SUDS AND FLOOD MAPPING URBAN FLOODS IN BERGEN, THE NETHERLANDS

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INTRODUCTION

The increase of the paved area and the effect of climate change can have a considerable impact on urban areas. One of the effects is the increase of storm water peak intensities and an increase in the frequency of these showers. These extreme events cause the sewer system to be overloaded and flood the streets and pose a possible health risk.

The popular beach resort Egmond aan Zee in the north-west of the Netherlands experienced two extreme storm water events in August 2006. The storm water events had an intensity of 60 mm/hour, which statistically should occur once in 50–100 years, and led to flooding of the area. The storm water flowed from the higher parts to the lower-lying centre and flooded shops (see photo), with damage to property and much (political) unhappiness. This flooding and the possible health risks could occur more often due to climate change and needed to be resolved immediately.

FIGURE 1. INTENSIVE STORM WATER EVENTS IN AUGUST 2006 LED TO FLOODING IN THE MAIN SHOPPING STREET IN EGMOND AAN ZEE

It is becoming commonly accepted that these problems need to be resolved by providing more space for water at ground level. The European Flood Risk Directive (EU, 2007) promotes flood risk management plans with non-structural measures aiming at resilience of urban infrastructures and preparedness of the social system. SUDS can be used as an effective way to reduce flooding. There is a growing consensus that sewer capacity is limited and that there is a need to consider all aspects of water drainage during extreme rainfall events.

MAIN STAKEHOLDERS AND THEIR INVOLVEMENT

The flooding problems had to be solved, and solutions using sustainable urban drainage systems would have a large impact in this area. Therefore a lot of stakeholders had to be involved:

- The municipality of Bergen; several departments were involved: urban planning, civil engineering, green, infrastructure;
- Consultancy agency TAUW; planning and implementation of sustainable urban drainage systems in several stages: long -and short-term measures;
- The water authority Hoogheemraadschap Hollands Noorderkwartier; guides municipalities regarding water quantity and water quality problems;
- The water authority Rijkswaterstaat; guides after-flood protection and the quality of water in the beach area;
- Residents; people participation is needed for the large-scale implementation of SUDS. Basins of 3000 m³ were implemented, which have a large impact in a dense urban area;
- Province Noord Holland; guides the municipality in Bergen on deeper groundwater level impact.

All stakeholders and their roles are summarised in Table 1.

Stakeholder	Role				Interest										
					Regulators and interest groups						Planning bodies				Others
	Decision-maker	Advisor	Developers	Long term ownership	Wild life	Heritage	Environment	Water quality	Water quantity	Local communities	Strategy planners	Development control	Building control	Road/Transport	
Municipality of Bergen	x		x	x			x	x	x		x	x	x	x	
Consultancy agency Tauw		x	x												
Water authority HHNK	x	x						x	x						
Water authority Rijkswaterstaat	x	x													
Province Noord Holland		x							x						
Local community							x			x					

TABLE 1. STAKEHOLDERS AND THEIR ROLES

WATER MANAGEMENT PROCEDURES

The European Water Framework Directive (WFD) aims at reduction of flooding and an enhanced protection of the aquatic environment. As a consequence, the WFD requires municipalities to address the emission from wastewater systems properly and to take action when these emissions affect the quality of receiving waters. Sustainable Urban Drainage Systems (SUDS) can play an important role in achieving this goal.

WATER MANAGEMENT SOLUTIONS

The implementation of SUDS in the densely populated polders (low-lying tracts of land with generally high groundwater tables and low permeable soil enclosed by embankments) of the Netherlands requires specific guidelines for design, construction and maintenance to prolong the lifespan of SUDS. However, the techniques used in the Netherlands can also be used in more undulating landscapes, adding flood risk management opportunities to the list of water quality applications that is already well established.

In order to make areas flood resilient and achieve Dutch quality ambitions there is a large variety of SUDS to choose from, such as: infiltration trenches and basins, (slow) sand filters, soakaways, ponds, swales, wetlands, bio-retention, filter strips, sedimentation basins, filters and pervious pavements.

SELECTED SOLUTIONS

For Egmond a wide variety of SUDS was available, choosing which systems were implemented was based on the following criteria:

- (removal) efficiency and reducing floods
- cost (building and maintenance)
- required space
- experience maintenance
- sustainability
- aesthetics
- robustness
- life cycle analyses

Experiences in designing, building and maintaining SUDS were gathered through an international literature review, interviews and fieldtrips.

In Egmond aan Zee several SUDS were implemented:

- swales
- improving the sewer capacity
- infiltration trenches
- infiltration basins
- pervious pavements
- water barriers to guide water

FIGURE 2. WATER BARRIERS TO PREVENT WATER FROM FLOWING TO THE LOWER CENTRE WERE INSTALLED. THE WATER IS STORED AND INFILTRATES TO REDUCE FLOODS

To implement SUDS in the right locations, flood mapping was used to establish the water flows in the Egmond area during storm water events. This method was used to search for above-ground measures against flooding.

In order to maximise the possibilities of interaction between professionals of different spatial fields (water, green, road) the maps were presented in a workshop using a touch table. Showing pictures and a visualisation of storm water flooding provides a relatively easily interpretable insight into the problem and the cause, making this tool ideal for multidisciplinary decision-making and the implementation of solutions like SUDS. Because the measures are implemented at street level, it is necessary for sewer specialists to discuss possible areas for ground level measures with professionals responsible for roads and green areas. These professionals from fields unrelated to water joined the discussion on how to solve the problem.

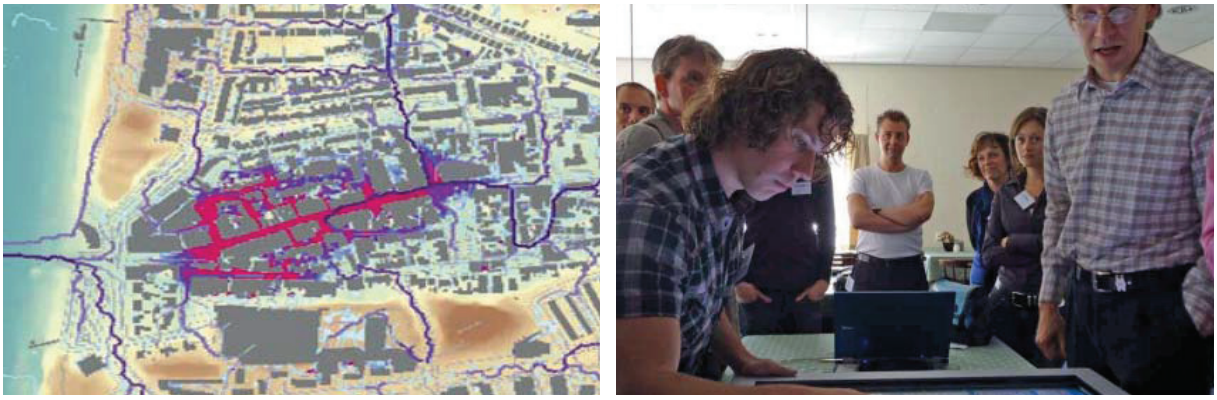

FIGURE 3. LEFT: RESULT OF FLOOD MAPPING; RIGHT: USING VISUAL TOOLS TO UNDERSTAND AND INTERACT WITH DIFFERENT STAKEHOLDERS

In order for the managers of the urban area in Bergen to take full advantage of the visual power of the maps a multi-disciplinary workshop was organized. In this workshop the results of flood mapping, showing the problems and possible solutions, were presented on the touch table. The touch table is used to:

- identify areas of interest;
- analyse the model output at those areas;
- decide whether to solve the identified problem;
- decide to find and discuss solutions;
- allow non-water professionals and specialists to understand easily interpretable visual maps;
- direct input from multiple disciplines to use in the decision-making.

This leads to fast decisions that are commonly accepted by the municipality and the parties involved.

DIFFICULTIES AND HOW THEY WERE OVERCOME

Implementing solutions in a dense urban area like Egmond aan Zee is a challenge. The area was developed over years, leaving little space for water to be stored or to infiltrate in the ground. To restore the natural water balance and make this area flood-resilient, numerous measures had to be implemented in a short time.

Plan of approach

First, a short list of quick and cost-effective measures was drawn up and discussed with all stakeholders. To prevent water from flowing from the higher parts to the lower centre, speed bumps were built and SUDS implemented to store the storm water and let it infiltrate where it lands. During the construction of these “simple” solutions, long-term plans were made which are highly effective but have a large impact on special planning and the community. Two large infiltration basins were designed for storing more than 6500 m^3 of storm water in the lower areas and prevent flooding. The basins’ volume was optimised by using innovative technical building solutions, constructing the walls above ground and lowering them during construction. This leads to lower space requirements, optimises the storage volume and minimises the obstruction for local residence in their daily lives.

To reduce the health risks, storm water sewers were inspected for foul water connections using temperature loggers. Wastewater from houses (e.g. water from showers, with a higher temperature) connected to storm water sewers were located and the systems were separated, reducing the risk of contact with wastewater and reducing emissions to the surface and groundwater.

KEY SUCCESS FACTORS

There are many factors that contributed to making the quick implementation of solutions to make Egmond aan Zee flood-resilient a success. Having so called “champions of change” in the municipality, consultants and a good cooperation from the water authorities was one determining factor. Using international technical and communication innovations and solutions was another.

The project Skills Integration and New Technologies (SKINT) encourages transnational knowledge exchange and the implementation of innovative technical and sustainable solutions which have already proved to be successful around the North Sea region. The problems and solutions in Egmond contributed to this transnational knowledge exchange. The municipality of Bergen in the Netherlands visited the municipality of Bergen in Norway and spoke at an international congress about the key success factors and lessons learned from this case study. Egmond aan Zee is also one of the districts in the transnational serious game WaterTown designed by the University of Abertay. The game is used to share knowledge about the problems and solutions whether they arise in the Netherlands, in Norway, in UK or in Scotland.

FIGURE 4. FLOODING IN EGMOND IN THE SERIOUS GAME WATERTOWN; RIGHT: APPLYING THE GAME AT DIFFERENT INTERACTIVE SEMINARS USING EGMOND AS A SUSTAINABLE EXAMPLE

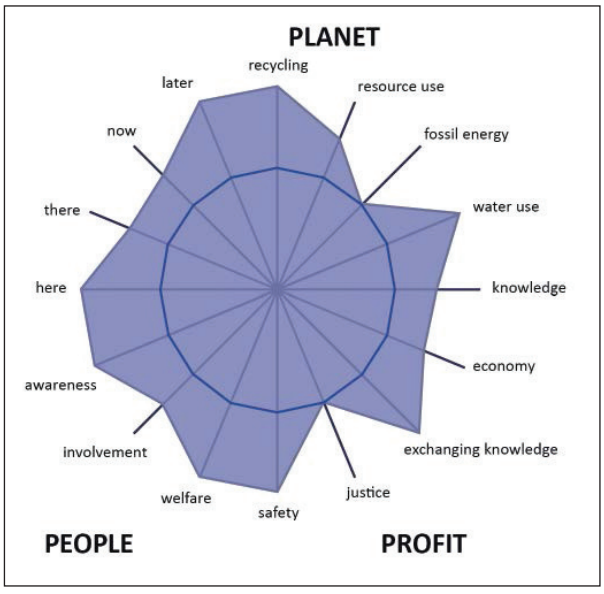

FIGURE 5. SPIDER DIAGRAM TO VISUALISE SUSTAINABILITY SCORE

SUSTAINABILITY ASSESSMENT

The solutions in Egmond aan Zee should be sustainable. This is an easy word to use but it raises a lot of questions in workgroups. Discussions about the sustainability of the different solutions have their origin in the different interests and ambitions of the various stakeholders. To rate the sustainability of this project, different categories are rated (“expert judgement”) and visualised in the spider web in Figure 5.

DISCUSSION AND CONCLUSIONS

Following the floods in Egmond aan Zee several solutions were implemented. With tools like flood mapping and international knowledge about sustainable urban drainage systems, in a short period of time this area was transformed into one of the most flood-resilient places on the globe.

The GIS-based method of modelling and mapping urban storm water flooding is an effective tool for deciding how to prevent urban storm water flooding in a cost-effective way. The output of the model is generated in a manner that allows specialists of various disciplines involved in determining measures at ground level to comprehend the process. The urban storm water flood maps visualised on the touch table improve the communication between various disciplines, generating an environment for fast, successful and cost-effective decision-making in the prevention of urban storm water flooding. Together with the serious game WaterTown from the University of Abertay, these communication tools will be used in several projects, like SKINT, which emphasise the need for speaking a multidisciplinary language to integrate the worlds of spatial planning and water management.

Transnational knowledge exchange is needed to raise awareness of the functioning of SUDS in different circumstances or countries. The monitoring and evaluation of SUDS in different European countries has yielded a wealth of experience which allows us to review and expand our guidelines of SUDS to guarantee their performance over time.