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Auteurs	Harry van Luijtelaar et al.
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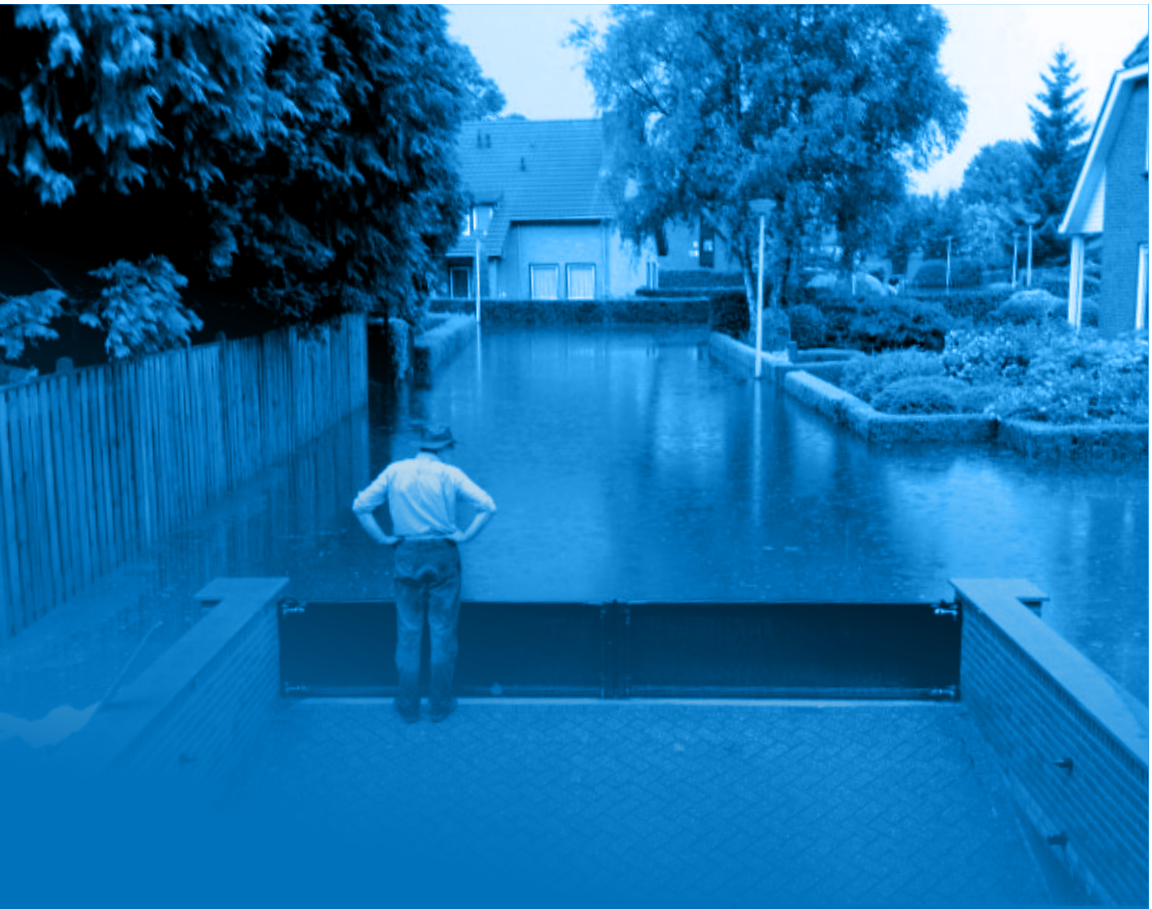

A review of solutions for rainwater problems in built-up areas

Examples and developments anno 2014

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During extreme rain events, intensities and volumes far exceed the standards used to design and test the drainage capacity of sewage systems in models. The standard design method uses rain events with a return period of 2 years, with a view to keeping storm flows within the sewer system and below street (flooding) level. (*Leidraad riolering, module C2100*).

A review of solutions for rainwater problems in built-up areas presents a wide range of practical and well-argued problem analyses and solutions. It also looks at current methods used to prevent further nuisance and damage. With this collection of articles water managers can better identify potential rainwater issues at an early stage and gain insight into how to tackle them.

Countering rainwater problems demands situation-specific solutions, and much is being done to further develop suitable check and design processes. The intention of this book is to document current methods and techniques not to present them as general standards, nor to pass judgment on them. We have simply made an attempt to present within the limited scope of these articles a straightforward record of the state of the art as it exists in 2014. We are fully aware that major developments are probably just around the corner.

This chapter presents an overview of the article summaries, grouped according to the following 6 subjects:

A. Precautions
B. Methods of analysis
C. Spatial planning
D. Residences and residents
E. New modelling tools
F. Authors workshop

2 Loon op Zand, precautions

Construction of storage and infiltration facilities to counter flooding

ing. Ronnie van Boekel (Buiten-Ruimte), r.vanboekel@buiten-ruimte.nl
ing. Gert Lemmen (Grontmij), gert.lemmen@grontmij.nl

Between 2004 and 2008 the Molenwijck district of Loon op Zand suffered severe flooding from rainwater on three occasions, resulting in a wave of complaints to the local municipal authority. The flooding was the effect of extreme rainfall compounded by the area being low-lying compared to its surroundings.
In order to study these problems extensive research was carried out using new simulation tools. The resulting model's reliability was then improved by adjusting the results by comparing them to field observations. The municipality organised public meetings and circulated newsletters to inform local residents about the proposed works. Residents were also asked to participate in the design process for the landscaping of two local parks. These local storm water storage and infiltration works now mean this area can cope with a once-per-century rain event.

3 Enschede, precautions

New surface-level discharge routes and retention areas prevent rainwater problems

ir. Erik Dekker (Witteveen+Bos), e.dekker@witteveenbos.nl
ing. Koen Wagelaar (gemeente Enschede), k.wagelaar@enschede.nl

Over the course of the last century, the outskirts on the north of the city of Enschede were developed from being a decidedly rural and sparsely populated area into an urban landscape with large areas of impermeable surfaces. The sewer system was gradually adapted to cope with the changed environment including the construction of additional temporary rainwater storage facilities. In recent decades the impermeable surface area has again increased, and the intensity of precipitation has also increased. As a result the sewer system has become prone to overloading. In 2010 heavy downpours caused water to enter buildings, and local authorities were forced to close flooded roads. In order to prevent future problems, the council proposed, in consultation with local residents, a set of precautionary works. Among other measures, these resulted in the construction in 2012 of new ground-level run-off channels as well as three retention areas in existing fields. Although some minor issues still need to be addressed, until now the countermeasures have proved to be up to their task.

4 Egmond aan Zee, precautions

Expert approach solves severe water problems

ir. Floris Boogaard (Tauw, TUDelft, Hanzehogeschool Groningen), floris.boogaard@tauw.nl
George Stockell (municipality of Bergen-NH), g.stockell@bergen-nh.nl

In the coastal resort of Egmond aan Zee, severe rainfall on a number of occasions resulted in major problems in the town centre with damage to houses and commercial premises. Following the floods of August 2006 the municipality of Bergen, together with consulting engineers, Tauw, drew up a programme of countermeasures to prevent similar problems occurring in the future. The majority of these measures were implemented between 2007 and 2013 and their performance is constantly monitored. A number of recent downpours produced no problems.

The measures for a small number of localities have still to be determined and implemented. Decisions over exact location and process for these remaining measures will be based on an analysis the monitoring data. The municipality will continue to monitor and maintain the rainwater processing facilities of Egmond aan Zee to ensure their continued efficacy.

5 Tholen, precautions

Ground surface-level measures provide robust, simple and affordable solutions to water run-off problems

Daniël van Veen BEng (municipality of Tholen), veen.d@tholen.nl

In recent years the municipality of Tholen has been hit by a number of downpours that have resulted in flooding problems causing damage to buildings and other property. In 2009 rainwater sewers were constructed with a view to avoiding overloading the combined sewer system at several locations. Nonetheless, intense rainstorms demonstrated the shortcomings of to prevent flooding and damage. Public consultation and additional field measurements revealed that amongst other problems many houses had their door sills at, or below, street level. Also, traffic bumps tended to dam up the streets, channelling the water into houses. Alterations to street level layouts were proposed following 1D/2D modelling and thereafter implemented. In the event of severe rainfall, the water is now channelled to areas less sensitive to damage. Although above ground features are far from new, they have once again demonstrated their value as a robust, simple and affordable solution to rainwater problems.

6 Helmond, precautions

'Water fields': decoupling rainwater from combined sewers to anticipate rainwater problems

ing. Frank Ramaekers (municipality of Helmond), f.ramaekers@helmond.nl
ing. Albert van Empel (municipality of Helmond), a.van.empel@helmond.nl
ir. Nina ter Linde (municipality of Helmond), n.ter.linde@helmond.nl

At the turn of the century the combined sewer system of part of the town of Helmond was due for replacement, while public spaces within the same area were considered well in need of a facelift. The creation of visible open water and retention of rainwater in public open spaces is also included in local water policy documents. Accordingly it was decided that a separate surface and foul water sewer systems would be constructed. Where appropriate infiltration sewers are used to divert the clean rainwater to a number of playing fields. The system has now been in use for over 13 years to general satisfaction. Each year, the fields get inundated on five to ten occasions for several hours, with puddles reaching 10 to 20 cm in depth. Sometimes water depths reach 50 cm, and even then the fields only take two days to dry out. No more rainwater problems have occurred since. By channelling rainwater flows into these relatively large recreational areas they function as an additional rainwater buffer capacity. A simple countermeasure has prevented residential areas flooding.

7 Leersum, precautions

Multi-stage rainwater storage and infiltration facilities

ing. Harm Middelburg (Copier Advies), h.middelburg@copiergroep.nl
ing. Gert Lemmen (Grontmij), gert.lemmen@grontmij.nl

In 2005, 2006 and 2007 extreme downpours in the hillside village of Leersum caused major flooding in houses, shops and the church. The local authority (Utrechts Heuvelrug) then decided to adopt structural measures to solve these problems in Leersum. Research and analysis by the consultancies DHV, Copier and Grontmij led the municipality to construct a range of large and smaller facilities to contain and retain the rainwater in stages also allowing it to infiltrate where it falls. This article discusses the implementation of these measures, focusing on the design principles and the model calculations. It also discusses the sizing of the facilities and the data being collected from these new storage and infiltration systems and the transfer of measurement data to the management department.

8 Borger-Odoorn (Exloo), precautions

Vertical infiltration: successful and cost-effective

Fokko Dijkstra (Wavin), fokko.dijkstra@wavin.nl
ir. Mark Vlok (Wavin), mark.vlok@wavin.nl

Up to 2007, the village of Exloo in the municipality of Borger-Odoorn regularly had problems with a combined sewer overflows that discharged into the local woods. This caused stench and visual pollution, to the dismay of tourists and local residents. In 2007 the municipality decided to put a stop to the overloading of the combined sewer, and opted for an innovative method to deal with the rainwater. Using a 'vertical infiltration technique' turned out to be both successful and more affordable than existing methods. Vertical infiltration facilities can be quickly and easily installed, causing little or no disruption to local residents. The Wavin company has since used the technique for large-scale projects.

9 Tubbergen (Albergen), methods of analysis

Improved insight into rainwater problems using an integrated model

ing. Benno Steentjes (Oranjewoud / Antea Group), benno.steentjes@anteagroup.com

Not only sewerage, but also surface-level flows, the layout of public spaces, and the nature of receiving waters all play their role when draining off precipitation. How can we gain insight into the interaction between these systems, and which model simulation best visualises potential flooding? In the municipality of Albergen these issues were addressed using six known problem locations. An integrated 1-D/2-D model simulation clearly offered advantages for mapping rainwater bottlenecks. Whether a similar integrated approach also offers the best solution in other urban areas is highly dependent on field experience and local knowledge. This article describes the Albergen research and its results. In addition it offers guidelines to rainwater modelling as well as other recommendations.

10 Nijmegen, methods of analysis

Researching possibilities of rainwater problem analysis using modelling methods

dr. ir. Jeroen Langeveld (Royal HaskoningDHV/TU Delft), jeroen.langeveld@rhdhv.com
ing. Bram Stuurman (Royal HaskoningDHV), bram.stuurman@rhdhv.com
Eduard Schilling (municipality of Nijmegen), e.schilling@nijmegen.nl

On 27 June 2009 the city of Nijmegen experienced a very local, once-in-a-decade downpour. Some parts of the city experienced significant flooding, with streets turning into fast flowing streams, whereas in other parts hardly any rainfall was recorded. The city council immediately gathered all the information they could on this storm event and the problems it caused. Having such an complete data set makes this a good case for comparing the current urban pluvial flooding modelling approaches. The research tested four urban flooding models in combination with a 1D sewerage model. In addition, the impact of the quality of precipitation data on model performance was analysed using four types of rainfall data (rain gauges and rain radar). Combining four sources of rainfall data and four modelling methods produced 16 combinations to be analysed. The model results were compared with data collected from sewer measurements and flooding observations. The conclusion is that only the highest quality rainfall radar data combined with the most detailed urban flooding model produces acceptable results.

11 Gilze en Rijen, methods of analysis

Unique approach by municipality and water board results in integrated regional methods

ir. Ewald Oude Luttikhuis (MWH), ewald.oudeluttikhuis@mwhglobal.com

In 2008 several locations in the municipality of Gilze en Rijen were severely affected by rainwater flooding. Loading docks, industrial parks, a roadside service station, a tunnel and a shopping centre were flooded. As this was not the first time that problems had occurred, it was decided to launch a structured campaign to tackle the matter. Together with the local water board, the municipality adopted a step-by-step approach to produce an integrated solution for the entire area. Options covering technical sewerage and surface water management aspects for both urban and rural areas were developed and investigated. The approach was unique in the way in it used rain data and simulation models. MWH used recent local rain data to produce a statistical 100-year precipitation sequence that included the current climate predictions. The close collaboration between the municipality and the water board has gone a long way to resolve the urban bottlenecks by taking measures in adjacent rural areas.

12 New Orleans, spatial planning

New, integrated and sustainable methods to combat precipitation problems in the U.S.

ir. Nanco Dolman (Royal HaskoningDHV), nanco.dolman@rhdhv.com
dr. ir. Frans van de Ven (Deltares / TU Delft), frans.vandeVen@deltares.nl

In the wake of hurricane Katrina in 2005 the Hurricane & Storm Damage Risk Reduction System (HSDRRS) around New Orleans was improved with reinforced levees and flood barriers. Within the floodwalls of the HSDRRS, the urban water system is based on the immediate discharge of rainwater run-off. This affects the urban hydrology of New Orleans. The lack of water storage capacity within the living environment leaves the city unable to cope with the excess of rainwater during the wet hurricane season. This season starts in September and lasts six months and this lack can result in severe (local) flooding. The remaining six months of the year are very dry, allowing subsidence of the soft marshy subsoil. As the result of a U.S.-Dutch collaboration, the Greater New Orleans Urban Water Plan was presented in September 2013. This first Urban Water Plan in the U.S. proposes an integrated and sustainable approach to urban water management and spatial development.

13 Municipalities, spatial planning

Successful anticipation of extreme rain events depends on collaboration within municipalities and with local residents

ing. Annelies Straatman (Hogeschool van Amsterdam), j.h.m.straatman@hva.nl
dr. ir. Jeroen Kluck (Hogeschool van Amsterdam, Tauw bv), jeroen.kluck@tauw.nl

This article describes how in recent years, a research team of the Amsterdam University of Applied Sciences has been investigating the ways municipalities deal with extreme precipitation events in urban environments. The research included the interviewing of municipal officials and discussing their experiences in implementing and embedding measures to counter flooding problems. Timely collaboration with public space managers is considered to be of special importance as ground surface features have an important role in preventing flooding of roads, houses and shops. Designing and implementing these measures requires the combined expertise and financial means of these various stakeholders. Another important point raised by those interviewed is the involvement of and collaboration with local residents.

14 Rotterdam, spatial planning

Additional water storage facilities reduce rainwater problems and make the city more attractive

ir. Jorg Pieneman (gemeente Rotterdam), jn.pieneman@rotterdam.nl
ir. Daniël Goedbloed (gemeente Rotterdam, nu Waternet), daniel.goedbloed@waternet.nl

Extreme rain events are a major challenge in densely built-up and populated areas such as the centre of Rotterdam. Problems caused by extreme downpours underline the need for additional rainwater storage. It is a challenge for urban designers to create public spaces and buildings which can, when necessary, also serve as rainwater buffers. The municipality and the district water board have collaborated to create a large increase in the rainwater storage capacity both above and below ground in the centre of Rotterdam. The resulting set of measures has not only reduced rainwater flooding in the city centre but are also seen as an attractive addition to the city landscape.

15 IJsselstein, residences and residents

Effective approach to tackle domestic rainwater problems during summer showers

ir. Arnout Linckens (Wareco Ingenieurs), a.linckens@wareco.nl

The residents of houses in IJsselstein were reluctant to go away for summer holidays, having experienced flooding caused by recent severe rain storms and for some more than once in one year. The nature of the problems varied greatly. In one house, water backed up and overflowed via the toilet bowl, in other houses convector heater wells flooded, or water was found to be entering through floors and walls. Insight into the situation was gained through interviewing residents and cross-section drawings detailing ground investigations, water level and ground level measurements.Using these the local authority could demonstrate to the residents what was necessary to alleviate the problems. The understanding and collaboration of the residents was ensured by fully informing and involving them in the solutions. No more problems were reported in 2012 and 2013.

16 Information, residences and residents

Information is everywhere – four ways to gather relevant data

Antal Zuurman M.Sc. (gemeente Nijmegen), a.zuurman@nijmegen.nl

Municipalities find it hard to gather proper information about problems caused by severe rainfall. Extreme downpours are few and far between and can be highly local. Most people are not quick to complain about occasional and short lasting problems. However, accurate information is necessary in order to gain insight into the causes and effects of flooding, especially if adequate countermeasures are to be taken. One of the available tools is computer modelling but the results need to be compared with and verified by data gathered in the field.This article sketches four methods of gathering data based on the experience of researching rain generated problems in the town of Nijmegen. The data cover how public open spaces react to rainwater runoff and the effects of severe events on private property. The four methods are researching archives, problem reporting, field inventories , and interviews with residents. The research in Nijmegen show how relevant information can emerge from the combination of data from different sources.

17 Domestic rainwater problems, residences and residents

Domestic rainwater problems – tools for sewerage experts

ir. John Evers (Kragten), je@kragten.nl

In recent years there has been an increase in extreme rain events. As long as the resulting problems remain restricted to public open spaces and street flooding is of short duration, the nuisance is tolerated. However, once rainwater, or even sewage, enters private residences, severe nuisance results, and emotions of residents will often run high. When analysing the situation, sewerage experts need to remain as objective as possible and filter the available information correctly. This can be difficult, all the more because undocumented historical interior and exterior alterations to houses often make it almost impossible to understand how the drains actually work. This article offers advice on how to discover the causes of rainwater problems and appropriate solutions.

18 Amersfoort, new modelling tools

Detailed runoff and infiltration model provides insight into rainwater problems and the efficacy of countermeasures

drs. Maarten Spijker (HydroLogic), maarten.spijker@hydrologic.com
ir. Wytse Dassen (HydroLogic), wytse.dassen@hydrologic.com
Ina Loovers (municipality of Amersfoort), i.loovers@amersfoort.nl

As part of the HydroCity project in Amersfoort, a highly detailed runoff and infiltration model was developed. The PriceXD model simulates the waterflows in a virtual model to visualise the effects of a range of rainwater events. It can show which proportion of rainwater runs off into the sewer system through storm drains, which part infiltrates, and which part runs off above ground. PriceXD models the urban hydrology in very fine detail by integrating high-grade spatial information and hydraulic models of both above and below ground. This allows urban water managers to better understand extreme events, and the actual nuisance caused by rainwater and helps evaluate the probable efficacy of both above and below ground countermeasures.

19 3Di development, new modelling tools

3Di – Technology and benefits of an integrated environment model for water in urban contexts

dr. ir. Elgard van Leeuwen (Deltares), elgard.vanleeuwen@deltares.nl
dr. ir. Wytze Schuurmans (Nelen en Schuurmans), wytze.schuurmans@nelen-schuurmans.nl

As part of the 3Di Water Management research programme, a mathematical model is being developed that integrates water flows in public open space and in sewer systems. A robust calculation scheme enables the model to rapidly provide a realistic and highly detailed (‘down to paving level’) image of the water flows in an area. It also provides insight into the effects of interventions in water and wastewater systems and public spaces. In this respect 3Di has progressed far beyond the simple calculation of standard rainfall events. The 3Di mathematical model provides a means to arrive at pragmatic solutions for water nuisance issues by simulating the real world.It offers results for immediate assessment by others and not only modelling experts. This article discusses the current state of 3Di. What will the integrated environment model look like? What makes up the underlying calculation network? What will it enable you to do when it is finished?

20 Ground level, new modelling tools

Use of AHN2 and MLM laser data provides improved foundation for countermeasures

ing. Marcel Glasbergen (ARCADIS), marcel.glasbergen@arcadis.nl
ir. Michel Moens (ARCADIS), michel.moens@arcadis.nl

With extreme weather events on the increase, municipalities are looking for ways to map not only the performance of sewer systems underground, but also the rainwater runoff and flooding at ground level. This requires highly detailed ground level information. The primary resources for such information are the Actueel Hoogtebestand Nederland - the Dutch Current Contour Database (AHN2) and the less well-known Mobile Laser Mapping (MLM). These offer interesting opportunities and each has its own specific criteria, and both are discussed in this article. Insight is also offered into the benefits by the use of AHN2 and MLM data in model simulations. The number of uncertainties can be reduced, thus improving the basis for determining countermeasures, both above and below ground..

21 Radar data, new modelling tools

Insight into extreme precipitation using multi-year radar data sets with high spatial detail

dr. ir. Aart Overeem (Hydrology and Quantitative Water Management Group of Wageningen University, and Royal Netherlands Meteorological Institute), aart.overeem@wur.nl

Extreme precipitation in urban environments can cause considerable problems. In order to gain more insight into the performance of sewer systems and the urban environment much is to be gained from studying an extreme event and its consequences. Two recently developed climatological radar rainfall data sets offer new opportunities. These data sets cover the periods 1998-2012 (6-km areas) and 2009-2012 (1-km areas) and provide countrywide rain data with great spatial detail. This article analyses the data to gain more insight into the occurrence of extreme events in the Netherlands and in particular in urban environments. It discusses the average frequency of extreme events per year, the most extreme precipitation events, and the frequency of extreme precipitation per municipality. The results provide a different way of looking at extreme events in urban contexts.

22 Design standards, new modelling tools

Looking beyond the standard design rain event

ir. Harry van Luijtelaar (Stichting RIONED), harry.vanluijtelaar@rioned.org

In the past five to ten years, problems caused heavy rain have increased in the Netherlands. The increase in the number of extreme downpours could help to explain the increase in rainwater problems. However, other issues also play a role, including the layout and redevelopment of public spaces, the phasing out of overflows, and schemes where rainwater runoff is directed away from combined sewers. The general effect is that runoff buffer capacity above ground level has become even more important. Unfortunately the current design method as laid out in the C2100 module (of the national sewerage manual) fails to take the ground-level buffer capacities into account. New techniques can combine the effects of extreme rainfall at ground level (runoff, storage, infiltration) with the underground sewer system. This can provide a basis for informed judgments regarding the vulnerability of an area and for choices over appropriate and effective countermeasures.

23 Report, authors workshop

Inspiring authors workshop on dealing with extreme precipitation

ir. Peter Ganzevles (Archirion), peter.ganzevles@archirion.nl

In November 2013, the authors of the articles in this book took part in an inspiring workshop. Each was given five minutes to present the gist of their article. Regardless of the tight schedule, the presentations raised many questions. The lively debates that followed covered; the countermeasures offered by municipalities to prevent flooding, the consequences of tackling water problems, and the methods available to provide realistic visualisations of sewer and waterway systems. It was not the intention to answer to all the dilemmas, or to lay down a systematic and consistent method for tackling flooding. The participants' impressions will serve as an introduction to this publication and perhaps a way forward when looking for effective and consistent methods.

24 Survey, authors workshop

Summary of topics from on-line workshop survey

ir. Peter Ganzevles (Archirion), peter.ganzevles@archirion.nl

By way of preparing for the 7 November 2013 workshop, the 32 authors and editors who worked on this book submitted a total of 60 propositions. After the workshop, they all responded to the propositions through an on-line survey. This article presents the most important results. Subjects that came up for discussion include collaboration with district water authorities, the value of design rain series and the spatial distribution of rain, model simulations, above an below ground countermeasures, and communication with third-parties. The survey results will be used to fuel discussions and the development and exchange of knowledge amongst experts and other interested parties. The general impression is that relatively limited countermeasures, in particular at street level, can prevent or reduce many problems caused by many severe rain events.