Water challenge

Current state of urban water management

The objective of water management in urban areas is to ensure that no damage is caused during peak periods of precipitation either within or outside of the city limits and that prolonged periods of drought do not cause problems in the city or the countryside. It also ensures that cities are supplied with clean drinking water and that wastewater is properly treated. The various factors in the urban water balance, precipitation and various kinds of wastewater on the one hand; and a loss of moisture, evaporation, infiltration and use, on the other hand, do not form a balanced whole. In the event of excess precipitation, most is still discharged through the sewage system, while even shortly after there can be a dry spell or water shortage which would require water levels to be replenished. The opportunities for improving this unbalance lie among others at the neighbourhood level. Applying a more natural approach to water management, for instance with, through the use of natural outflow or buffering, more use of onsite infiltration into the soil, better utilisation of rainwater, reuse of wastewater in due time, and improved urban planning which incorporates local characteristics into the management plan, will be more cost effective and efficient in comparison to centralised water management.

This vulnerable and artificial balance of the urban water cycle is becoming increasingly more unbalanced due to the effects of climate change and growing urbanisation. Combinations of the measures described in this book can contribute to making the urban water system more robust against climate change.

Policy

Governments, water boards, water supply companies, universities and commercial parties are working together on the challenging task of making the Netherlands climate proof. The foundation for the development of new policy was laid 10 years ago in the National Spatial Strategy, The Fourth National Policy Memorandum on Water Management, the Commission for Water in the 21st Century and the Administrative Agreement on Water Affairs. The policy for the period 2009 through 2015 is formulated in the National Water Plan. Instruments are currently being developed within the Delta Program which will be operational as of 2014. It is important to operationalise these objectives as efficiently as possible by translating them into applicable measures. In order to reach truly efficient solutions the various aspects need to be integrated, starting with the conceptual phase. The desired measures in the form of a combination of centralised and decentralised systems can only be implemented if awareness is raised among urban residents, something which can be achieved by including design in the process. People see and respect what they feel is of value to them and improves their quality of life. At present there is a growing interest among designers such as architects and urban planners to design differently.

Instrument

The Water Assessment has been compulsory since 2001 for all planning related to the water system. The Water Assessment as an instrument has enabled water to be taken into account from an early stage in regional development. However, when it concerns location choice this instrument has proven to be not effective. The emphasis lies mainly on water quantity and not on drought prevention, water security and water quality. Currently the instrument is being enlarged to ensure that the agreements made during the planning process also become legally binding. [Slumpe, 2008]

Investments

Within the context of sustainable water management, investments have been planned for the improvement and repair of the sewer system, buffer basins and wastewater treatment facilities, with costs running into the billions. Through new solutions, for example by using part of the required investments for containing rainwater, infiltration, or delayed discharge and buffering, these investments can simultaneously be used to improve the design, experience and natural value of a neighbourhood. Now is the time to further develop these concepts and to utilise these investments in a sustainable manner.

The hydrological urban water cycle

Water is constantly in motion: as vapour through the air, as surface water in rivers, lakes and oceans and as groundwater in the soil. Atmospheric moisture precipitates as water droplets, snow or hail, or condenses aboveground as fog, dew or sleet.
Precipitation falls on the land and on the water. Part of the precipitation which falls on land is absorbed by foliage (canopy interception), part evaporates (transpiration), part seeps into the soil (infiltration), and part flows into surface water (runoff). Water flows under the influence of gravity or pressure differences. It can flow horizontally, resulting in an inflow into surface water, or vertically upwards (seepage) or down (percolation). The permeability of the soil and the pressure differences determine whether water moves horizontally or vertically. Eventually all water, whether through rivers or soil, is expelled into the ocean, where it again evaporates and the cycle starts again.

The urban water cycle

Water enters the city in various ways: as surface water, groundwater, precipitation, or as drinking water via the water supply system. The drinking water used in an urban area is extracted from groundwater or is purified surface water, and after being used it is mainly expelled through the sewer system to a wastewater treatment plant where it is treated and discharged into the surface water. The groundwater table is influenced by extraction, drainage and land reclamation and by the large percentage of impervious surfaces in an urban area. Precipitation in an urban area is mostly discharged immediately, not counting the percentage absorbed by the soil. Over the past several years this policy has been changed, and now the aim is to buffer, infiltrate and delay runoff of rainwater on-site. The new policy has only been implemented in newly built districts and some renovated districts. The volume of water that needs to be exported depends on the amount of precipitation, the amount and type of impervious surface, the type of soil and the groundwater table. Part of the precipitation evaporates, is buffered or infiltrates into the soil.
The urban water cycle is not a closed system. At first glance, the man-made urban water system appears to be very efficient and was and is still for the most part aimed at a quick discharge of rainwater and household wastewater to a treatment system or surface water. Precipitation on paved surfaces is still mainly transported through the sewer system. This happens through a combined sewer system (mainly in older urban city quarters), a dual system or improved dual system which is now standard for new housing developments. The combined sewer system aims to expel water as quickly as possible. With heavy rainfall there are peak discharges, which lead in the combined system to an overflow of polluted water into surface water. With a combined system the wastewater is transported together with rainwater to the treatment plant, after which the treated and cleaned effluent is discharged into the surface water. In cases of heavy precipitation the treatment system capacity may be insufficient, resulting in untreated water being discharged directly into the surface water and therefore in pollution thereof.

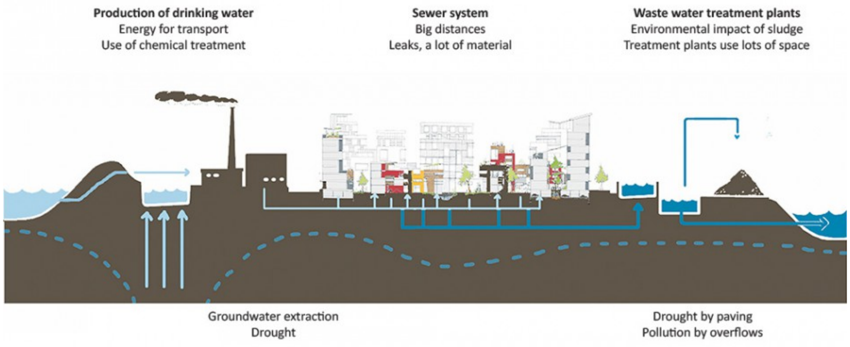
The diluted wastewater that does arrive in the treatment plant is not treated as thoroughly as usual. Due to the dilution, the micro-organisms do not receive sufficient nourishment in the diluted waters and die off. These micro-organisms are crucial for the treatment process and it takes time for them to recover.

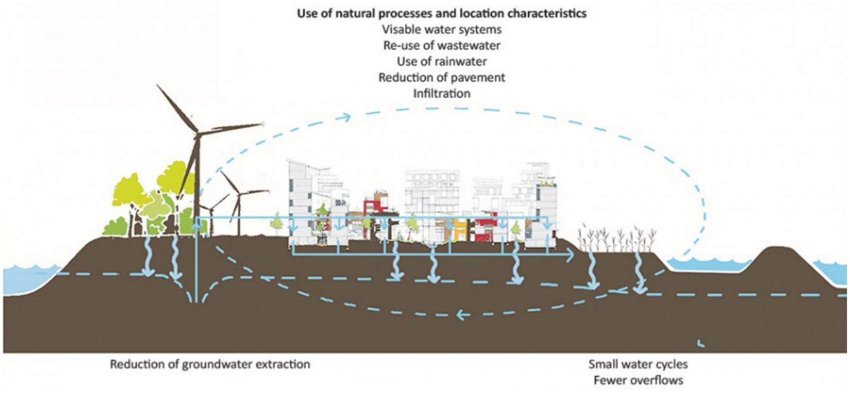
When renewal or restructuring of the sewer system is required, where possible, the combined system is replaced by the dual system or improved dual system (Dutch) or decoupled. When restructuring due to lack of space the combined system cannot always be replaced by an improved dual system. In these cases decoupling can be a good alternative.

To prevent unwanted overflow, a switch was made to the dual system. With a dual system rainwater is transported separately through storm drains and expelled directly into the surface water. The drawback is that polluted rainwater, e.g. from busy roads, is also discharged into the surface water. In the meantime the improved dual system has become the new (Dutch) standard. With an improved dual system the first fraction of rainwater is led to the treatment plant and the rest is expelled into surface water. However, this system also has its limitations; heavy metals loosen slowly from paved surfaces and thus end up in surface water through the second fraction of runoff.

To relieve the sewage system, the aim is to “hold it, store it and drain it” in the new housing developments and urban renewal projects.

Drinking water conservation has gained interest the past few years and has been applied through water-saving faucets and toilets. The possibilities of reuse are still barely being utilised but have been incorporated as policy objective in the National Water Plan. In the neighbouring countries of the Netherlands this is already a tried and tested technique and is already partially captured in policy and laws. Recently more attention has been given to closing water cycles locally, as in the concept of a “circular city”, for example reusing rainwater for household purposes.





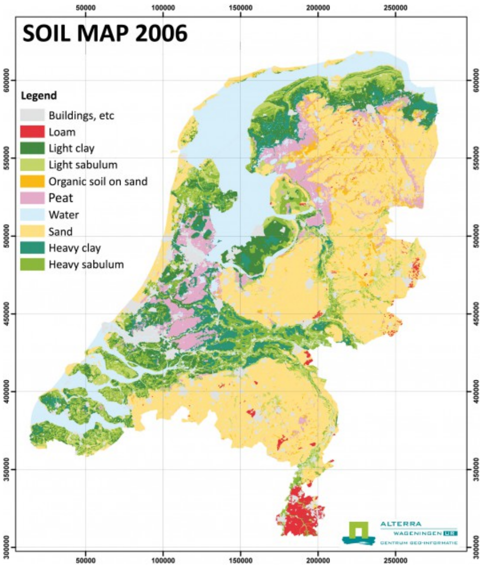
Soil, basis for a water plan

When designing a water plan it is essential that soil type is taken into consideration. The properties of various soil types can mean that certain systems are not suitable for use in that area. Dry sandy soil is porous and water passes through it quickly, making it suitable for infiltration. Compact wet clay soils, on the other hand, are dense and water does not pass through easily, making aboveground drainage and retention a better choice and the only option.

Soil is a porous medium which, in the upper layers, usually consists of three states: solid particles, water and air. Soil characteristics are usually discussed based on the properties of the solid particles, which are discerned as either minerals or organic matter. They are mainly determined by the proportion of organic and mineral matter and particle size (texture) of the mineral part which consists of a mix of grains of varying size which have different natures and properties. The distribution of particle size is one of the most important soil properties. The most important soil types are gravel, peat, sand, clay and loam. Gravel is the most permeable and loam the least permeable, due to particle size. Most soils consist of a mixture of these types.

The consistency of the Dutch subsoil resulted from a number of geological processes. All of the Netherlands, except for the southern part of Limburg is part of the drainage basin of the North Sea basin. Oceans and rivers have filled this ever-subsiding basin with sand and clay. The deltas of among others the Rhine and the Meuse consist of matter which has been transported and deposited by the rivers. The sea with its currents, wave action and tidal movements has partially taken these deposits and deposited them elsewhere, adding its own matter to the mix. In the northern part of the Netherlands ground moraines have been created. During the ice ages lateral moraines were created in the centre and eastern part of the Netherlands. Finally, the wind has caused quite some changes as well: local deposits have been blown away and deposited elsewhere. Due to these processes the higher parts of the Netherlands (mainly the east and south) consist of sandy soils. The region along the coast consists of sandy coastal areas with former peat areas behind these which now consist mainly of sea clay and, along the rivers, riparian clay.

The different soil types all have different properties with regard to water permeability. In general, the larger the particle size, the more water passes through and the less water is retained. This means that clay does not allow much water through and also retains water above the water table. Gravel and sand are much more permeable, and the soil which lies above the water table in these regions is dry. Together with the water table, this has consequences for the water system to be designed in an urban plan. The groundwater table is found under the first part of the soil profile. Below this there are two more phases: solid particles and water. With rainfall the water table will rise. By how much depends on the field capacity of the soil type, which is usually between 5 and 10%. This means that the soil can absorb 5 to 10% of its total volume in moisture, by which the water table will also increase, respectively by 10 to 20 times the inflow of precipitation. A soil type with a low field capacity will be quickly saturated when the water table is high. While a soil type with a high field capacity and a low water table will be able to absorb more water. In the west of the Netherlands there are mainly low-lying clay grounds with a high water table and a low capacity coefficient; in the east lie the higher sandy soils with a lower water table and higher field capacity.



Designing water

Visible water has a greater need for space than subsurface systems do. Streets are wider with open gutters, infiltration systems are larger than storm drains, and an open retention basin is larger than an overflow. Sometimes, though, aboveground solutions in the form of green roofs, removing impervious surfaces and the use of rainwater can offer solutions if the street profile doesn't provide sufficient space for underground solutions. Much of the extra aboveground need for space can be combined with other functions: a hollow road can serve as a gutter, playing fields and public green areas can easily serve a second purpose as infiltration areas, and open lots can be allowed to become temporary ponds. If the water system is taken into account in the urban planning at an early stage, much is possible without too many radical extra measures. The measure in which water can be used as the structuring element varies. In the simplest system a visible, sustainable alternative to a conventional system is applied, such as with aboveground precipitation runoff schemes. More sophisticated systems utilise the possibility of alternative water systems such as rainwater use and local onsite wastewater treatment and furthermore enhance the possibilities to create natural areas. The soil types described earlier (clay and sand) lend themselves to a design which applies totally different system components as well as having differences in space requirements and visibility. In the case of wet clay, an aboveground approach is deemed best: retention in ponds, ditches and discharges to surface water, or infiltration by way of a drainage system. For buffering, a retentive surface is required in order to be able to design shores and embankments in such a way that fluctuations in the water level are possible through sloping green banks or stepped quays. In the case of dry sandy soils, rainwater is infiltrated in the soil. This can be done visibly aboveground using marshy pools or with a drainage system underground. This last provision is less visible; the water disappears into the soil. The infiltration system can also be applied over a larger area, for instance per building. The main goal of the techniques described here are the improvement and management of the water quantity, quality and the quality of life in a city or district. The means available for this are retaining and purifying the water and making the water system visible. Furthermore, by creating cycles the amount of drinking water used in the city or district can be reduced. It is essential that the total water balance is taken into account with each conscious utilisation of water in a built environment. Only then is it possible to come to sensible, sustainable decisions in which the various measures are attuned to one another and form a cohesive whole. A combination of certain measures can be counterproductive, while a combination of other measures can in fact provide added value. An example of measures that counter each other is the use of rainwater in combination with grass roofs. As the grass roofs retain water, there is hardly any excess rainwater available for other purposes. A combination of measures which produces added value is, for instance, the retention of rainwater on a terrain in combination with completely decentralised treatment and reuse of wastewater. Connecting to the central sewer system is not required in this case. For instance, a constructed wetland used for treatment purposes can also have a high landscape value. Design of the surroundings, ecological value and user functionality go hand in hand here.

Integral water plan

For an integral water plan it is important to first determine the natural conditions: soil type, water table, precipitation, seepage, surface water, etc. Next, the water flow produced by human activities must be mapped, including the quantitative and qualitative determination of household or other wastewater, the need for clean water for the various purposes and the required quantity and quality. Depending on the existing situation, the goals and priorities in relation to water management can be formulated. These are further developed into a total water concept in which the various measures are attuned. The goals should always be attuned to the possibilities for the specific situation and the natural water balance.

In practice this means that on high, dry and sandy soils the rainwater is infiltrated into the soil or stored in open water. On lower lying, wet clay soils the water is stored aboveground as much as possible. The reason for this is that with dry soils the groundwater is replenished and no drainage system over large distances is required. With wet soils the aboveground storage creates a retention area which slows the water from running off too quickly. Clay soils are limited in their permeability. In existing urban situations the possibilities depend on very specific local situations.

The water that needs to be transported consists of rainwater from roofs and other impervious surfaces. The rainwater from roofs is generally clean enough; this means that this water can be stored or infiltrated without prior treatment. The runoff water from roads can be contaminated and determining whether treatment is necessary must be done using measurements or estimates.