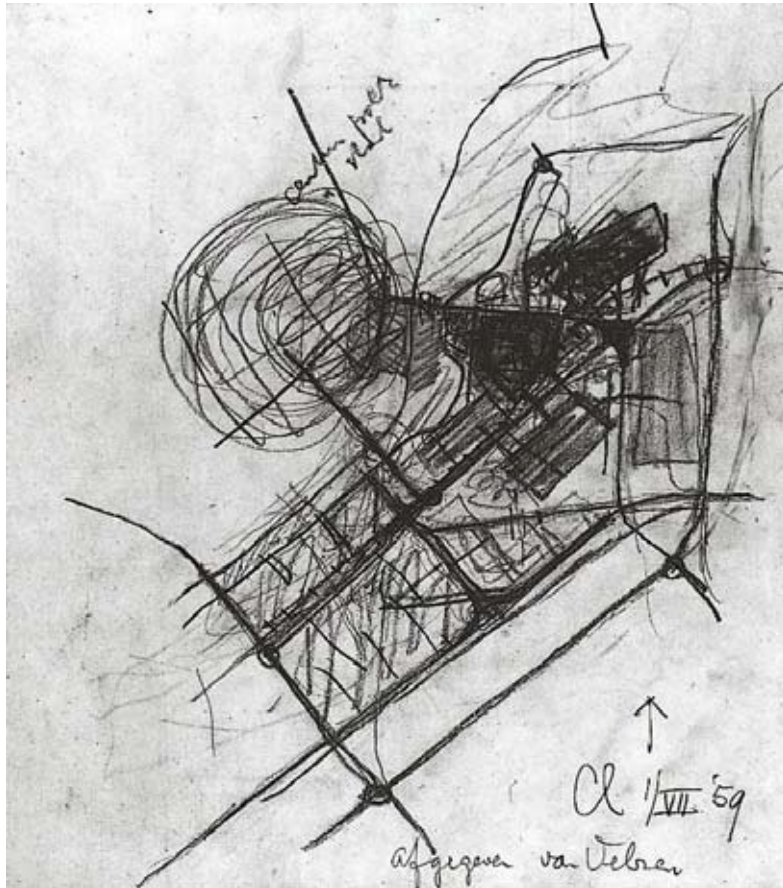
Stevin's ideal city



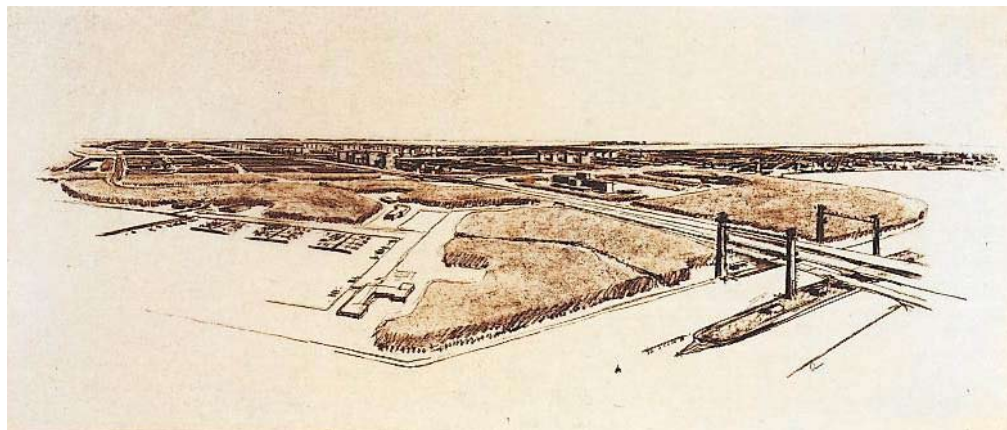
Willemstad based on Stevin



Batavia based on Stevin



Missed chances in history of urban design:
Lelystad at bay - Cornelis van Eesteren



PRINCIPLE 1

URBAN DEVELOPMENT OF NEW TOWNS RELATED TO WATER MANAGEMENT

The forming of the Dutch polder city was based on different landscapes: peat reclamations, reclaimed land and polders. They resulted in different types of New Towns from the 17th to the 20th century and dealt differently with the existing water structure, because of different technologies or approaches. This study reviewed urban development in New Towns related to water management. The main question is: what were the main water criteria guiding the design of New Towns in Dutch history? These towns ranging from the 17th to the 20th century are the spatial image of the approach to water management issues in that time.

Design process

In the relationship between city and landscape design a clear shift is seen in history. The city of Willemstad (founded 1583) is a clear synergy between the a symmetrical Dutch Renaissance ideal of Simon Stevin and the polder parcelling system (Burke, 1956). The main elements of the polder - dike, canal system and plots - are converted into an urban system. This is also the case in 19th century Hoofddorp, where the intersection of the main canal with a road led to the establishment of a town. The expansions of Hoofddorp later on developed from plot to plot, but were more and more filled in with introvert socio-spatial concepts. Nagele, founded in 1957, represents a rational geometric design based on and designed together with a polder system.

The first plan for Lelystad by Cornelis van Eesteren displayed a waterfront at the dike, the locks and a projected bay, but this was

later knocked off the table because time had changed (Brouwer, 1997). The implemented plan is characterised as a loose structure filled in with introvert social spatial neighbourhood thoughts. The current city plan shows little relationship with the landscape of the polder (van de Ven, 2008).

Using the context

These New Towns all dealt differently with the existing water system of the polder. Where the plan of Willemstad expressed a desire to have a better control of the polder water level, Lelystad and the later expansions of Hoofddorp use technology and planning per neighbourhood without taking the existing water system in account. This is a pragmatic approach became possible in the 20th century, but it complexes the water system on a citywide and regional scale.

Nagele, also built in the 20th century, dealt quite simple and straightforward with the existing water system. A bent was created where the town found it's centre, providing together with the land parcelling a context, which was then the guiding principle of design and meant the melting of technology, science and art in one functional entity (Hemel and van Rossem, 1984). Polder and

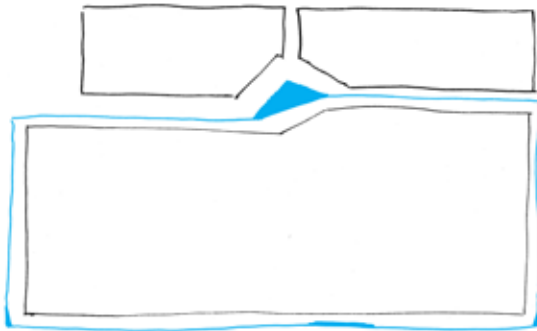
city in Nagele where designed as one.

Technology

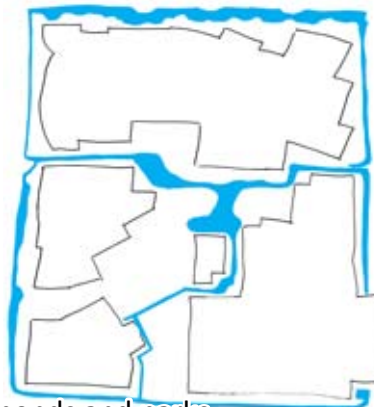
The applied water technology in the New Towns represents the spirit of the time. Willemstad was modern in its time with windmills and locks to provide maximum control over water within the city limits. Nagele has the same water system as the rest of the polder. But Lelystad and Hoofddorp use different water levels per district separated from the polder. But all these three most recent New Towns rely on by electric and diesel pumps placed far outside the city limits.

Lelystad's neighbourhoods development

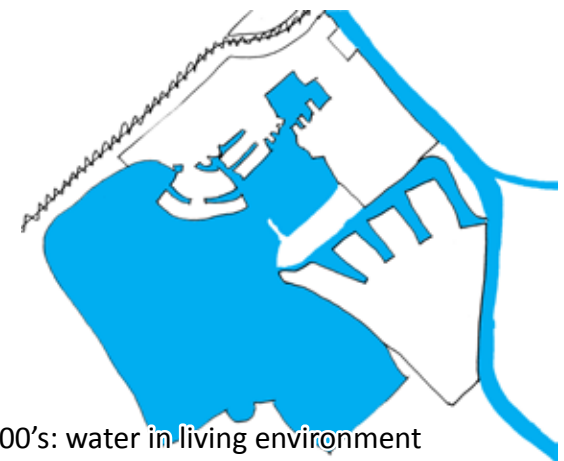
The final structure plan of Lelystad was based on the American city and shows little relationship with the landscape (van de Ven, 2008). The new water system was designed per neighbourhood, without a lot of coherence at a higher level. In de first neighbourhoods there is little surface water present, about 3%, mostly in small canals behind houses. They sometimes provide a border function, but there is just one with a more park-like function.



1960's: very little surface water



1980's: ponds and parks



2000's: water in living environment



But the position of water in later neighbourhoods changed. It started with the influence of landscape architects who made parks and landscapes such as the beautiful Zuigerplas (van de Ven, 2008). In the Schouw district water was more and more integrated in the form of ponds and parks, but not yet in the living environment. The distance between housing and park was therefore still too big. In more recent districts it is all about living around and on the water. Especially in the environments around the lake Bovenwater.

Water management and city design

What were the main water criteria and their place as a design principle of polder New Towns in the Netherlands? It is clear that the use of water as a design principle was different in the studied towns. Willemstad is positioned and outlined because of its place at the Hollands Diep and the desired control of water. Nagele and

Hoofddorp find it's centre in the (created) highlight of the water system, respectively a bent and a crossing. But they have nothing to do with controlling water levels, something which is done by machinery set up far outside the city. But the cities are carefully placed inside the polder and designed in one .

Lelystad is in this case the exception, because of the complete lack of position and centrality regarding the water system. This neglects water and the water system as a manmade genius loci and results in a city, characterized by (Geuze and Feddes, 2005) as: "A city without merits, far from the coast, yearning for the waterfront."

Where they conclude their book Polders! melancholily: "Wherever the Dutch situated Kaapstad well-aimed at the Tafelbaai and Manhattan at tongue between the Hudson and the East river, they left Lelystad and Almere get lost in the new polders."

PRINCIPLE 2

WATER AS CARRIER IN LARGE URBAN PLANS

During the Archiprix 2008 prize-giving ceremony the observation was that urbanism is back in a number of renewed visions. Most plans applied oneself on a higher scale-level and derive their concepts from their environment. It is especially the big scale which was avoided some time but it is this scale on which most interesting plans are made now.

But seen in the light of expected climate change and yearly subsidence of our polders by urbanization and intensive farming we also have to change to another way of urbanism. And because stopping the ongoing urbanization is no realistic option, it's in the line of expectation Dutch polders will urbanize more and that precisely this urbanization will be the thriving force of the accommodation of more water (Hooimeijer et al, 2001).

The plans for Meerstad and Warande both contain a large building assignment in large-scale polder areas. The plans try to model and

edit the polder landscape to make it ready for the new function. Water is an important instrument in this process.

To the east of Groningen there is an open wide agricultural area for which a plan is drawn up of about 10.000 dwellings and 135 ha business. In the current situation the area is characterized as an 'in-between' area, where the connection between the different scenic qualities and the current urbanization is missing.

The masterplan Meerstad is carried by a big new lake in the middle of the plan area. This is water what is used as a design tool to give the landscape more cachet and identity, but also functions as peak buffer in times of extreme rainfall. The zoning plan reserves a large area for the development of this lake, plus an additional area for 'water and land', what seeing the collages, point in the direction of floating houses.

In Lelystad a big expansion in the south is foreseen with the name Warande. The plan for this area is described as an big expansion in a landscape which must be conquered (Harsema, 2005). In the Flevopolder this has been done before, but the big size of the polder has quite often been tamed by the design of suburbs with



Meerstad lake as carrier and experience



APPROACH

an introvert structure, situated between boundaries of green and traffic (idem).

The plan Warande covers a wide arable land between Lelystad and a big forest area named Hollandse Hout. The pattern of paths and waterways in this forest is mirrored in the strict parcellation of the arable land. In this way landscape and city grow to each other according to Harsema (2005). This seem to work for roads and green, but not that much for the water system.

The use of water in both plans differs. In Meerstad a lake is used as big landscape element to give the new city district a new centrality and formality. The use water in Warande is more based on the existing poldergrid which is transformed to bigger and smaller watercourses with here and there a right-angled pond. It seems as the Flevopolders grid proves more dominant than the poldergrid in Groningen. This can be explained by consistency of the modern polder grid in the Flevopolder versus the irregularity of the 'splinter' peat cultivation polders of Groningen.

Water as design tool in Warande is used to emphasize the existing poldergrid as landscape carrier. The grid gets stronger by the use of water which endorses it. In Meerstad water carries the landscape in a new way, by adding a new element, that of a big lake. The landscape is messy and unclear and a large lake is used to clean up and give direction to the region as a whole. Furthermore the Meerstad lake plays a role in the water management system, which increases its value as a design tool.



Watersports



Living with water

PRINCIPLE 3

POLDER AS TESTING GROUND

In history, the polder proved an ideal place for experiments with living typologies. Its emptiness and functional character leave room for consistent realisation of concepts. The struggle with water forced us to develop a strict planning tradition which produced unprecedented large-scale urban projects as the construction of the ring of canals in the 17th century in Amsterdam. But also in more recent times polders proved ideal for realizing ideas about form and function. The Bijlmermeer expansion in Amsterdam built the seventies of the 20th century - named after the lake the area used to be - is the example of a consistently realised urban plan. Sadly enough is turned out to be quite unsuccessful as large parts of it are demolished these days. But it demonstrates the Dutch belief in manipulability, 'maakbaarheid' of landscape and city.

Wouter Reh has approached our polder history in his Delta Darlings (2003) farewell speech by looking in terms of cultivations. We colonised the natural landscape, began building a network of cities and are now in the third cultivation: "Which began with modern urbanism and resulted in a mix and strong relation between landscape and city. This present phase is stagnating caused by the governments restraining planning policy. The government played a restrictive factor in the last decade, instead of making the third cultivation possible and helping to create quality.

Strategic projects should be aimed at producing landscape-city ensembles in which both qualities are embedded in a new way. But a collective lack of imaginative powers is holding us back. This leads to the terrain of spatial design, in which the development is aimed at reliable images of ensembles. On which qualities can be tested and connected into series, who portray and show the perspective of the third cultivation."



Peatpolder



'Trekvaart' network of cities



City and land - Amsterdam Urban Expansion plan

First cultivation

The first cultivation of the Netherlands was formed by a colonisation of the natural landscape formed by dunes, estuary, tidal marches and peat cushions with the purpose to grow food by means of farming. The social format was formed by the tense relationship between the free colonists who lived elsewhere in villages and the nobility, who represented the feudal system. The most important element characterizing this cultivation is the peat plot, a basic module in which one could retrace the entire Dutch landscape. Technical instruments were the axe and plough. The peat cultivation landscape is the matrix of the Dutch landscape

In this time planning of the Dutch water city was introduced and cities were expanded in peat polders and added spatial shapes such as wharfs, weigh houses, markets and town halls to accommodate trade and government.

Second cultivation

The second cultivation was caused by the development and expansion of the network of the Dutch cities, in which different phases are recognized, but who do not fundamentally differ from each other, because city and culture landscape still remained separate entities. The control of water increased because of the development of watermill technology, in the form of connected passages of mills and new types of mill. The water management system became regional and with increased capacity.

The characterizing element was the Dutch reclaimed land, on private initiative, without direct government involvement. This was a lucrative investment for the bourgeoisie and the new land was often fitted with country estates.

The Dutch city expansions in this period were characterized by

rationalism, based on ideas of the Ideal City of Simon Stevin. This determined the measure system of urban plots in the Dutch city of the 17th century. Also a connected system of cities through roads and water ways was constructed.

With the coming of the industrial age the relation between city and landscape became problematic. The economical coherence was broken and polarised. Cities industrialised and attracted crafts and local industries, leaving the landscape only for agricultural production. This caused a functional separation between city and landscape. The new city expansions were realised by speculators under liberal government, which resulted in fast money earning on the housing of labourers.

The reclamation of the Haarlemmermeer was the first State project in the Netherlands, but was still dominated by a show of agriculture politics, speculative profiting, landscape experiments and idealism. The heart of the problems with the Haarlemmermeer is that there was no image of the landscape ensemble which makes this polder lies in this phase of the cultivation.

Third cultivation

The start of the third cultivation is Modern urbanism and planning, because this caused a definitive breach with Dutch tradition. The social format was the welfare state, in which the government took care of everything. Purpose of this cultivation was to form urban regions, who functioned socially and economically independent from the landscape.

The development went radically the other way, making city and landscape just more mixed and related into an economic, social, functional and spatial unity. This is fundamentally different from the other cultivations.

3.3. SUSTAINABILITY

The national government gave Almere the assignment to grow in 2030 to a city with 300.000 inhabitants. Almere will then be a city bigger than Utrecht, the fourth largest city in the Netherlands. The Municipality of Almere (2008) sees this expansion of as an opportunity to realise sustainable development on big scale. In the search for a vision on sustainability the municipality embraced the Almere Principles, a customized version of the Cradle to Cradle theory.

The Cradle to cradle theory is a new vision on the sustainable design. This is defined by the commission Brundtland in 1987 as development in which the current generation provides its needs without limiting the possibilities of fulfilling this needs of future generations. But the Cradle to cradle (C2C) vision goes beyond this: try to fulfil our own needs and providing future generations of more possibilities to do so. Try to be good, instead of being less worse (McDonough and Braungart, 2007).

The Almere Principles is a shortlist of crystallized C2C:

1. Cherish diversity

To enrich the city we recognize diversity as a determining characteristic of robust ecological, social and economic systems. By appreciating and encouraging diversity on every terrain Almere will prosper as a city rich of variation.

2. Connect place and context

To connect the city we shall anchor and strengthen its identity.

The city will maintain, from her own strength and to mutual advantage, active relations with her surrounding communities in the broadest way.

3. Combine city and nature

To give the city meaning, we shall pursue unique and robust combinations of urban and natural tissue and to an increased sense of human solidarity with nature.

4. Anticipate on change

To continue building on the evolution of the city, we shall incorporate a large extent of flexibility and adjustability in our plans and programmes and by that make unpredictable opportunities possible for future generations.

5. Keep innovating

To bring the city forward we shall encourage new and improved processes, technologies and infrastructures and support experiments with knowledge sharing.

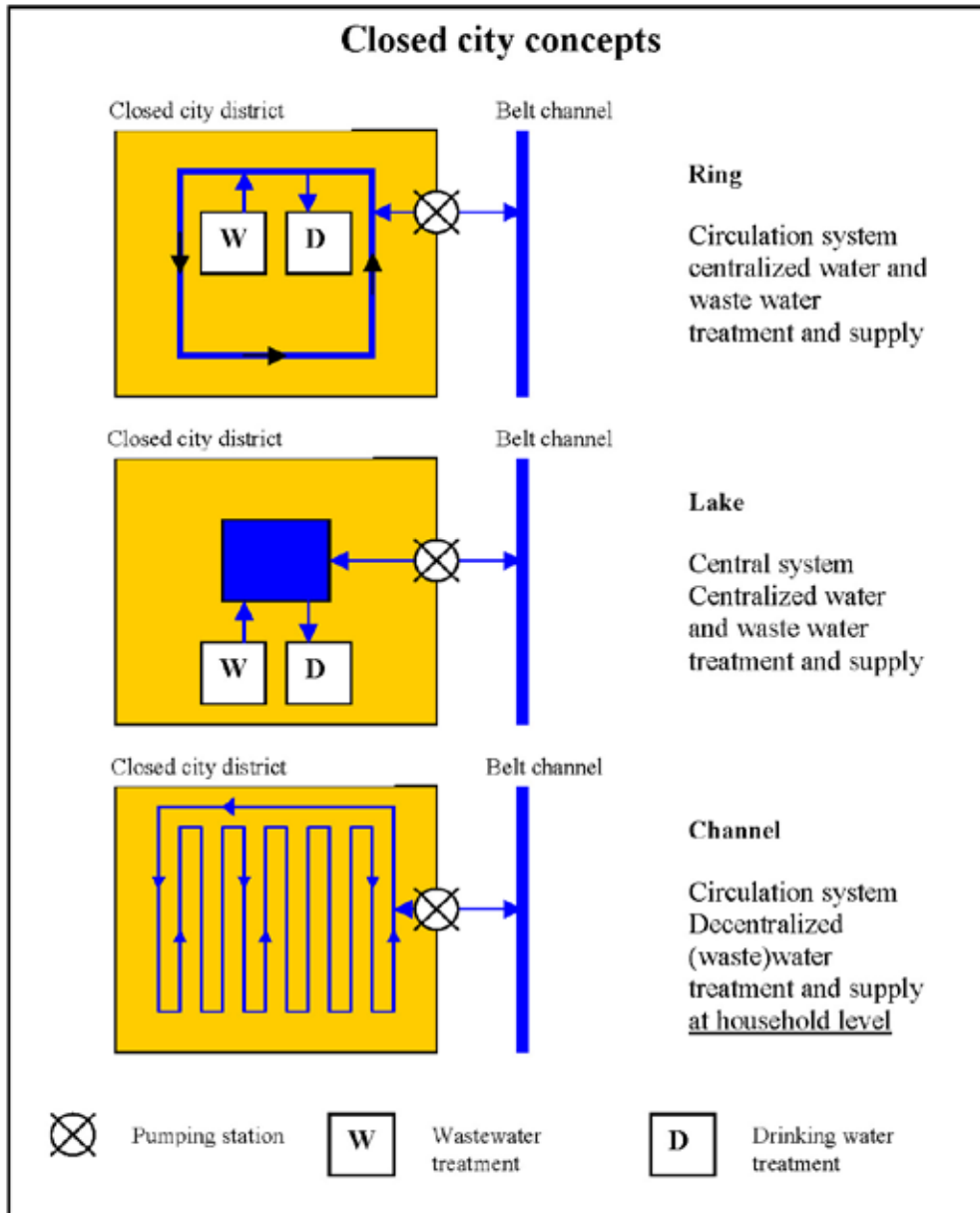
6. Design healthy systems

To preserve the city we shall take advantage of C2C solutions in our urban systems, in the knowledge of the mutual dependency of ecological, social and economical health on every scale level.

7. People make the city

From the acknowledgement that citizens are the thriving force in making and preserving the city, we support their pursuit to realise their unique possibilities, with inspiration and dignity.

THE CLOSED CITY



Another sustainable approach used in this project is the concept of the Closed City. The city nowadays can be seen as the centre of artificial and natural flows of water, goods, energy and waste. These flows move from the city to the surrounding and vice versa. In this view the city can be seen as a parasite, exploiting and polluting its surrounding.

The Closed City is a city that does not have adverse effects on its surroundings, such as water depletion or emission of pollution (de Graaf, 2005). Several ways of water supply and layout of the urban surface water system can be made for the Closed City such as the ring, the lake and the channel. The main goal is always to close life cycles and isolate and disconnect them from the environment.

A starting point is precipitation, which is the main source of water for the Closed City. This is retained as much as possible in the urban area, by disconnection techniques, infiltration, storage reuse and circulation. In case of exceptional dry conditions, water from a belt channel can be supplied to the city. This is in line with the Water Policy in the 21th century (WB21).

The goal for disconnection of systems is 100%, but this is more an ambition, as a city will never be completely autarkic. Especially in Dutch polders where there is a yearly rainfall surplus.

3.4. GOING EAST, NOT WEST

The question whether Almere has to expand to the west or east is difficult to answer. The future is uncertain and decision making has more dimensions than only a technical, financial or societal point of view.

But with a quick-scan on different subjects there are some difficulties foreseen which threatens the feasibility of developing westwards, especially on the field of water management.

Ecology

Planning in the IJmeer lake is constraint by Habitat Bird regulations, as well as by the neighbouring National Landscape's of the Green Heart & Low Holland (Wolters-Noordhoff Atlasproducties, 2007).

Society

Any building in the IJmeer is opposed by for instance sailing societies and the major environmental NGO's as well as prominent influential people who live close by in villa parks. They already successfully protested against a new highway (A6/A9) from the bridge Almere-Amsterdam to Amsterdam-Southeast.

Economy

It is without question expensive to construct islands. The investments are very high and they have to be earned back by either dwellings in high density or expensive dwellings. The fragility of the financial balance is high, as this is now experienced in the delays in the IJburg expansion of Amsterdam.

Foreseen benefits in the combination with infrastructural

connections through the IJmeer doesn't seem feasible either. It is more cost-effective to upgrade existing road and rail network (Milieufederatie Noord-Holland et al., 2004).

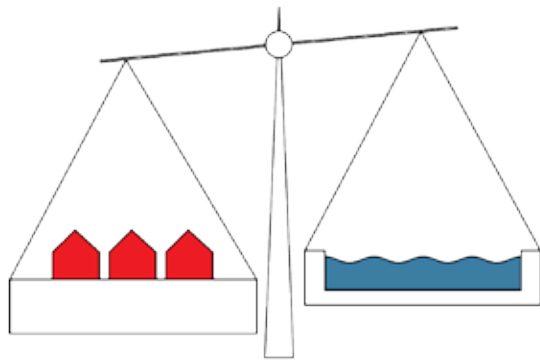
Water management

The water board aims to maintain a certain flexibility in the water levels of the lakes and keep a zone around the dikes free of building (Waterschap Zuiderzeeland, 2008). They only foresee development of a small number of big and high islands outside the dikes.

Moreover the urbanization demand should be aimed at maximization of water management goals: use urbanization as thriving force for solving water problems. Expansion in the west will solve for some part water (quality) problems but will worsen water quantity and flexibility options as described hereinabove. This aspect is critical in the discussion making around the question where to expand.



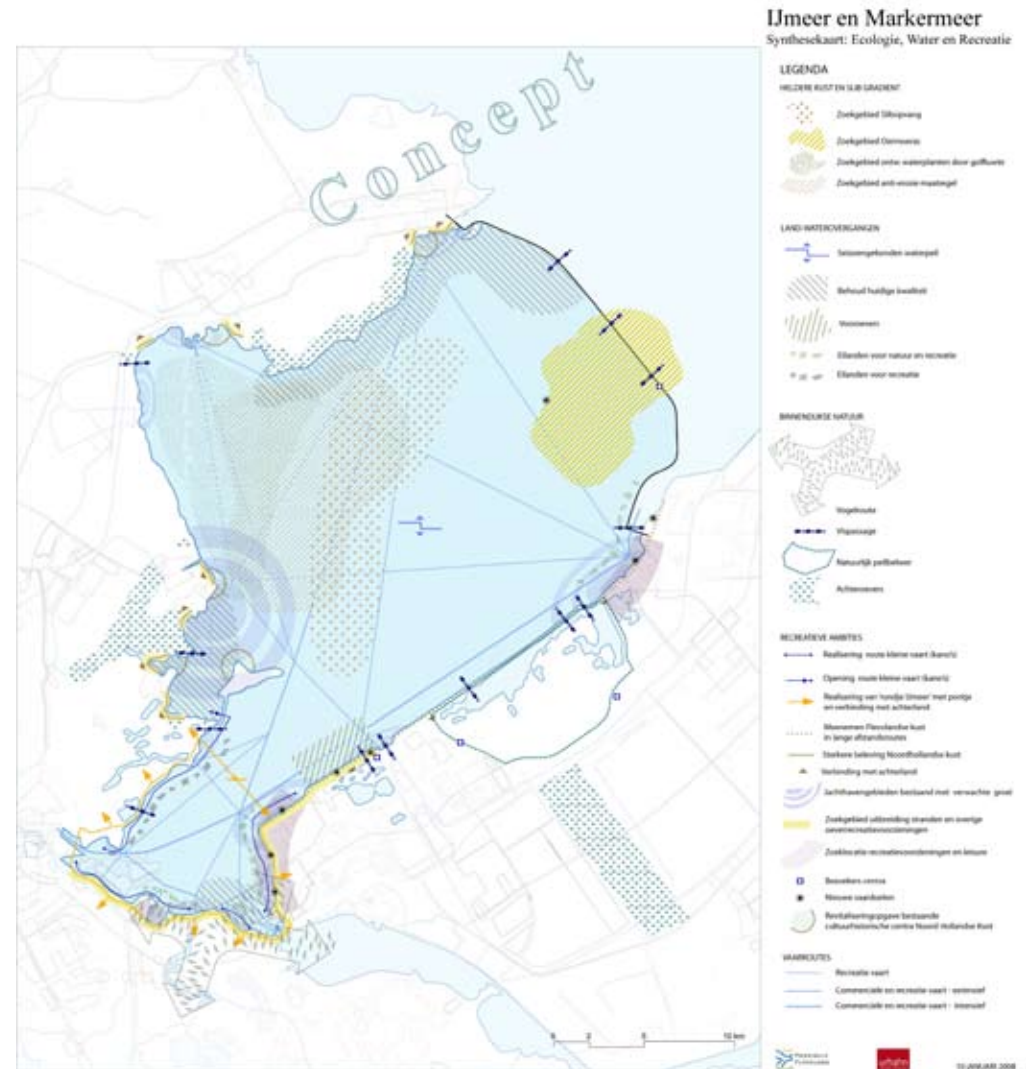
APPROACH



However there are some possibilities to improve ecology and water conditions. The project group Future IJmeer Markermeer has presented a map with sites where developments would have the most effect. What is interesting about this group, is that it consists of the Provinces North/Holland and Flevoland, the municipalities of Amsterdam, Almere and Lelystad, the ministry's of Spatial Planning, Transportation and Agriculture and environmental NGO's. Therefore products of this group are interesting as they seem to have a high consensus and managerial feasibility. But these plans only talk about small developments with little urbanisation.

Therefore the economical, societal and ecological feasibility of plans in the IJmeer on short term is highly disputed. This makes it very unclear how and how much of the claim of 65.000 houses from 2010-2030 could be realised on this side of Almere. Especially seen in the light of demographic trends who see a population decline after 2050.

Seen in this perspective, Almere East is a far more feasible location for most of the building assignment. The place it has taken in the eyes of the municipality as 'closing entry' of the building assignment will be utilized.



WATTED

SYSTEM

POIDER

TECHNOLOGY



CHAPTER 4 TECHNOLOGY

ENGINEERING

H₂O

4.1. SOIL ANALYSIS

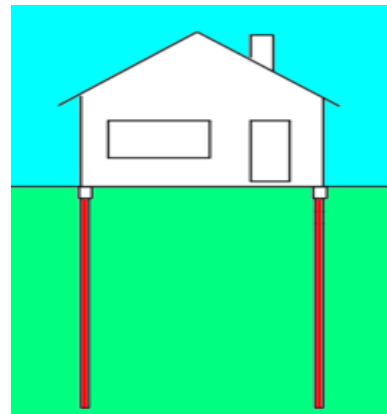
WHY

Building considerable number of dwellings in Almere East will demand an innovative construction method, considering expected subsidence and a the high groundwater level in the area. Otherwise this area threatens to become a new Gouda (Waterschap Zuiderzeeland, 2008).

Gouda is build mainly on weak soil and receives extra funding to deal with the maintenance costs, which are higher because of subsidence problems with infrastructure and public space. Research from Cebeon pointed out that Gouda needs an extra 2,8 million Euro per year and the Ministry of Home Affairs has agreed to this (Gemeente Gouda, 2006). This makes clear that soil can have a great effect on the costs of foundation and maintenance later on.

Dependent on the expected subsidence and water nuisance measures per location have to be taken. When little subsidence and water nuisance is expected, traditional building methods will be sufficient. But if much water nuisance and high setting is expected, innovative methods can be a solution.





HOW

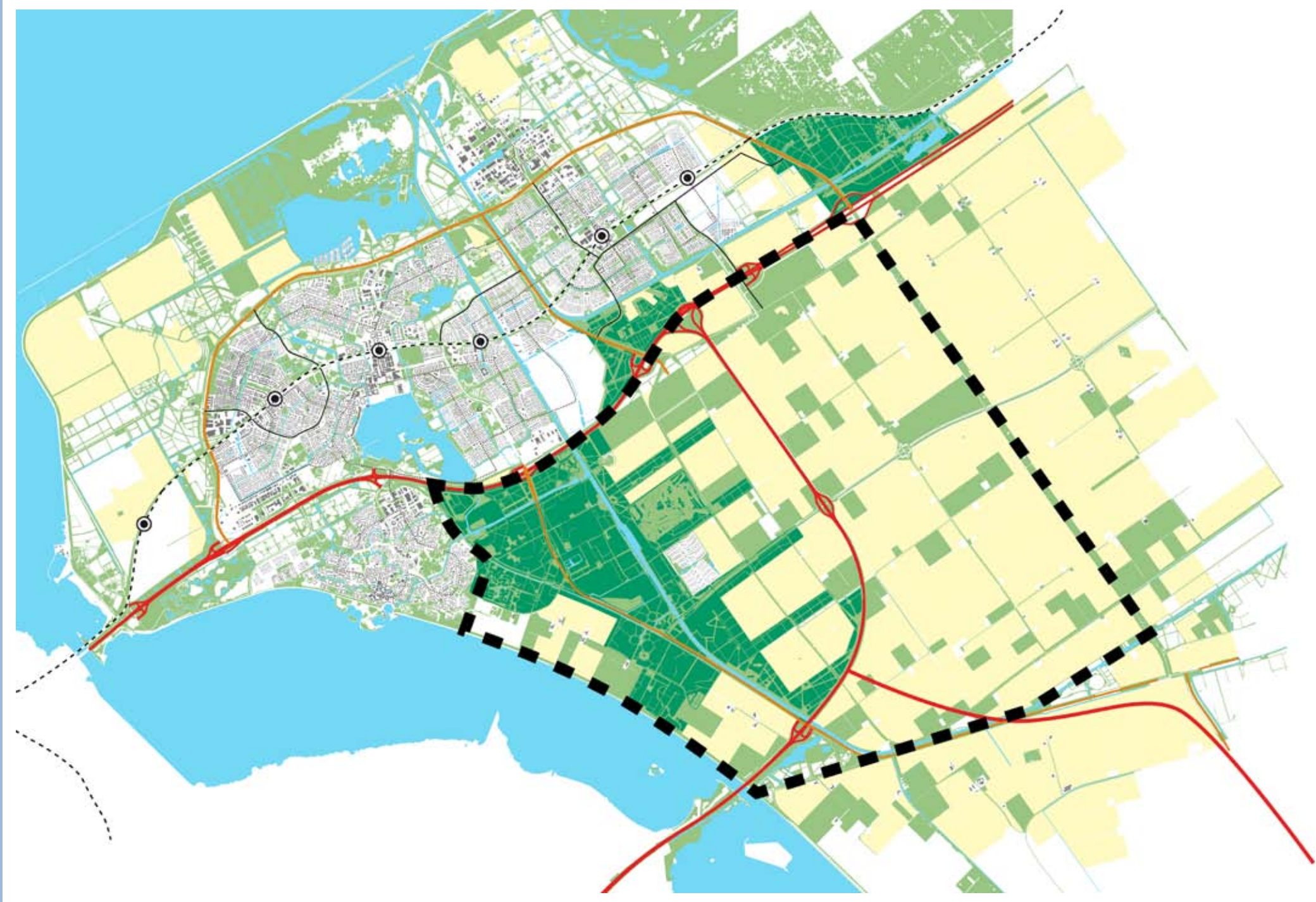
Traditional techniques are ground consolidation, footings and pile foundations. The most general way of land preparation is by stressing the soil with an oversized pile of sand or other soil sorts. This will make the soil consolidate and will increase its capacity and passableness. After a while the pile is removed and the area is ready for building (housing) foundations.

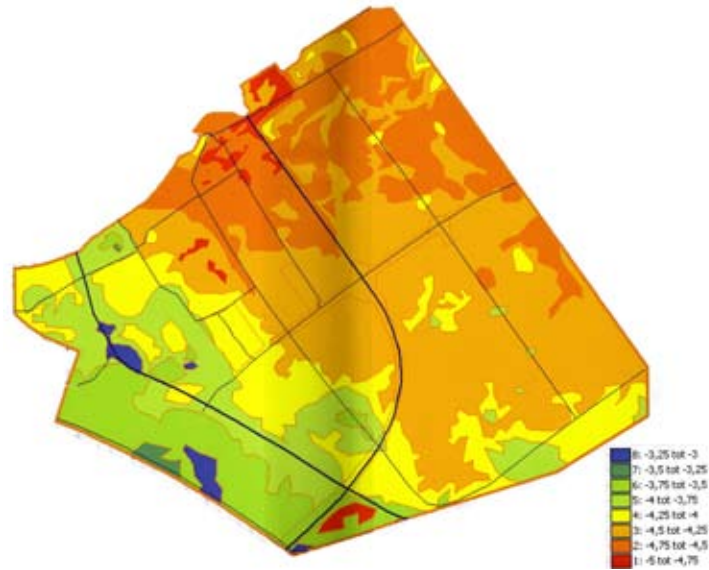
When a construction is light and the soil has enough capacity, footings can be used. But in the west of Holland, with its weak soil, pile foundations are almost always used. This method diverts the weight of the structure to an underlying sand layer with enough capacity.

Innovative techniques are now being developed for areas with a big expected subsidence. Crawlspace-less building and wetproofing are one of these techniques. Floating, amfubic, mould and pole dwellings are other examples of how to deal with water nuisance and subsidence. These techniques will be discussed later.



Innovative





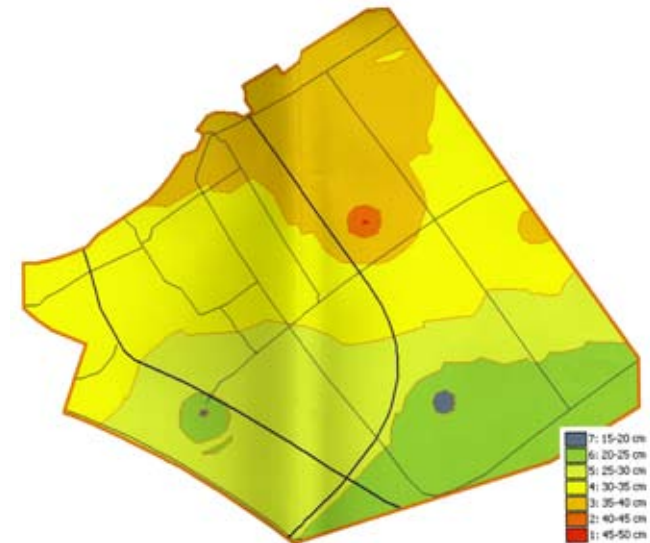
GROUND LEVEL HEIGHT

The ground level height is measured in metres (minus) NAP: Normal Amsterdam Water Level. In Almere East this varies from -3 to -5.

The map on the left shows the differences in height. Clearly visible is that the ground level drops in the north, and the south is relatively high. One could distinguish three more or less same-sized areas: the deep area (-4,5 to -5), middle area (-4,25 to -4,5) and high area (-3 to -4,25).

SUBSIDENCE SENSITIVITY

As it is a relatively new polder, a reasonably amount of subsidence will occur. The map on the right shows estimates until 2050. This will vary from 15-50 cm, roughly distributed in the same way as the actual ground level height.



EEM DITCH

The former location of the stream of the river Eem in the landscape is hidden on ground level, but can be discovered in soil structure. Around this ditch there are a lot of fluviatile sediments. This could give trouble with building (conventionally).

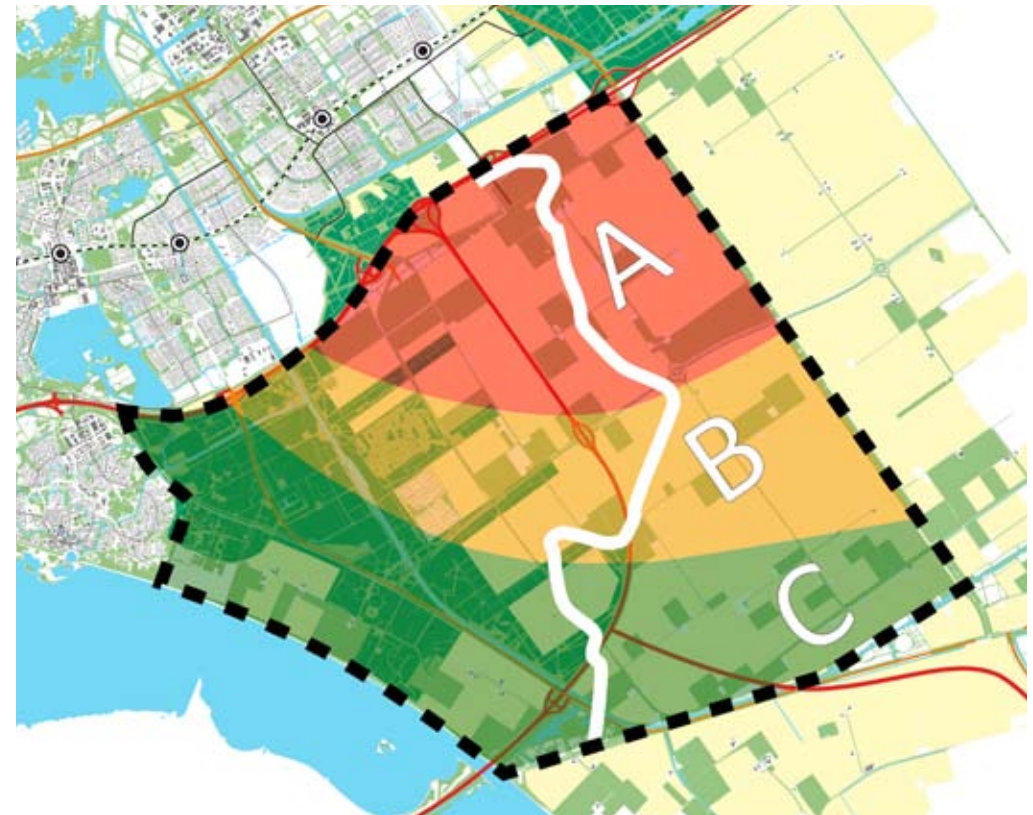
SOIL AS GUIDING PRINCIPLE

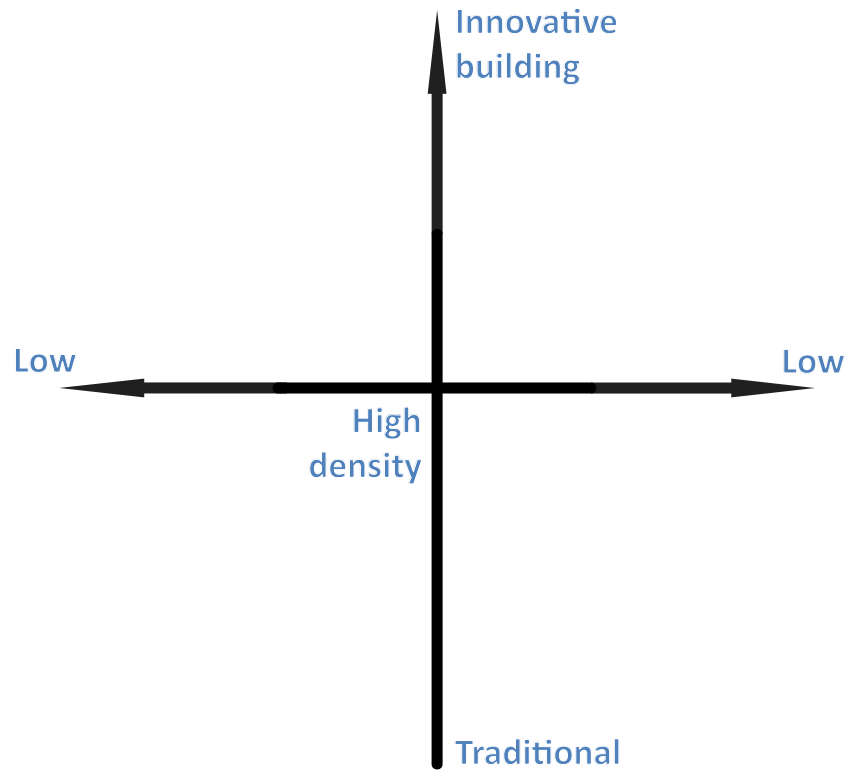
When the soil properties are used to guide urbanization density and typology, the following conceptual map can be drawn. Area A is the deepest part and will subside the most. This place is suitable for the highest ambition on water robust building.

Area C is the highest part and without drastic measures suitable for conventional building.

Area B has mean ground level and can display the shift from conventional to innovative building.

The Eem ditch can be dug out to show medieval context and link the different areas. This could be used as water way or water retaining. The soil is unsuitable for foundation of any kind and can facilitate experimental forms of construction and/or floating combinations.





4.2. WATER ANALYSIS

POLDER WATER SYSTEMS

A polder is an area that lies lower than the surrounding water and of which the water level can be artificially controlled. Polders are usually crossed by watercourses. For water management it is necessary that the ditched and canals are able to flow trough well, to be sure of this they have to be maintained.

A polder is a hydrologically entity, meaning it has no connection with outside water other than through man operated devices.

A windmill or pumping station (sometimes more) controlles the polder water level; through inlets (fresh) water can be let in. A polder is surrounded by dykes mainly.

In some parts of the polder a higher water level can be handled, this is then controlled by dams.



Polders enable living under sea level

Polders are man made controlled hydrological entities

FLEVOPOLDER ASSIGNMENT

Water management in Flevoland is characterized by a small percentage of surface water of about 1% with a relatively big pumping capacity of 11 till 18 mm a day. Almost all areas in Flevoland have a draining of 1,40 meter. But the urban areas of Almere and Lelystad have a draining of 1,80 meter. De drainage is primarily done by drains one meter under ground level with an in-between distance of 4 up to 48 meters (Vermeulen, 2002).

The water management system in the Flevopolder is divided into 13 areas, based on polder water levels and the management regime (pumped or propelled) and the availability of measuring information.

Conversion to an urban area

To foresee in the housing need of the Northern wing of the Randstad, Almere has to grow with 65.000 dwellings in the period of 2010-2030. This is divided among the following urban expansions:

- Almere Poort (in progress);
- Almere Pampus (planning-phase); and
- Almere East (planning-phase).

For the water system of Southern Flevoland these urban expansions have consequences. The following happens in a way that compensating measures are needed.

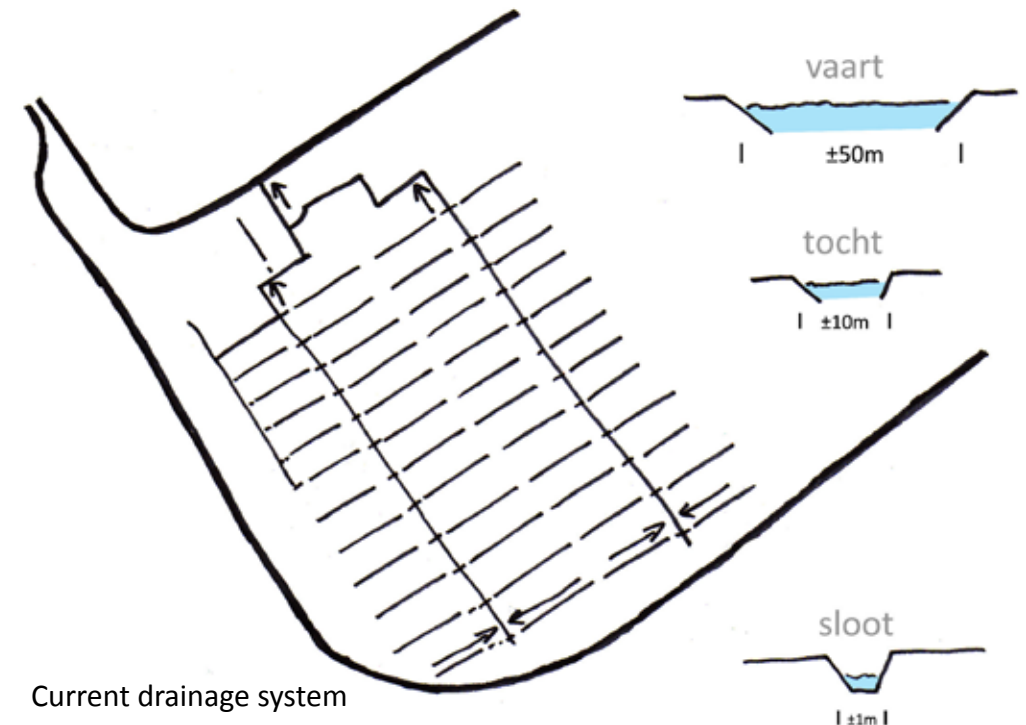
1. Also without urban expansions, a part of the plan-area won't meet the inundation demands of the water board for the countryside.
2. With the function change, the area has to meet the inundation

- demands for urban areas of 1:100 years, instead of countryside demands of 1:80 years;
3. With the increase of the hardened surface, precipitation streams faster off. Due to this an inundation could sooner arise.

Current water assignment according to 1:100 years inundation, the Flevoland standard: 1100 ha (Nelen & Schuurmans 2007)

Future water assignment consists of: (Harry de Brauw 2008)

- Natural land subsidence: 2500 ha
- Consolidation (subsidence) due to urbanization: 30 cm average
- Climate change showers and long drought: 900 ha
- Urbanization peak discharges: 10% surface water

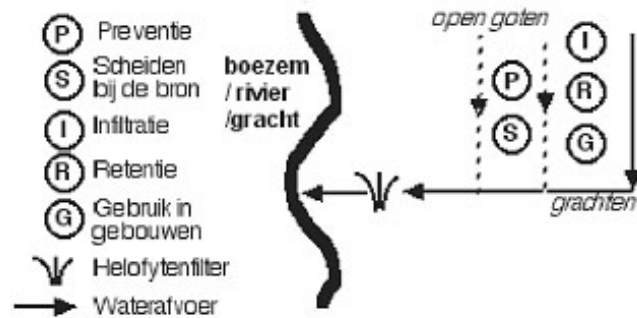


Current drainage system

GUIDING PRINCIPLES

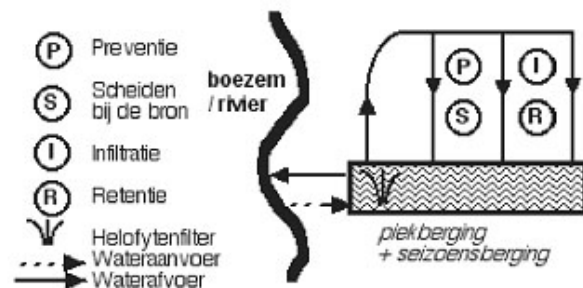
Delay model

The model the principle of 'keeping clean and delay' can be applied with help of technical and spatial measures. The runoff is delayed and disconnected from the wastewater sewer. The model fits in dense districts with hardly any surface water.



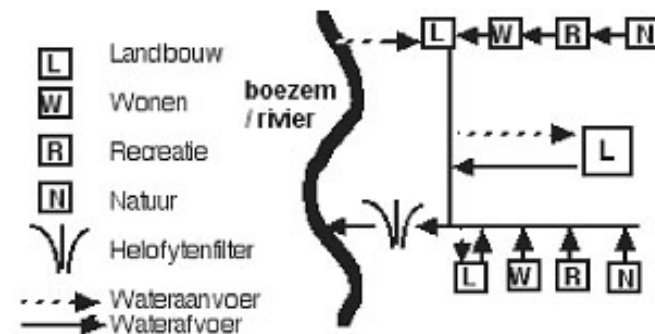
Circulation model

This model can be applied in city and rural areas with a lot of public space and an own surface water system. In this situation a circulation of the surface water can be implemented. The water here passes filtering reed or rush fields. In winter as much water as possible is retained that the inlet of water in summer will be unnecessary. This season buffer can, if desired, take place in lakes at the edge of the city. A peak buffer is also part of the system. The delay model is possible within this model.



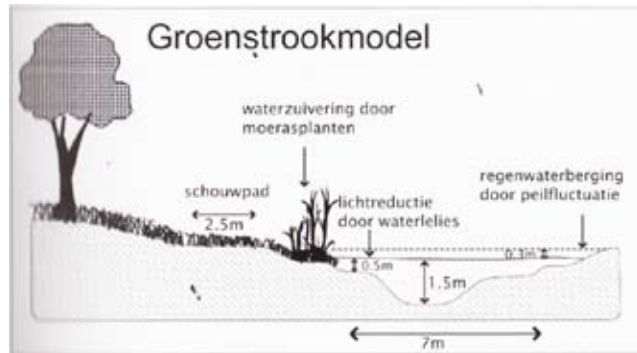
Link model

This model is meant for the regional scale. The circulation model on district model is here one of the links. The other links are natural, recreational and farming territories. With the parallel and serial links the flowing principle of 'clean to dirty' employed. Water streams from natural to recreation to living and eventually to farming territories. The use of the local hydrology is of importance with making these plans according to this guiding principle.



Green-strip model

This model is a principle solution for waterways who are positioned in a green-strip. This takes in account the room for maintenance vehicles on the banks which can be used by pedestrians and cyclists. The canal is dimensioned with steps of different depths in a way that ecology, safety and water buffer are all integrated. This can be only applied when there is enough room in the city.



Two network theory

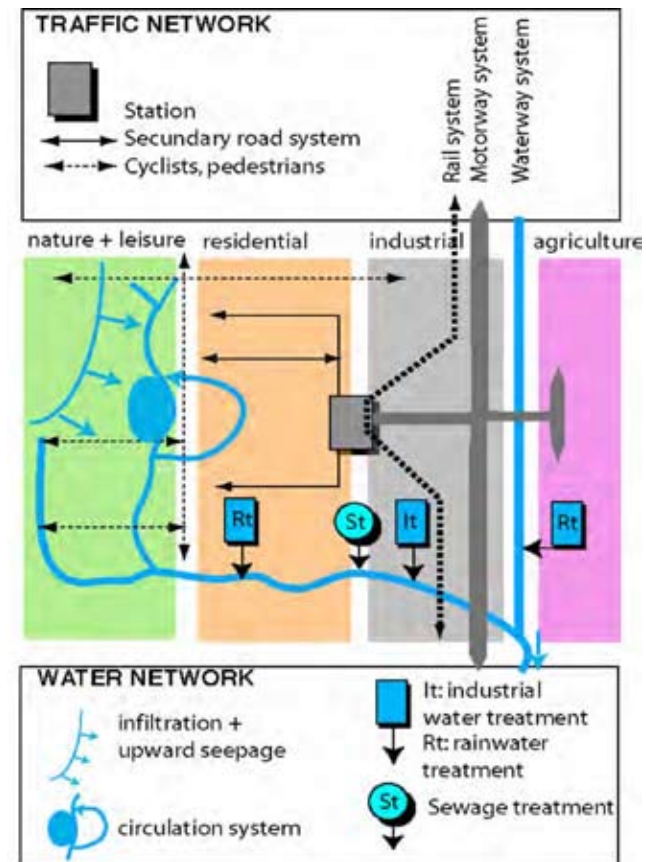
The two networks method is a general urban design guiding principle which wants to create a framework of spatial bearers for urban development (Tjallingii and Berendsen, 2007). It chooses the spatial networks of traffic and water as a starting point. It is especially suited for guiding strategic plans on a regional level. The arguments for this strategy are:

1. The essential spatial contrast between dynamic and quiet zones (fast and slow lanes) in the urban landscape is carried spatially and functional by traffic and water. This means that in the design has to be looked for a synergy between water and green with the creation of conditions for urban oases of quietness. The synergy between traffic and activity is the carrier of the dynamic zones in the city. The ideal place to live is between both contrasting worlds: green and quietness at one side and dynamic and services at the other.

2. The striving for sustainable environmental technical management leads to a strategy of retaining and keeping clean of water streams. An approach which is aimed at the retaining

assignment as well as quality objectives. The strategy is for traffic streams aimed at bundling of main traffic streams and parallel roads by what traffic flow can be stimulated, and also aiding to noise control.

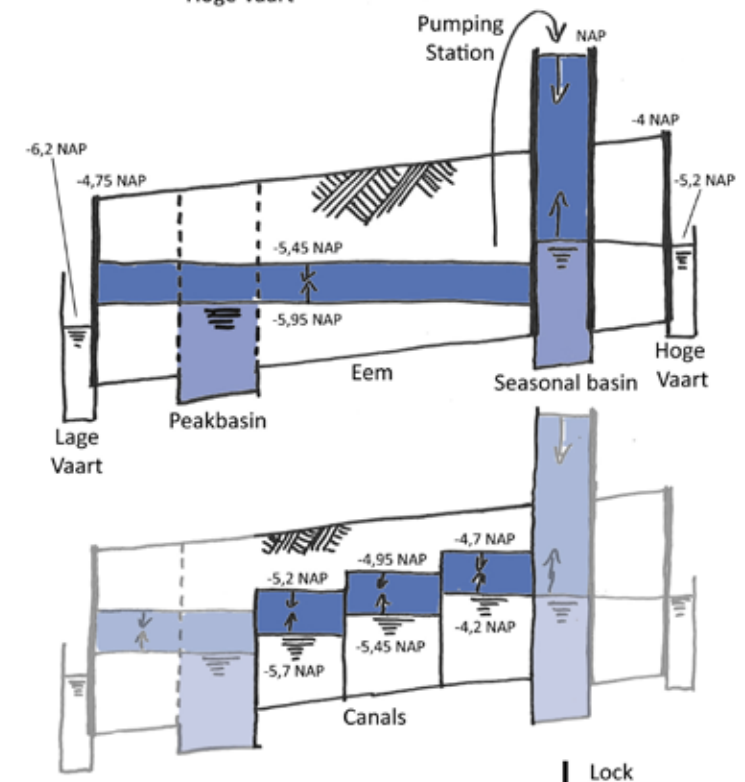
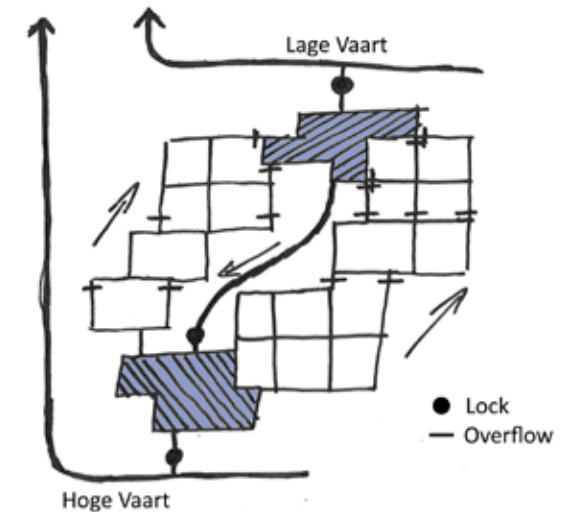
3. The water and traffic networks form a durable framework what allows a flexible fill-in fitting in with the uncertainty inherent of long-term planning. This combines ecological and economical tasks. Moreover this points out a bigger role of the government by planning, realisation and maintenance of the framework and a bigger role for the market with the implementation.

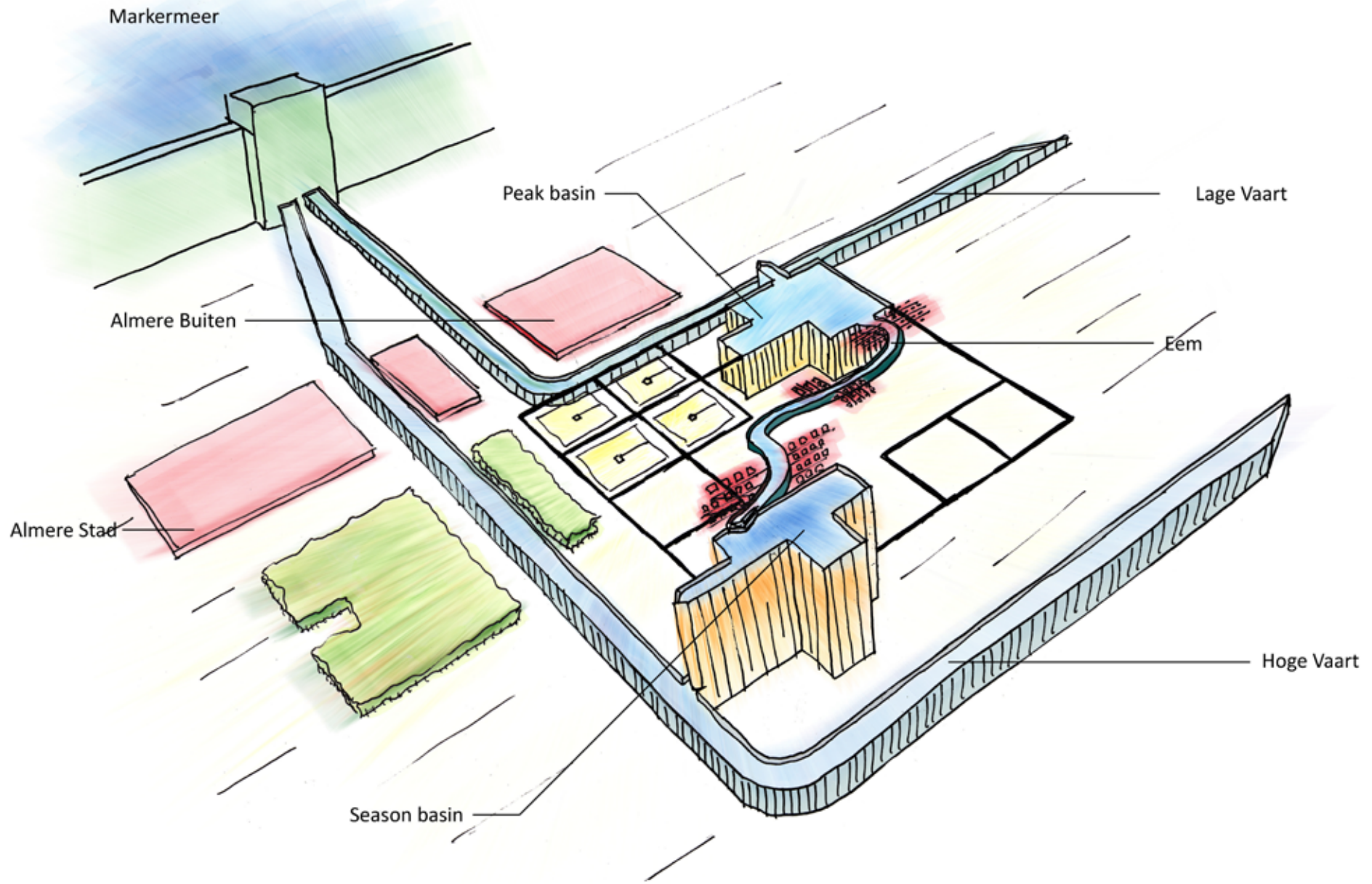


4.3. WATER SYSTEM DESIGN

The main design principle is to disconnect water nuisance of the area into a circulation model based on the Closed City. This means that there has to be enough water storage in the area to deal with seasonal and extreme situations. The seasonal storage capacity is best realised on the highest point of the area. The peak storage for extreme rainfall is best realised on the lowest point of the area. These basins have to be part of the circulation system. Additional storage capacity is realised in flexible water level management.

The water system is reviewed in the existing context of water safety within the primary dyke ring. The deltacommission Veerman has thought out future scenarios to deal with climate change for the whole Netherlands including the Markermeer region.

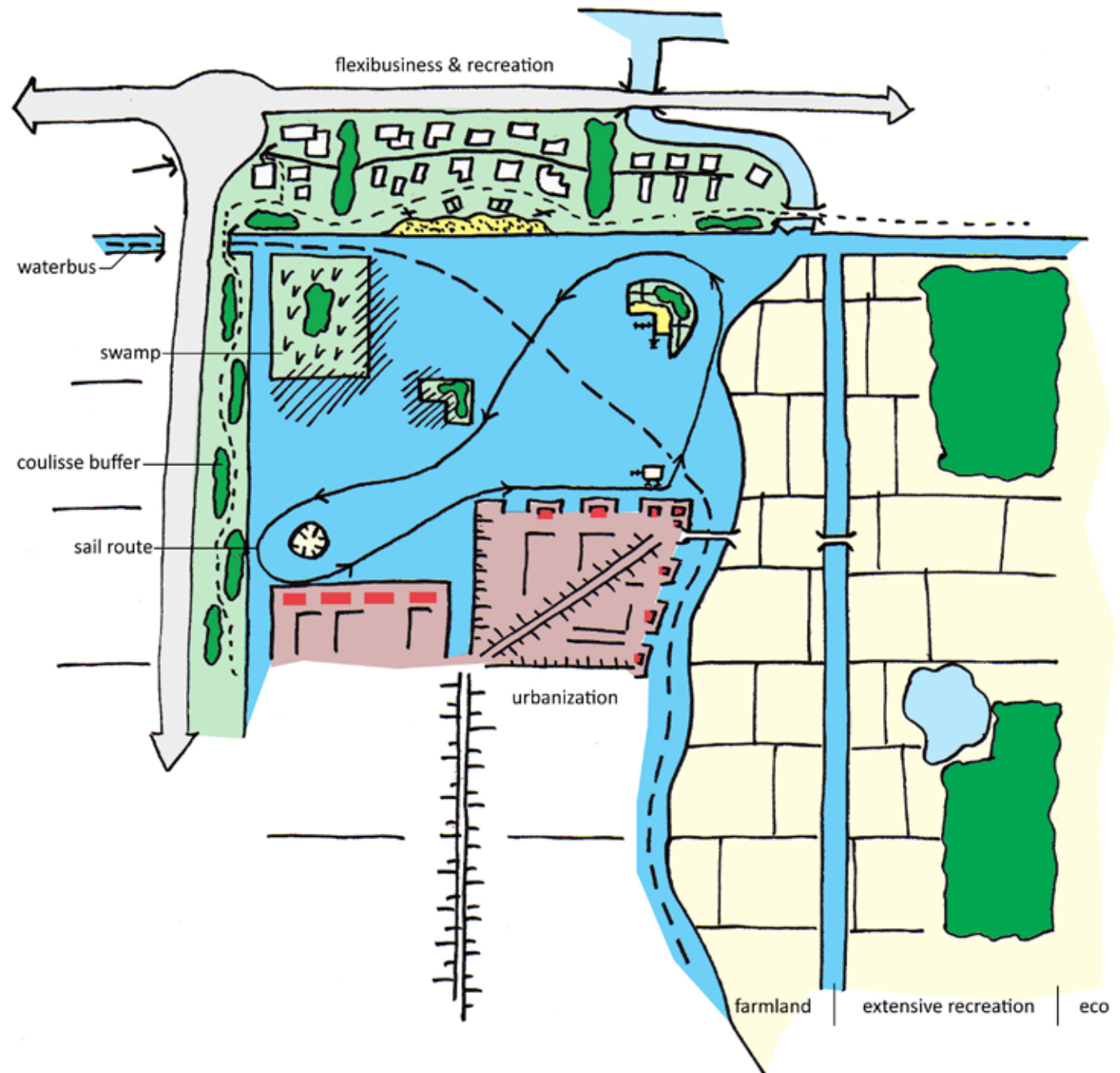




LOW TIDE LAKE

The Low tide lake is positioned at the lowest part of the plan area. It is used for dealing with extreme rainfall and an essential link in the water system. The lake is designed to be a good sailing lake with a deep route but also shallow waters with waternature. This ecological zone also filters the water which streams in from the total area. The lake has different sides, one being strongly urban, another being recreational business park and the others being farmland and a highway with coulisse (sound) buffer.

The depth is from shallow (less than 1,5m) to quite deep (up to 30m). The exact depth derives from the need for raising sand for the 'Megamould'. Living in the 'Waterfields' means a direct connection with the lake, with its recreational possibilities but also with its flexible water level. This will be explained later at the 'Waterfields' chapter.





Sailing competitions



Nautic living at the lake



Shallow zones with waternature



Transport over water



Parading at the urban waterfront

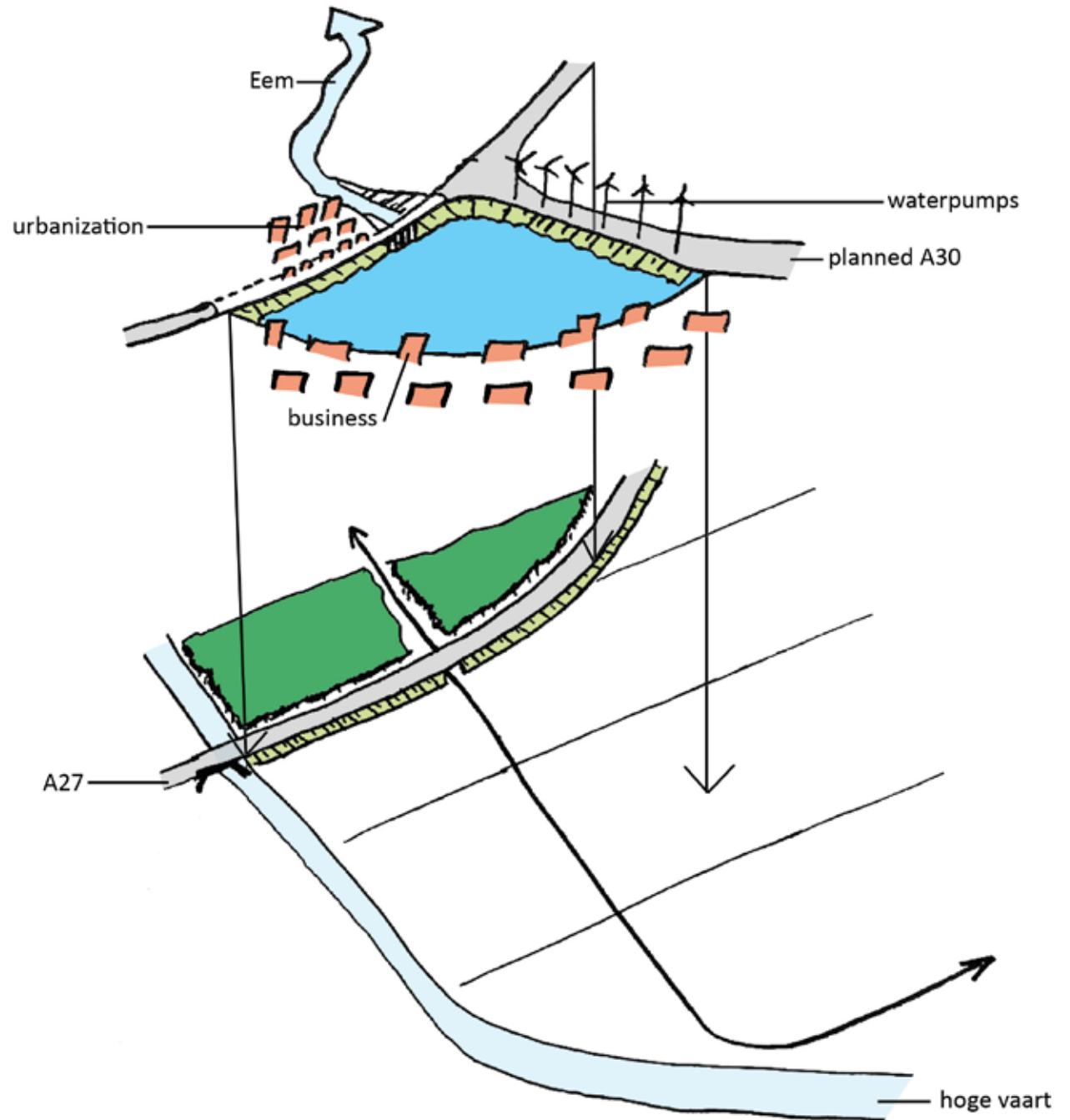
HIGH TIDE LAKE

The High tide lake is located at the highest point of the plan area. The function in the water system is that of seasonal buffer in times of drought.

Its is also positioned in the triangle of the current and the future highway embankment and the bussinesspark. This creates possibilities for raising the water level up, even up to NAP. The lake can then function as a 'water battery' in more ways, not only storing water for the circulation system but also storing potential energy. This can be generated by letting water flow through a turbine and pumping it up by wind energy. This source of energy can be stored with this, which will extend the possibilities of the now unreliable windenergy.

The banks of this lake have to withstand large water level fluctuations and are not that suitable for vegetation. This can be solved by the use of floating vegetation.

The lake can very well be used for watersports like cable surfing or water skiing, combined with the facilities of the business park.





Gravity dam creating a dramatic scenerly



Floating gardens - Amsterdam



Watersports possibilities in the broadest way



Waterbattery creating a windpower buffer - Plan Lievense



'Cathedral' of engineering - Pumping station Lely



Exciting experience of water machinery - Seaworld Adventure Park



Adult water play - Square Bordeaux



Urban mirror - Square Bordeaux

VISIBILITY OF WATER SYSTEMS

Water systems are often not recognizable for the common people. Technological advancements made machinery like pumping stations and sewer systems smaller and hidden under pavement. The disadvantage of this development is that people cannot enjoy the water or dynamic created by these systems, and that while water systems can be so much fun!

There are more and more examples of watersquares, -parks or just nicely designed buildings who breath the atmosphere of their function. The pumping station Lely in Medemblik is an example of this visualization of function into a cathedral of water engineering. The Bordeaux square is famous for its changing water, from mirror to dams to dry surface again. This is a continuous source of activity in the city.

In Almere East this playful element of water is important and the design of dams, locks and water pump must be done in a way which shows its main function as an experience, an art!

URBAN PLAN



CHAPTER 5 WATERCITY

WATERCITY

5.1. INNOVATIVE BUILDING

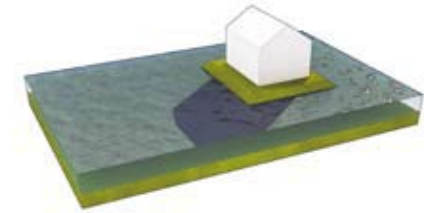
In areas with a great sensitivity for subsidence, traditional building methods are not suitable to get the soil stable. New innovative building methods have to be developed for these areas. It also adds to the demand for new living typologies with water. Extensive research has been done on different types with their strong and weak points and the demand of the market. Dura Vermeer has studied on the possibilities of 'building with water' and on the case Haarlemmermeer.

The Haarlemmermeer plan consists of a housing typology of four types. The mould (also mound or knoll) is a small hill on which the dwelling is placed. These hills stay dry always, while the surrounding can be used to retain water when necessary. Nuisance to the dwelling itself is minimized but the infrastructure has to be prepared to this kind of situations.

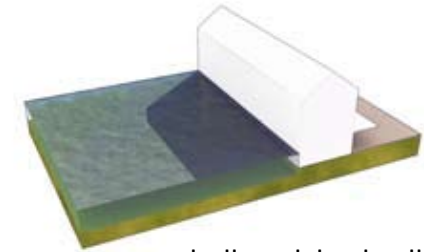
The hollow 'dyke' concept relies on dry-proofing the first floor of dwellings. This means that the house itself can withstand about 30-50 cm water level raise against the facade. This is an extension of crawlspaceless building, which creates the possibility of higher ground water levels. Nowadays crawlspaces are not necessary anymore.

Floating dwellings have water as foundation and do not need a traditional foundation. The floating dwelling is fixed in the horizontal direction but can move in vertical direction with the water level. The great advantage is that subsidence and water have a very little effect in terms of nuisance. On the other hand floating dwellings are more expensive.

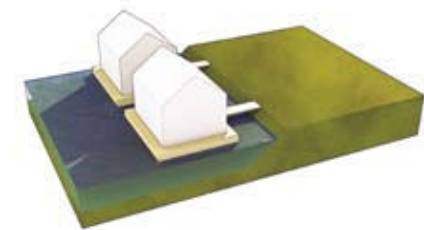
Pole dwellings are placed safely above maximum water level, it can have an either dry or wet surface level.



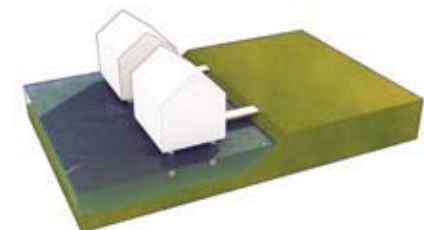
mould dwelling



hollow dyke dwelling

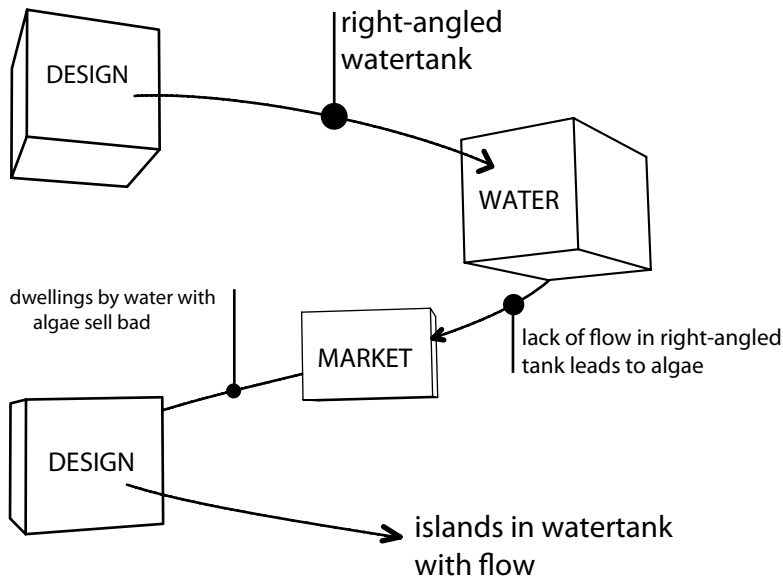


floating dwelling



pole dwelling

Dura Vermeer has analysed these typologies on their strong and weak points and their expected popularity on the housing market. This results in the following table with aspects concerning the market:



MARKET	Strong	Weak	Demand	Detail
Mould	Fits to standard types Simple maintenance (Sense of) safety	Use of space	85-90%	Common target group with water as extra quality
Hollow dyke	Intensive space use Much water	Limited outside space		
Floating	Adventurous Freedom Identity Flexible programme	Niche market Swell Unfamiliar Maintenance Legal status	10%	Special target groups
Poles	New Niche product	Unfamiliar product	2%	Special target groups (possibly common)

Another way to deal with uncertainties is with low life span building. These buildings are built with less robust and lighter materials. This also minimizes the mass and moreover the subsidence of the underlying soil. The investments in infrastructure are minimized and the vulnerability (defined as damage times recurrence time) of the area decreases.

Zone A	lightweight raising	pile dwelling	low life span	floating	dry proof	mini moulds
single family dwellings	+	diffuse	+/-	diffuse	++	diffuse
apartment building	--	+	-	--	+	++
public functions	-	+/-	+/-	+	-	++
business/industry	--	--	++	--	--	-

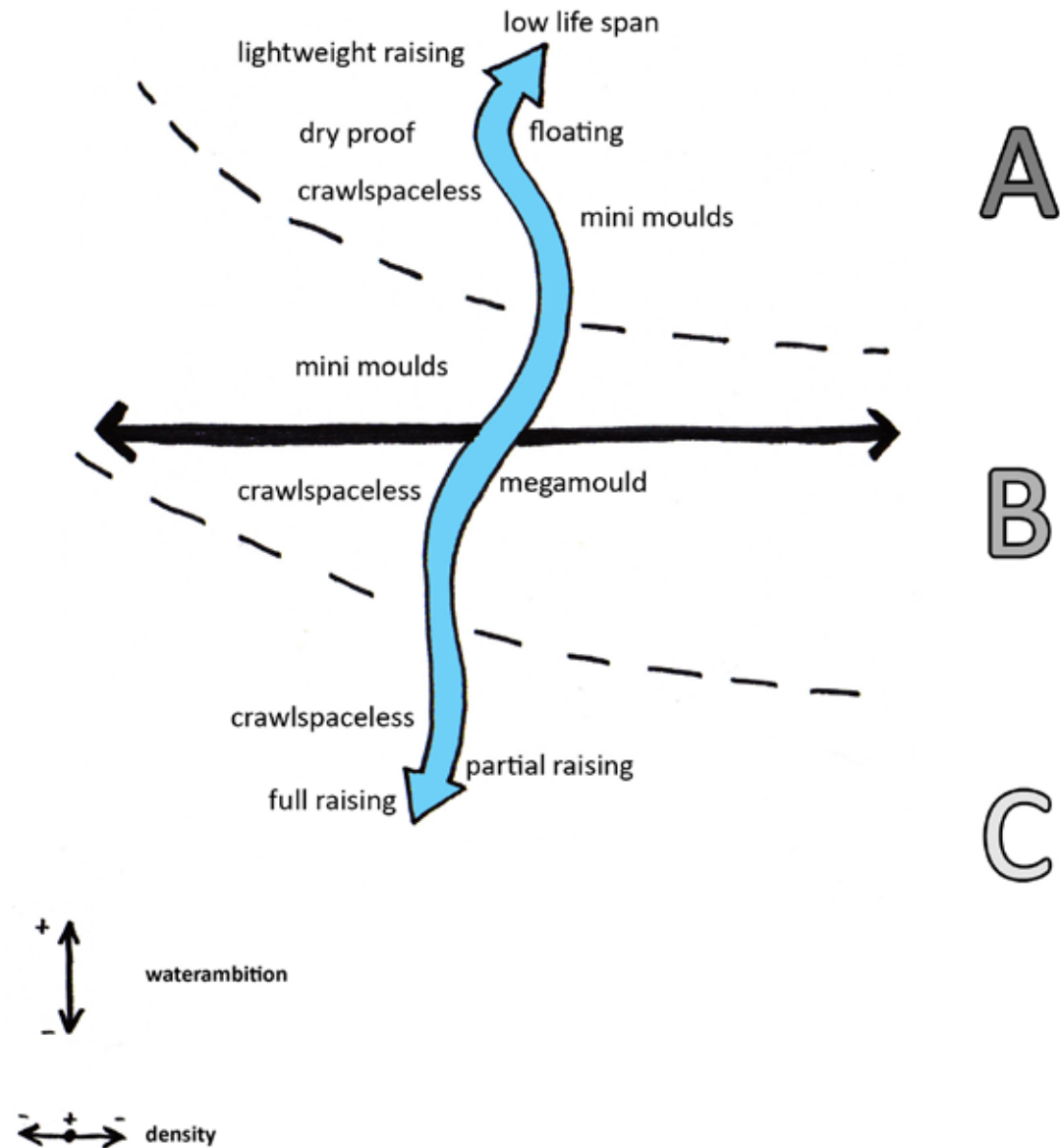
Zone B	mega mould	mini moulds
single family dwellings	++	diffuse
apartment building	++	++
public functions	++	++
business/industry	-	-

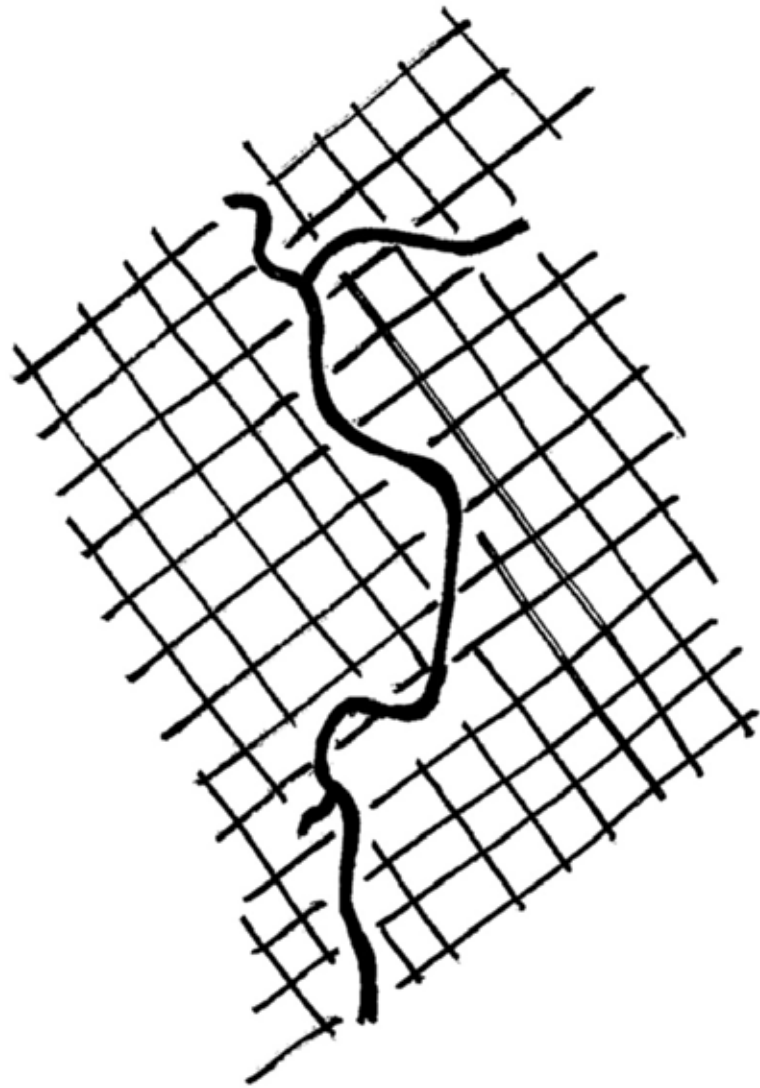
Zone C	full raising	partial raising/canal s
single family dwellings	+	++
apartment building	+	++
public functions	+	++
business/industry	++	--

WATER PRECONDITIONS

The plan area is modelled to the geological underlayer in the zones A, B and C. These zones roughly match the three water levels defined in the water system. The water ambition increases towards zone A, following the Eem from zone to zone. Different types of water living typologies can be set out on this scheme.

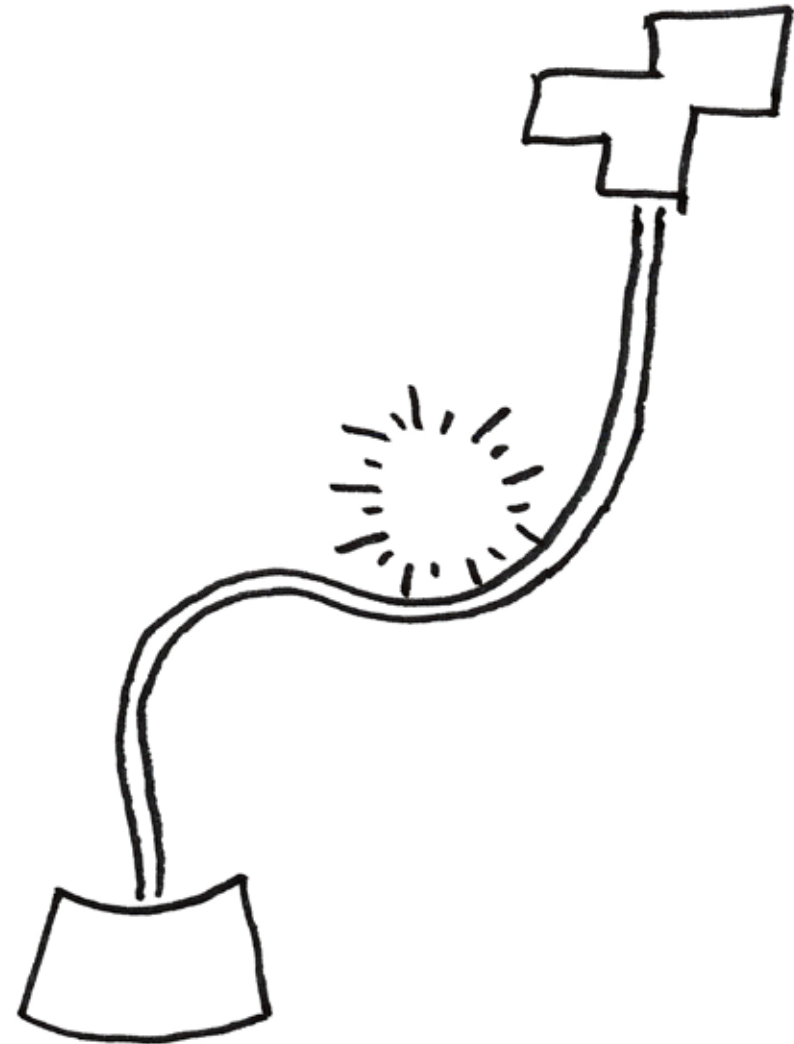
Another principle on which the model is shaped is the two networks strategy, which relies on concentration of investments and the differentiation of quiet and dynamic areas.

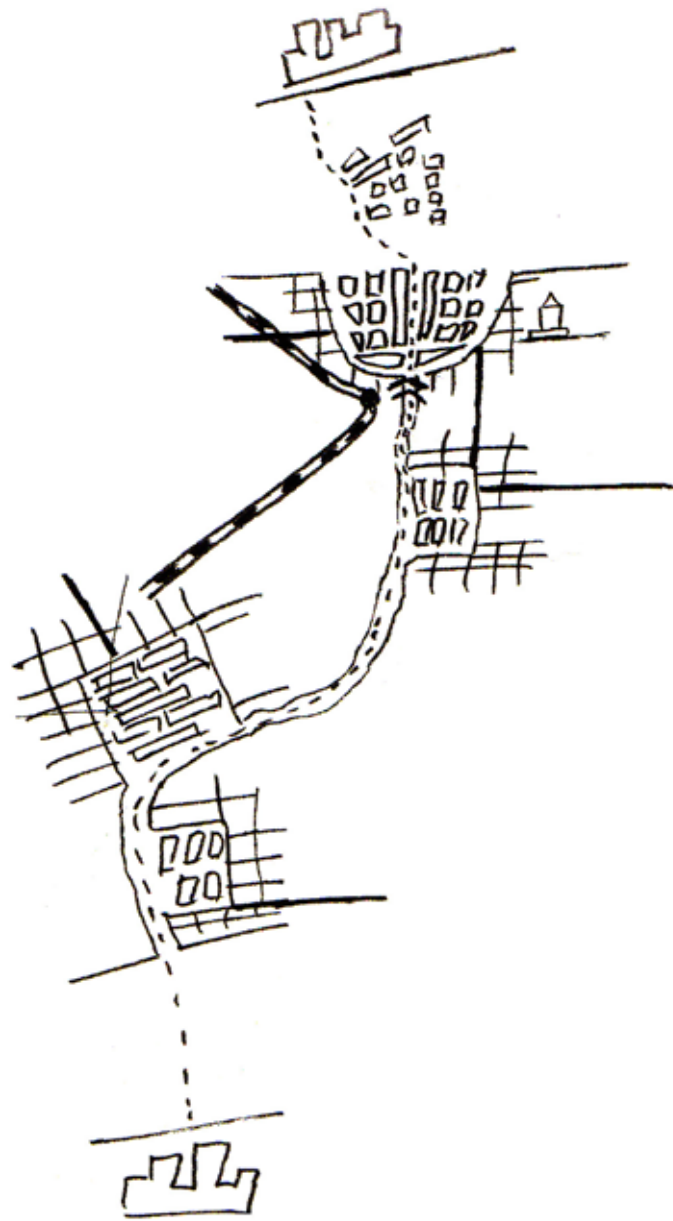




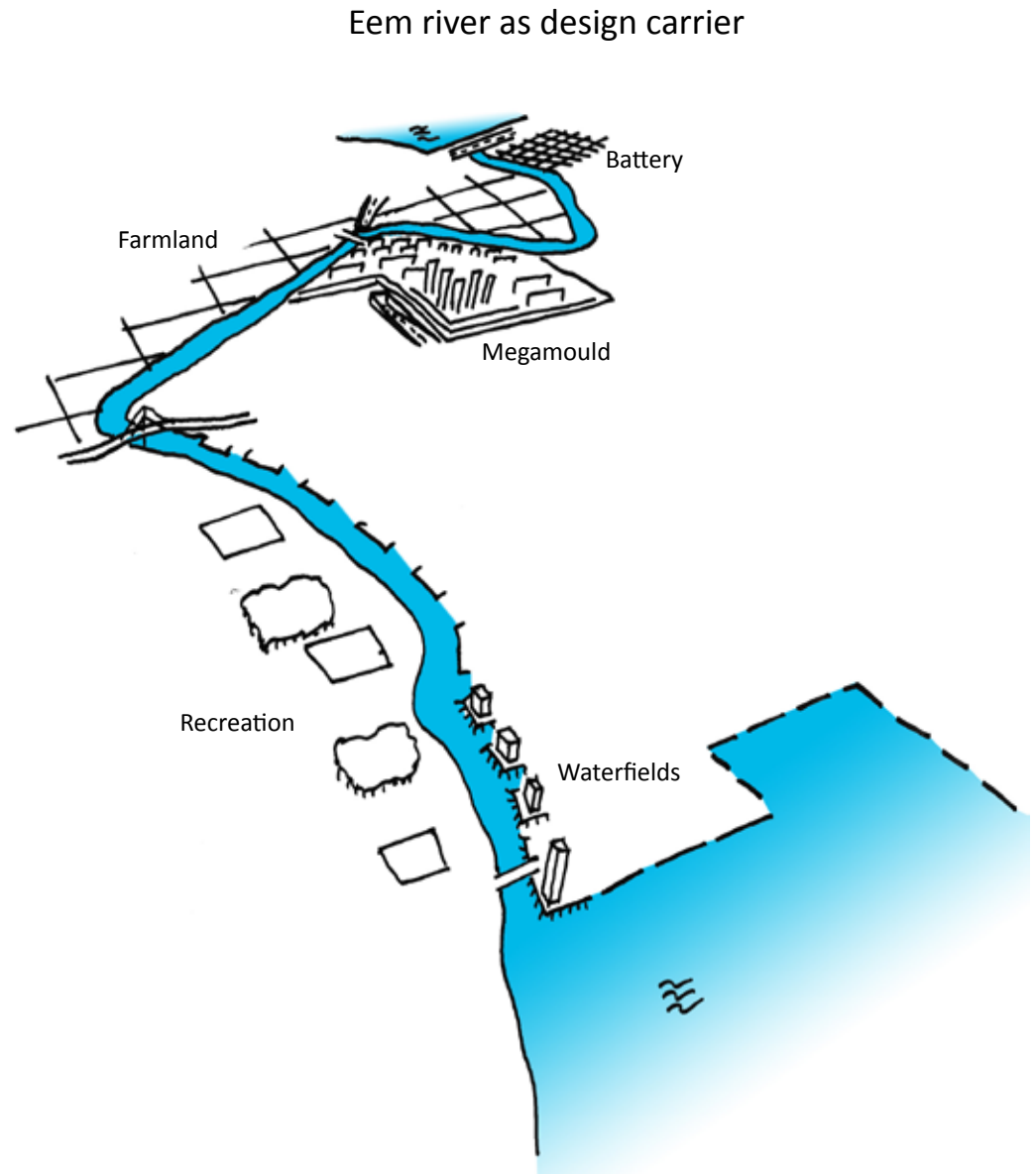
Field of tension between riverbed and parcelation

Anchor points for urbanization

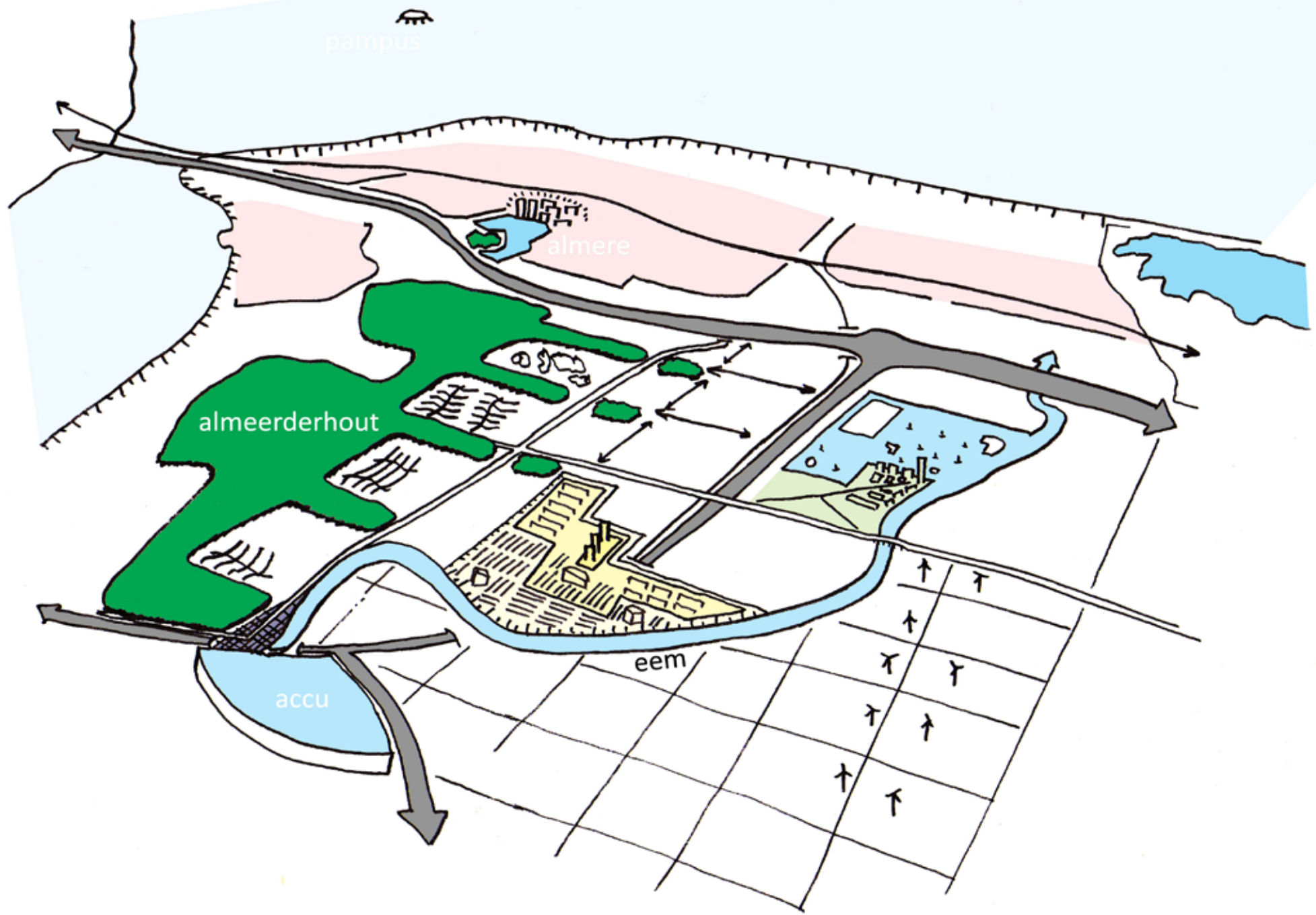




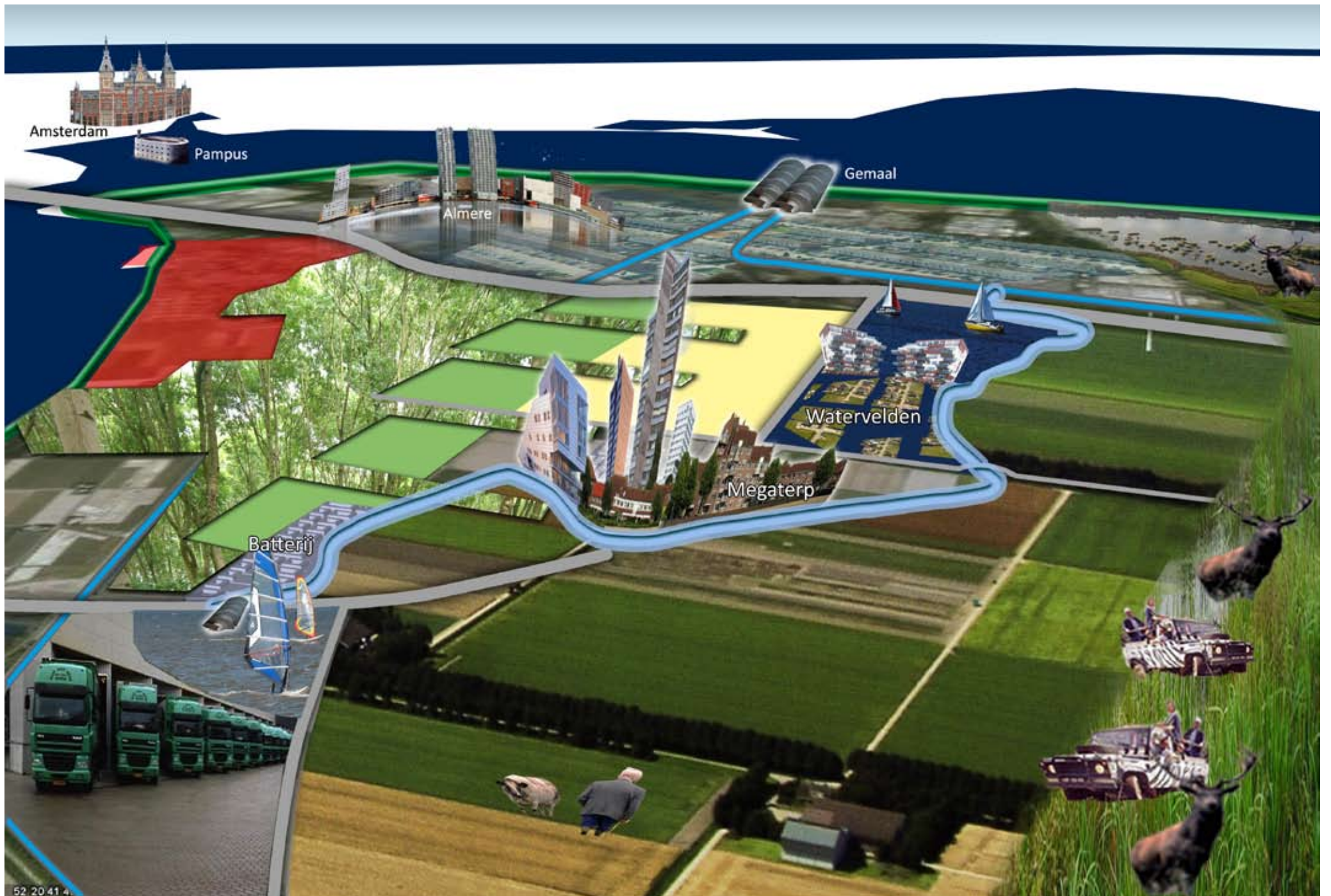
New Dutch Water City



Eem river as design carrier



URBAN PLAN



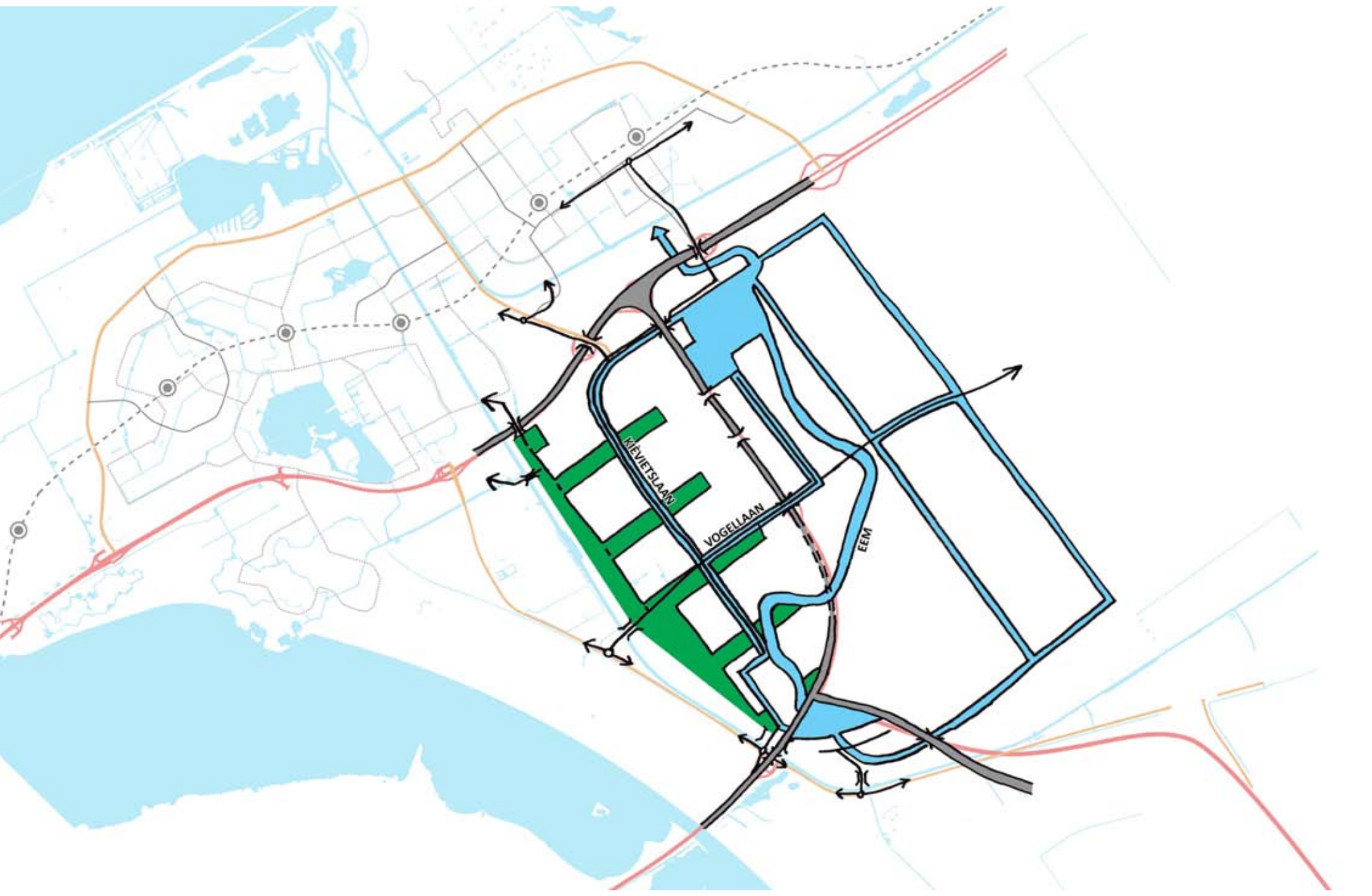
WATER

5.2. FRAMEWORK

The proposed water system introduces a new set of lines and elements in the city map. The river, basins and canals create a frame on where other developments can be positioned. But the frame does not only include waterways, also existing roads and new connections to the surrounding add parts to the frame. Also the 'forest chambers' add to the framework.

The purpose of the definition of a frame is to set up and collect a network of important lines for the creation of the city map. This anchors the new urban plan in existing tissue and the designed water system. In the following paragraphs the most important lines will be described, with precise sections as well as references.





VOGELLAAN

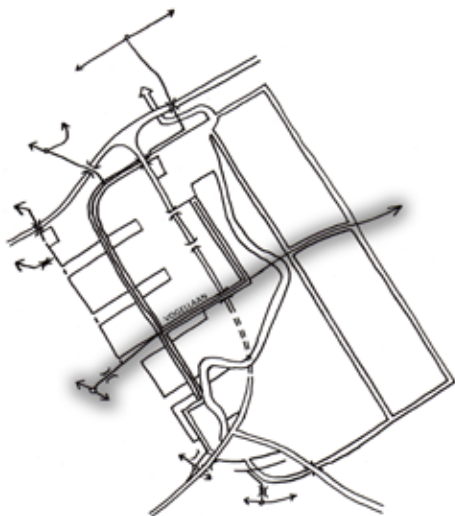
The Vogellaan is already the crucial link in the area, connecting the underlying roads with the region. With the urbanization of the polder, this line importance will grow.

The line has different functions as main water canal for drainage, slow traffic route, high quality public transport route and main car route. The broad profile of the Vogellaan is used to harbor these functions in a parkway atmosphere. It also connects to the vast measures of the polder.

The route over the Vogellaan gives an overview over the area with all it's variety in heights, water and character. Beginning in the Almeerderhout with it's forest villa's it will cross the Kievietslaan and then pass the waterfields, meadows and megamould. After this it will cross the river with a high bridge, providing a stunning panorama of the polder and nature reserve ahead.



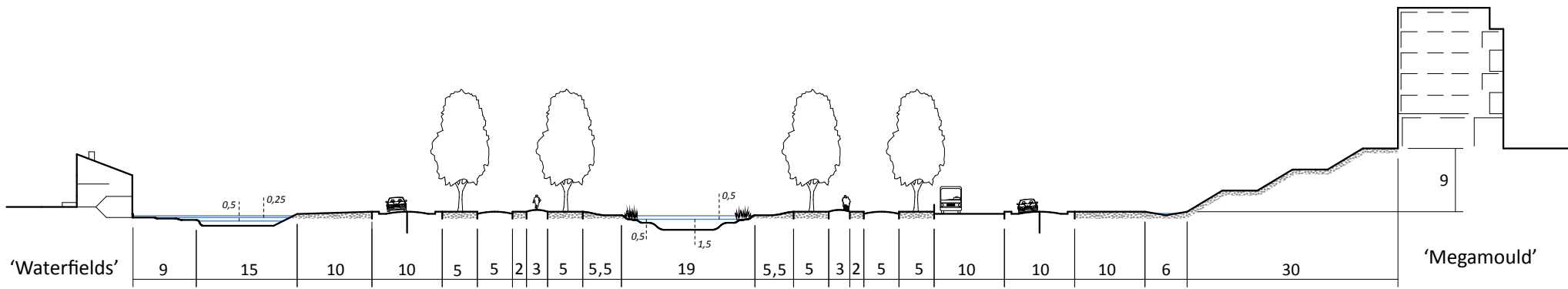
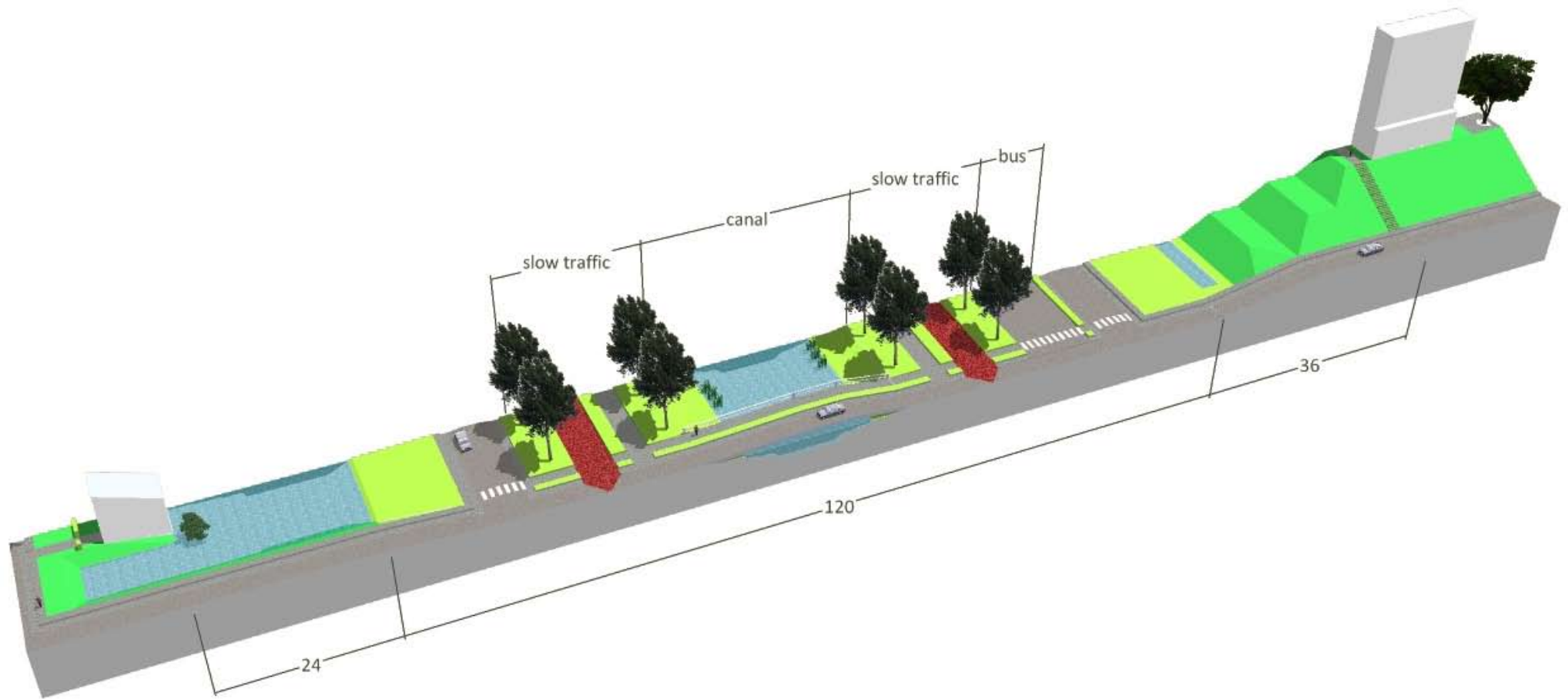
Current section of the Vogelweg



Lowrise blue-green waterfields



High urban front of the megamould



VOGELLAAN

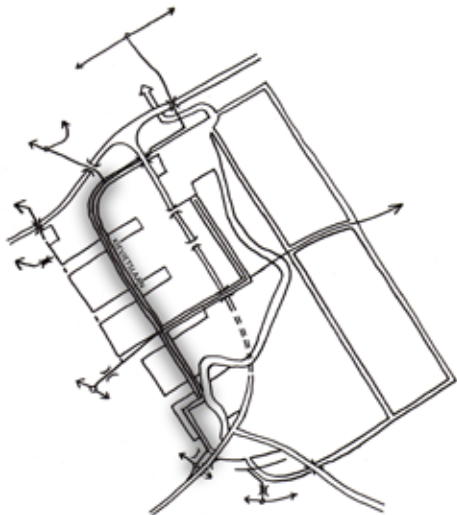
KIEVIETSLAAN

The Kievietslaan is an important link in plan area, running from north to south. It lies between the forest chambers and the farm plots. It is a slightly smaller section than the Vogellaan but also combines different functions for water management, public transport and slow and fast traffic. The layout is that of a parkway, the experience that of a sequence of forest and farm plots.

In the current section of the road, there is enough spatial reservation to implement the functions and keep the tree lines. The width and tree lines provides continuity between the polder and the urbanised area.



Current section of the Kievietsweg



Villas in the woods



DIY plots with selfbuilt mould

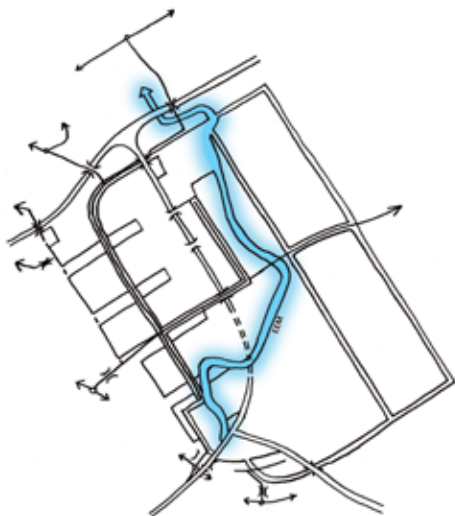
EEM

The Eem river is the aorta of the water system, connecting the two basins and taking care of the circulation system. With a width of 50 metres the meandering river takes the measure of the polder landscape. The centres of urbanization are connected to this strong line in the landscape.

The river bursts with activity, in the water but also on the sides. Water taxi's and yachts fill the river travelling from centre to centre. And as a cycling route the river is a scenic tour showing different atmospheres in the polder.



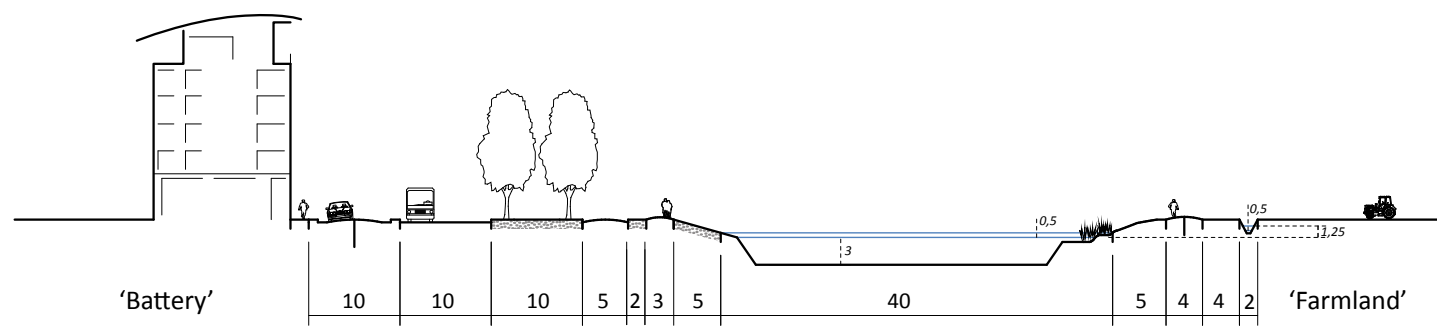
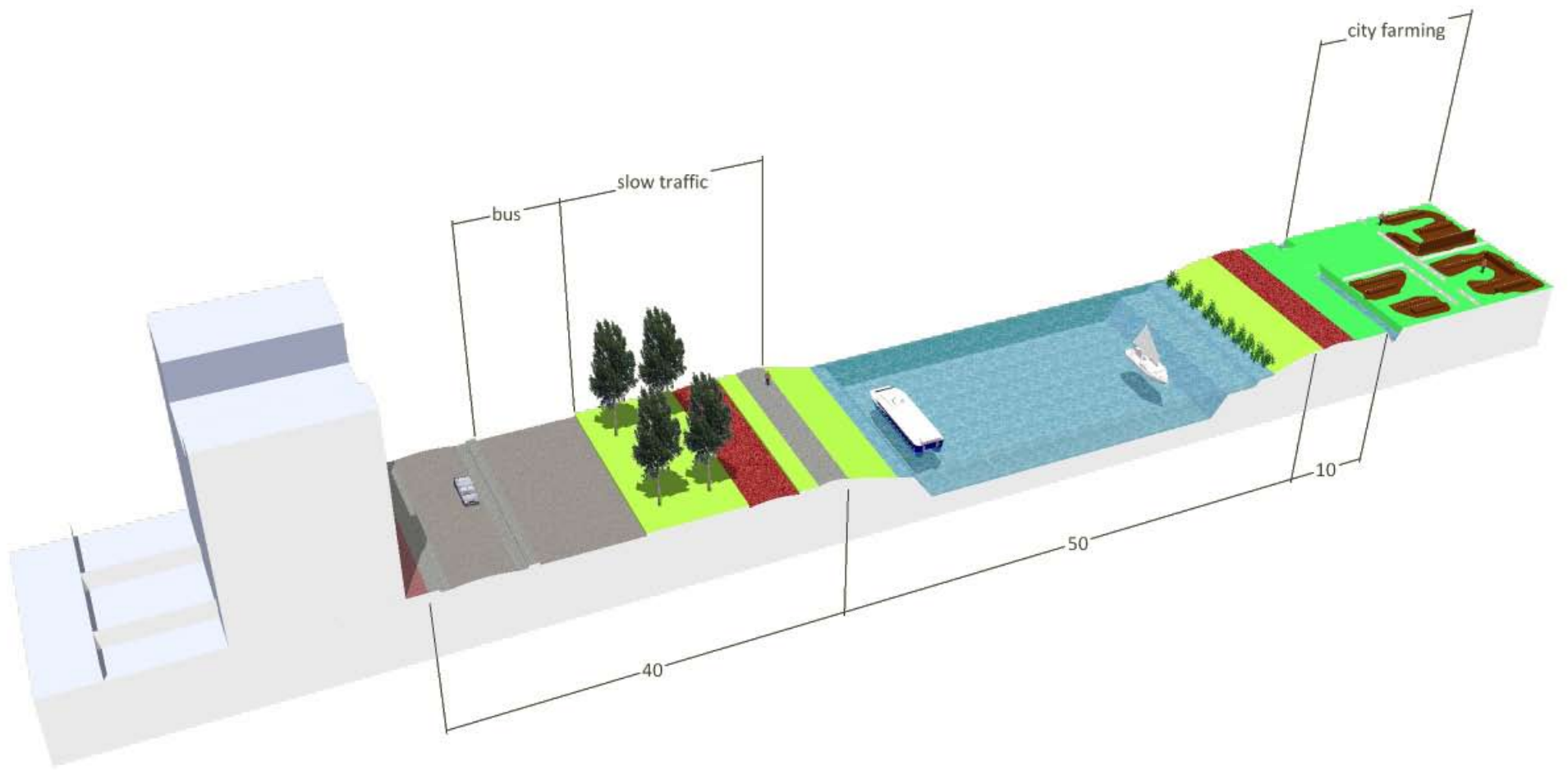
Impression of the future Eem river



Urban bank with water activities



Rural bank with farmland



E E M

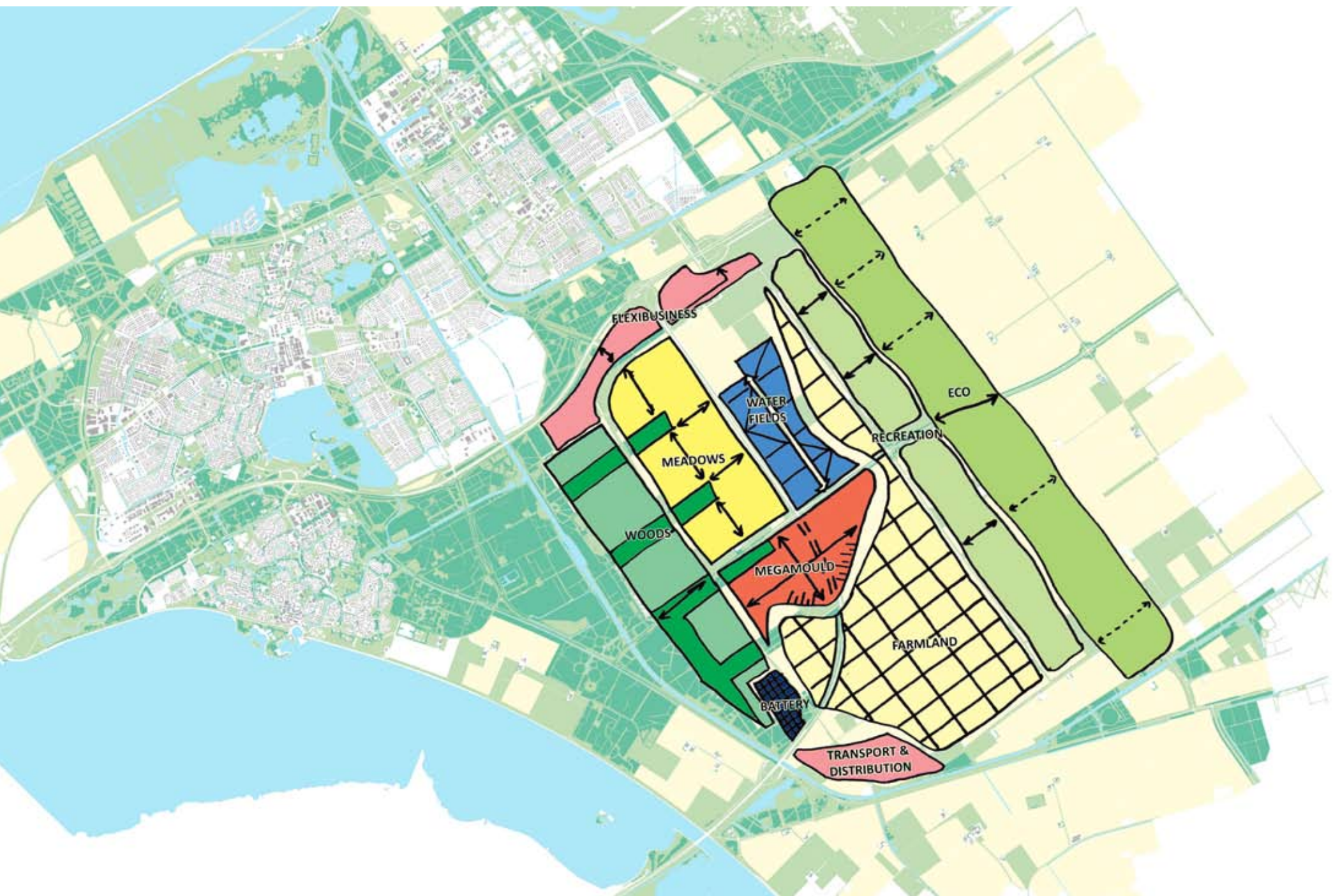
5.3. FIELDS

The framework creates fields in the area. These fields all have a different characteristic according to the local circumstances, soil type and water ambition. In the next paragraphs every field will be defined with characteristics, references and impressions.

The three most concentrated fields of development are 'Waterfields', 'Megamould' and 'Battery'. These are the three centres of the new Almere East. The 'Meadows' and 'Woods' are diffuse urban/rural areas with less programme and less defined urban characteristics. The businessparks are in the North and South positioned, where the water ambition makes the difference. A large area stays farmland, preserving the unique characteristics which now define the area.

The Oostvaarderswold ecological zone is foreseen on the eastern border of the plan area. A recreational area is attached to buffer farmland from ecological land and to let the people of Almere enjoy the wonders of nature.





WATERFIELDS

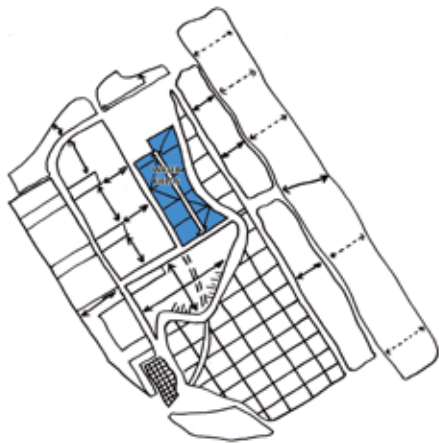
Dry fields lie in a dense network of watercourses. There are a maximum number of dwellings in direct contact of water. This also gives the possibility to have your own boat or yacht. Water can inundate the garden and in extreme situations the water level can even rise to the facade, which is 'dry-proof' ready. The predominant housing type is the single-family row house. These rows are placed on the fields which connects to dykes. These dykes then connect to the surrounding and the public spaces.

The public functions are organized on heightened islands connected with bridges. The islands form coulisses between the fields and the lake and river.

Medium density 50 dw/ha
Medium FSI (0,6)
Medium OSR (0,75)



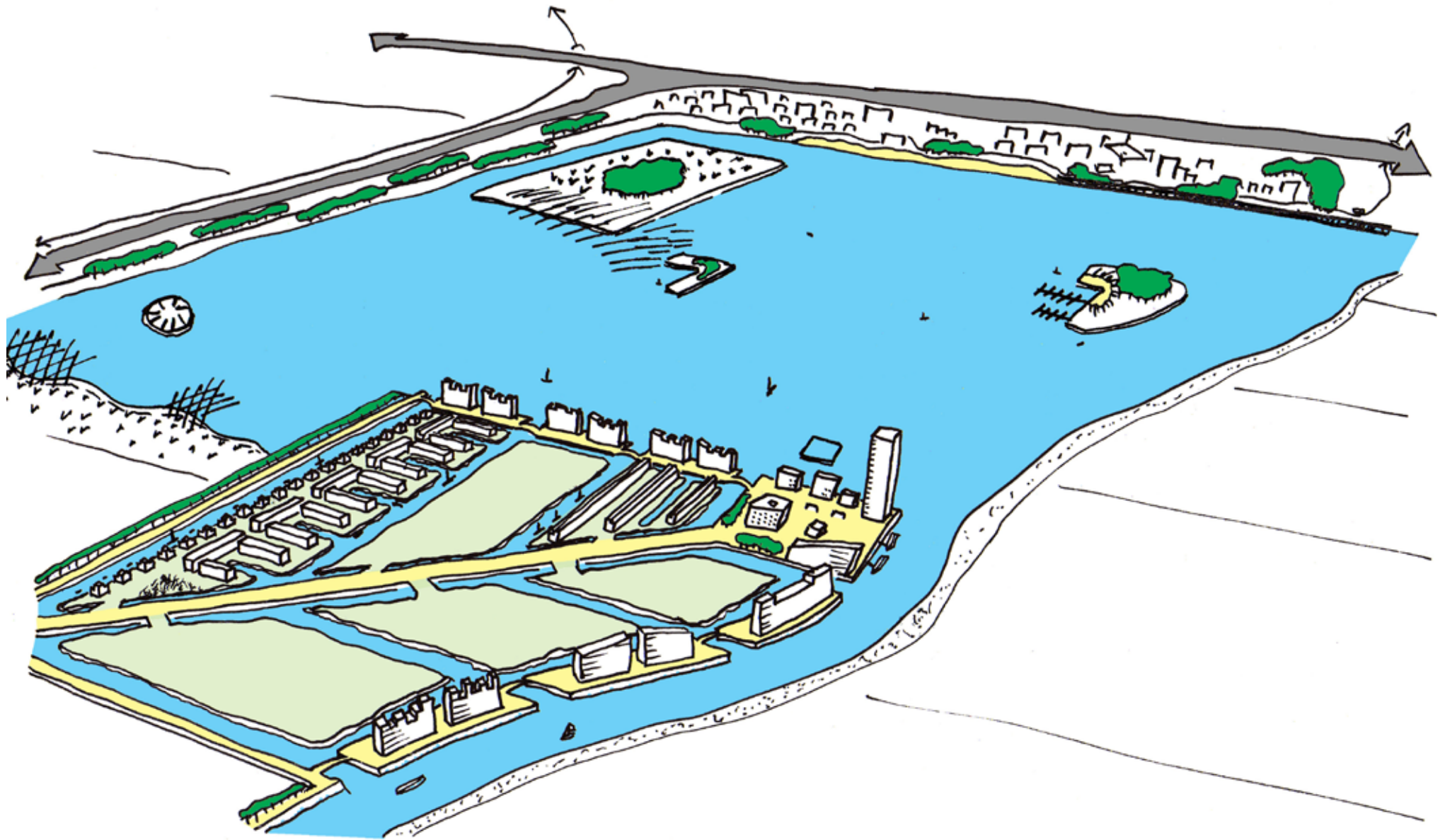
Fields of dwellings close to the water



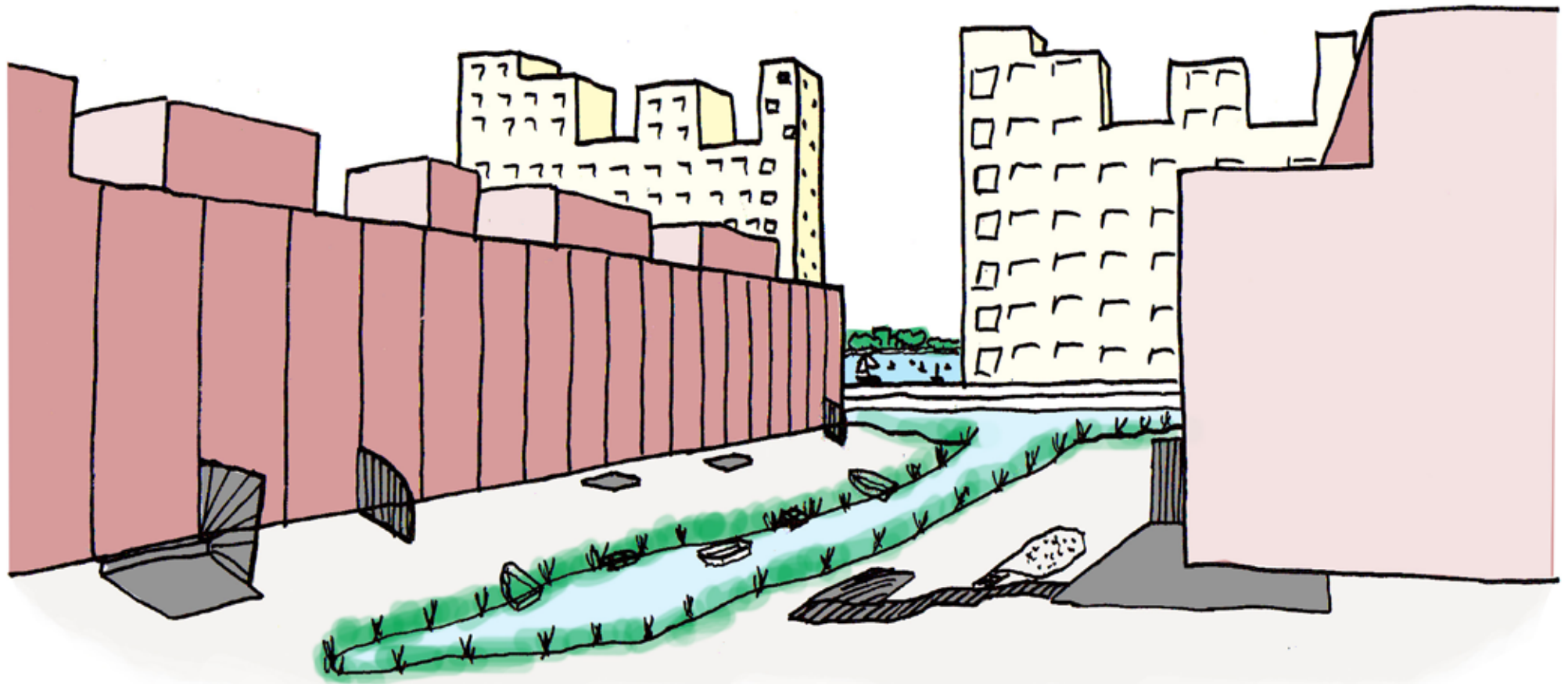
Stratification of dyke, water and land



Coulisse buildings



Lake oriented waterfields behind coulisse



Living behind the coulisse at the low tide lake



Stratification of tree, field, lake urban front and megamould

MEGAMOULD

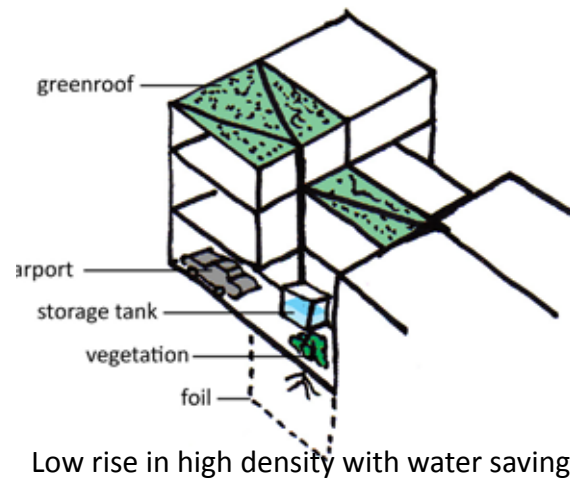
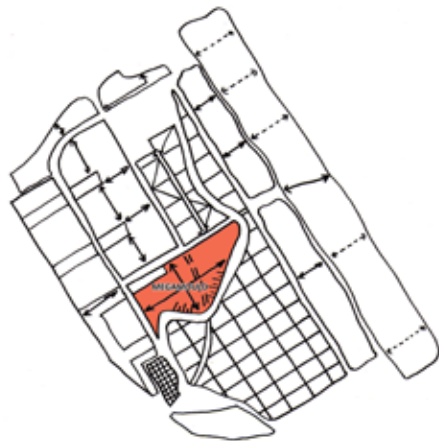
The mould is the ultimate symbol of high-water protection. But after the development of dykes in the late Middle Ages the mould became unused as urbanization strategy. In this urban water project the mould deserves a second chance!

The mould is formed with terraces from NAP -4 to NAP +8. It is bordered by the river bank on the south side and forms to the polder landscape on the other sides. It is a viewpoint to experience the wideness of the area and focussed at optimal sun orientation. The height creates a need to retain water in basins in order to grow vegetation. The mould is heavily urbanised with primarily low rise in high density. Giant sculptural blocks are added to create orientation and to create a dialogue with the vast landscape around.

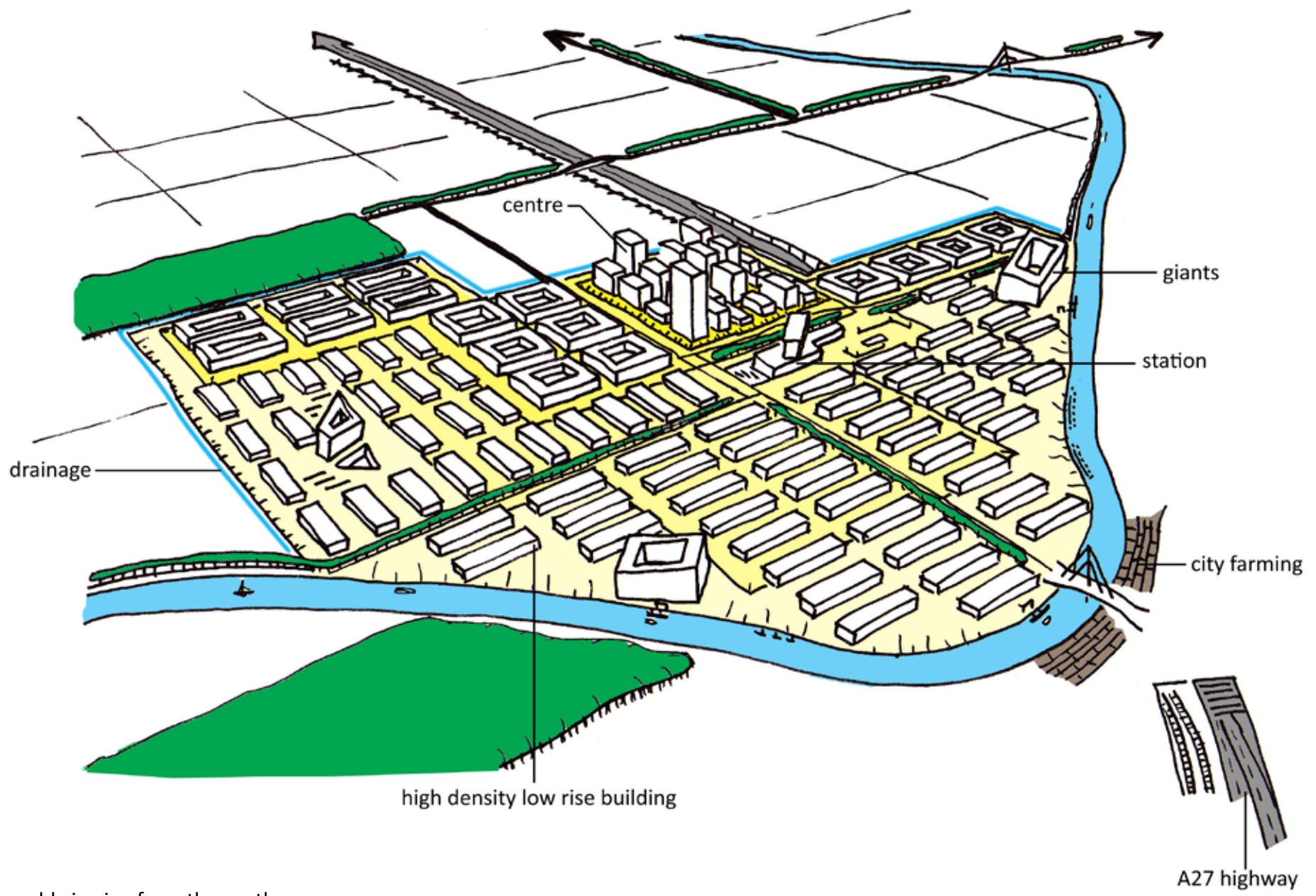
High density 100 dw/ha
 High FSI (1,7)
 Low OSR (0,25)



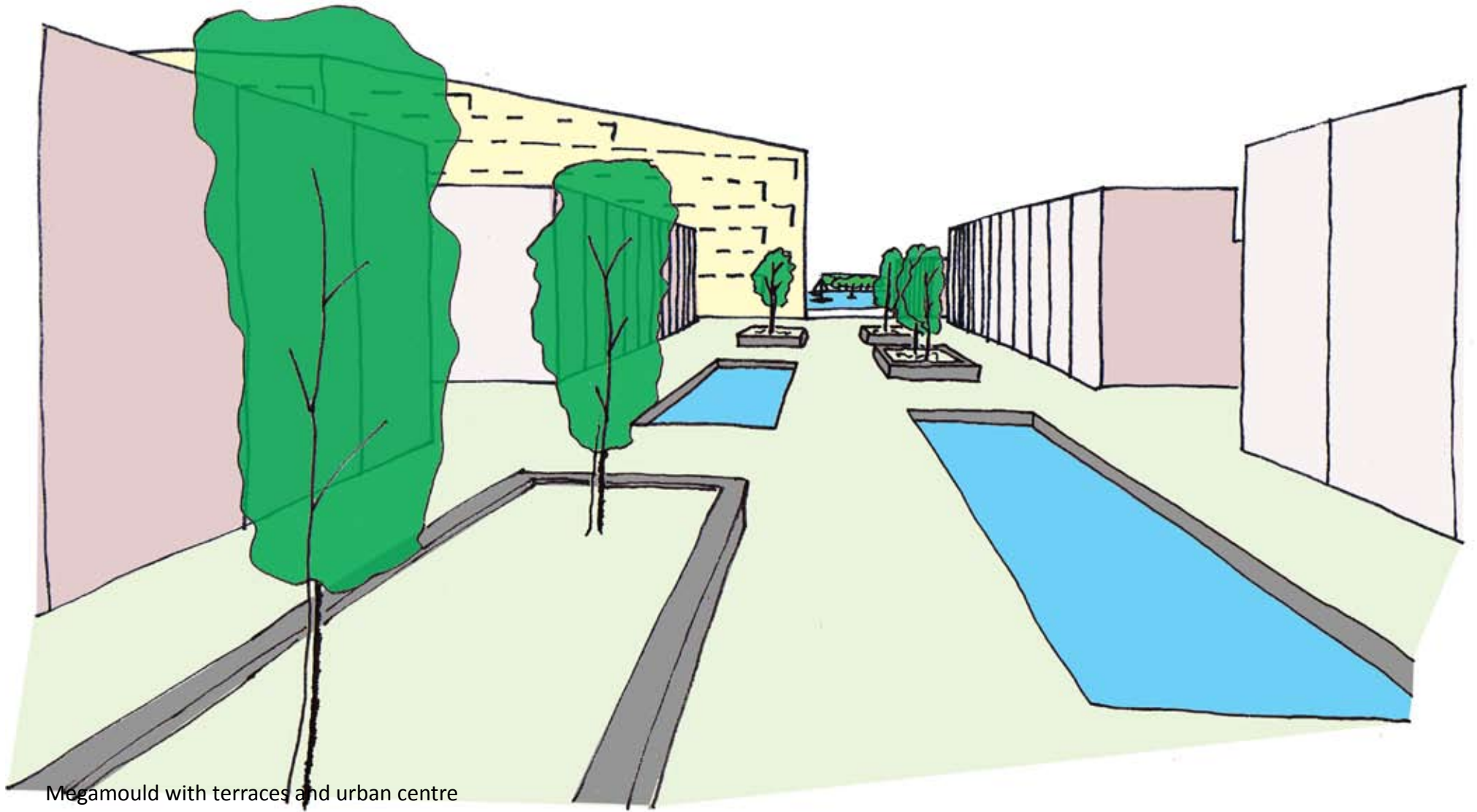
Urban mould: high and dry



Water storage in public space



Terraced mould viewing from the south



Megamould with terraces and urban centre



Field, water and modern megamould



Section of the megamould



High urban atmosphere with water and vegetation basins

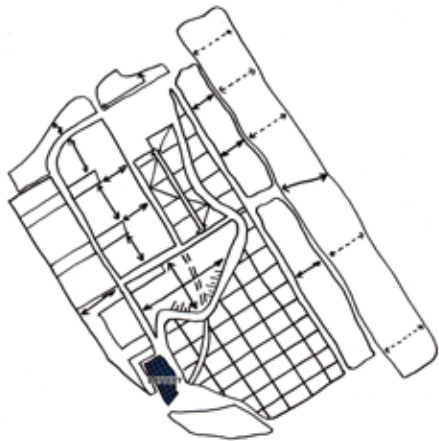
BATTERY

The battery centre is located at the interface of the civil engineering system. The seasonal storage together with its dykes, dams and water pump creates a genius loci and is used as the centre of the urban area. The water level is either high or low, which depends on the connected canal. The choice is between two water levels with 1,25m difference. This creates the possibility of multiple levels in the public space. The urbanisation is characterized by closed blocks on islands with stone canal banks with trees and street furniture. Variation in water levels with locks and water pumps is experienced in the public space.

High density 75 dw/ha
High FSI (1,5)
Medium OSR (0,5)



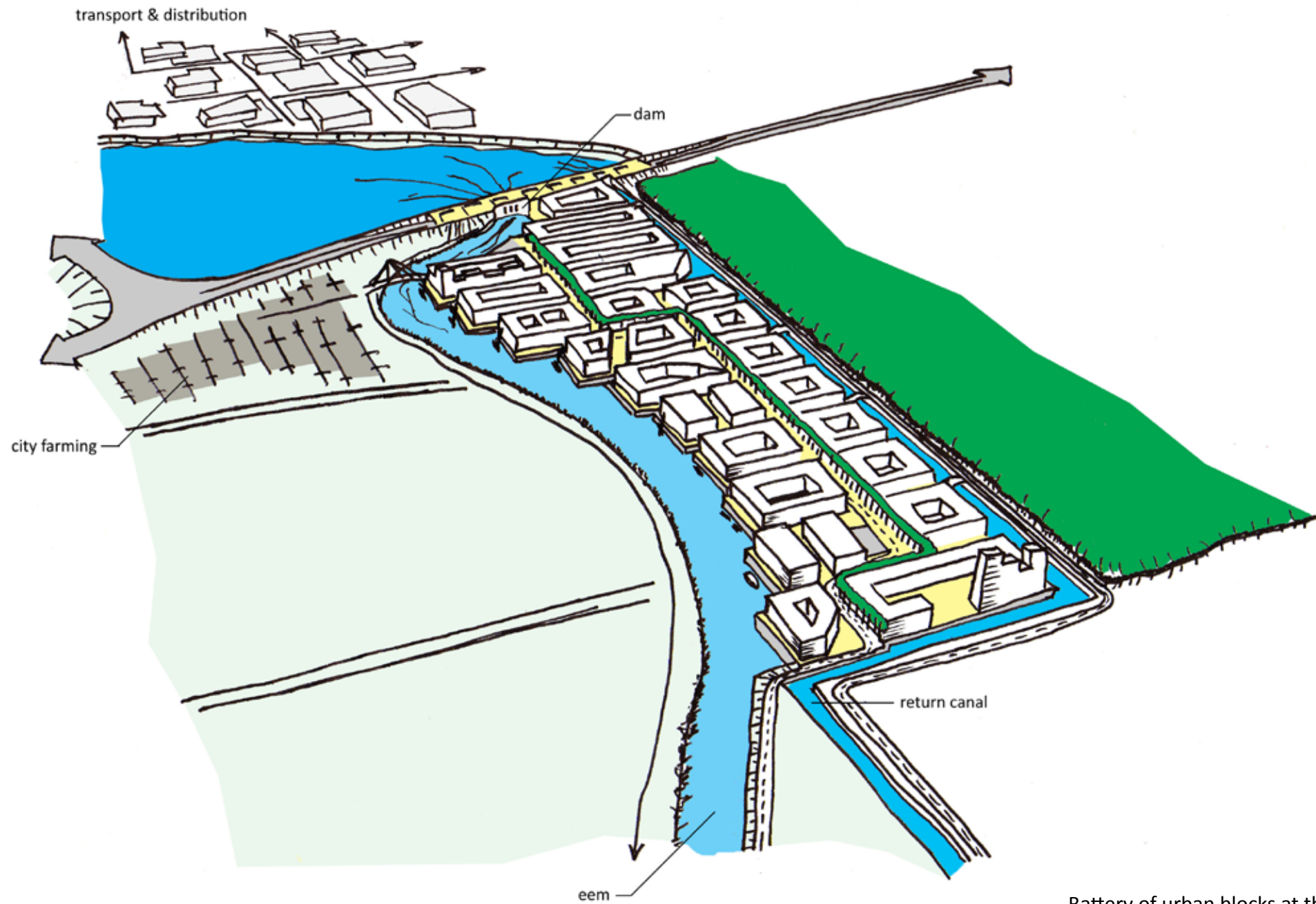
Multi-stage paved canal banks



Water machinery experience



Dynamic water flows



Battery of urban blocks at the dam



City farming, the river and the urban blocks - viewing the dam



Water flushing from machinery, extreme sports and paved embankments

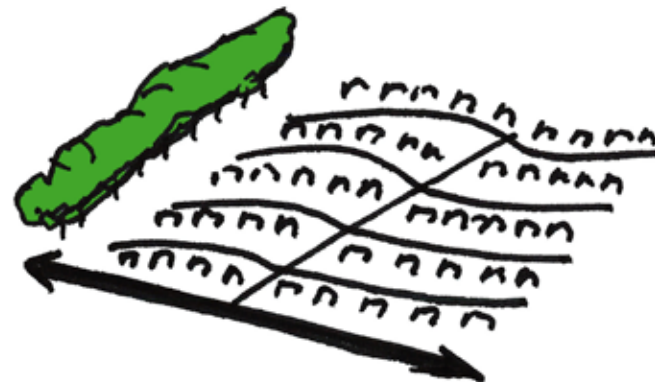
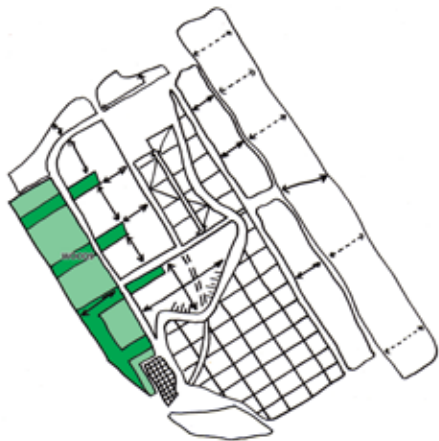
WOODS

The first urbanization of the area is Vogelhorst, a field of villa's oriented on the forest chambers in which its built. It has an almost American suburban atmosphere with curving roads and parkways where self built homes are draped around. This connects to the main road, the Vogelweg, and to some bicycle paths. Next to it a golf course is located.

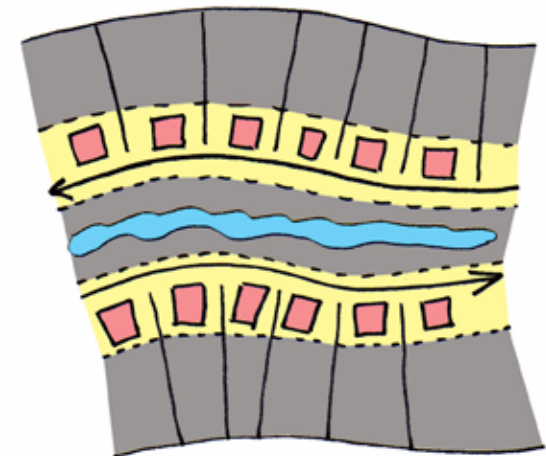
The principle of forest oriented villa's can be reproduced in the total strip bordering the Almeerderhout forest. The villa's can be made water robust by using a cunette method of partial raising.



Suburban forest villa's



Typology: connecting road and adjacent forest



Water robust strategy: cunettes

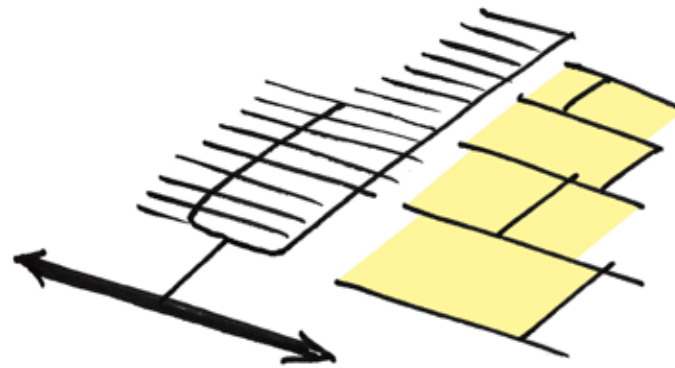
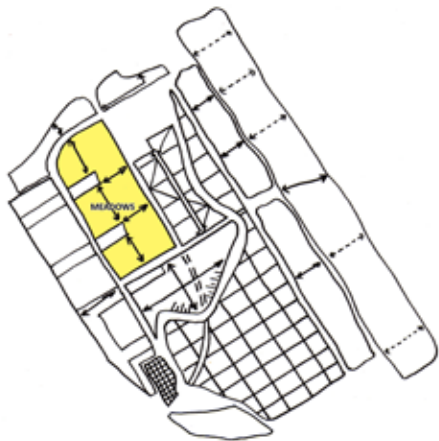
MEADOWS

The area now has some free hobby-work-living plots organised in ribbons through the agricultural landscape. These plots know a high level of self responsibility, which can be encouraged and expanded to the field of water management. Experiments with private water management and 'building your own mould' can be conducted here

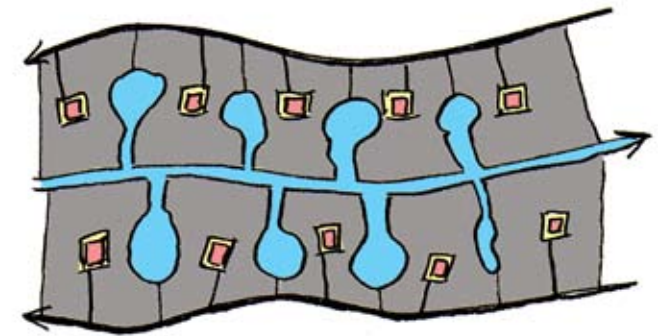
The landscape can be conquered by these ribbon developments without losing the agricultural character of the area.



DIY plots in the meadows



Typology: connecting road and adjacent farmland



Water robust strategy: mini moulds

BUSINESS

There are two business parks in the area, concentrated around the two highway intersections. The 'flexible business park' in the north lies in a water sensitive zone. As a consequence the infrastructure will be focussed at light and decentralized systems. Also the buildings should be developed for a low life-span. This makes reconsideration of the area possible by the year 2050.

In the south the 'transport and distribution business park' has a longer life-span and can handle heavy infrastructure.

Both areas are business parks where recreational facilities are encouraged. Team building activities can be scheduled in normal business days because they can be done close by. Workers health can be improved on the workplace. Also the interest and appreciation in the office buildings surrounding will increase.



Eye-catching office buildings



Teambuilding activities close-by



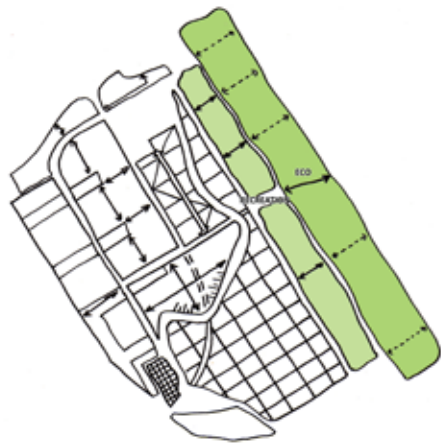
Inviting outdoor environment

OOSTVAARDERSWOLD

The national, provincial and local governments have committed themselves to expand and connect the Oostvaardersplassen. This is the biggest wetland in the Netherlands and has an above-national significance for primeval European forest species as the Heck cattle, Koniks and Red Deer. The plan is to connect the Oostvaardersplassen with the Veluwe through an ecological zone known as the Oostvaarderswold. This makes migration of the big grazers possible and introduces the Wild Boar, European Badger and Red Squirrel.



'Now I can walk all the way till Germany!'



Missing link in the polder



Possibilities for extensive recreation

5.4. WATER SCENARIOS

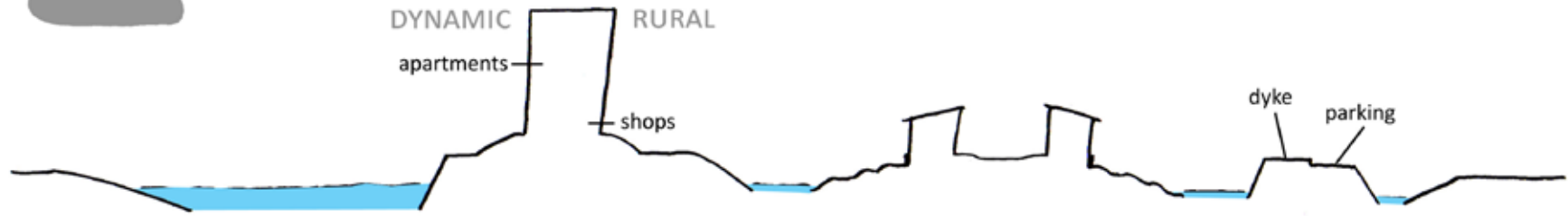
In the plan area there is a diversification of water mitigating measurements. These building methods adapt and react to the local soil/water situation. The three centres of urbanization are: waterfields, megamould and battery. The pictures on the next pages sketch the scenarios normal, drought and rainfall.

The **waterfields** consist of dry-proofed dwellings who see the water level fluctuate in their terraced gardens. The street side will not inundate, but in extreme situations their (whole) garden will. Public and mixed functions are placed in larger buildings on dry footprints. These islands (or mini-moulds if you like) are interconnected with dykes and bridges providing a 'watersafe' network for transportation and car parking.

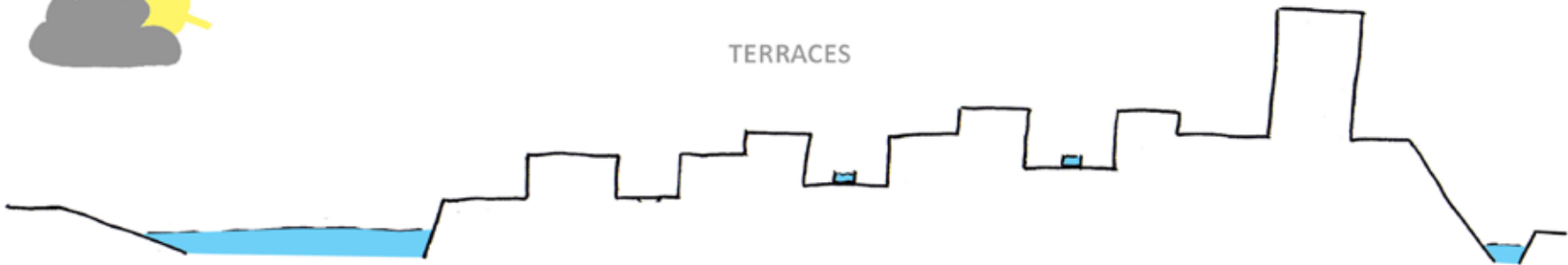
The big buildings also function as coulisse between the dynamic area of lake and river and the rural area where the fields with dwellings lie.

The **megamould** is organized in terraces facing south. The terraces are raised, from 3 to 12 meter height. The top terraces lie high above sea level. This creates a dryer environment than normal in polders. This will enable to grow different vegetation. In wet times rainwater can be infiltrated through the mould without centralized sewer systems. But in dry times there will be a relative drought in the area. This encourages the use of open water basin and to retain water as long as possible.

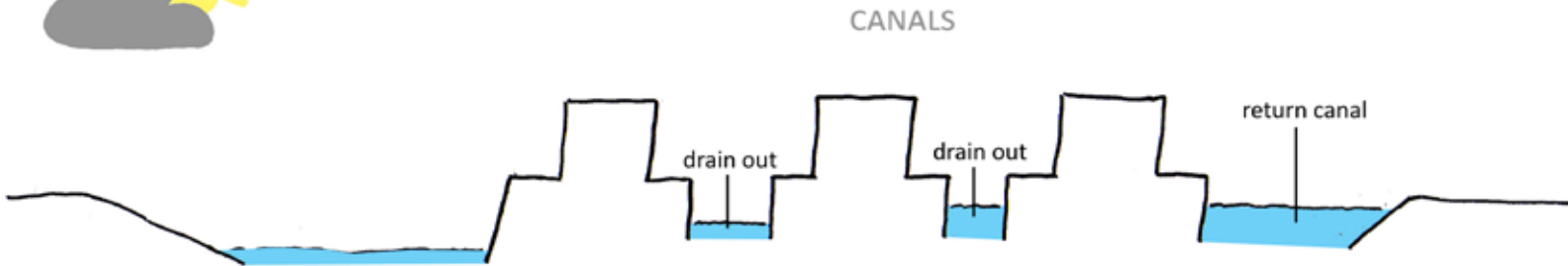
The **battery** is built up by a system of canals. The low water level of the Eem river on the one side and the higher dammed up water level of the circulation canal. By a system of locks the water level can be dramatically changed and this introduces water as a play element in this centre. The layout of the canals can be in two levels, which can be used according to the water level. Furthermore it is focused at the heart of the water system for the whole plan area: the dam and pumping station.



'Waterfields'



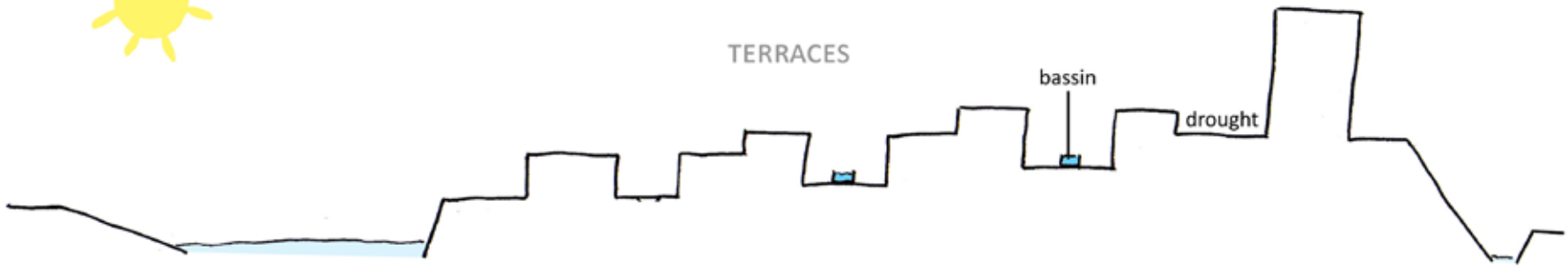
'Megamould'



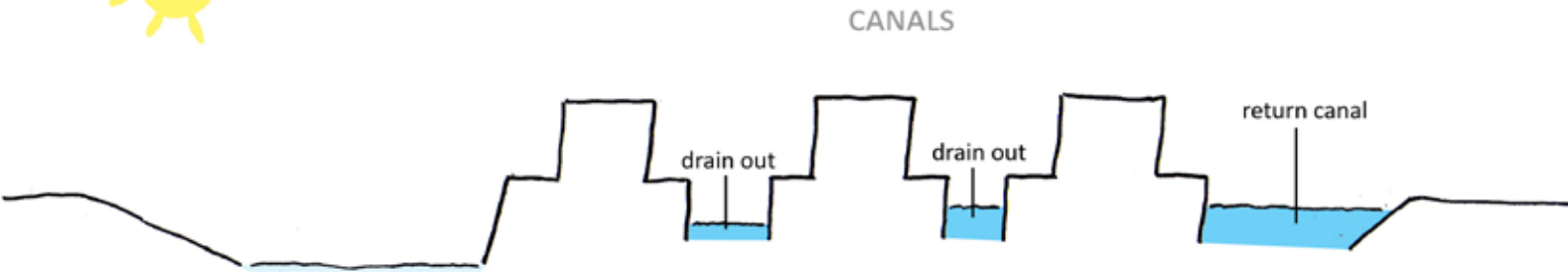
'Battery'



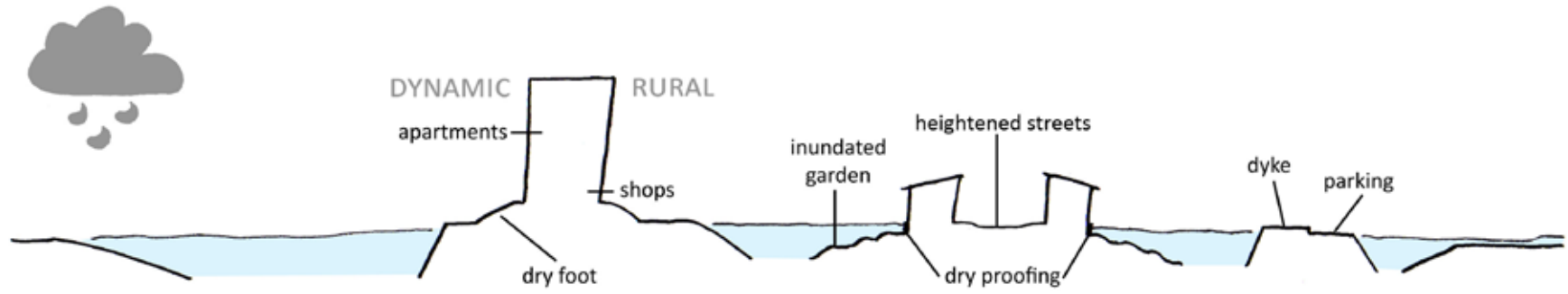
'Waterfields'



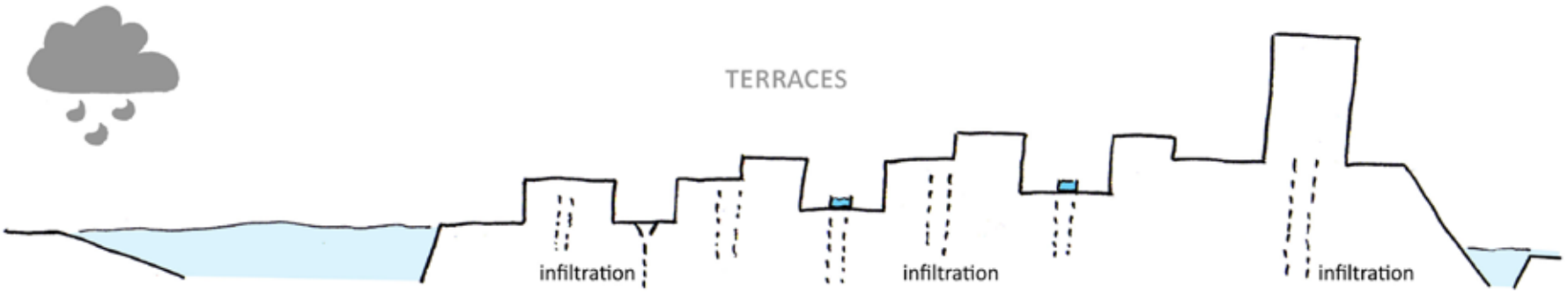
'Megamould'



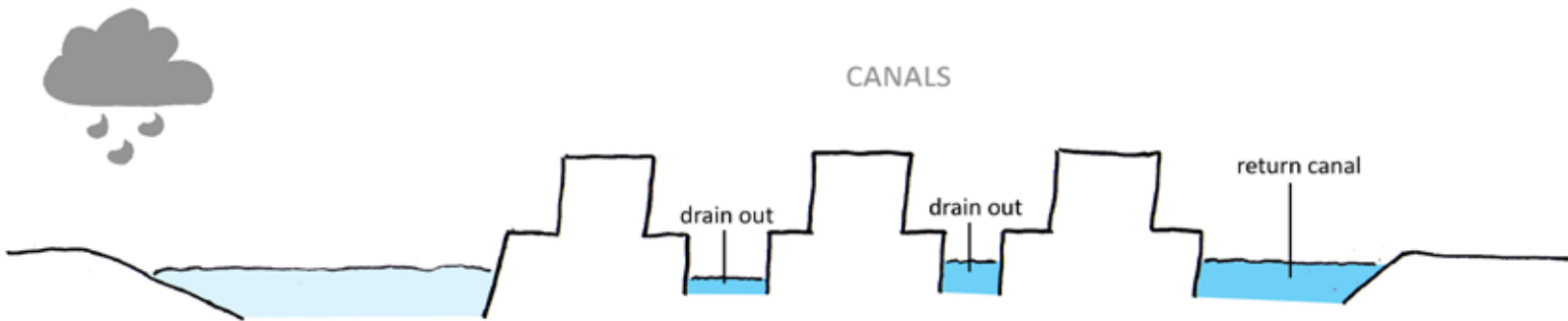
'Battery'



'Waterfields'



'Megamould'



'Battery'



The land of far far away...

5.4. CONNECTIONS

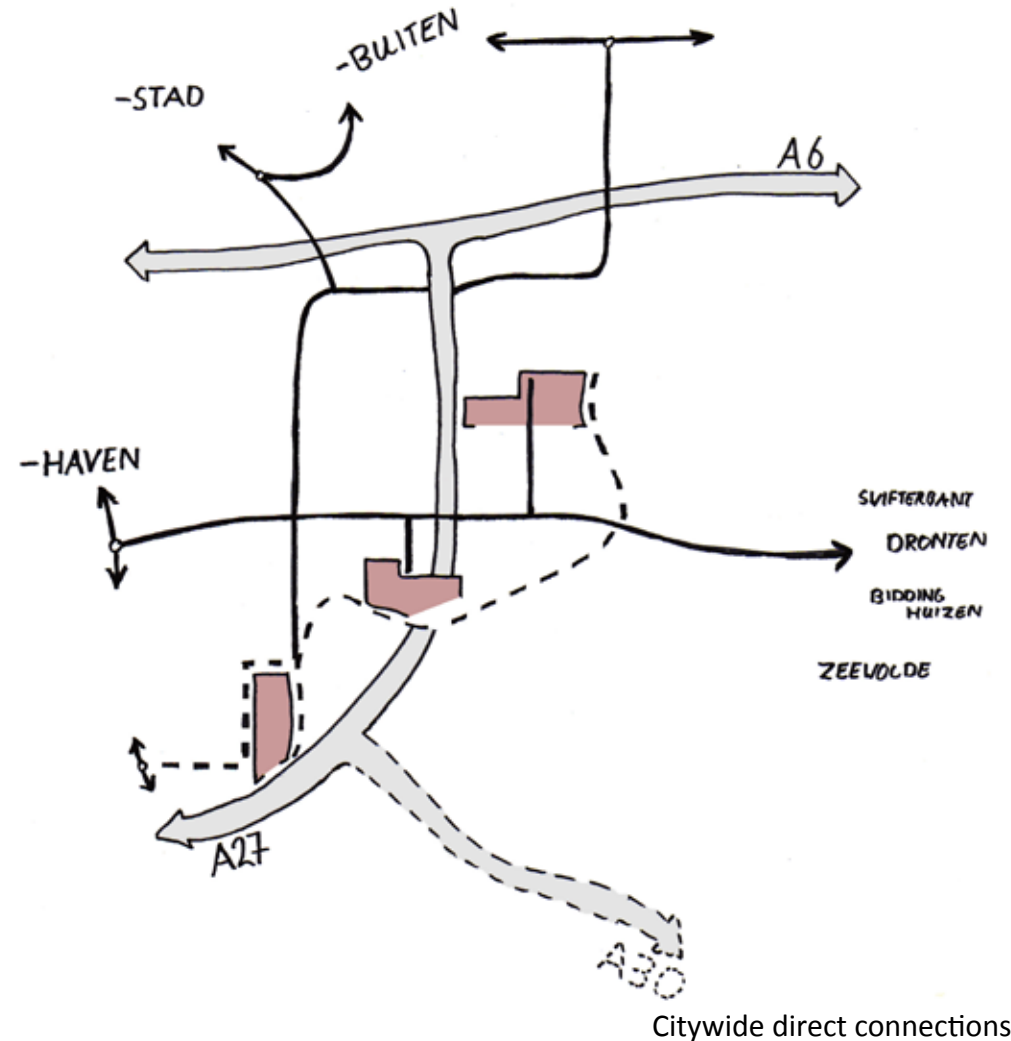
The plan area lies in the polder as a new centre of Almere. It adds a new core in the polynuclear model, as already foreseen in the sketches of Teun Koolhaas.

This makes connections with the city and the region of extra importance. Also in terms of mobility and public transport it has to be very well connected to other large centres of living and working.

The important spatial carriers Vogellaan, Kievietslaan and the Eem river are the universal connections with the city and region. This is a continuation of the polder systematic and creates a clear framework for car, bicycle and public transport. On the other hand above-local traffic should be discouraged.

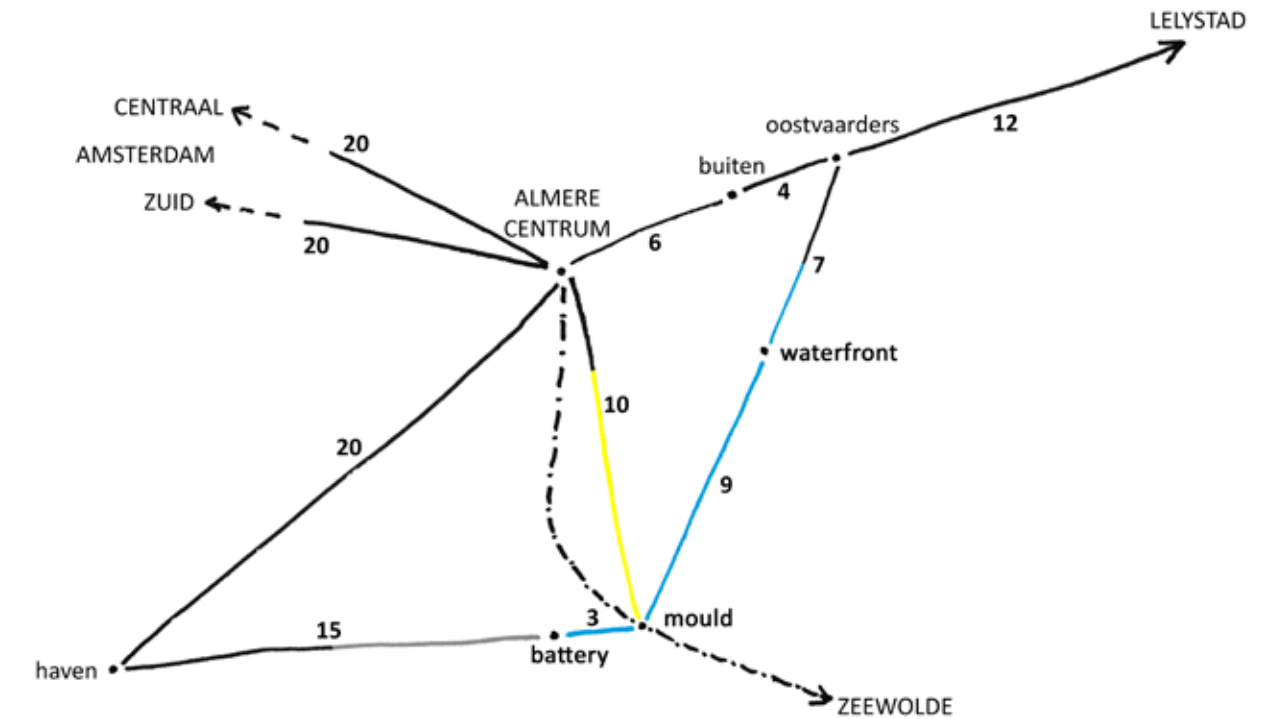
This results in a network of citywide directly routing through the underlying network. And indirect connections of this network to the highways. This way cut-through traffic is minimized.

This breaks with the practice in Almere to use the highway for citywide connections. Main disadvantages of this practice are an increased pressure on the already busy highway system and the disorientation of visitors (and even inhabitants) of the city.

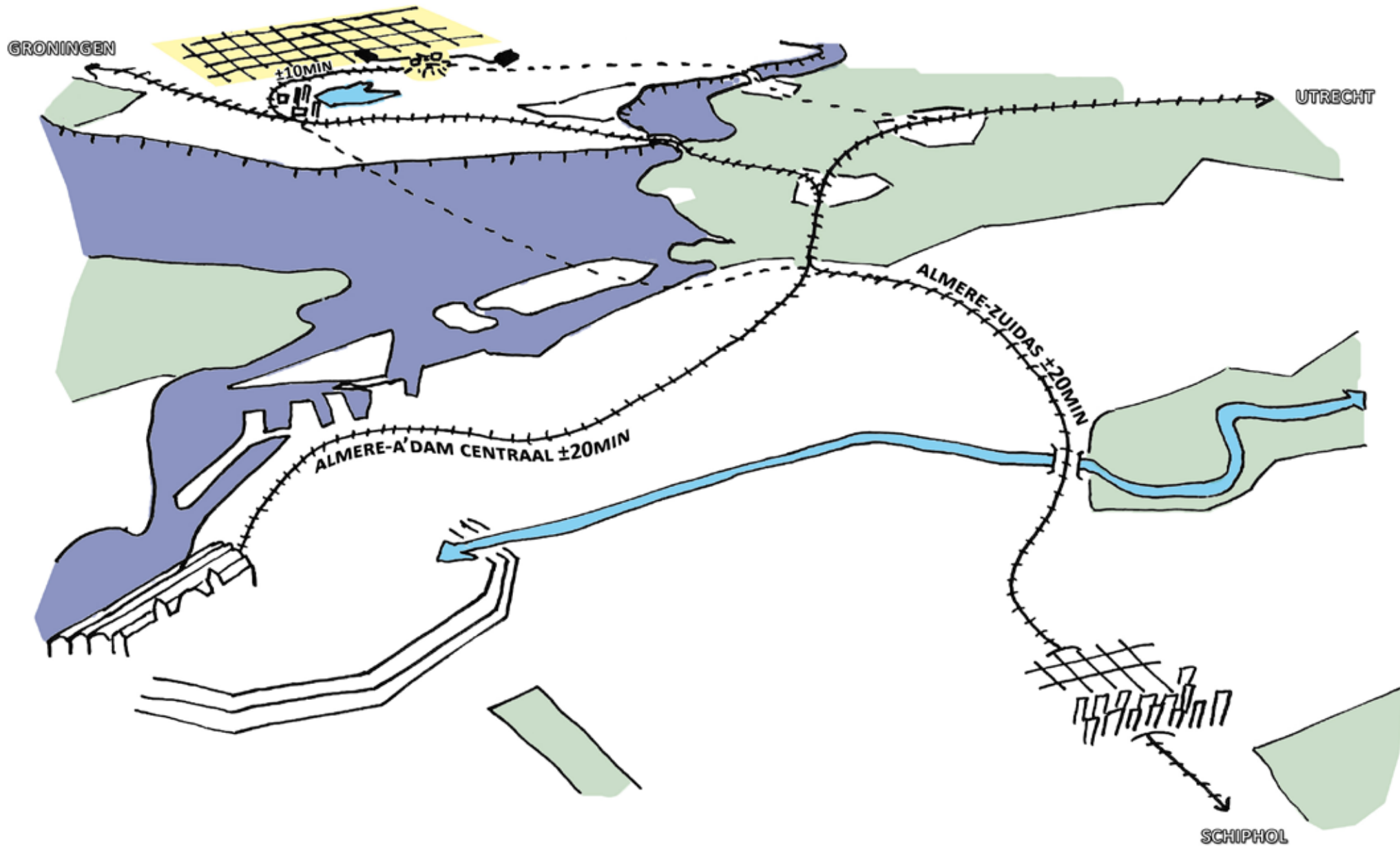


OUTPOST OF THE DOUBLECITY

In the plan a (light)rail connection to Almere City is planned. This connection exists also in all municipal scenarios and with the expected population this will be feasible. The travel time between Almere East and City will be drastically shortened till about 10 minutes. This makes the area lie on a quite reasonable 30 minutes from Amsterdam Central and South, being able to play a role in the Doublecity's housing market and economy, providing alternatives for people working in Amsterdam.



Time-space diagram



Almere East: outpost of the 'doublecity'

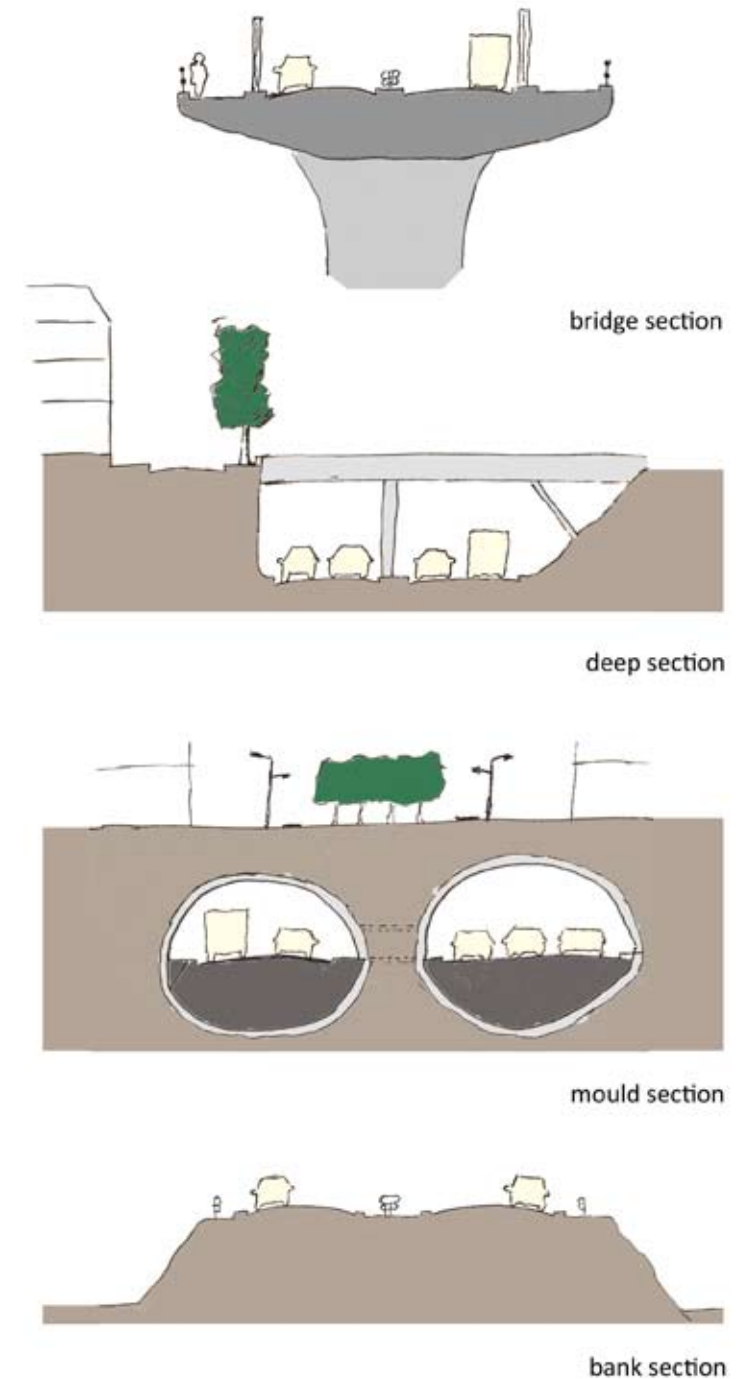
HIGHWAY EXPERIENCE

Highways are an essential part of our modern mobile society. They enable people to travel fast from place to place on an individual basis. The first highways being constructed were designed as parkways and panoramas through the landscape. The car travellers perspective was the starting point, resulting in beautiful viewpoints on the route between city and landscape.

But in the last decades city and landscape came closer to each other, not always resulting in a qualitative mix. The ribbon developments triggered by the highway system layout now prevent the driver from enjoying the landscape. Together with the sound hinder prevention measures in the form of sound barrier walls the landscape panorama of the driver threatens to disappear completely. This must be stopped by taking the driver in account again in urban and infrastructural design.

In Almere East the driver has now an incredible view over the open landscape and the principle is to make this landscape more exciting with water and urbanization. The road itself is then transformed into different parts with its own section and panorama. The sequence of this panorama is the experience of this part of Almere for the driver.

Coming from the interchange A6-A27, the North, the road starts as a bridge over the Low tide lake or passing it on ground level, providing a view over the lake and the urban waterfront. After the lake the highway continues deepened not hindering the urban tissue. At the Megamould, the highway dives under and surfaces again after the Eem river. Here the embankment shows the polder panorama before leaving Flevoland over the Stichtsebrug.



Waterfront view



Deepened highway fitted in urban tissue



Diving under



Wide horizon of the polder

WATERBUS

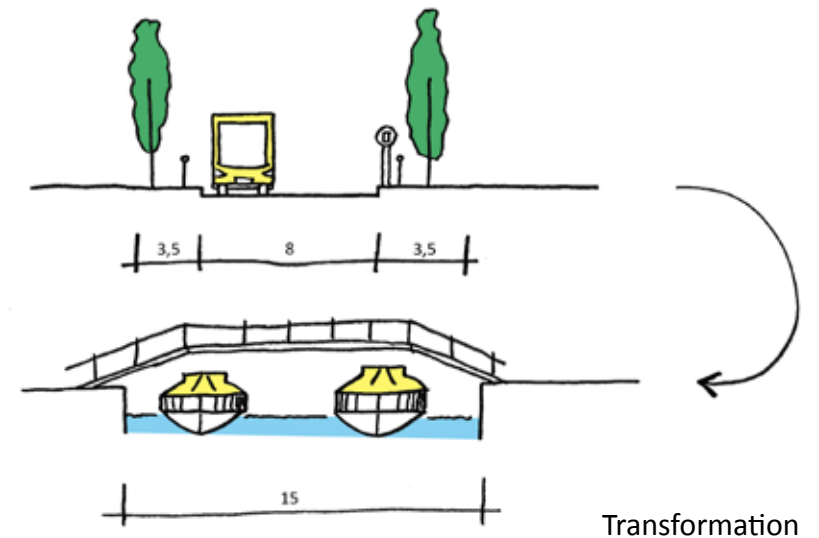
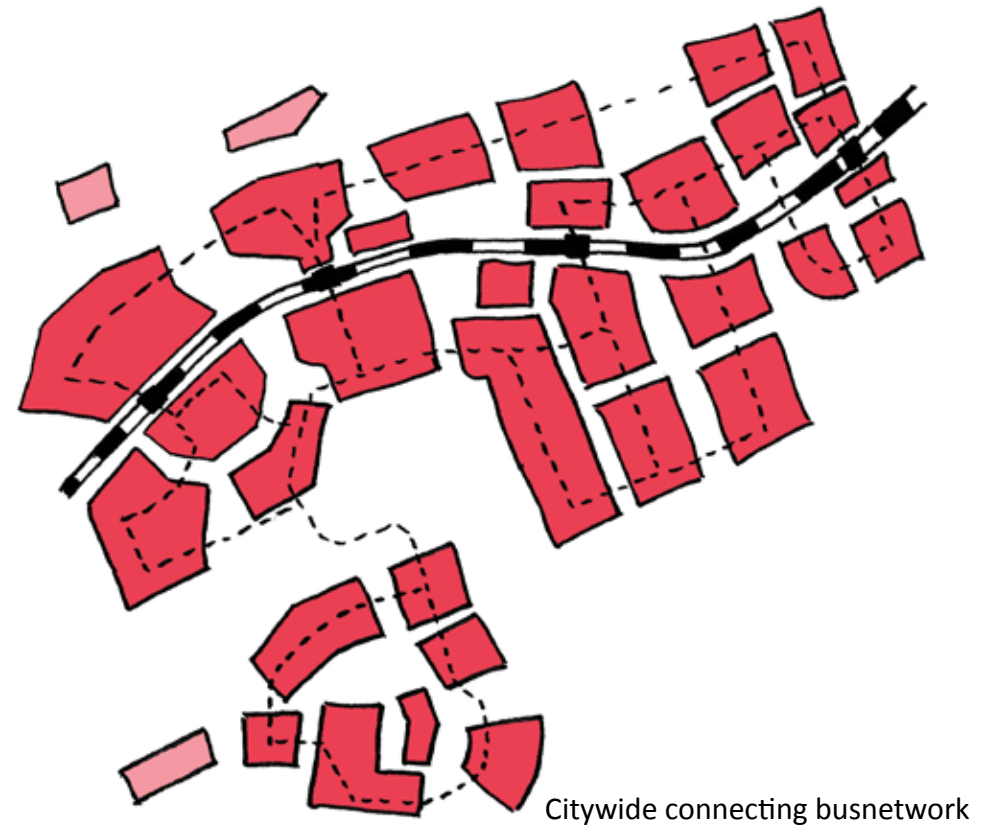
The city of Almere has a high quality bus transport network which is very consistent implemented in the city. The typical bus lane has a profile of a two lane road enclosed by fencing and not bundled with other means of transport. Crossings are sometimes on different levels while passing busy roads, canals or slow traffic. But mostly on the same level with streetlights with bus priority.

The network of bus lanes is oddly enough the only network which connects the hearts of city districts consequently with each other. Other networks such as the car rely much on cul-de-sac principles for reasons of hinder and cut-through traffic. The slow traffic network has a smaller reach and has a less dominant profile.

So the bus network is a dominant and consistent implemented connector between districts. The only problem is that is it dangerous and inaccessible for pedestrians and other means of traffic. This is a missed chance and calls for a transformation!

Almere East has to become a full part of the city, also in terms of public transport. With the focus on water in Almere East, this can be an interesting approach of public transport.

This led to the idea of the waterbus which uses a network of canals. And canals have are a qualitative public space which people enjoy and use for orientation. If this proofs successful this idea could spread allover the city, transforming the existing network in canals and bring more water to the city!



The success of transportation on water relies on a few factors:

- locks, which cause a delay of about 20 minutes,
- frequency, which must be at least twice an hour, and
- speed limits and physical conditions.

The water system is designed with as few locks as possible, because routes with locks are probably not profitable. The frequency can be high when there are enough passengers, so with a smart positioning of the stops.

For the urbanist the physical conditions needed for a successful exploitation of the water bus are most important. In Almere East the canals who are wide enough are the Eem, Hoge Vaart and Lage Vaart. The Lage Vaart is the least interesting as it only passes the north side of the plan area. The Eem is connecting the best places but is a meandering river. This will effect the operational speed of the water bus.

By far the most interesting is the Hoge Vaart, which linear structure makes it ideal for high speed transport over water. It can connect Almere East from the Battery to Almere City Parkwijk station. The rentability of this connection should be researched in conjunction with the total public transport network of the region.



Water bus in Venice



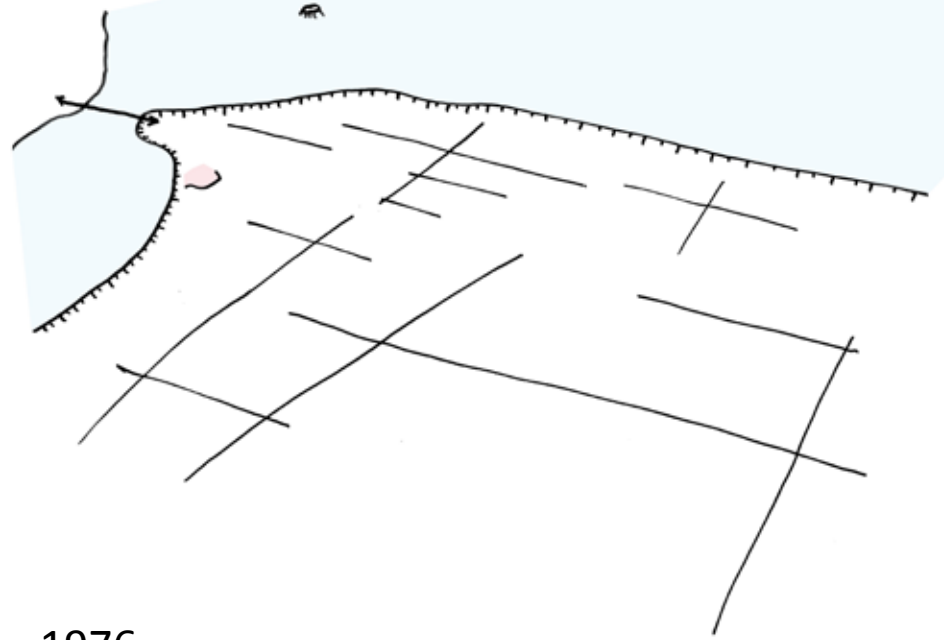
Linear canal - Hoge Vaart

3.3. DEVELOPMENT PROCESS

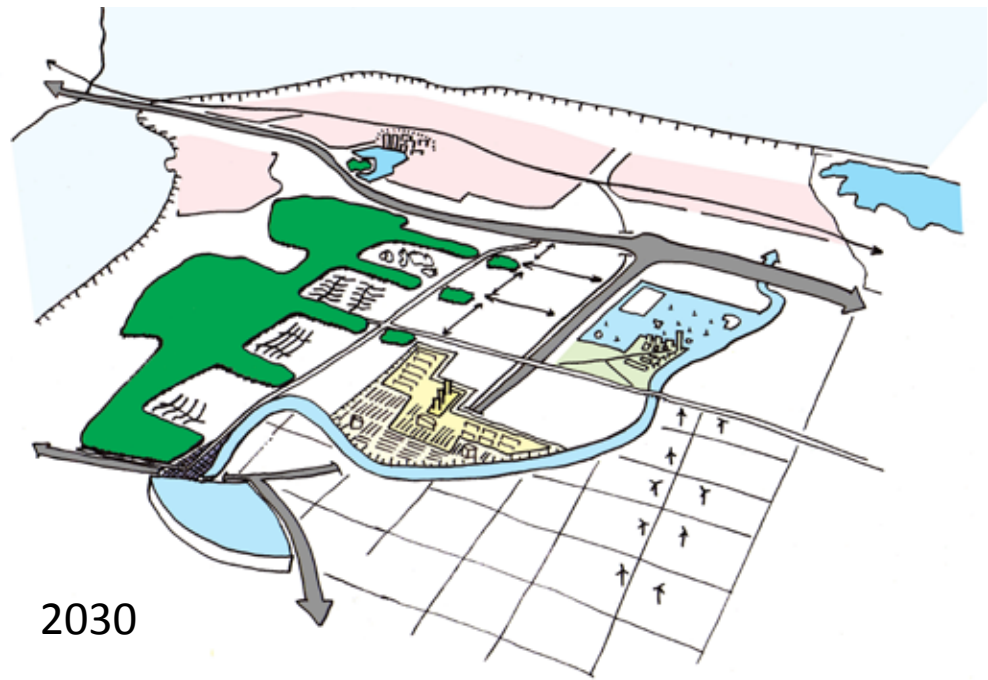
The cultivation of Flevoland went tremendously fast, from sea to land to city in less than fifty years. The large-scale reservations for green, infrastructure and urbanization are now thankfully filled in by the city of Almere (in the southeast of the polder).

The linearity of this process of spatial reservations has advantages in terms of costs. When space for infrastructure has been reserved the construction of this infrastructure will be straightforward and without conflicts which ask for demolishing or ingenious but expensive engineering works. The downside of spatial reservations is exactly the same, but then seen in the light of urban composition. The lack of a certain stratification of the landscape and of the city makes it monotonous and boring. And this is one of the main common criticisms on Almere.

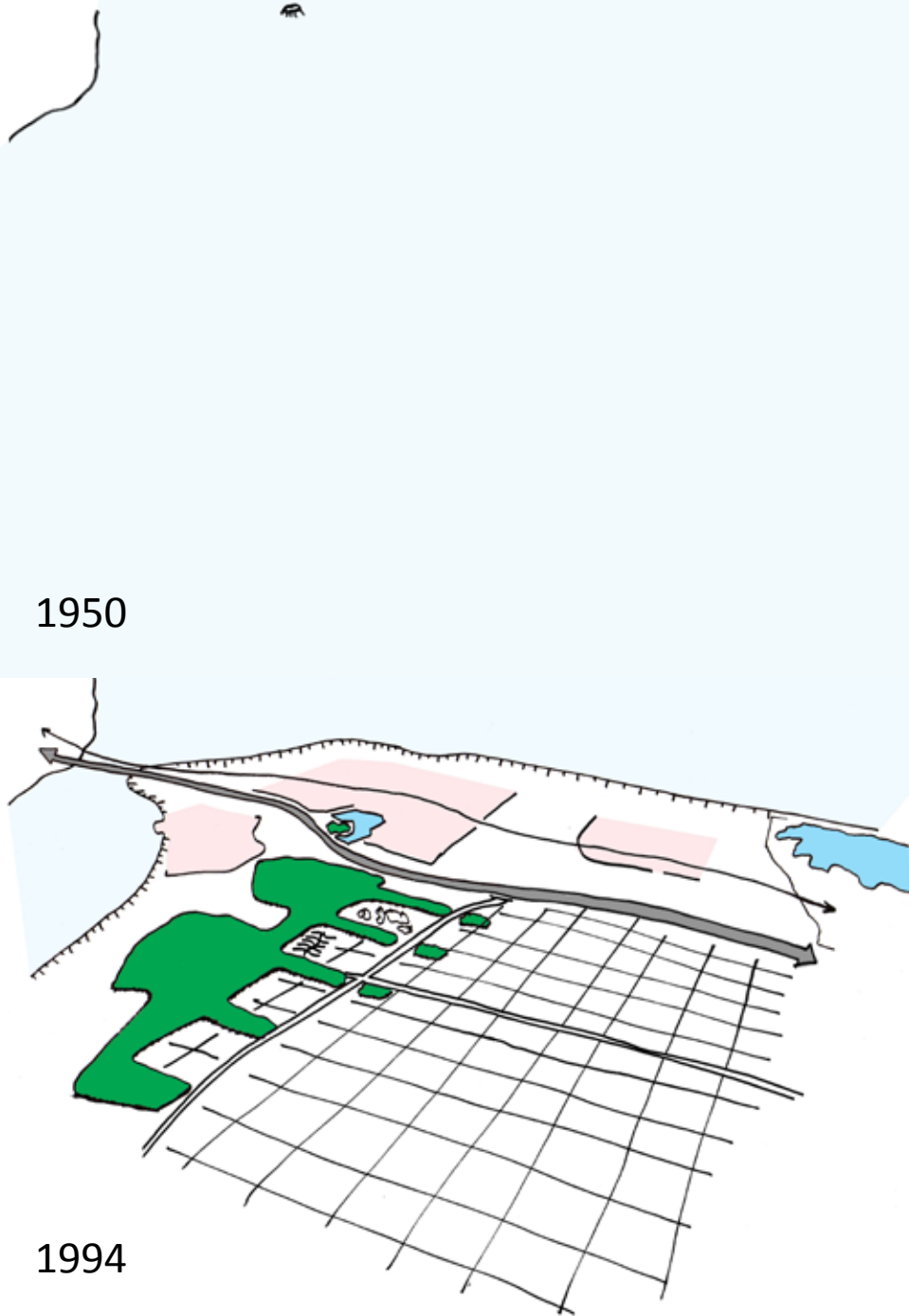
The development of this plan for Almere East connects an historical layer with the current one. And based on the network of interesting conflict points the urbanization is tuned. This creates a certain stratification in the urban landscape which has not been carried out before in Almere. In the pictures on the other page the process of making the polder, creating a functional landscape and then picking back the historical Eem ditch for the creation of an urban landscape is sketched.



1976



2030



1950

1994

Landscape

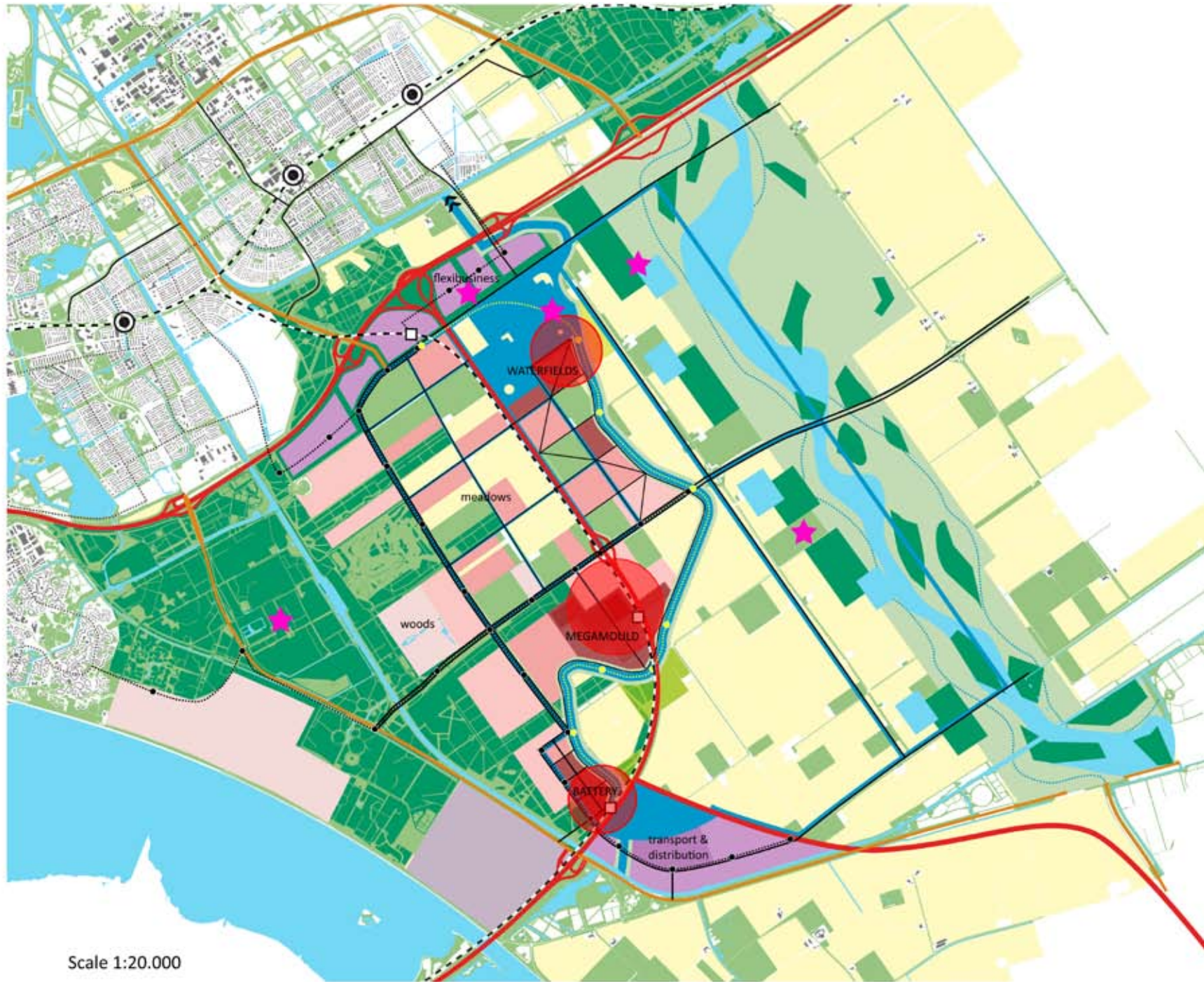
- Forest
- Ecology
- Water
- Meadows
- Agriculture
- City farming

Urbanization

- Business
- Dwellings 60-80 dw/ha
- Dwellings 40-60 dw/ha
- Dwellings 36 dw/ha
- Dwellings 15 dw/ha
- Dwellings 8 dw/ha
- Amenities concentration
- Recreational attraction

Traffic

- National car network
- Regional car network
- Avenue
- Road
- Lightrail
- Waterbus
- Bus



Scale 1:20.000

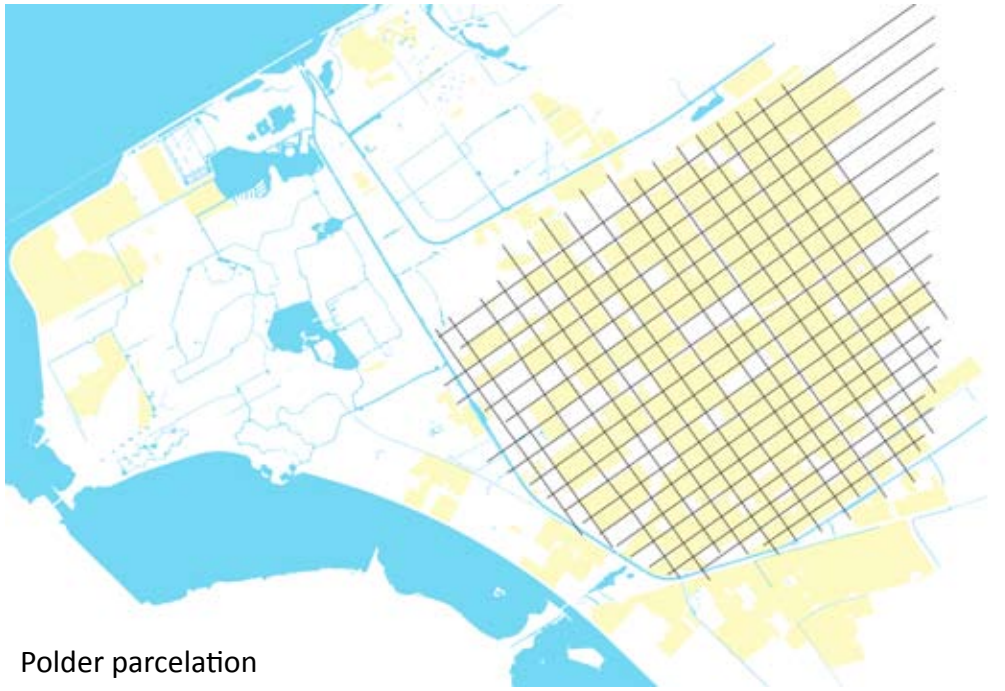




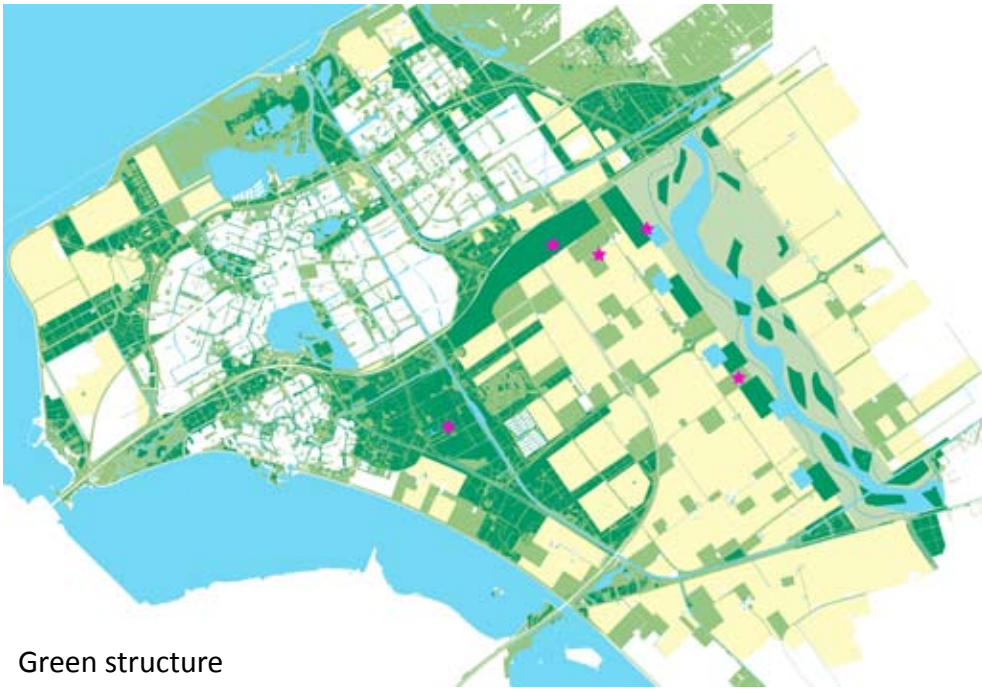
Plan area



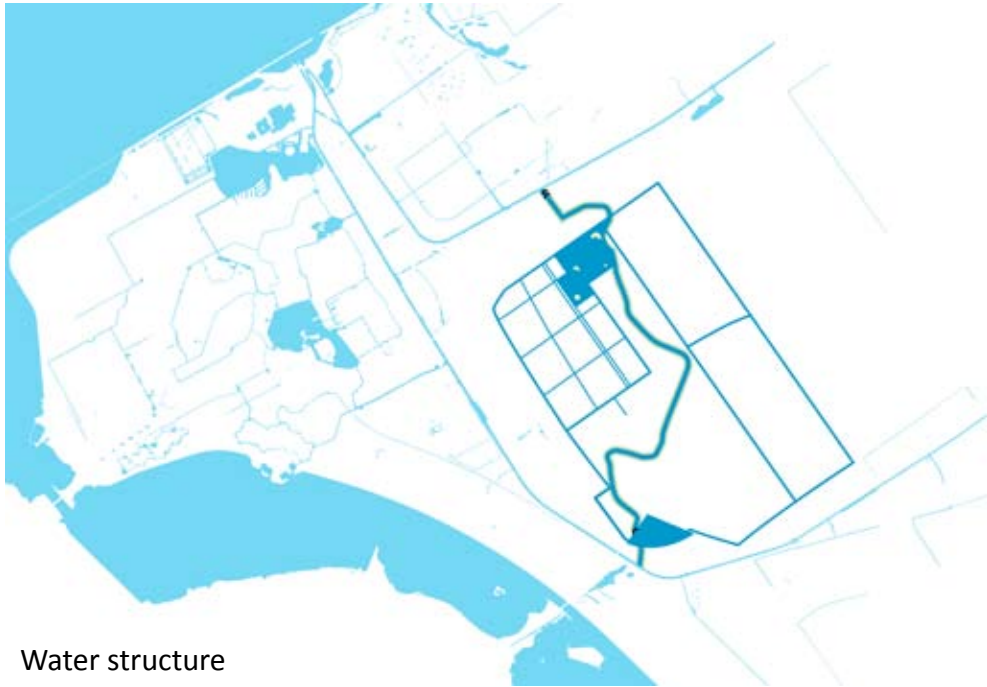
Soil layers



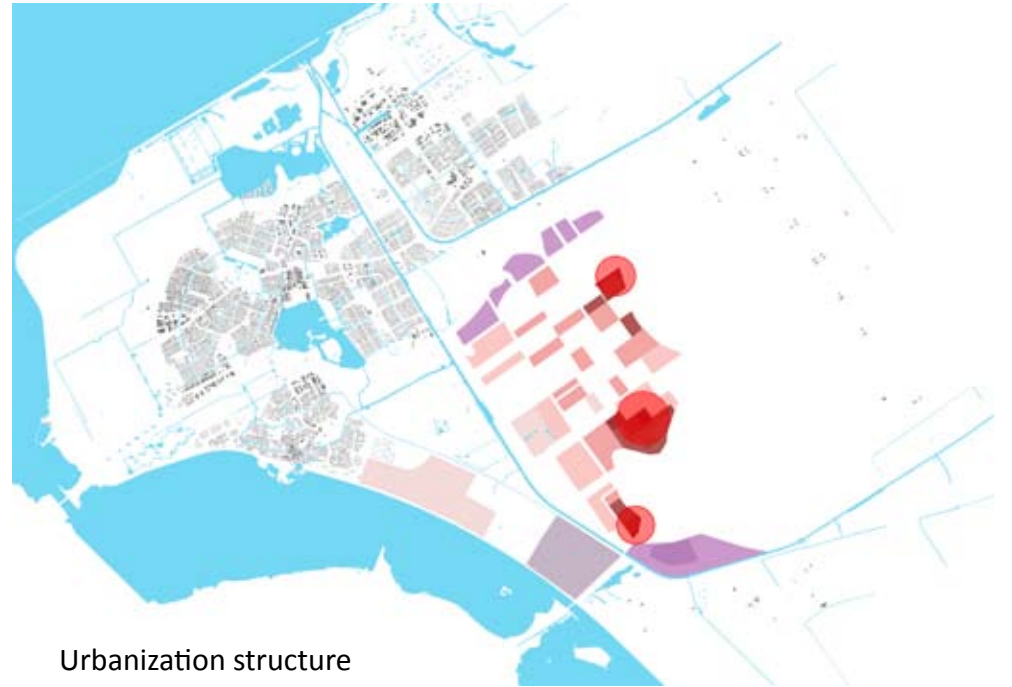
Polder parcelation



Green structure



Water structure



Urbanization structure



Road system



Public transport system

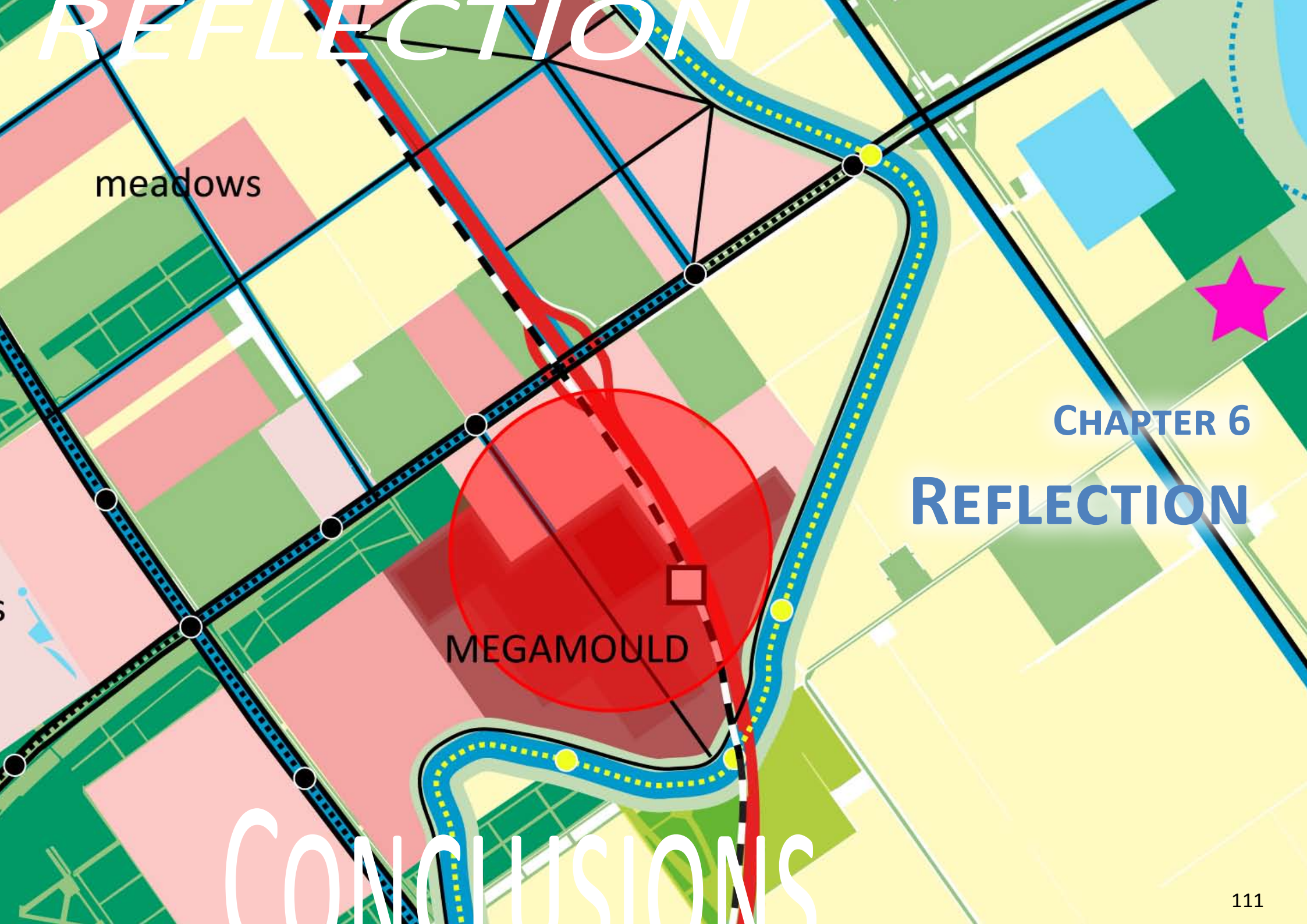
REFLECTION

meadows

MEGAMOULD

CHAPTER 6
REFLECTION

CONCLUSIONS



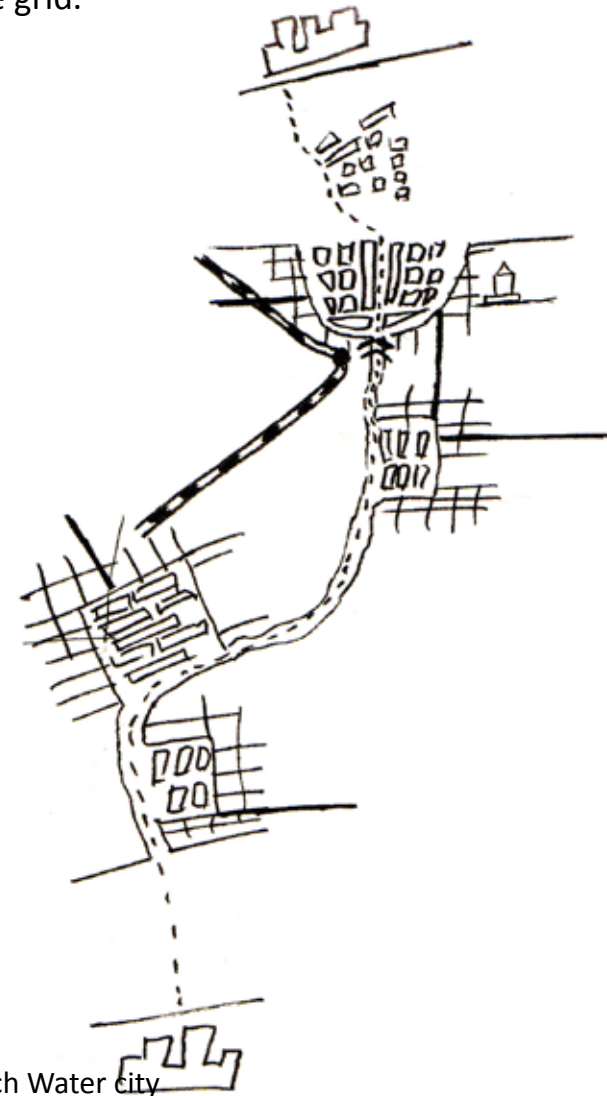
6.1. PRINCIPLES REFLECTION

A number of principles were drawn up in this design project and the final design will be tested on these principles in the following paragraph. The principles are mostly design principles derived from literature and plan study and applied in the Almere context. The soil and water analysis provided input for these design principles.

The design principles are all about water in urban design, but all from a different perspective. The first essay shows the historical aspect of New Towns and water management. This literature study resulted in a few recommendations: precise analysis of the current water system, use 'manmade' genius loci, integrated design of city-land ensembles and show how water systems work in an urban experience. All these factors played a role in the design process. By the cooperation with a civil engineering student the precise analysis of the water system was possible. We then proposed a new water system which implied new 'manmade' genius loci. This changed the landscape dramatically into a new blue-green environment on which the red could make fully use of the new created artefacts. Examples of these artefacts are: Eem river, high and low tide lakes and pumping station and locks. This framework was then used to distribute the urbanization by using the artefacts as centre points. This strategy results in a drastic other plan than that of the existing cities Almere and Lelystad, which were 'left lost in the polder'. The integration of polder water and urban design anchors the plan in its surrounding.

The second essay shows how water can be a carrier in urban

plans by introducing lakes or canals. This can be used to clarify an area which had trouble-spots. It can also strengthen an existing structure. In Almere East the dug up river introduces a formerly unknown shape in the polder: the meandering river. The area of tension it creates carries and structures the total plan area. The lakes connected to the river follow the polder grid and anchor the river with the grid.



New Dutch Water City

The water system has a clear functional task: to counter water nuisance now and in the future. This functionality adds a dimension to the design by which the positioning of the lakes and river finds a logical place.

The third essay was about the polder as testing ground. This touches the third cultivation as defined by Wouter Reh and which is now in an impasse. The third cultivation is characterized by the design of both city and land in one integrated design. The Flevopolder is less half a century old and the land is therefore very new. The cultivation strokes this newly created land is now: 1. This makes the stratification of the landscape almost zero. When the landscape structure in Almere East is just simply filled in by urbanization, the cultivation stroke will still remain: 1.

‘High tide in the polder’ is developed dually: a technical water system design and an urbanization design. These two designs match spatially but derive from a different design view. This creates two layers realized subsequently on the existing cultivation layer. The cultivation strokes of Almere East will then be: 3. The proposed first layer shows similarities with the creation of a network, in this case a water network, in the history of the ‘trekvaarten’. These canals with regular transport service shaped the land between cities into a water network. The rationality of a network/system in the trekvaarten is the same as the rationality in the water nuisance system in Almere East.

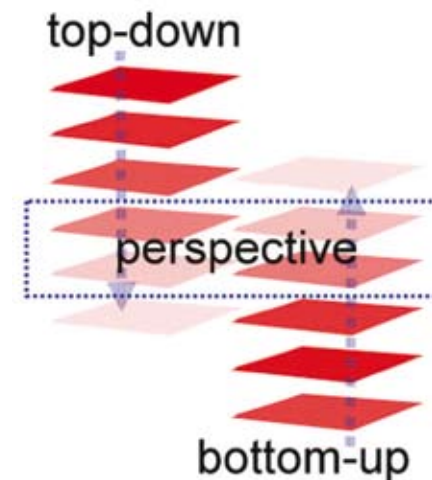


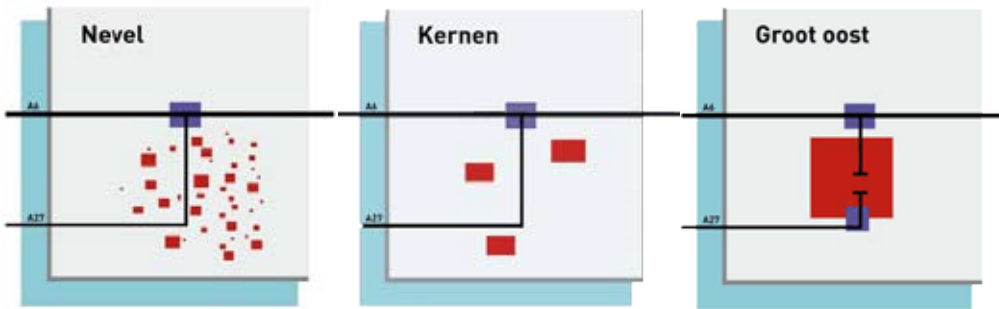
6.2. MUNICIPALITY PLANS

The Municipality of Almere has studied on the spatial possibilities of expansion to 400.000 inhabitants. This resulted in the report Almere 2030+, which presents three different scenario's for the city's growth. These three scenario's foresee various developments for Almere East. The plans can summarised to three planning principles: concentration, deconcentration and bundled deconcentration.

These principles are rather abstract, as they do not rely on an analyses of the potentials of the area itself. The programme is leading and organised by abstract planning models together with transportation considerations. This is an top-down way of planning based on higher scale considerations. It leaves the area itself with its characteristics aside.

'High tide in the polder' shows the possibilities of the area from the water management point of view. Soil and water analysis lie on the basis of this design. It shows the possibilities of the area, but is not only a finger exercise. Knowledge gained of the area, mainly about water and living with water, can itself be important criteria to base a scenario choice on. This so called bottom-up information can be decisive in scenario choice, but forms at least a valuable addition to the top-down considerations.

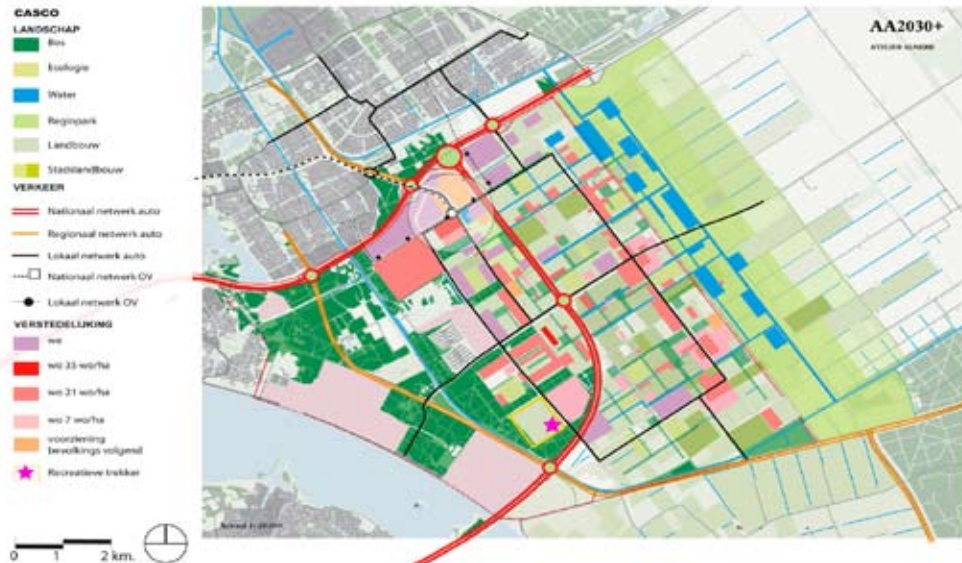




ALTERNATIEF A GROOT OOST + REGIOPARK



ALTERNATIEF B NEVEL EN LANDBOUW



ALTERNATIEF C OOSTELIJKE KERNEN + BOS



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VAN NEDERLAND

De Almere
Principles

VERANDEREN
T M U
R E D N A R E V



KAARTEN VAN HET ZUIDERZEEPROJE

Atlas van de
Nederlandse watersta

CHAPTER 7

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