Rotterdam:
Dynamic Polder City = Land + Water + Culture

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ABSTRACT

The planning culture in the Netherlands is based on the experience of building cities on very wet and soft soils. The design of Dutch polder cities was from early on a balance between land and water for building site preparation. The relation between technological development and urban development can be ordered in six phases: natural (-1000), defensive (1000-1500), offensive (1500-1800), early manipulative (1800-1890), manipulative (1890-1990) and adaptive manipulative water management (1990-). Rotterdam is chosen to represent the heritage of Dutch talent with regard to the design and construction of water and land into dynamic cities. This is important because awareness and knowledge about historical principles makes it possible to draw a line into the future.

Keywords: *planning culture, water management, building site preparation, Rotterdam*

1. INTRODUCTION

"God created the world, but the Dutch created Holland". The Dutch have a rich and internationally renowned 'fine tradition' when it comes to the intense relationship between urban development and civil engineering. Their expertise and knowledge of hydrological laws 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 urbanization of the Dutch polders. Dutch cities are hydrological constructions with a spatial layout that is strongly connected to the division of land and water through building site preparation. In the Netherlands, the relation between technical efficiency and the specific characteristics of the territory, as well as the way cities and landscapes are designed, is different in each era.

In the post-war era the characteristics of the Dutch territory have been altered with the use of far-stretched technology, and the landscape and cities are designed with a high degree of rationality. The natural conditions of the territory are made subordinate to the thriving principle of a man made culture, in Dutch the *Maakbaarheids* principle. Technology can seem to make everything possible, but is very inflexible to change. Climate change is currently putting pressure on the hydrological system and technical parts of that system cannot adapt with the change. More severe and frequent rainstorms, high temperatures and drought are very influential on the hydrological system; rivers flood or dry up and rainstorms flood cities. In Rotterdam a lot of attention is paid to the subject and even a climate director has been installed, as both threats are present. However, to be better equipped to handle the hydrological changes, a clear view on the relation between the civil engineering and urban design professions that are responsible for building on wet and soft soil and balance out land and water is necessary.The

landscape is the carrier of the hydrological system and different ways to deal with the conditions of the territory in order to prepare it for building cities have never been systematically investigated. A blind spot is formed by the total lack of attention towards the fact that the Dutch have built their cities on wet and soft soil, very inconvenient for building, probably because it is so self-evident. Only one publication is available about building site preparation, Segeren and Hengeveld (1984), which also states that a lot research is still to be done. Gerald L. Burke wrote the most important reference about water cities, *The making of Dutch towns* (1956), which offers a systematic typology of water cities, unfortunately only till 1700.

Rotterdam is an interesting case study to investigate the relation between urban design culture historically, and the wet circumstances of the territory. This is necessary because awareness and knowledge about historical principles makes it possible to draw the line of history into the future. The Dutch heritage and future are based on the relation between land and water, nature and culture; this relation determined the construction of the landscape and cities, and the development of technology, culture and prosperity.

This paper analyzes urban expansions from Van der Ham's (2002, 31) different phases defined for the landscape, here altered for urban developments: natural water management (until 1000), defensive water management (1000-1500), offensive water management (1500-1800), early manipulative water management (1800-1890), manipulative water management (1890-1990) and adaptive manipulative water management (1990 until today). For each phase a case study in Rotterdam is chosen to show the relation between land and water and how this influenced urban development. This framework can be formulated into a principle that offers a critical perspective onto the future.

Figure 1:
The Development of Rotterdam, 1000, 1340 and 1500 (Source: Atlas of Dutch Water Cities)

2. NATURAL, DEFENSIVE AND OFFENSIVE WATER MANAGEMENT (-1800)

Until the eighth century, the Dutch lowlands were uninhabitable marshlands where the forces of water and wind had free reign. People learned to adapt ways of living to the wet surroundings. Van 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 small 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 manly due to the lack of a community, as people were living in small groups with little power in changing the natural conditions.

The Frisians were an exception. They were more organized in, for example fighting Viking attacks, and alter nature for their benefit by creating moulds. This first form of building sites preparation began in Friesland from 900 A.C. The mounds were intended as refuges in times of high tides, and the first buildings on them were the churches, symbols of community. Later they became larger and settlements arose.

All settlements in the Netherlands started on higher ground, along rivers, the sandy ridges at the coast and on the *geestgrond* [sandy soil between dunes and polder]. 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 settlements takes into account the most geographically convenient physical circumstances in the region. Secondly 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.

Van Ham placed the change in attitude from natural water management to defensive water management around the year 1000, when dikes were introduced as means of protection (Van der Ham 2002). This new technology directly affected the location and establishment of settlements. The dike enabled water, in the form of a harbor, to be introduced into the settlement. Many dike and dam cities were set up in the thirteenth and fourteenth centuries and the sites were prepared for building by raising them with debris.

2.1 Dam city

The conceptually most interesting type of water city of the defensive phase is the dam city, like Rotterdam, because of its integration of technological intervention with economical and social structures. Figure 1 shows the development of Rotterdam. The first map is around the year 1000; the peat area along the Maas and the Rotte is still under free reign 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, but it did not offer the enough protection and the settlement Rotta was lost. In an article about the Rotte and its first settlement, Guiran studied the soil build-up and 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, 91-97).

Around 1270 probably the third dike ring - the Schielands Hogezeedijk - was already built, and the dam was constructed where it crossed the river 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 made these areas vulnerable to flooding. The dam had a water-defense function, but with a drainage sluice it also took care of discharging river water from the smaller river onto open water. A combination of the scouring effect of the sluice water and the tidal movement were cleverly used to maintain the harbor at the correct depth and make the town accessible to seagoing ships.

The economic importance of water transport between the sea and the hinterland was embodied in the dam with its drainage sluice; the dam and sluice became the heart of the city. The drainage sluice was able to accommodate only relatively small ships, and the cargo from larger ships had to be transferred or traded on the dam. The dam would become a market, and the peat river estuary outside the dike a sheltered harbor. The dam town and the polder were therefore bound closely together, not only hydrologically but also economically and socially. In Rotterdam the central social venues on the Middeldam, like the city hall and the house of the Count of Holland, were the spatial expression of this (Van der Schoor 1999, 21).

The principle adaptation in natural and defensive water management offers a critical perspective onto the future. Living directly with the forces of nature offers quality and beauty that is maybe lost in trusting technology.

2.2 Polder city and Waterstad

Windmills came into use on a larger scale around 1500, marking the technological transformation to the next phase of offensive water management. This phase is characterized by a new, pro-active attitude towards water as people started to develop technologies to control water management conditions. With this new mechanism, larger volumes of water could be moved, and a more effective method was offered to keep larger scale areas and the cities dry. The power of uniting the mills with new hydrological instruments, such as sluices and dams, changed the approach towards the water from defensive to offensive. The establishment of the Republic of Seven United Provinces and its army socially underpinned this technological unity by establishing the place where knowledge about wet and soft soils was developed. The power of political unity represents an enlargement of society, city and water systems; the protection of a plot grows into the protection of a polder, the protection of a polder into the control of whole rivers. The phase of offensive water management is the phase of the polder city, the literal representation of the power of political unity.

The settlements of the two first phases, mould, river, coast, 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 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 realized cautiously. First, the size of the expansion needed to be determined, which needed to comply not only with the requirements of that time, but for centuries to come as well. Secondly, a technical plan was needed to ensure that water could be discharged and controlled, and that city canals 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 and a transport function with access to warehouses (Burke 1956). The water level of the canal system was regulated and excess water discharged by means of sluices and windmills. Then, the reclaimed land needed to be raised to the required protection level, 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 foundation piles were driven in order to stabilize the housing in the deep-set stratum of sand.

Since the mid-thirteenth century, a dike stretched out along the Hoogstraat (High Street) in Rotterdam, with a dam in the Rotte providing the settlement with its name. The Rotte and the dam came under the control of the Water Board of Schieland, established in the thirteenth century (Peilbesluit). 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 and two moats, Coolvest to the west and Goudsevest to the east, gave the settlement its characteristic triangular shape (Van Ravesteyn 1928, 134). However, polder expansion turned out to be less attractive then the waterside where business centered along the Maas. So instead of building into the sinking polder like Amsterdam did, the people of Rotterdam decided to expand the city into the river Maas. Already in the thirteenth century people started to use the salting outside the dike for harbor activities (Van Ravesteyn 1928, 105). The layout of the new part of the city was very simple and before the sixteenth and seventeenth century there was actually no plan. The houses grew together following the shape of the river and the harbors. 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 harbor is represented by its size. It was made very spacious, which has been useful when the ships grew larger and larger far into the nineteenth century. The result was a spacious *Waterstad* that had a high quality of space and a clean water), environment, 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 problematic in the inner city every century and especially when industrialization took force (Van Schoor 1999, Van Ravesteyn 1929, Schadee 2000).

The phase of offensive water management is based in the principle of fertility. The Dutch Golden Century produced great prosperity, social coherence. The power of unity is evident in the building of beautiful hydrological cities and is the phase where the Dutch planning tradition is born defining the genius of cooperation, looking ahead, and balancing nature and culture.

3. EARLY MANIPULATIVE WATER MANAGEMENT (1800-1890)

The phase of early manipulative water management was kicked-off by the new power of the steam engine. Industrialization turned Dutch cities into places where people concentrated around jobs in

the factories and the ever growing harbors. The social and functional change of cities in this era, where people from the country-side were suddenly packed together in dense neighborhoods, cannot be underestimated. The new steam power started a scale enlargement and acceleration that is still going on today.

After the defensive and offensive phases, the new power now made it possible for greater intervention in the water system. Water could be moved in a controlled way with greater power and the movements. Everything became possible, from the building of channels, the closing of sea arms and the artificial lowering or raising ground water levels.

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, when most of these expansions were built, the Republic suffered from political decay and economical stagnation and later the French invasion. This downward development ended in 1814 when the monarchy was instated, but only after 1850 did city development restart again.

3.1 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 2). The expansion was interwoven with the new water task of the city; many people died from cholera due when the water in the inner city became contaminated. In the dense city the river, canal and ground water was used for everything, producing a very bad smell and an unhealthy living environment.

Rose's answer to this problem was an independent water system for the city, independent from the countryside where the water management goals had very different aims. Rose, together with landscape architects J.D. and L.P. Zocher designed the *Waterproject* as an ingenuous plan combining the preparation of the surrounding wet and soft polders together with a new water management system into an integrated urban design.

Figure 2:
The Waterproject (Source: GAR)

The first aim was to flush the waters in the inner city to improve water quality. The second aim was the desperately needed expansion. Rotterdam was digging harbor after harbor, and many people where 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 also directly socially profitable. 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 new polder 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 situated inner dam city through ditches and culverts. There was an intensive investigation done into the heights of the ground floor, (see figure 3). At the side of the river the new power of two steam engines pumped water that was let into the inner city out again (see Hooimeijer *et al.* 2001, Berends 2001).

Unfortunately the original problems of hygiene were not solved with the *Waterproject*; the flow was sufficient in principle, but too much rubbish was still thrown into the water. Only after the introduction of a sewer did the hygiene in the city improve.

The *Waterproject* represents the available technology and the urban planning tasks of the era of early manipulative water management. It also represents the practice of the building industry the general plan of the urban designer is filled in by the building practice in the final stage. In the plan, the building blocks where filled in following the polder pattern and the pattern of ditches that were dug to drain the polder. 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 builds sand strips under the planned roads and developers build the roads, where after the municipality takes over the maintenance. Houses are built on piles above the ground floor, and due to the fact that the backyards are not raised the space in the basement can be used for living, usually as a bedroom. This way of preparing an area for building influences the design and use of the city on all scales.

The early manipulative phase demonstrates the power of the new technology and introduces the principle of systemization. This principle gives a critical perspective on how the multiple demands of dynamic cities can be integrated by one urban plan tuning the natural, cultural and technical systems - and made profitable. The *Waterproject* can still be considered as an example to learn from today.

Figure 3:
The Heights in the Waterproject (Source: GAR)

4. MANIPULATIVE WATER MANAGEMENT (1890-1990)

At the end of the nineteenth century, explosive urbanization and technological prosperity put pressure on the polder cities. The manipulative era (1890-1990) is marked by the induction of the engine and electricity, which had an immense influence on the city and the water system. The car, industry and industrialized building processes and technology organize a new spatial order. This results in a situation wherein technically everything is possible and there is no connection to the "natural" laws of the water system. The power that started with the steam engine is accelerated in this phase.

The building of the sanitation and drinking water infrastructure brings segregation between the systems for groundwater level control, the discharge of wastewater and the supply of drinking water. The larger part of the urban water system disappears underground. At the same time industrialization brought the car claiming more and more space. Many open waters, bad smelling or dangerous due to bad lightning, were filled in, again 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 element in the urban design of the city.

The possibility of spouting up a layer of sand to improve the wet and soft soils in the polder comes just at the right time when industrial building methods enter practice. Blijdorp, an expansion of Rotterdam, is the perfect illustration of the first urban type that comes with this new method of building site preparation. The technological perfection after the Second World War delivers the second urban type, modernization, of this era of which Ommoord is exemplary. The third and last type comes about in the 1970s when partial sand layers are applied to keep some of the original landscape in the urban design. Zevenkamp is used as case for this urban type.

4.1 Blijdorp

The Housing Law (1902) made it mandatory for a municipality larger than 20.000 inhabitants to make expansions plans. This law gave a boost to the new profession of urban design; previously, engineers and architects built cities. Considering the new way neighborhoods were built, described above, it was very hard for the municipality to make a plan and keep all the developers to abide by it. The first expansion plan for Rotterdam (1906), Blijdorp, was more a combination of the plans of the private developers than an independent urban design. Eleven years after this plan, after many more plans and a lot of misery trying to get the land-owners and developers on the same page, the municipality decided to buy all the land and develop the area themselves. The fact that they could prepare the whole site at once with the new technology of spouting up a layer of sand provided an added advantage of this decision. The largest advantage of this technology was they did not have to agree on the urban plan before applying the layer of sand because any plan could be realized on it. Here the urban design and realization is disconnected from the polder pattern, the historical pattern of land, water and culture. Building site preparation, the technology of balancing out land and water, becomes disconnected from urban design (Gemeentewerken Rotterdam 1984, 14).

Figure 4 shows the spouting up of the north side of Blijdorp. The south side of the Schie was done in 1924. During the spouting of the north side they used water to make sure there would be no sand storms.

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 it resembles Plan South for Amsterdam by H.P. Berlage as a twin. Car infrastructure is the backbone of the plan, and the water and green structure is like a shadow.

The manipulative era signifies the principle of *Maakbaarheid* (man-made) through the accelerating powers of the car engine and electricity. Blijdorp, the first urban type it delivers, is the result of new methods of building site preparation that disconnects nature from culture and urban design from the physical geographical conditions of the site. Yet, the technology is not perfected yet and the water system is still a part of the urban plan. This new technology brought a new organization of city development and initiated a cultural change. This insight offers a critical perspective on the effects of industrialization.

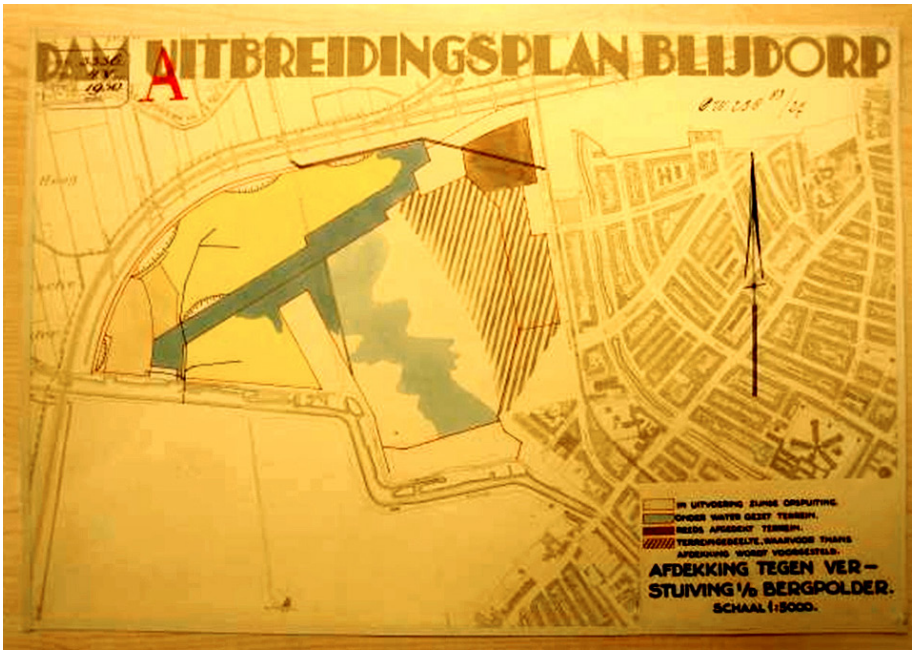

Figure 4:
Blijdorp spouting up sand (Source: GAR)

4.2 Lage Land and Ommoord

The enlargement of urban scale and the disconnection of urban design from the characteristics of the land cumulated in the post-war era. Water as an urban element become completely insignificant when situated on top of the layer of sand, the water system becomes completely artificial. This fulfills the *maakbaarheids* principle, a paradigm of belief in a man-made 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 re-allotment of the agricultural pattern leaded to a completely different landscape.

In his inaugural speech on November 12th 1975 titled *Spel met water, grond en land* [Game with water, soil and land] W.A. Segeren, extraordinary professor in water construction and polders recognizes a direct relation between the location of the settlement, the way of life, and the surroundings. After WW II the city expansions were located, then 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 made and measures taken for the discharge and drainage of the built area (Segeren 1975, 7-9).

The spouting up of a layer of sand technology of building site preparation 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 standardization of urban design through the uniform production of apartment buildings and houses denying any local characteristics to the urban expansions (Segeren 1975, 11).

In Rotterdam expansions were made on the south bank and east of the city in the dried 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, the Lage Land, and presented these at the CIAM conference 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 put to design a sub-city in these low-lying polders for the ever-growing number of residents of Rotterdam.

Rotterdam could not expand north and the city centre was moving to the west, so they considered the eastern expansion, even in the deep wet polders, as the best contra balance.

The plans were extraordinary because they combine a radical way of building preparation, building on piles and lowering of the groundwater table, with an international vision on urban development.

Bakema's concept of the 'visual unit', vertical city, was connected to the 'district idea'. The district idea - where residential neighborhoods merge harmoniously into a concentric and hierarchical whole - 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 converge. In the plan for Alexanderpolder these 'visual units' were directly linked to the highway and functioned as autonomous urban units. The geographical circumstances of the deep lying polder and the poor soil condition were the reason for Stam Beese and Bakema introduced the idea of vertical neighborhoods (Schild 1982, 139-197). By founding the highway and these 'Mammoths', as Bakema called them, on piles, the city was disconnected technically from its landscape that could be used for agriculture and recreation. These Mammoths, of vertical neighborhoods are 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 on the open agricultural landscape (Palmboom 1993, 38).

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 a mill wing.

The executed design of Lage Land is in two ways interesting. For building site preparation the choice was made to lower the groundwater table, in a time when usually the layer of sand was applied, 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 is endless; the polders in the Netherlands due to their rhythm and quantity have that characteristic.

After working on the Lage Land, urban designer Lotte Stam Beese also made the design for Ommoord positioned in the same dried lake. She writes about the influence of bad soil conditions and the effect that applying a layer of sand has on the urban design:

The failure starts with the choice of the location of the new residential area. We have no good choice for a proper place,…[…]. The result is that due to the need for houses the residential areas come about with a rational-theoretical model, just like the Roma army camps, and miss the natural geographic that used to characterize former settlements: the valley, the river crossing or mouth, the presence of water or the safety of a mountain tip. The presence of the geographical characteristics and the internal coherence with them produced the urban design; it gave these settlements and their resident's identity. Therefore it is not surprising that the current city expansions show great resemblance with the Roman army camps in lack of morphology. These camps also had no structural connection to their geographical situation, were independent and characterized by a singular function. Ommoord is built on the worst soil conditions possible. To be able to build there the whole area has to be drained with sand piles. This is not only very expensive but also restrictive in the detailing of the urban plan. For example a walking way on sandy soil in Drenthe can be made just by the people walking there, but here the walking way needs to 'be made' improved soil. The brick fence of playing areas needs a pile foundation in these conditions and is therefore too expensive. All these simple impossibilities produce an urban plan without an inoffensive character and become emphatically wanted and technically efficient. Added to this is the fact that technology always strives to perfection. But are we happy with ultimate perfection, with efficiency beyond efficiency? Why do children prefer to play in the mud and in messy places and do adults like to go to campsites and organize pic nics?

The only positive side of the location of Ommoord is the river Rotte and the Rotte lakes. These are going to be expanded end better enclosed according the recreation plan 'Rotte-meren'. This condition means some meaning of place to the new residence and a more plural functioning of the area. Already from the high flats the view on the landscape is stunning. The lack of a natural geographical environment, like described above, is visible in many new expansions: houses and flats are arbitrary lined up without taking the residents into a characteristically environment. [….] Why all the fuss, the disgust and dissatisfaction that is expressed in the media? The answer can only be that there is a consciousness about the lack of a residential environment for residents to feel at home. Everybody needs a home. (Stam Beese)

Lotte Stam Beese tried to establish in Ommoord an urban identity that connects people by the use

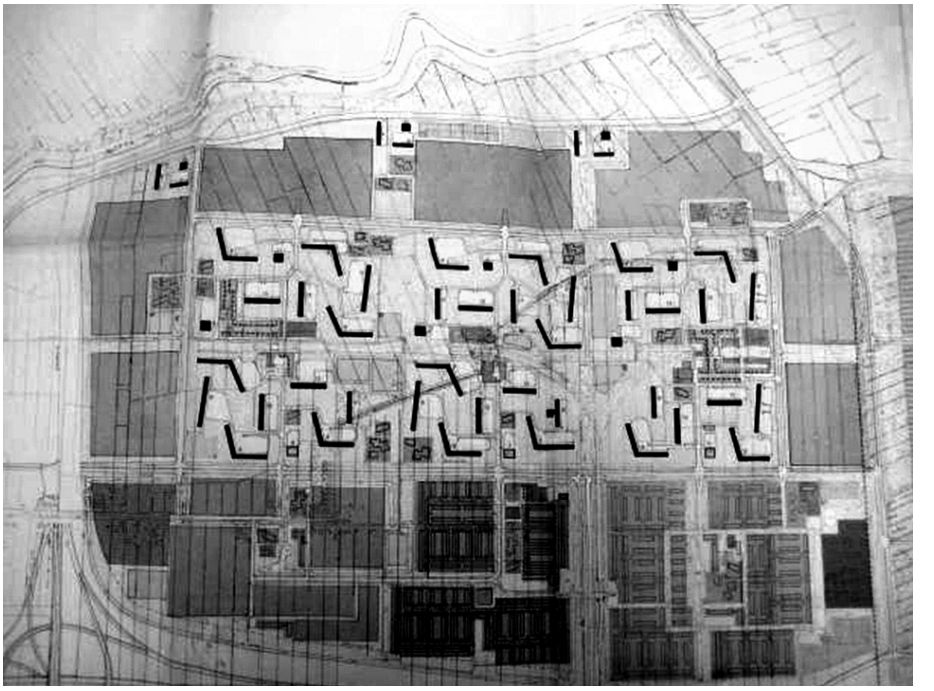

Figure 5:
Ommoord (Source: NAi)

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 compensated for the lack of private outdoor space (Damen *et al.* 1993, 87). Figure 5 shows the urban design for Ommoord drawn over the original polder pattern.

This manipulative era urban type, as lucidly described at Stam Beese, thrives on the perfection of technology disconnecting identity of place. 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.

Lage Land is a maverick in the post-war tradition since it is not heightened with a layer of sand and some characteristics of the land water parceling is taken into the design. The interest of this plan made for the CIAM conference is that it makes a coalition between keeping nature as it is, while making use of concrete to build on, provides a modernistic urban vision of technological culture *in* nature. This coalition can be exemplary for the future.

4.3 Zevenkamp

By, the 1970s the post-war era was criticized 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 into the real identity of the city. A respect for nature became a theme in reaction to technocracy and man-made culture. The publication by Rachel Carson, *Silent Spring* (1962), opened the eyes to man's bad influence on nature. Also the report by the Club of Rome, *Limits to growth* (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 1972). In the 1970's nature and ecology became more important in spatial planning and the landscape architect came as a new player. The landscape architect reintroduces water as a spatial element in the city. Also the search for urban identity rediscovered the old water towns inspiring plans for reopening filled-in water landscapes.

Even though Zevenkamp was developed through spouted-up sand technology, the urban design took an original landscape element, the 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 center, 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 it hides the hydrological system 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.

The urban type of the 1970s is a return to the physical geography of nature in urban construction, and a modification of building site reparation to do so - the partial sand layer. It was the first step towards adaptive manipulative water management and new urban types.

5. ADAPTIVE MANIPULATIVE WATER MANAGEMENT (1990-)

While adaptive and manipulative may seem contradicting terms, it names the last phase as 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 twenty years for mainstream society to adopt a new spatial attitude towards natural systems as part of policy and practice. This process is still in progress enforced by the changes in the hydrological system and territorial conditions due to climate change. Especially the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) changed the view on the responsibility of men towards nature in 2007. 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 (Intergovernmental Panel on Climate Change 2008).

The technical approach of management of the manipulative era led to the current situation where more extreme storm events tied to climate change cause flooding in the polder cities. The days of the use of pipes and pumps - the work of the civil engineers - are over. Water needs to be reintroduced directly into the urban design of the cities. This requires a spatial approach where fluctuations in water supply and ecological water systems are taken into account.

In the Netherlands the approach towards urban planning is one of liberal and de-centralized political character. National reports set out very general guidelines and are aimed more at economics than spatial order. But then again, water is integrated in national planning reports like Nota Belvedère (1999) and ‘Anders omgaan met water, waterbeleid in de 21e eeuw in de stad’ (2000) [Another way with water, water policy of the 21st century]. The first increases attention towards history and landscape and the second is a change in the attitude towards water in response to the near disasters in the 1990s. Nature and culture make a strong comeback in the national agenda based on both reports.

5.1 Nesselande

In Nesselande, water is introduced as the qualitative carrier of the plan. The use of ecological sensible material, a city heating system, and a subsidy for sun energy are the starting point to ensure sustainability. A naturally cleaning, independent, open water system for drainage and storage guarantees water quality. The inhabitants have to live by five rules to maintain water quality: 1) no washing cars, 2) ecological material in de the gardens, 3) dogs are only allowed in specially drained areas, 4) use of chemicals is prohibited, and 5) avoid use of fertilizer. Besides the overall importance of water to structure the area, this attempt to make the residents aware of

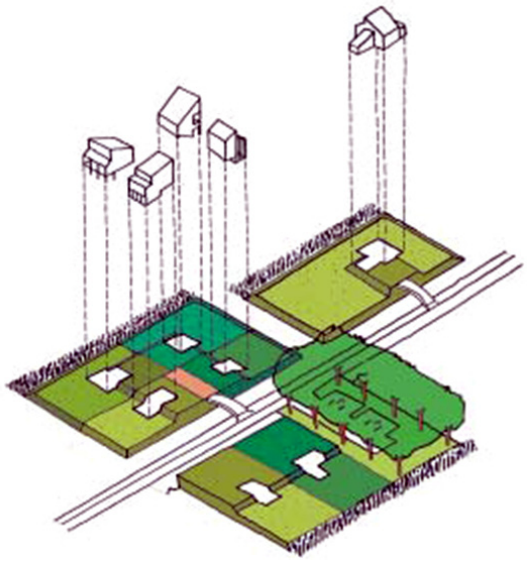

Figure 6:
Moulds in Nesselande
(Source: Palmbout Urban Landscapes)

the wet situation of their neighborhood is establishing a necessary social carrying capacity to change towards true adaptively.

One of the districts in Nesselande is called Water City and is designed by Frits Palmboom and his office Palmbout Urban Landscapes together with H+N+S Landscape architects. Of interest is the fact that the urban designers reintroduce the mould as a strategy to give open direction to the plan. The ground floor of the lots is very low - 4,80 meters below mean sea level - and are not raised to have a direct relation between the water and the gardens. The roads are situated on dikes witch are 80 centimeters higher than the lots. The lots are given moulds 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 mould but can make use of the height difference to make 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 6).

The principle of vulnerability marks the era of adaptive manipulation, which is characterized by consciousness about the vulnerability of natural system and also more perspective on what qualities and opportunities the water and the natural system can bring to the urban system. Urban interventions in the landscape are done with a critical perspective on the effects of these interventions.

5. 2 Zestienhoven

The most recent expansion plan of Rotterdam is Zestienhoven. Here a park, sports facilities and community gardens are situated next to Rotterdam's airport. The urban design is therefore more a redesign to make it available for housing that that it is a 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 giving a leading role due to the fact that the area is very low and wet with a high degree of seepage. From the water management point of view a few scenarios where developed and the most optimum one, in relation to the costs and profits, functional and ecological aspects, was chosen and worked out in a master plan.

The urban design brings back the original polder pattern in an open water system that, alternating with an artificial underground system, forms a grid; these waterways are dug out of the layer of sand that

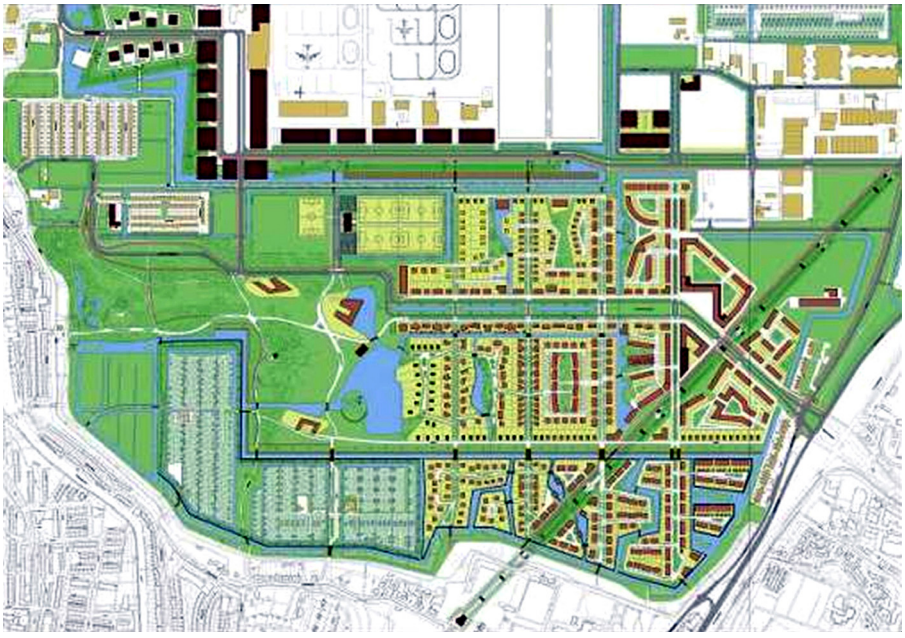

Figure 7:
Zestienhoven (Source: dS+V)

was applied here. The building sites are raised with sand, to prevent seepage and cover soil pollution. Around these fields the green structure is kept in tact. Ten percent of surface water is projected to secure a flexible water structure. Figure 7 is the preliminary plan that shows the allotment and the water structure as a grid. Many houses are situated along the water. On the west side the park and the public gardens on the south side are persevered. The diagonal is the High Speed Train Line.

While the master plan is based on the water system and soil conditions, municipal urban designer Mattijs van 't Hoff and engineer at Public Works and project leader Peter Spakman encountered many problems in the plan's realization that could have been prevented. The ten percent 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. These problems, according to Spakman, manifest themselves in the implementation phase, and suggest that it is important not to have a very specific master plan with specific demands from the urban design, engineering and financial side of the project. It is better to make a more general master plan with guidelines from the all sides - urban design, engineering and finance -leaving room for more specific demands in the implementation phase.

The waterway turned out not to be feasible, bringing about a large technical and expensive enterprise, and a new design for the ten percent surface water had to be made. In the meantime, architectural historian Mariëtte Kamphuis investigated the area and discovers a historical map that offered inspiration for the solution to the problem (Kamphuis 2009). On the historical map, on the location of the problematic seepage, little islands are visible. These islands make sure that the ground does not break open and are therefore the natural solution for the problem and the logical spatial solution for the landscape characteristics an conditions of the area.

The principle of vulnerability makes evident that hydrological conditions are like a time machine, a continuum that sets the agenda for future land use. Also, that the time factor needs to be incorporated into the organization of urban development; technology needs to be orchestrated and balanced with the natural conditions of the site.

5. FOR THE FUTURE

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

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 the Dutch urban design as it is today is based in 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 the line for the future. The landscape as a carrier of the hydrological system, the original balance between land and water should be developed in new ways of building preparation to design or redesign water cities.

The principles coming from each phase put forth the following hypothetical strategies for the future. From the adaptive principle a flexible mental and physical attitude and the introduction of the aspect of time to incorporate uncertainties is a productive strategy. The fertility principle shows that cooperation and boldness in making the most of the potential of the territory, taking the original waterscape into account and make spatial diversity by the use of technology and landscape, delivers hydrological cities, knowledge development and prosperity. The systemization principle shows that when the disciplines of engineering and urban design work together the integration of tasks and solutions (spatial and technical) can be realized. A fourth dimension should be added to the toolbox of urban design, the dimension of water levels. The engineers should add the spatial consequences of the hydrological system for urban development. Both can, from different angles, contribute to new developments as urban engineers.

Finally the *maakbaarheids* principle and its opposition the vulnerability principle together make for a strategy that first of all must me aimed at consciousness. This consciousness about the impact of the technical system and the vulnerability of the natural system is crucial for new developments. With a critical eye

on constructions and with sight on not only the vulnerability of natural system but moreover the quality that the natural system can offer urbanity the new balance can be found.

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