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Hooimeijer, F.L.

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Fransje Hooimeijer

Introduction

The famous saying 'God created the world, but the Dutch created Holland' is about the two provinces called North and South Holland that make up the Randstad. The Dutch have a rich and internationally renowned 'fine tradition' in dealing with the characteristics of their territory when it comes to the intense relationship between urban (landscape) development and civil engineering. Their expertise and knowledge of hydrological principles have helped them successfully to make land out of water through the ingenuous technology of polders. The dynamics of the regional water system, which include groundwater and rainwater in combination with surface water in a lowland delta facing the North Sea, is crucial for the process of development and urbanisation of the Dutch polders. Dutch cities, especially in the Randstad, are hydrological constructions with a spatial layout that is strongly connected to the division of land and water on regional and local scales through civil construction and building site preparation (Hooimeijer *et al.*, 2005). In the lower parts of the Netherlands, the relation between technical efficiency and the specific characteristics of the territory as well as the way cities and landscapes are designed and have evolved over time.

In the post-war era, the characteristics of the low-lying Dutch territory were altered with the use of far-stretched technology, and the landscape and cities designed with a high degree of rationality. The natural conditions of the territory were made subordinate to the thriving principle of a societal culture, in Dutch, the *maakbaarheids* principle ('makeability'). Technology seems to make everything possible, but is very inflexible to change. Climate change is currently putting pressure on the hydrological system. More severe and frequent rainstorms, a higher sea level, more water running down the rivers, high temperatures, and drought are very influential on the hydrological system, but technical parts of that system cannot adapt.

This chapter will examine the case of Rotterdam as one of the most representative cities in the Randstad in dealing with water and adapting to the current challenges. The city pays a lot of attention to water and to climate change. In 2009, it was the very first Dutch municipality to install a climate director as all pressures to the hydrological system mentioned above are present in the city. However, to be better equipped to handle the hydrological changes, a clear view is needed on the relation between the civil engineering and urban design and planning professions that are responsible for managing building on wet and soft soil and balancing the conditions of land and water. This investigation of the historical relation between urban design culture and the wet circumstances of the territory shows historical principles on which it is possible to draw a line into the future.

To structure the investigation, time is defined in separate phases (based on Van der Ham, 2002: 31 but altered for this perspective) characterised by the availability of technology, the attitude towards the natural system, and consequently, the urban design. The phases are natural water management (until 1000), defensive water management (1000–1500), anticipative water management (1500–1800), offensive water management (1800–1890), manipulative water management (1890–1990), and adaptive manipulative water management (1990 until today). For each phase a representative case in Rotterdam is chosen to show the relation between land and water and how this influenced urban development. The first three phases are discussed in the next section. The other phases are discussed in separate sections. The chapter rounds off with a brief conclusion.

Natural, defensive, and anticipative water management (until 1800)

Until the eighth century, the Dutch lowlands were uninhabitable marshlands where the forces of water and wind had free rein. People learned to adapt ways of living to the wet surroundings. Van der Ham described this period of time until the year 1000 as distinguished by 'natural water management', as nature ruled over culture (Van der Ham, 2002). There were initiatives to control the natural landscape by digging drainage ditches to grow crops in the fields, but for the people living in the lower Delta, there were no means of protection from the water. This was mainly due to the lack of a community, as people were living in small groups with little power to change natural conditions.

The Frisians were an exception. They were more organised in, for example, fighting Viking attacks, and altering nature for their benefit by creating mounds. The first form of building site preparation began in Friesland from 900 AD. Mounds were created that functioned as refuges in times of high tides, and the first buildings on them were churches, symbols of community where the whole village could find shelter in times of flooding. Later mounds became larger and settlements arose.

All settlements in the Netherlands started on higher ground, along rivers, the sandy ridges at the coast, and on sandy soil between dunes and later the hinterland (the so-called *geestgrond*). Settlements expanded in the eighth and ninth centuries for military and, later, economic reasons. Villages were created on economic routes and military boundary lines.

The physical characteristics of settlements during the time of natural water management have two important spatial characteristics. First, the settlement is positioned within the most geographically convenient physical circumstances in the region. Second, this location must be close to water, but water must not be part of the layout of the settlement, since that would make the settlement more vulnerable.

The change in attitude towards the natural system from natural water management to defensive water management occurred around the year 1000, when dikes were introduced as a means of protection (Van der Ham, 2002). This new technology directly affected the location and establishment of settlements. The dike on the one hand protected larger areas to live in and on the other, enabled water in the form of a harbour to be introduced into the settlement. Many dike and dam cities were created in the thirteenth and fourteenth centuries, and the sites along the dikes were prepared for building by raising them with debris.

The dam town

The conceptually most interesting type of water city of the defensive phase is the dam town, like Rotterdam because of its connection to the larger water management scale and the integration of technological intervention with economic and social structures. Figure 4.1 shows the development of Rotterdam, which started as a fishing settlement. The first map depicts the situation around the year 1000; the peat area along the Maas and the Rotte is still under free rein of the water. The first mentioning of the settlement 'Rotta' is in 1028, but centuries before that, there were people living on the banks of the peat river Rotte, where it flows into the river Maas. In the second half of the eleventh century, the first dike ring was built. However, it did not offer enough protection, and the settlement Rotta was lost. Studies of the Rotte and its first settlement proved that in the first half of the twelfth century, people had already started to use piles and mats of woven ash wood to prepare sites for building (Guiran, 2004).

By about 1270, the third dike ring – the *Schielands Hoge Zeedijk* ('High Sea Dike') – was built, and a dam was constructed where the dike crossed the Rotte (Van der Schoor, 1999: 21). Dam cities were established in the most rewarding places where smaller rivers flowed into a larger river. A dike at these points was the most important requirement for the creation of towns in the polders because soil compaction and subsidence resulting from the drainage of peat for agriculture made these areas vulnerable to flooding. The dam had a water-defence function, but with a drainage sluice, it also took care of discharging water from the smaller river originating in the peat area onto open water. A combination of the scouring effect of the sluice water and the tidal

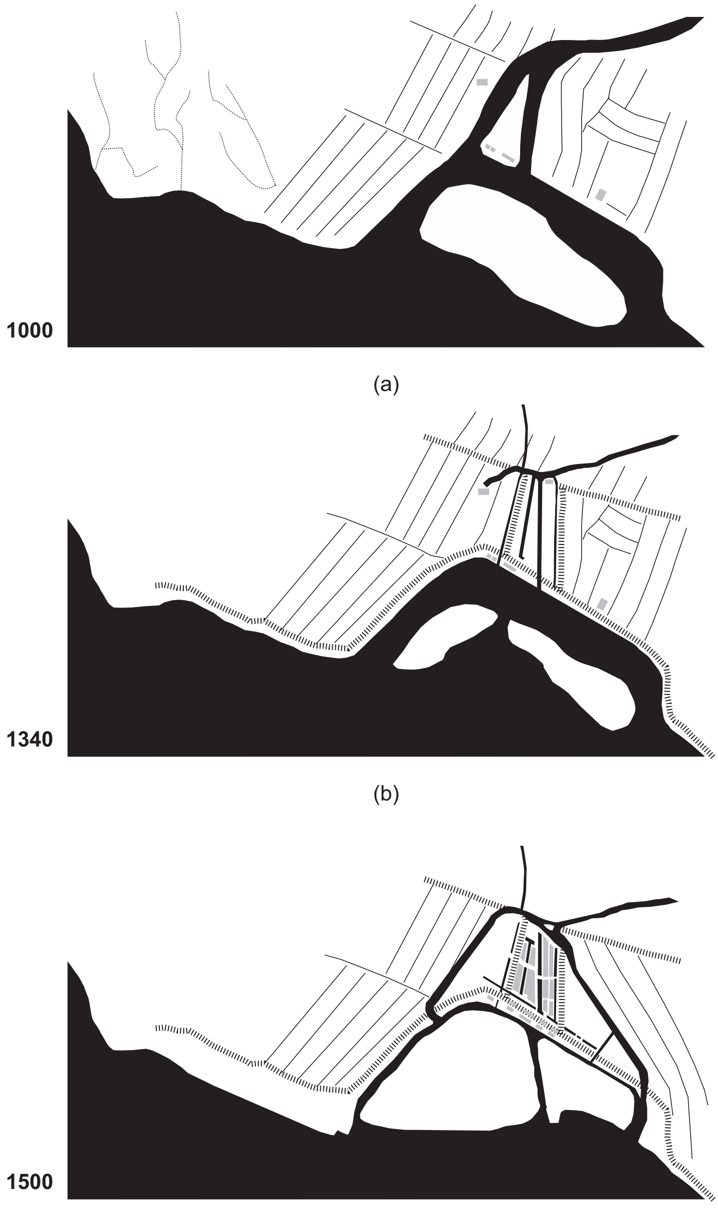

Figure 4.1 The development of Rotterdam: 1000 (a), 1340 (b), and 1500 (c).
Source: Hooimeijer *et al.*, 2005.

movement was cleverly used to maintain the harbour at the correct depth and to make the town accessible to seagoing ships.

The economic importance of regional water transport between the sea and the hinterland was embodied in the dam with its drainage sluice. The dam and the sluice became the heart of the town. The drainage sluice was only able to accommodate relatively small ships, and the cargo from larger ships had to be transferred or traded on the dam. The dam became a market, and the peat river estuary outside the dike became a sheltered harbour. The dam town and the polder were therefore bound closely together, not only in hydrological terms but also in economic and social terms, and in connecting the regional and the urban scale (Van der Schoor, 1999: 21). For the cities in the Randstad this was obviously a very prosperous situation as the wider region came together in these places. The larger scale that these dikes introduced in organising the landscape also had a great effect on the northern provinces like Friesland: the mounds came out of use and were no longer the key to strategic settlements.

Polder city and 'Waterstad'

Windmills came into use on a larger scale around 1500, marking the technological transformation to the next phase, anticipating water management. This phase is characterised by a better understanding of the nature of water systems and by people working with this knowledge. With windmills, larger volumes of water could be moved, so a more effective method was offered to keep large-scale areas and towns dry. The power created by uniting the mills with new hydrological instruments, such as sluices and dams, changed the approach towards the water from defensive to anticipative. The establishment of the Republic of Seven United Provinces accelerated knowledge development by establishing the army: the institution where knowledge about wet and soft soils was developed. The power of political unity represents an enlargement of society, a new relation between regions and cities as water systems were organised on a larger scale than before. The protection of a single plot grew into the protection of a polder, and the protection of a polder grew into the control of whole rivers. The phase of anticipating water management is the phase of the *polder city*, where the polder is not only a physical phenomenon but also the literal representation of the social phenomenon: the power of political unity.

The settlements of the two first phases, mound, river, coast, military stronghold (*burcht*), *geestgrond*, dike, and dam towns, form the first important characteristic of the polder city: the higher-level 'dry core' on which the settlement started. Prosperity and growth led to expansion of built-up areas on the surrounding wet soil, derived from peat or already prepared for cultivation, but not yet prepared to be built upon (Burke, 1956).

Of the various dry cores on which the peat polder cities were developed, the dam town is the most meaningful. One could say that dike residents, who lived alongside a peat bog and controlled the water by building a dam together, were conceptually ahead of the peat polder city dwellers. This is where a second important characteristic can be seen: the need for 'strict control', as the expansion of the polder city needed to be realised cautiously. First, the size of the expansion needed to be determined; this needed to comply not only with the requirements of that time but also with those for the time to come as the necessary works were vast and costly. Second, a technical plan was needed to ensure that water could be discharged and controlled and that city canals could maintain a constant water level. In most cases, expansion was initiated by building an encircling outer canal which was connected through the outer area by means of a sequence of parallel canals. The outer canal was primarily built for drainage but also had a military or defensive function as well as a transport function with access to warehouses (Burke, 1956). The water level of the canal system was regulated, and excess water was discharged by means of sluices and windmills which were often located on top of city walls, as in Amsterdam and Delft. Then, the reclaimed land needed to be raised to the required protection level, and was consolidated, and prepared for building. Mud excavated from the canals was used for raising the land level and was supplemented by fill, which often needed to be transported from far away. In the ground, long wooden foundation piles were driven in order to stabilise buildings in the deep-set stratum of sand.

Since the mid-thirteenth century, a dike had stretched out along the Hoogstraat ('High Street') in Rotterdam, with a dam in the Rotte providing the settlement with its name. Before the invention of the windmill, only direct discharge into the river could keep the water in the polders at the most convenient level for growing crops. The discharge rivers all flow through the settlement in the same north–south direction, steering the way the city developed. Also, roads were laid out at right angles to the river (Van Ravesteyn, 1928: 114).

When the settlement was granted town privileges in 1340, its burghers needed a ring of protecting water. Two moats, Coolvest to the west and Goudsevest to the east, gave the settlement its characteristic triangular shape; see Figure 4.1a (Van Ravesteyn, 1928: 134). However, polder expansion turned out to be less attractive than the waterside, where business was centred along the Maas. So, instead of building into subsiding polders like Amsterdam did, the people of Rotterdam decided to expand the city into the river Maas. Already, in the thirteenth century, people had started to use the salting outside the dike for harbour activities (Van Ravesteyn, 1928: 105). The new quarter was appropriately named *Waterstad* ('Water City'). It was a bustling centre of shipyards, warehouses, sail-making, and rope-making and later grand merchants' houses.

The layout of the new part of the city was very simple, and before the sixteenth and seventeenth centuries, there was actually no plan. The houses grew together following the shape of the river and the harbours. Parts were inside the dike and parts outside, making dikes important urban elements of the layout (Van Ravesteyn, 1929: 22).

The simple layout is directly related to the costs for building site preparation: the wider the house, the more expensive the foundation. The importance of the harbour is represented by its size. It was made very spacious, which was useful when the ships grew larger into the nineteenth century. The result was a spacious Waterstad that had a high quality of special environment and moreover clean water in the canals, especially compared to the dense inner city north of the Hoogstraat. It was taken for granted that the Waterstad, located outside the dike, was vulnerable to flooding from the Maas. Meanwhile, space and clean water became more progressively more problematic in the inner city and especially when industrialisation took force (Van Ravesteyn, 1929; Van der Schoor, 1999; Schadee, 2000).

By creating the Waterstad area, Rotterdam took profit from its strategic position in the Randstad Delta. It introduced the possibility for Rotterdam to develop a flourishing port economy and trade economy, competing with established port cities like Antwerp and Amsterdam.

Offensive water management (1800–1890)

The contour and layout of all the principal water city types that were prior expansions of the polder city were preserved far into the nineteenth century. After the Golden Century of the seventeenth century, when most of these expansions were built, the Republic suffered from political decay and economic stagnation and later the French invasion. The deterioration of conditions ended in 1814 when the monarchy was instated, but only after 1850 did city development restart. A new phase of offensive water management began, made possible by the power of the steam engine. Industrialisation turned Dutch cities into places where people were concentrated around jobs in the factories and the ever-growing harbours. The social and functional change of cities in this era, where people from the countryside were suddenly packed together in dense neighbourhoods, cannot be underestimated. The new steam power started a scale enlargement and acceleration of the growth of cities as well as massive interventions in the water system. Water could be moved in a controlled way with much greater power. Almost everything became possible, from the building of water channels, the closing of sea arms, and the artificial lowering or raising of groundwater levels.

The Waterproject

The first large-scale city development in the Netherlands was the expansion of Rotterdam with the plan called *Waterproject*, designed by military engineer and city architect W.N. Rose (1801–1877) (see Figure 4.2). The urban expansion was interwoven with the aim for better water management in the city. Many people had died from cholera because the water in the inner city was contaminated. In the dense city, the river, the canals and the groundwater

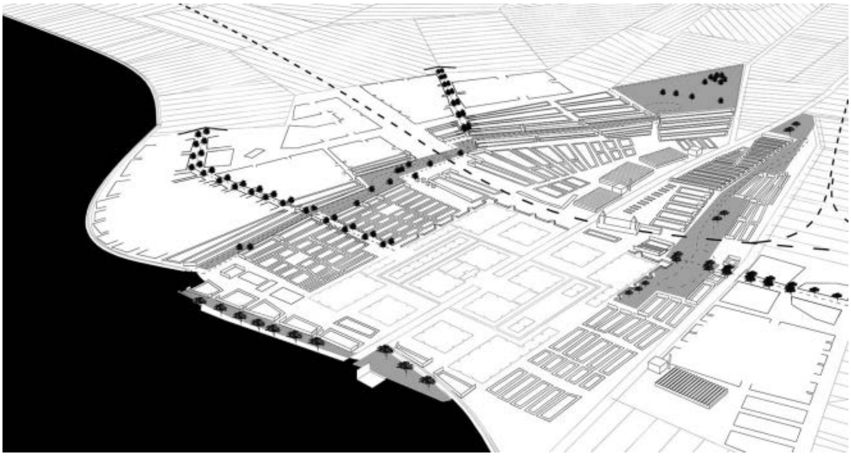

Figure 4.2 Principle drawing of the Waterproject.
Source: Hooimeijer *et al.*, 2005.

were used for everything, producing highly unpleasant smells and an unhealthy living environment.

Rose's answer to this problem was the design of a city water system entirely independent from the regional water system, where water management served the interests of agriculture. Rose, together with landscape architects J.D. and L.P. Zocher, designed the *Waterproject* as an ingenious plan, combining the preparation of the surrounding wet and soft polders together with a new water management system into an integrated urban design.

The first aim was to flush water through the entire inner city to improve water quality. The second aim was the desperately needed expansion. Rotterdam was digging harbour after harbour, and many people were attracted to the jobs this brought. Only the lowering of the groundwater level in the polders made it possible to build new houses there.

Rose asked the Zochers to draw the plan with a park for walking for the poor and living quarters for the rich, which also made the project profitable in improving urban quality. The plan combined the most important urban tasks of that time, while integrating the characteristics of the territory with the technology available within an urban design. The location of the dike that was necessary to build an independent water system and the new polder areas, was carefully situated from one existing dike to another. Along the dike, a waterway was dug that collected all the water from the new expansion that flowed from the higher inner dam city through ditches and culverts. There was an intensive investigation done into the surface levels to accommodate the water flow (see Figure 4.3). Where the waterways reached the Maas, the new power of two steam engines pumped water that was let into the inner city into the river (see Berens, 2001; Hooimeijer and Kamphuis, 2001).

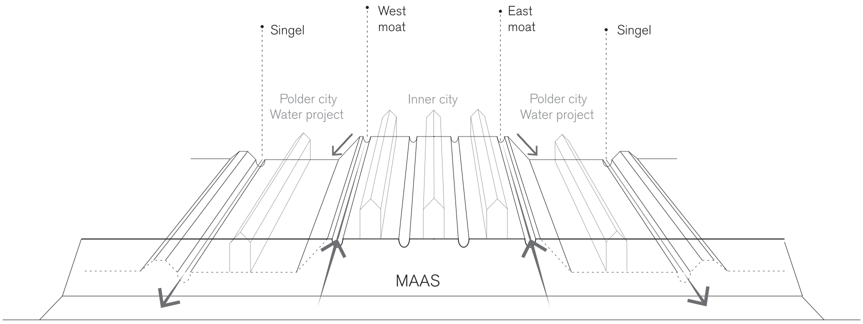

Figure 4.3 The various heights in the Waterproject.
Source: Own illustration based on Van den Noort, 1990.

The Waterproject represents the available technology and the grand issues of urban planning during the era of offensive water management. It also shows how cities were developed during this period. Main infrastructures were built by the municipality while the areas in between were filled in by private developers. Here, the building blocks were situated in line with the original polder pattern. This century-old structure represents the integrated culture of the water system, the division of land and water, and the pattern of ownership. In these areas, the municipality built sand strips under the planned roads, and developers the roads, and afterwards, the municipality took over the maintenance. Houses were built on piles above the ground floor, and because the backyards were not raised, the space in the basement could be used for living, usually as a bedroom. This way of preparing an area for building influenced the design and use of the city on all scales.

Manipulative water management (1890–1990)

At the end of the nineteenth century, explosive urbanisation and technological prosperity put pressure on the polder cities. The manipulative era (1890–1990) is marked by the introduction of the engine and electricity, which had an immense influence on the city and the water system. The car, industry, and industrialised building processes and technology created a new spatial order. This resulted in a situation when technically everything was possible and there was no connection to the 'natural' laws of the water system. The building of sanitation and drinking water infrastructures brought segregation between the systems for groundwater-level control, the discharge of waste water, and the supply of drinking water. The larger part of the urban water system disappeared underground. At the same time, industrialisation brought the car, claiming more and more space. Many open waters, bad smelling or dangerous due to bad street-lighting, were filled in, leading to a reduction of the ratio of open water in the city (De Vries, 1996). Even though the water structure of the polder city remained important for drainage, discharge, and storage, it was no longer used as an element in the urban design of the city.

Blijdorp

At the beginning of the twentieth century, two main forces changed urban development practice in the Randstad and Rotterdam immensely. First was the adaptation to regional infrastructure in dealing with train tracks and later provincial car infrastructure. Second was the 1901 Housing Act that made it mandatory for a municipality larger than 20,000 inhabitants to make expansion plans. This law gave a boost to the new profession of urban design while previously engineers and architects had built cities. Considering the new way neighbourhoods were built, by private entrepreneurs, it was very hard for the municipality to create a plan and make all the developers abide by it. The first expansion plan for Rotterdam (1906), Blijdorp, was more a combination of plans of private developers than an independent urban design. Eleven years after this and many more plans (and a lot of misery trying to get landowners and property developers on the same page), the municipality decided to buy all the land and develop the area themselves. The possibility to prepare the whole site at once with the new technology of hydraulically filling the land with sand from the harbours was an added advantage of this decision. The largest advantage of this technology was by the fact that there was no need to agree on an urban plan *before* applying the layer of sand because any plan could be realised on it. Here the urban design and realisation was disconnected from the polder pattern, the historical pattern of land and water and land ownership. Building site preparation and the technology of balancing out land and water became disconnected from urban design (Gemeentewerken Rotterdam, 1984: 14).

Blijdorp was the first large-scale hydraulic filling project in Rotterdam. The south side of the Schie was done in 1924. During the filling of the north side, water was used to keep the sand in place. The disconnection of building site preparation from the urban design meant that the characteristics of the territory played no role in the design. This is clearly the case for Blijdorp and also for the famous Plan South for Amsterdam by H.P. Berlage that looks just the same (Heeling *et al.*, 2002). Car infrastructure is the backbone in both plans, and the water and green structure is like a 'shadow'. Technology at this time was not perfected yet and the water system was still a part of the urban plan. Industrialisation brought the larger scale into urban development and a new organisation of city development in which the issue of how to deal with water management faded into the background, and issues related to car traffic, road, and rail infrastructure related to the wider Randstad development moved to the foreground.

Lage Land and Ommoord

The enlargement of urban scale and the disconnection of urban design from the characteristics of the land dominated in the post-war era. Water as an urban element is almost completely insignificant when situated on the top of the layer of sand. Indeed, the water system becomes completely artificial. This fulfilled the *makeability* principle, a paradigm of belief in a manmade culture that relies on technology and systematic approaches. This was applied to all aspects of society: social cohesion, social facilities, and control of the city as well as the water system (Cornelis, 2000). During this phase, the spatial order of the Netherlands was fundamentally changed. The large projects of urban expansions, recreation, infrastructure, and land consolidation in agricultural areas led to a completely different landscape.

In his inaugural speech on 12 November 1975, titled *Spel met water, grond en land* ('Game with water, soil, and land'), W.A. Segeren, Extraordinary Professor in Water Construction and Polders in Delft, recognised a direct relation between the location of the settlement, the way of life, and the surroundings. After the Second World War, the process of city expansions was to decide on location, the soil and the water system were investigated, and then the civil and technical interventions were determined to improve the soil conditions. Weak soils were strengthened with sand, calculations for foundation piles were made, and measures were taken for the discharge and drainage of the built area (Segeren, 1975). The hydraulic filling with sand meant that urban designs could be uniform on any soil condition. There was no incentive to react to specific conditions with the urban design because all conditions became the same. Industrial building influenced the standardisation of urban design and planning through the uniform production of apartment buildings and houses, denying any local characteristics to the urban expansions (Segeren, 1975).

In Rotterdam, expansions were made on the south bank and east of the city in the drained lake Alexanderpolder. Lotte Stam-Beese, senior architect and urbanist at the Rotterdam municipality, and Jaap Bakema, independent architect and urban designer, made visionary plans for Alexanderpolder, called the *Lage Land* (the 'Low Land'), and presented these at the *Congrès Internationaux d'Architecture Moderne – CIAM* (International Congresses of Modern Architecture) in Aix-en-Provence in 1953. They chose this site in collaboration with the director of the city development office, Cornelis van Traa, because a great task was set to design a sub-city in these low-lying polders for the ever-growing number of residents of Rotterdam. The city could not expand north while the city centre was moving to the west, so city planners considered an eastern expansion, even in deep, wet polders, as the best counterbalance. The plans were extraordinary because they combine a radical way of building preparation, building on piles, and lowering of the water table, with an internationally inspired vision on urban development.

Bakema's concept of the 'visual unit', a vertical city built-up of high-rise towers, was connected to the 'district idea', where residential neighbourhoods merge harmoniously into a concentric and hierarchical whole. It was a construction on the flat surface of the city map. The 'visual units' made this a three-dimensional composition by introducing a sort of vast elementary sculpture in which architecture and urban design converged. In the plan for Alexanderpolder, these visual units were directly linked to the larger scale of the highway and functioned as autonomous urban units. The geographical circumstances of the deep-lying polder and the poor soil condition were the reason that Stam-Beese and Bakema introduced the idea of vertical neighbourhoods (Schilt, 1982). By founding the highway and these 'Mammoths', as Bakema called them, on piles, the city was disconnected technically from its landscape, which could be used for agriculture and recreation. These mammoths of vertical neighbourhoods were, according to Bakema, the best solution in dealing with the bad soil conditions in the Lage Land. People with an open state of mind and lifestyle could live in this city on piles with a view of the open agricultural landscape (Palmboom, 1993). Eventually, when Stam-Beese designed the executed plan for *Lage Land*, only a very small part of the Mammoth concept remained in the shape of four large flats that are positioned in the form of a mill wing.

The executed design of *Lage Land* is interesting in two ways. For building site preparation, the choice was made to lower the water table, at a time when the usual practice was the raising of land with sand, and the dimensions of the urban design were very much related to the dimensions of the original polder pattern. Stam-Beese was assigned to design a city that was endless; the polders in the Netherlands, due to the orthogonal structure and quantity, have that characteristic.

After working on the Lage Land, urban designer Stam-Beese also made the design for Ommoord positioned in the same drained lake. She recognised the fact that the technical approach towards the poor soil conditions with layers of sand led to urban designs that do not connect to the *genius loci* (Stam-Beese, n.d.). Stam-Beese tried to establish in Ommoord an urban identity that connects people by the use of a green heart with facilities surrounded by flats that had a view to the surrounding landscape. These parks were made with an irregular surface to make them appear more natural. This and the view were intended to compensate for the lack of private outdoor space (Damen and Devolder, 1993).

This manipulative era urban type, as lucidly described by Stam-Beese, thrives on the perfection of technology and disconnecting settlements from the identity of the landscape. The water problem can be addressed technically and was completely disconnected from the urban plan. This did not add up to the desired urban quality, and this era can be used to make a critical stand against using technology to alter the physical geography of a site.

Zevenkamp

By the 1970s the post-war era was criticised as a time of technocracy and narrow-minded views on social structures. There was a strong urge to free society from these conventions and to search for the 'real identity' of the city. A respect for nature became a theme in reaction to technocracy and manmade culture. The publication by Rachel Carson, 'Silent Spring' (1962), revealed mankind's bad influence on nature. Also, the 1972 report by the Club of Rome, 'Limits to Growth' (Meadows *et al.*, 1972) and the oil crisis in 1973 put the causal relation between economic growth and the effects on the environment in a clear perspective (Meadows *et al.*, 1972). Therefore, in the 1970s nature and ecology became more important in spatial planning, and the landscape architect arrived as a new player. The landscape architect reintroduces water as a spatial element in the city. At the same time, the search for urban identity rediscovered the old water towns which inspired all sorts of plans to bring back the hidden water landscapes.

Zevenkamp is an example development that although it was developed through hydraulic filling of sand, the urban design took an original landscape element, a ditch called the *Ommoordse Tocht*, as the backbone of the plan. The ditch was excavated out of the layer of sand as the central axes of the plan where the most important public space was situated. The new waterway was designed to give identity to the function of the surroundings it flows through. In the centre, it is a canal with brick quays giving the area the identity of a dam city representing the social and economic heart of the expansion. This way, even though the original hydrological system is hidden under a layer of sand, the urban design made a connection to the original landscape and made use of the century-old identity of Dutch towns. It was the first step towards adaptive manipulative water management and new urban types.

Adaptive manipulative water management (1990 to the present)

While adaptive and manipulative may seem contradicting terms, they name the last phase distinguished in this chapter. It indicates that there is no consensus about how to spatially make the right adjustments in order to adapt to climate change. After 1973, the prelude towards the adaptive manipulative phase of water management was initiated, but it took over 20 years for mainstream society to adopt a new spatial attitude towards natural systems as part of policy and practice. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2001), in particular, changed the view on the responsibility of people towards nature. The conclusions are quite clear about the impacts of climate change, the vulnerability of natural and human environments, and the potential for response through adaptation.

The first national planning report which supported the rediscovery of water as an element of urban development is the *Fourth Report Extra* or *Vinex* (Ministerie van VROM, 1990), which addresses the expansion of towns concerning living, working and recreation. One million houses were planned for the period up to 2015; a number that was later readjusted to 600,000. The report led to a whole new urban typology, characterised by diversity, called Vinex areas, large-scale developments mainly on the outskirts of larger Dutch cities that were solely allocated to housing. Water is also integrated in other national planning reports like the 1999 so-called *Belvedere Memorandum* (Ministerie van OCW *et al.*, 1999) and new national strategy called (in translation) *Another Way with Water: Water Policy of the Twenty-first Century* (Ministerie van V&W, 2000). The first increases attention towards history and landscape, and the second proclaimed a change in the attitude towards water in response to the near flood disasters in the 1990s. Nature and culture make a strong comeback in the national agenda based on both reports.

Nesselande

In Nesselande, one of the four Vinex areas in Rotterdam, water is introduced as the carrying structure of the plan. Alongside that, the use of ecological sensitive material, a district heating system, and subsidies for the use of solar energy are the starting points to ensure sustainability. A naturally cleaning, independent, open water system for drainage and storage guarantees water quality. The inhabitants have to live by several rules to maintain water quality, such as restrictions on washing cars and materials used in the gardens. Besides the overall importance of water to structure the area, this attempt to make the residents aware of the 'wet' situation of their neighbourhood, located nearly 5 metres below sea level, is expected to change the attitude towards water into a more adaptive approach.

One of the districts in Nesselande is called Water City (*Waterstad*) and is designed by Frits Palmboom and his office, Palmbout Urban Landscapes, together with H + N + S Landscape Architects. Both offices are widely known for their ecology-based design approach. Of interest is that the urban designers reintroduce the mound, or in Dutch *terp*, as a strategy to give open direction to the plan. The surface of the building lots is very low – as said nearly 5 metres below sea level – and is deliberately not raised to remain on the same level as the water to preserve a close relationship between water and garden. The roads are situated on dikes which are 80 cm higher than the lots. The lots are given mounds on the same level as the roads and connected to them to make road, water, and electrical infrastructure possible. Each house needs to be situated somewhere on the mound, but architects can make use of the height difference to create a spatially varied house. In this way, no restrictive rules are needed, and the building site preparation has become an integrated part of the urban design (see Figure 4.4).

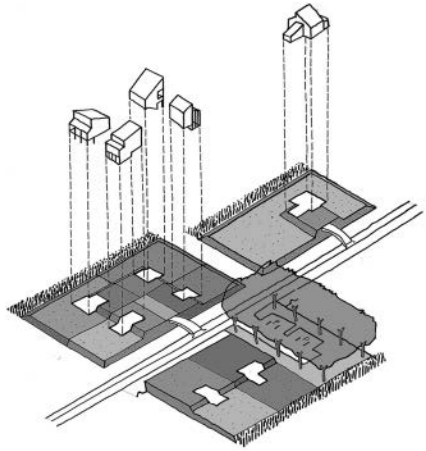

Figure 4.4 Mounds in Nesselande, 1999.
Source: Palmbout Urban Landscapes.

Zestienhoven

The most recent expansion plan of Rotterdam is Zestienhoven, close to Rotterdam The Hague Airport. Here, a park, sports facilities, and allotment gardens are situated next to the airport, and these are expected to roughly stay as they are. The urban design is therefore more a *re*design to make the area available for housing instead of completely new plan for an empty area. This is part of the new strategy of Rotterdam to intensify instead of expanding the existing territory (Gemeente Rotterdam, 2007).

With the development of *Zestienhoven*, water management was also given a leading role due to the fact that the area is very low (about 6 metres below sea level), with a high degree of seepage. From the water management point of view, scenarios were developed, and the optimum one (in relation to the costs and profits as well as functional and ecological aspects) was chosen and worked out in a master plan. This plan brings back the original polder pattern through an open water system forming a grid. Waterways are dug out of the layer of sand put here in earlier years. Building sites are raised with sand to prevent seepage and also to cover soil pollution. Around these sites, the green structure is kept intact. Ten per cent of surface water as demanded by the water board is projected to secure a flexible water structure, meaning that when there is heavy precipitation water can be stored. Figure 4.5 shows the preliminary plan with the building plots and the water grid. Many houses are situated along the water. The park on the west side and the allotment gardens on the south side are kept in their original state. The diagonal is the high-speed train line.

Figure 4.5 Preliminary 2009 plan 'Zestienhoven'.
Source: dS+V, Rotterdam Municipality.

While the master plan is based on the water system and soil conditions, many problems were encountered in the realisation phase, problems that could have been prevented if more detailed data of the water system was taken into the initial planning phase. The 10% surface water that was demanded by the water board is situated at the south side to accentuate a natural height difference. This made a close relation to the existing landscape and created the main ecological and recreational structure. However, the waterway had to be heavily sealed, due to severe seepage. As problems like this manifested themselves in the implementation phase, the realisation grew that it is important not to have a highly detailed master plan in such a complex situation. Instead, it is better to make a much more general and strategic plan with some key guidelines from relevant domains – urban design, engineering, finance – leaving ample room for more specific demands in the implementation phase.

Conclusion

> Without a long start in history, we shall not have momentum needed, in our own consciousness, to take a sufficiently bold leap into the future.
>
> (Mumford, 1961: 3)

The tight historical relationship between the natural system and the design of polder cities is exemplary for the future. The Netherlands is a water machine of which all cogs are connected to each other. Dutch cities are hydrological constructions, with a spatial layout that is strongly connected to the rules of water. It could be argued that the practice of Dutch urban design as it is today is based on the way the Dutch dealt with the water. This overview in six phases offers insight into a 'fine tradition' and how the self-evident relation between water management and urban design is shaped through time. The main conclusion is that the hydrological system is timeless, forms conditions for human social infrastructure, shapes the dynamics of the city, and sets out clear lines for the future. The landscape as a carrier of the hydrological system, including the original balance between land and water, should be taken on board when designing and redesigning water cities. Various levels of scale are connected to each other, like communicating vessels. The local scale of a new urban extension is connected to the regional scale by the polder system. Together the polders discharge to the channels and rivers as part of the delta in which the Randstad is situated. At this scale the main defence from the sea is crucial, especially when decisions are taken on large new developments while there are predictions of (serious) sea-level rise on the long term.

This chapter shows that each phase puts forth strategies for the future. The eras of natural and defensive water management are examples of how a flexible mental and physical attitude can incorporate uncertainties over time, which in this time frame is rather useful. The anticipative water management phase is an example of how cooperation and boldness lead to making the most of the potential of the territory. It also shows how taking the original waterscape into account can create spatial diversity by the use of technology and landscape while delivering hydrological cities, knowledge development, and prosperity. The offensive phase of water management shows that when the disciplines of engineering and urban design work together, a sound integration of spatial and technical challenges and solutions can be realised. It is clear that the knowledge and impact of water levels should be added to the toolbox of urban planning and design. Engineers should add the spatial consequences of the hydrological system for urban development. Both can, from different angles and closely working together, contribute to new developments as truly urban engineers.

Finally, the last two phases together make for a strategy that first of all must be aimed at developing sound consciousness: consciousness about the impact of technical systems and the vulnerability of the natural system is crucial for new developments. With a critical eye on constructions and with sight not only on the vulnerability of natural system but also moreover on the quality that the natural system can offer urbanity, a new balance can be found.

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