TU Delft

October 6th, 2009

Adaptive strategies and the Rotterdam floodplain

Han Meyer, Willem Hermans, TU-Delft

Introduction

Driven by the increasing concern with the natural environment and by considerations on the effects of climate-change, 'working with nature' has become a new paradigm in the world of Dutch planning and design.
This paradigm is linked to the theory of the 'layer-approach', which was meant to understand the complex system of the urbanized delta and to develop sustainable spatial interventions in this system.
In practice, during the last 15 years a design-approach has been developed which emphasizes the layer of the natural system and sub-soil. However the results of this approach for the layers of infrastructures and urban patterns are not clear and subject of controversies.
This is especially clear when the possibilities for 'adaptive strategies' concerning building in floodplain areas are discussed and investigated. The question with 'adaptive strategies' is: should we take the existing flood-defense systems 'for granted', or is possible (and desirable) to take into consideration quite different options concerning the relation between 'behind the dikes' and 'outside the dikes' – with other words: should we reconsider the relation between floodplain-area and protected urban area?
The meaning of this question will be illustrated with a design-research in the Rotterdam-region.

Rotterdam - aerial view looking to the west, 2006

International comparison

Compared with other European deltas, the Dutch delta and especially the case of Rotterdam can be considered as a specific case.
This is especially clear when we study the importance of the dike-systems in relation to the flood-plain areas. The floodable area in the Dutch delta is much larger than in the other deltas (figures 1 – 5).

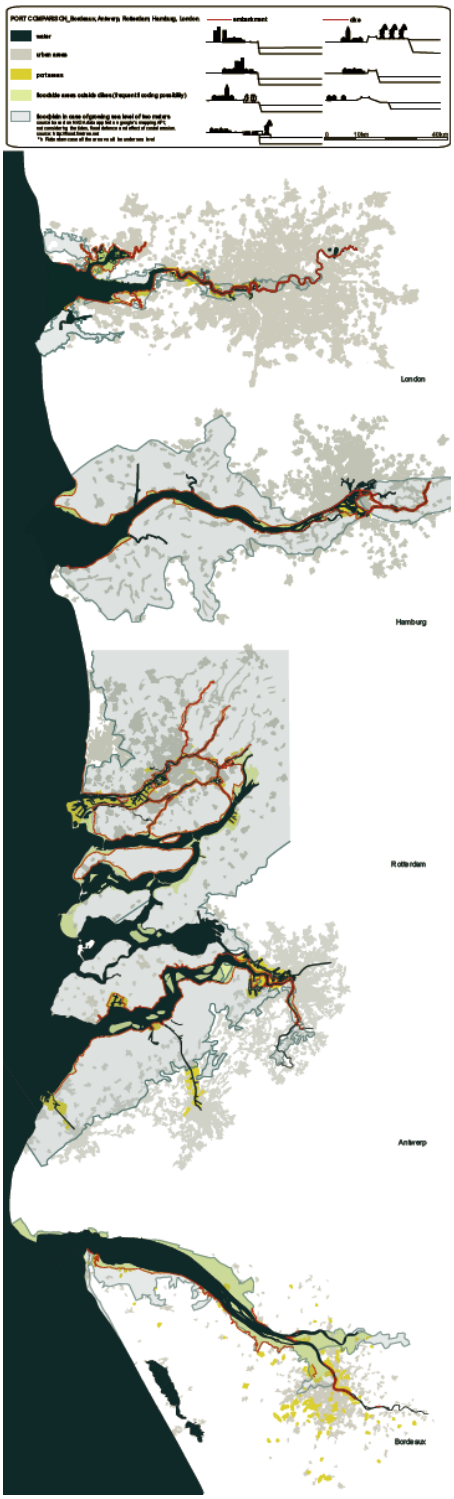

Figure 1: Five European urban deltas, indicating wetlands (green) and floodable area in case of lacking dikes (light grey)

When we look closer to the urban patterns in the concerned European deltas, a second specific characteristic of Rotterdam is shown: except of Hamburg, other delta-cities provide hardly any possibility for urban development outside of the protection-line of dikes or quays (red lines). The *amount* of potential urban area in the densily urbanized area is rather unique in Rotterdam.

Figure 2 Antwerp

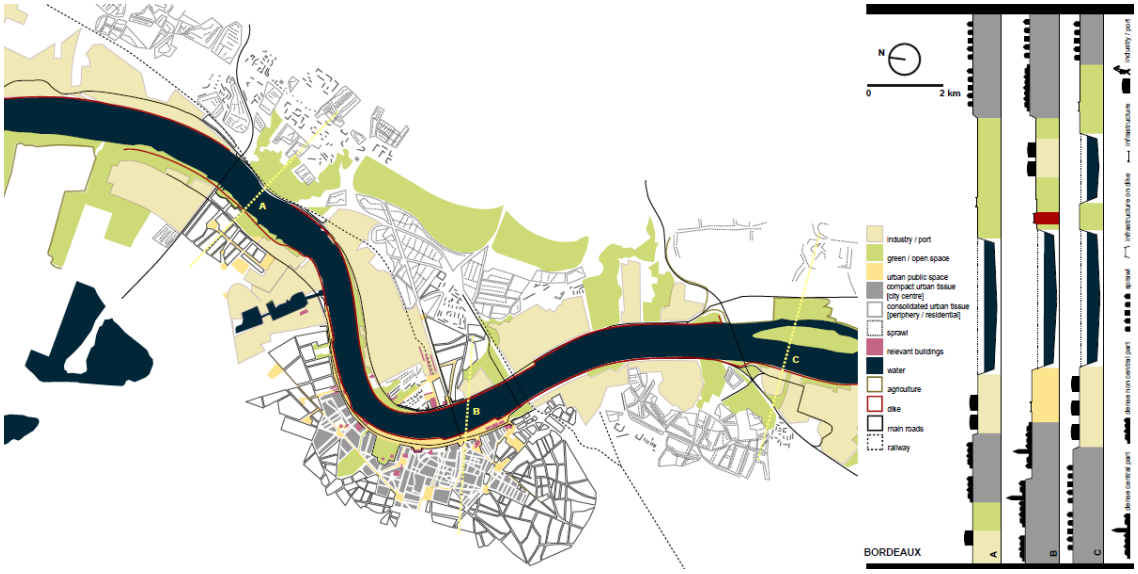

Figure 3 Bordeaux

Figure 4 Hamburg

Figure 5 London

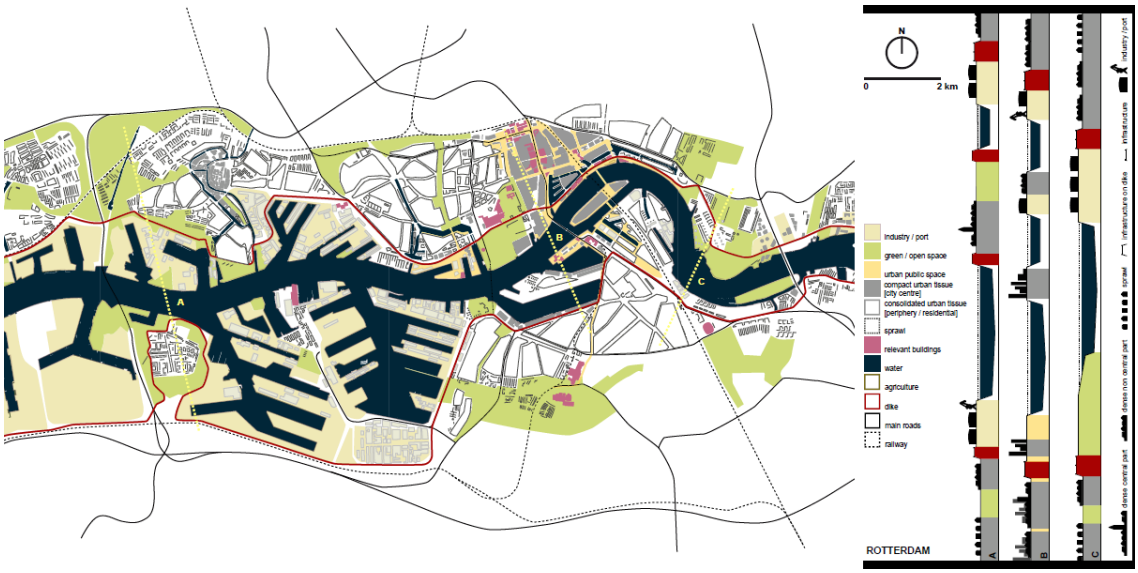

Figure 6 Rotterdam

The result of this specific position of Rotterdam as delta-city, is the absence of a substantial strategies concerning building in flood-plain areas in other delta-cities. The overview of figure 7 shows that the most interesting examples can be found in Hamburg, Rotterdam and some in Antwerp.

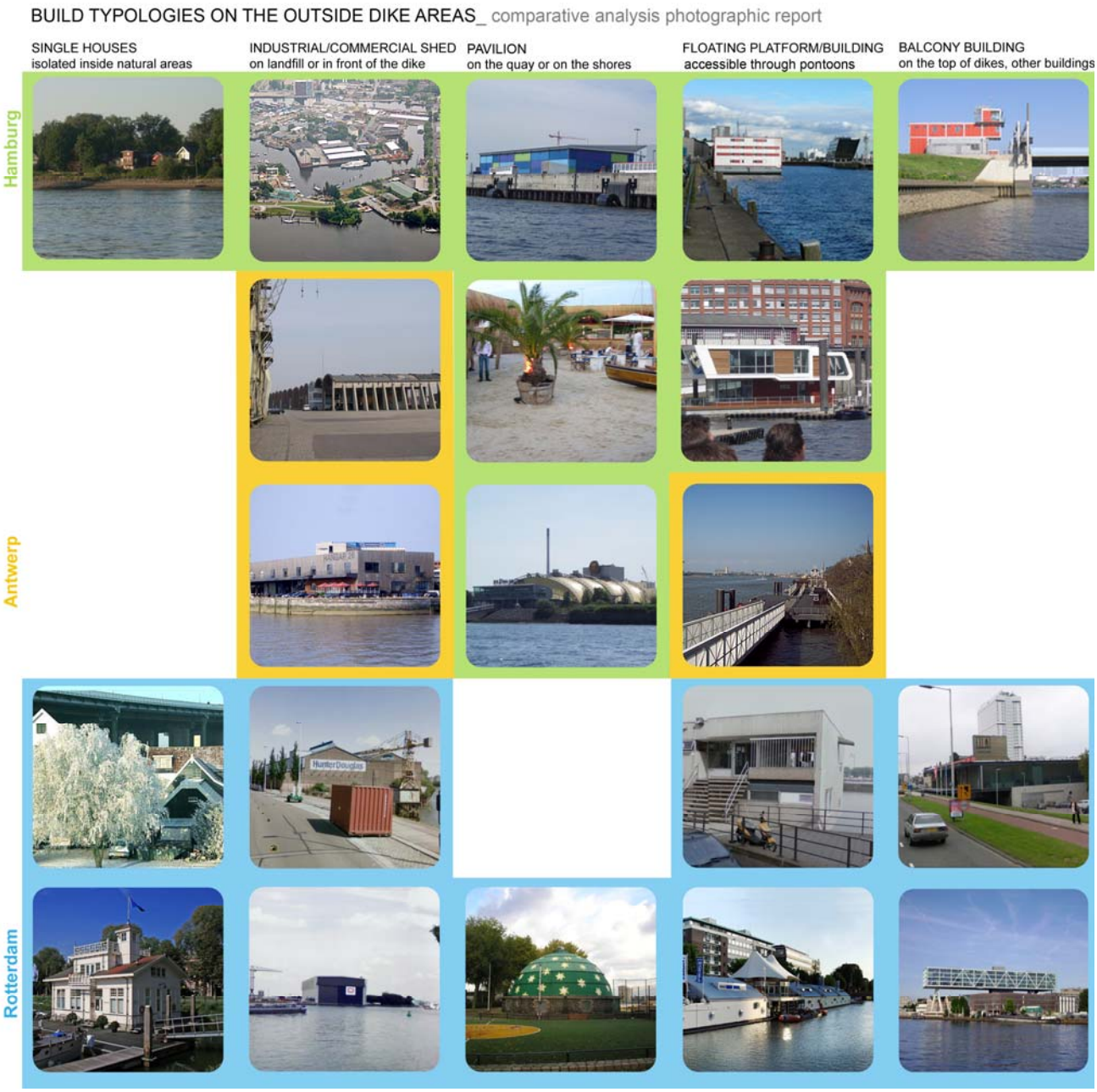

Figure 7 - building typology in floodplain areas

Figure 7 – continued -

Considering the specific position of Rotterdam as delta-city, it is clear that it is necessary to develop a specific approach. A first attempt for this approach will be described underneath.

Revisiting the layer-approach

An important innovation in design- and planning concepts and strategies in the Netherlands was the introduction of the 'layer-approach'. A pioneer-plan in this approach was the '*Plan Ooievaar'* ('Plan Stork') for the central river-area in the Netherlands. Plans of Rijkswaterstaat (National Water Agency) to heighten the river-dikes in the 1980s met serious resistance because of an increasing concern of the public with the cultural and natural values of the river-landscape. (Bervaes et al.)
In 1986 the Eo Wijers Foundation[1] organized a design-competition concerning a new lay-out for the river-areas in the Netherlands. '*Plan Ooievaar'* was the first price winning design, aiming a repair of retention-areas and wetlands along the riverbanks of the Rhine near Arnhem. The plan should result into a come-back of the ecological balance of the river area before the canalizing – symbolized by the return of the storks. It was the start for a series of 'de-polder'-projects in the river- and delta-area in the next decades, with the aim to create new wetlands which provide more space for river-water as well as a repair of environmental qualities.
The landscape-designer Sijmons, involved with the mentioned *Plan Ooievaar',* was one of the first who developed a new theoretical model for spatial planning and design: the 'framework-approach', which is a plea for the design of strong 'frameworks' in the urban landscape: A framework can be regarded as a system of natural and man-made structures like rivers, roads, forests, which can sustain for a long time and which can adapt several urban programs and natural developments. (Sijmons, Venema; Sijmons 2002).
An variation of the framework-approach is the 'two-networks theory' of Tjallingii, focusing on the networks of water and roads as the most important elements of the framework (Tjallingii).
In the course of time, these theories about framework and two networks have been elaborated to the so-called 'layer-approach', which regards the spatial environment as a composition of three layers:

(1) At the bottom ,the fundamental layer of the subsoil of the territory itself, with its natural characteristics of soil, water, etc.
(2) In the middle, the layer of infrastructural networks which create conditions for settlement, economic activities and mobility
(3) At the top, the layer of human occupation: urban patterns, economic activities, etc.

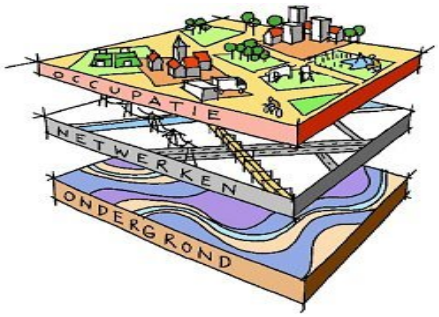

Figure 8 – The layer-approach, as presented in publications of the Ministry of VROM

In this model the two layers of subsoil and networks together can be regarded as a framework which should be sustainable for a long time and which creates the conditions for the development of the top-layer of urban settlements (Sijmons 2002).

[1] Eo Wijers was an important Dutch regional designer during the 1960's and 1970's. He was chief of the National Agency for Spatial Planning and professor Regional Design in Delft. After his death the foundation was formed in order to continue his intellectual legacy. The main-activity of the Eo Wijers Foundation is the organization of a biennial competition on an important regional design question. See de Jonge 2008.

During the last ten years, the model of layers functions as an explanation of previous planning-cultures as well as a plea for a new planning-culture. The post-war planning culture has been regarded as a top-down approach which started by formulating ambitions concerning the top-layer and then 'translated' these ambitions to the two other layers – finally with dramatic consequences for the natural environment.
The new planning-culture has been presented as an approach that flows in the opposite direction. This new 'bottom-up' approach starts by analysing and understanding the dynamics of the natural system of the landscape, and only then define infrastructural interventions – interventions which would take into account or even use the dynamics of the landscape. New conditions for land use and occupation would be defined in light of this new paradigm.
The approach seems to create the conditions for more attention to a sustainable natural environment, and in the same time to a more liberal urban development. For this reason, the model was considered as the ideal representation of the two governmental policies during the 1990's and start of the 21st century: it represented as well the 'working with nature' approach as the neo-liberal plea for abolishment of national spatial planning. The memorandum which represents pre-eminently this combination, the '*Nota Ruimte'* (2005) refers to the layer-approach explicitly.
However, in daily practice, the layer-model has functioned as an ideological framework for two different approaches in two different areas: the 'working with nature' was relatively effective in rural areas, with a relatively low pressure of urbanization. The most successful results of the working with nature approach can be seen in the river-area of the central and eastern parts of the Netherlands.
Next to it, in the densely urbanized region of the Randstad the new liberal urban developments dominated, without any 'framework' or layer-approach.
Both approaches could be elaborated without boring each other, in an atmosphere of 'peaceful coexistence'. However the big question for regional planning and design in the Netherlands is more and more the development of a comprehensive planning policy, where different planning-goals do more than just coexist next to each other. It has become clear that this territorial separation between both approaches can not be continued anymore. Both approaches meet each other in the Randstad-area, because of the adjusted ambitions of the government concerning spatial planning in the Randstad, and because of the increased insight that also (and especially) the Randstad-area should be involved in a series of measures to protect the country against the effects of climate-change.
Especially the Rotterdam-region can be considered as an important test-case to develop a comprehensive approach: this region is one of the most problematic and vulnerable urban regions of the Randstad, struggling with a one-sided economy and with high degrees of urban poverty and segregation; in the same time the region is a crucial bottleneck in the national water-management strategy, were the results of increasing peak-discharges of the rivers and sea-level rise meet each other.
The Rotterdam region can be considered as the case par excellence in the Netherlands which challenges to develop a comprehensive strategy, combining urban regeneration and climate-sustainability. The Delta-committee also emphasized the importance and difficulty of a fruitful strategy for the Rotterdam-region: in their map the Netherlands with proposed interventions and measures, they indicated the Rotterdam-region with a dotted line, indicating 'further investigation and elaboration is necessary'.

Rotterdam: a city on the edge

The spatial development of the city of Rotterdam has been determined strongly by its position at the edge of the south-west delta-area of the Netherlands: this position defines its economic position and social characteristics and its spatial structure.
To understand this position, it is necessary to say something about the physical characteristics of the Dutch delta. Until 1000 years ago, the Dutch lowlands were a large lagoon behind a long barrier of sandy dunes, beaches and islands. Behind this barrier the lagoon with the wetlands was transformed into a relatively dry area , composed by river-sediments (clay) and peat.
When people started to drain this delta-area in order to cultivate and urbanize it, the soil

started to subside and became vulnerable for storm-surges. Especially the river-mouths of Rhine, Scheldt, Meuse and IJssel were vulnerable spots in the protecting barrier-line. Several storm-surges during the 10th – 14th century created large inlets in the Northwest and in the Southwest, transforming the originally modest river-mouths into large estuaries: the Zuiderzee (South Sea) with the IJ-inlet, and the Southwest delta. Dike-construction became necessary to protect the maintained areas. During the 1300s and 1400s the first large dikes were constructed at the south side of the IJ and at the north-side of the Southwest delta. These two dikes, together with the barrier of dunes at the western edge, created a relatively safe enclosure of the central part of the county of Holland (van de Ven). This enclosure still plays an important role in the water-management and flood-control of Holland as 'dike-ring 14', as part of the system of dike-rings which is the fundament of water-management and flood-control in the Netherlands. Dike-ring 14 surrounds the area with the highest safety-standard and created the condition for a process of intensive urbanization (de Vries, van de Woude), resulting in what we call 'Randstad' today.
This dike-ring created an important condition for the development of the two largest port-cities: Amsterdam at the northern edge of this dike-ring area, with a direct access to the sea by the Y and Zuiderzee; at the southern edge of the area we find the city of Rotterdam, with a direct access to the sea by south-west delta. The location of both cities behind the dike created a safe condition for urbanization; the access to the sea by the IJ, Zuiderzee and South-west delta created the condition for a port-economy (Meyer).

Because of the different positions of Amsterdam and Rotterdam to the big rivers, two different solutions were developed. The port of Amsterdam suffered increasingly from the process of sedimentation by tidal currents of the Zuiderzee. The closure of Amsterdam from the Zuiderzee by a closure-dam at the eastside of the city, and the digging of a new canal to the North-sea, seemed to be the best option to stop the process of sedimentation and to create a new access to the port. The construction of the lock-system 'Oranjesluizen' and the North Sea Canal (also with a lock-system at the sea-side) in the 1880s resulted in a controlled water-level around Amsterdam (Ten Horn-van Nispen e.a.1994). Together with the construction of a second closure-dam at the north of the Zuiderzee in the 1930s, the part of Holland north of the IJ could be integrated in the same safety-system as Dike-ring 14.
The case of the south-side of Dike-ring 14 is quite different. Directly adjacent to this edge one can find the main-outlets of the rivers, resulting in the south-west delta.
The dike and the river were a sharp border between two different landscapes: North of it the area covered with peat and characterized by long lines (dikes, canals) as result of the earliest exploitation; south of it we find the real delta-area, with mainly clay-soils and characterized by an archipelago-like composition of islands, floodplains and estuaries (Palmboom).
While the importance of the river Nieuwe Maas with the Nieuwe Waterweg as main-channel to the sea was increased, Rotterdam started also to extend as well the port as the urban area on the south-banks of the river. During the 19th and 20th centuries the two parts of the city at both sides of the riverbanks developed in two different ways:
The north bank, with the historic city, maintained its role as city-centre, and developed some prosperous urban districts. The south bank is still part of the deltaic landscape and shows a more fragmented character; the former structure of the area as a conglomeration of small islands is still recognizable in the urban pattern of this part of the city (Palmboom). Next to the urban development, this riverbank itself became the main-territory of port-development of the 19th and 20th century. The first generations of the population of this part of the city found their jobs mainly in port-related industries (Bouman, Bouman).
The result is a city with a strong difference between both sides of the river: Rotterdam-Centre and Rotterdam-South. Both sides are different in the sense of spatial structures, economic activities, social and cultural structures. However a large part of Rotterdam-South has been developed as a 'tabula rasa' according to modernistic principles, denying any original character of the territory (Zweerink).
With the departure of port-industries from the river-banks during the 1980s and 1990s, Rotterdam-South became one of the most problematic urban areas of the Netherlands, characterized by high rates of unemployment, poverty, low degrees of education, racial tensions, etc. Since 2006, the area of Rotterdam-South is one of the main targets of a program

of the national government to improve social and economic conditions in problematic urban areas (van den Brink).
From the 1980s, the regeneration of the obsolete port-areas has been linked to the target to upgrade the conditions for Rotterdam-South, by improving housing-conditions and creating more spatial coherence between the two parts of the city at both river-banks (Meyer).
However, the recently increased attention to the effects of climate-change for water-management and flood-defence, and the increased attention to competitiveness and identity, have created new perspectives and chances for a new interweaving of targets concerning hydraulic engineering and targets concerning urban regeneration.

Research by design: working with the identity of a deltaic city

The linkage of targets in the field of water-management with targets in the field of urban regeneration have been discussed in the City of Rotterdam already for several years. In 2005 the city presented 'Rotterdam Water-city 2035', which was a first attempt to develop a comprehensive perspective related to both targets. (de Greef; Baan & Koekebakker) This plan is a first attempt to combine the need of a new water-infrastructure with a strategy to emphasize the specific identities of the several urban districts. Especially the strategy concerning Rotterdam-South is focused on exploiting the specific structure and history of the area, instead of on emphasizing large-scale infrastructural connections between the northern and the southern urban area.

This design-strategy has been developed further by a design-studio of the post-graduate Master-course EMU, supervised by prof. Han Meyer and ir. Willem Hermans.[2] The direct reason for this studio was the presentation of the Rotterdam-region as 'further investigation and elaboration is necessary' by the Delta-committee. Not only rainstorms produce increasing problems, but also the role of this region as the meeting-point of the problems of increasing peak-discharges of the rivers and a rising sea-level. The coincidence of a peak-discharge of the rivers with a storm surge on sea would have effects even worse then the flood of 1953, when a big part of the South-west of the Netherlands was flooded and almost 2000 people drowned. The policy of the decades after 1953 was focused on shortening the coastline by the delta-works: the construction of a system of dams in the estuaries.
But this policy has been regarded as not fruitful anymore and is substituted by the mentioned policy focusing on 'building with nature'. The big question therefore is: is it possible to design a system which offers a protection against flooding according to the 'building with nature' philosophy, and which in the same time also contributes to a more competitive and attractive urban environment of Rotterdam-South ? So is it possible to change the double vulnerability of Rotterdam-South (a social, cultural and economic vulnerability and a higher vulnerability for flooding than the north) into a double profit ?

The design-project started to focus on the development of flood-protection-systems in the Rotterdam-region, and the possible options for the future to improve the protection-level especially for Rotterdam-South.
One of the conditions for the future scenario's is the plea of the Delta-committee (2008) to repair the open discharge of the rivers to the sea – which means the dismantling of one or more of the dams of the delta-works.

Four alternatives were taken into consideration:

[2] EMU is the postgraduate European Masters in Urbanism, organized by a consortium of TU-Delft, KU-Leuven, UPC Barcelona and IUAV Venice. See http://www.emurbanism.eu

1. ***Degrading*** the role of the Nieuwe Maas and Nieuwe Waterweg as discharge channel, and directing most of the water of the rivers to the estuaries south of Rotterdam. The Nieuwe Waterweg can be closed with locks. More locks will be constructed in the rivers at the east side of Rotterdam. The dikes south of the Rotterdam-region, alongside the Haringvliet, will be heightened and strengthened, resulting in a higher safety-standard for the southern part of the Rotterdam-region. As a matter of fact, the Dike-ring 14 will be extended to the south. The result is that the water-level in the urban area can be controlled completely, like in the case of Amsterdam. This solution supposes that the most important port-activities will be concentrated in the reclaimed port-area *'Maasvlakte'* at the sea-side of the lock-system. The result is a uniform protection-level in the whole Rotterdam region, a completely controlled water-level and a decreased availability of accessible deep-water port-quays.

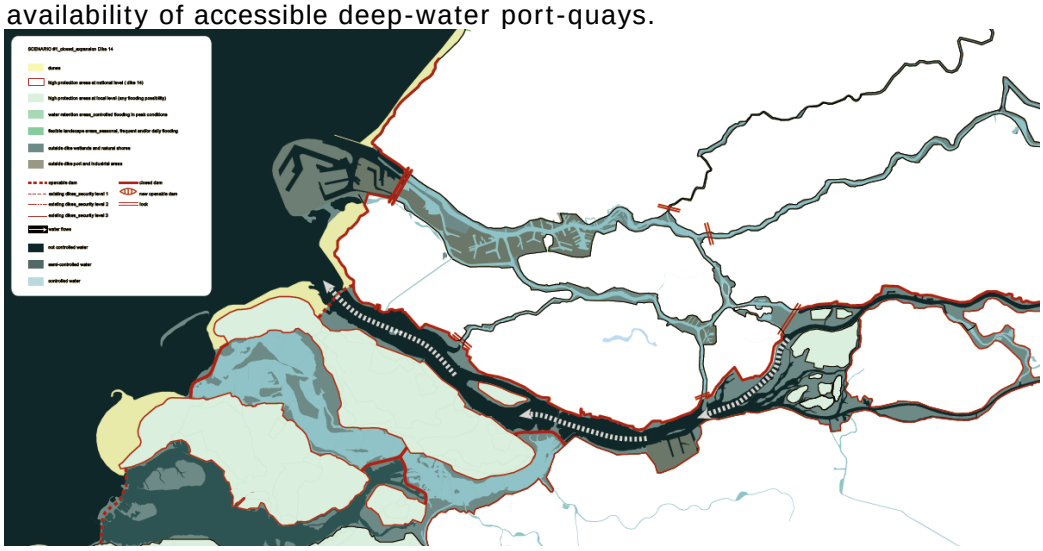

Figure 9 – Closing the Rotterdam-region with a system of locks

2. ***Maintaining*** the role of the Nieuwe Maas/Nieuwe Waterweg as part of the discharge-system of the river, and surrounding the region with a series of movable storm-surge barriers. Also in this case the dikes south of Rotterdam, alongside the Haringvliet, will be heightened and strengthened, resulting in a higher safety-standard for Rotterdam-South. Only in case of serious storm-surges the movable dams will be closed. Also in this case the complete region will be integrated in the protection-level of dike-ring 14. The difference with the first option is that in normal circumstances the influence of river-currents and tides in the urban area will be maintained, and port-activities can be continued in the existing port-areas.

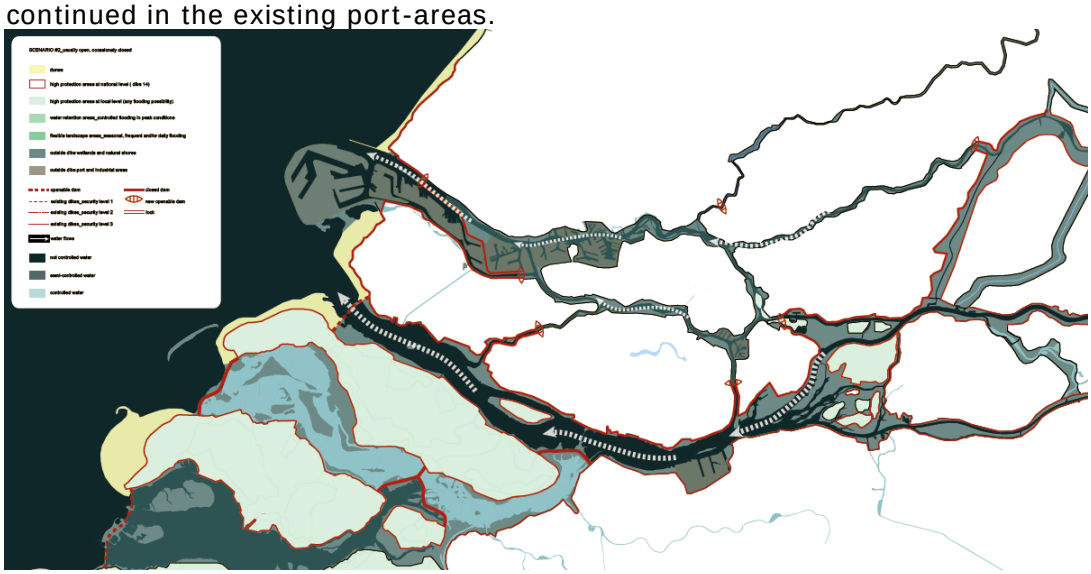

Figure 10 – The Rotterdam-region surrounded with a system of storm surge barriers

3. ***Maintaining*** the role of the Nieuwe Maas/Nieuwe Waterweg as part of the discharge-system of the river, and surrounding the south part of the Rotterdam-region with an improved dike-ring which delivers the same safety-standard as dike-ring 14. The influence of river-currents and tides in the urban area will be maintained, and port-activities can be continued in the existing port-areas. The difference with the second option is the strengthening of the dikes around the south part of the region instead of the construction of a series of movable barriers.

Figure 11 – heightening all existing dikes in the Rotterdam-region

4. ***Upgrading*** the role of the Nieuwe Maas/Nieuwe Waterweg as discharge channel, supported by an additional system of re-opened creeks and river-arms, which can be flooded in periods of extreme river-discharges. Storm-surge barriers in the sea-mouths will be maintained, to protect the inland against extreme surges from sea. The result is a landscape which will be influenced by rivers and sea in different ways. Tidal differences will be maintained. The re-opened old creeks and river-arms will be part of the green landscape most of the time, but in periods of extreme high river-discharges they will be flooded temporarily. The influence of river-currents and tides in the urban area south of the river Nieuwe Maas/Nieuwe Waterweg will be strengthened, and port-activities can be continued in the existing port-areas. Safety for residential areas should be ensured by strengthening the dikes around the former islands.

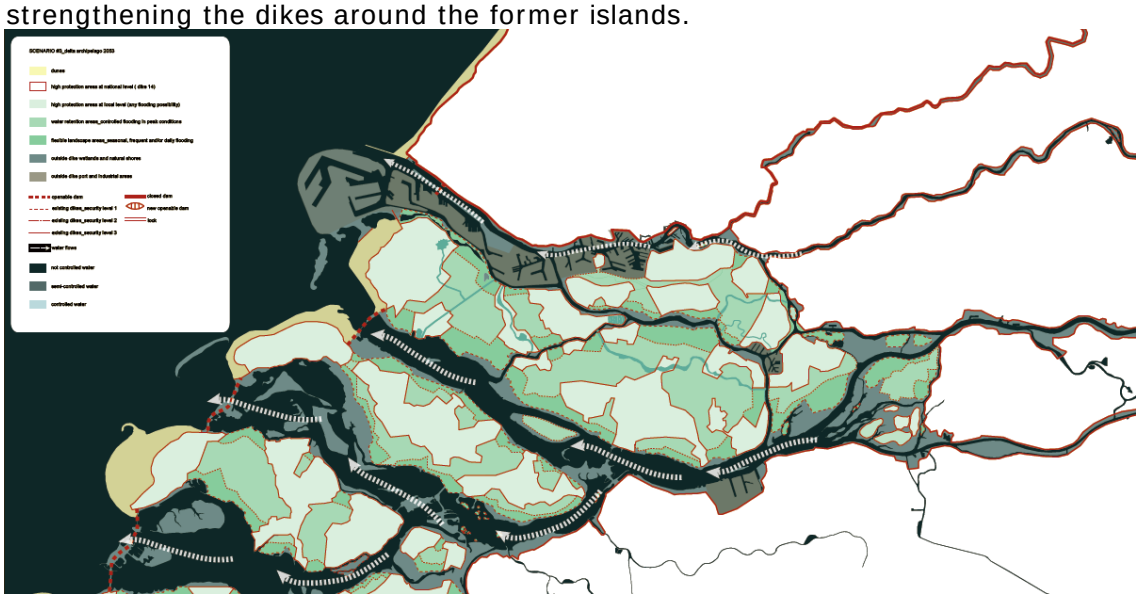

Figure 12 – making parts of the polder-area floodable

All these four variants show four different ways of manipulating the influence of river-discharges and sea-level rising by four different infrastructural systems. Continuing the model of the mentioned layer-approach, the variants emphasize the importance of a careful plan and design of the layer of infrastructural networks, as the fundamental 'framework' which provides the conditions for the two other layers:
For the layer of the sub-soil of the territory (including water-management, river-discharges, flood-control, soil-subsidence, ecosystems and biodiversity) and for the layer of human occupation (including urban environments, industrial economy and agriculture).
In the consideration concerning each alternative, of course the financial aspect will be crucial. However what is important is that this financial aspect should not only concern the investments in the layer of infrastructures, but also the long term benefits of the two other layers.

a network of urban wetlands

A consequent approach would take into regard all the effects and opportunities for the different layers of all variants, delivering arguments for a public and political debate about advantages and disadvantages of each alternative.
Because of limited time, the design-research focused on the alternative nr. 4. From a point of view of water-management this model seems to be attractive, especially concerning the increased capacity of the region to contribute to the temporary storage of river-water in periods of peak-discharges and storm-surges in the same time. It delivers also optimal conditions for stopping the process of soil-subsidence because of the introduction of a substantial water-network.

Figures 9 - 12 show the different scenarios concerning the regional strategies, while figure 13 shows the consequences of the different scenarios for the local conditions, explained with the section of the dike, the inside and outside the dike areas and the different river-conditions.

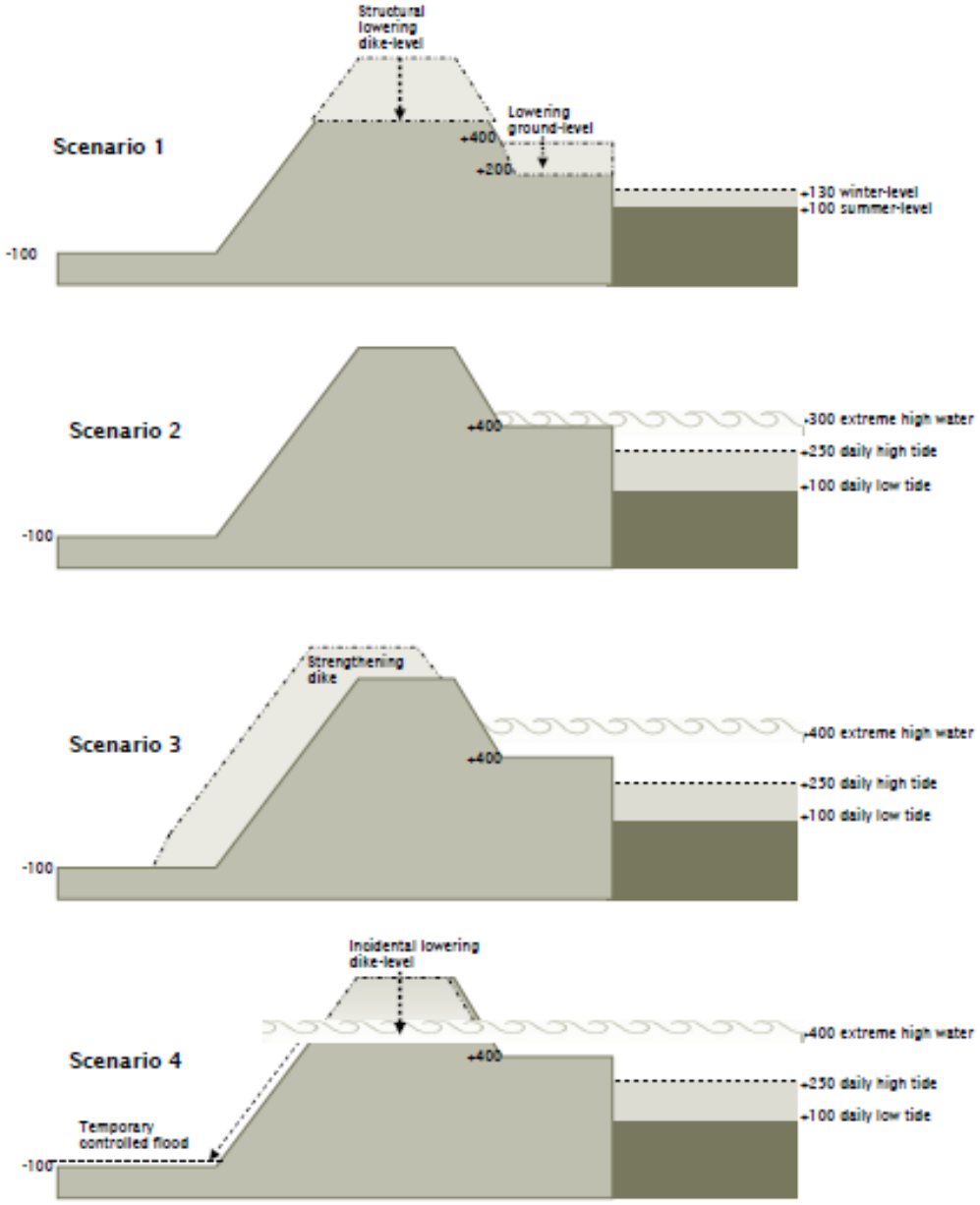

Figure 13 – dike-sections related to scenarios of regional flood-defence systems

Figures 14 shows differences concerning possible urban typologies related with the different scenarios.
All these four scenarios show four different ways of manipulating the influence of river-discharges and sea-level rising by four different regional strategies concerning the manipulation of river-discharges. Continuing the model of the mentioned layer-approach, the variants emphasize the importance of a careful plan and design of the layer of large scale infrastructural

a

b

c

d

Figure 14 – urban typologies related to regional flood-defence systems: living with a controlled water-level (a); living with a semi-controlled water-level (b); living with an uncontrolled water-level (c); living with a controlled flooding (d).

networks, as the fundamental 'framework' which provides the conditions for the two other layers:
For the layer of the sub-soil of the territory (including water-management, river-discharges, flood-control, soil-subsidence, ecosystems and biodiversity) and for the layer of human occupation (including urban environments, industrial economy and agriculture).
In the consideration concerning each alternative, of course the financial aspect will be crucial. However what is important is that this financial aspect should not only concern the investments in the layer of infrastructures, but also the long term benefits in the urban system as well as in the ecological conditions of the river-landscape.

From the point of view of urban development, the alternative nr. 4 seems to deliver the most challenging opportunities for creating conditions for a transformation of the urban area of Rotterdam-South into an attractive 'delta-city' with a special delta-identity. Instead of maintaining the existing urban structure, and adding some new water-elements, the urban area will be transformed essentially into a new type of attractive water-oriented city, which is quite different and contrasting with the urban environment at the northern border of the river.
While the northern border can be regarded as a 'balcony', with waterfronts providing a view on the delta-landscape, the southern border provides the conditions for living *in* the delta, in and next to the delta-wetlands, with a large variety of water-elements and of residential areas linked with the water in many different ways.
The design-project shows just some examples ('pilot-projects') of different residential areas in this urban wetland: new residential areas in the flood-plains of former docklands, and new urban areas next to the re-opened creeks and river-arms, with the possibility of controlled flooding (see figure 15).

Moreover, the system of flood-plains, creeks and river-arms which will play a role as an extended network of urban wetlands, creating substantial conditions for improving the eco-

system of the delta and extending the biodiversity.

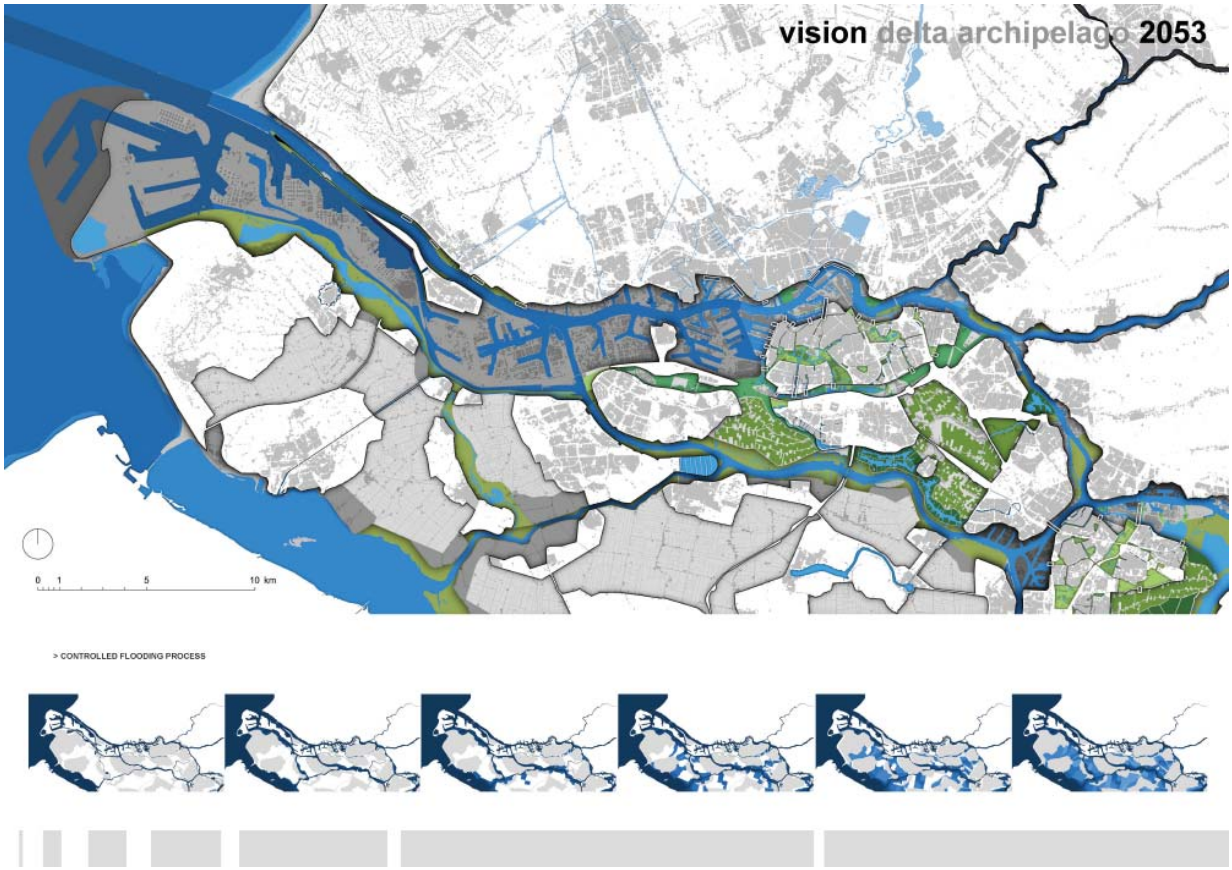

Figure 15 - regional design Rotterdam-region, with controlled flood-areas

The conditions for port-development in this alternative can be regarded as optimal. The present land-use in the port-area is dominated by oil-storage and petrochemical industries. Because of the future-expectations concerning energy-production, the port-economy will be forced to change radically. In alternative nr. 1 the future port of Rotterdam is supposed to be concentrated on the 'Maasvlakte' reclamations, focusing on container-transhipment. However, the port is developing also strategies for transhipment, storage and processing new energy-sources: bio-fuels, earth-warmth, wind- and solar energy, etc. Also these new economic activities will need space with adjacent deep-water channels. Because of this reason alternative nr. 1 can be considered as not realistic, while nr. 4 offers the best conditions.

Creating conditions by designing the layer of infrastructures

The current debate on dealing with the effects of climate change still has a rather technocratic and depoliticized character (Roth, Warner). The method of the scenarios creates the opportunity to involve hydraulic engineering strategies in a more comprehensive debate on the societal aims of the future of city and landscape. The different scenarios show that a specific choice for an hydraulic engineering solution creates specific conditions for urban planning & design, and vice versa.
The aim of the project is to show a *method* which creates the possibility of a new way of balancing different aspects of fundamental choices in water-management and spatial planning in the urbanized areas of the Netherlands.
In this method the focus has been put on a balanced plan and design of the layer of infrastructures of dikes, dams, sluices and water-elements. This layer is the real 'framework'

which delivers conditions as well for the layer of the subsoil of the territory, the soil-water balance, the ecological conditions, as for the layer of human occupation, with the urban environment and industrial areas.
The essence of the four scenarios is that they show four alternative frameworks, with four different conditions for natural processes (the bottom layer) as well for urbanization and economic processes (the top layer).
The next step should be an elaboration and careful consideration of the conditions which will be delivered by the several framework-layers for the two other layers.
These elaborations and considerations are only possible with a close collaboration of different disciplines: hydraulic engineering, geomorphology and hydrogeology, economy, bio-environmental sciences and urbanism.

Concluding remarks

The complexity of the effects of climate change and the increased concern with the environment in urbanized delta-areas like the Netherlands makes a comprehensive approach necessary, which combines the problems and challenges concerning safety against flooding with a strategy concerning economic and urban development, and environmental improvements of the delta-landscape.
This approach is not just a complete rejection of 'hard core' civil engineering. More important is a method of 'fine-tuning', which creates the possibility to attune specific hydraulic concepts to policies of urban development and ecological issues, as shown in table 1. The described method of the four scenarios is an example which shows the possibility of this fine-tuning: it shows that different regional hydraulic concepts have quite different consequences and opportunities for urban development and environmental qualities. These consequences and opportunities can be elaborated much more than is possible in the framework of this paper. It creates the possibility of balancing in a careful way the optimal solution for an urbanized delta-region like the Rotterdam region.
Such an approach means: (a) an interdisciplinary collaboration instead of sectored working of different disciplines next to each other; (b) working through the scales instead of a traditional 'top-down' approach: addressing constantly the consequences of a regional concept for local conditions, and vice versa.
This approach of interdisciplinary fine-tuning will also be relevant for other urbanized and urbanizing delta-areas.

	Regional hydraulic system	Local water-condition	Urban pattern	Water-edges	Urban cohesion	Port
Scenario 1	Closed system: All water-entrances provided with locks	Controlled water-level. Difference summer-level and winter-level ca. 30 cm.	Direct relation to water-edges	'soft' water-edges are possible. Small differences between water-level and ground-level	Possibility to lower the dikes, resulting in more cohesion between areas in- and outside the dikes	Port should be concentrated on new reclamations (Maasvlakte 1+2) in the sea
Scenario 2	Semi-closed system: All water-entrances provided with storm surge barriers	Maintenance of daily tidal variation from +1 m NAP to +2.5 m NAP. Maximum high water level +3 m NAP	Continuation of current patterns: sturdy urban blocks, flood-proof ground-floors	Quays with 2 meter distance to lower water-level or broad slopes	Maintenance of existing dikes as physical barriers	Maintenance of current situation
Scenario 3	Improving the current dikes	Maintenance of daily tidal variation from +1 m NAP to +2.5 m NAP. Maximum high water level +4 m NAP	Adaptive building typology: floating and/or raised buildings	Quays with 2 meter distance to lower water-level or broad slopes	Heightening and broadening existing dikes, decreased cohesion in- and outside the dikes	Maintenance of current situation
Scenario 4	Local lowering of dikes; controlled flood-areas inside the dikes	Maintenance of daily tidal variation from +1 m NAP to +2.5 m NAP. Maximum high water level +4 m NAP	Adaptive building typology: floating and/or raised buildings outside the dikes; flood-proof buildings in controlled flood-areas inside the dikes	Quays with 2 meter distance to lower water-level or broad slopes	Local lowerings of the dikes, resulting in more cohesion between areas in- and outside the dikes	Maintenance of current situation

Table 1

References

Baan C. de, Koekebakker O. eds. (2005) *The Flood. Catalogue 2nd International Architecture Biennale Rotterdam*, Rotterdam

Bervaes J. e.a. (1993), *Landschap als geheugen. Opstellen tegen de dijkverzwaring*, Amsterdam: Cadans

Bouman P.J., Bouman H.J. (1952) *De Groei van de grote Werkstad. Een studie over de bevolking van Rotterdam*, Assen: van Gorcum

Brink G. van den (2007), *Prachtwijken ? Mogelijkheden en beperkingen van Nederlandse probleemwijken,* Amsterdam: Bert Bakker

Delta-commissie (2008), *Samen werken met water. Bevindingen van de Deltacommissie 2008,* The Hague

Greef P. de, ed. (2005) *Rotterdam Water City 2035,* Rotterdam: Episode Publishers

Meyer H.(1999), *City and Port. Transformation of Port-Cities – London, Barcelona, New York, Rotterdam,* Utrecht: International Books

Ministeries VROM, LNV, V&W, EZ, (2005), *Nota Ruimte - Ruimte voor ontwikkeling,* The Hague

Palmboom F. (1987), *Rotterdam Verstedelijkt Landschap*, Rotterdam: 010 Publishers

Sijmons, D., Venema H. eds. (1998), = *Landscape*, Amsterdam: Architectura & Natura

Sijmons D. (2002), *Landkaartmos en andere beschouwingen over het landschap*, Rotterdam: 010 Publishers

Ten Horn-van Nispen M.L. (ed) (1994), *Wonderen der techniek. Nederlandse ingenieurs en hun kunstwerken. 200 jaar civiele techniek*, Zutphen: Walburg

Tjallingii S. (1996), *Ecological Conditions. Strategies and Structures in Environmental Planning*, Wageningen: Wageningen University Press

Ven G.P van de (2004*), Man-made lowlands. History of water management and land reclamation in the Netherlands,* Utrecht: Matrijs

Zweerink K. ed. (2005) *Van Pendrecht tot Ommoord. Geschiedenis en toekomst van de naoorlogse wijken in Rotterdam*, Bussum: Thoth