Multifunctional Spaces for Flood Management – an Approach for the City of Hamburg, Germany

Infrastructure, climate change adaption, heavy rain, flood management, flood protection, multifunctional space, joint municipal task

Axel Waldhoff, Juliane Ziegler, Gerrit Bischoff and Sabine Rabe

If design criterion of sewer systems is exceeded, sewer overflow and flooding of streets and properties with tremendous damage can be the consequence. Taking the risks and consequences of climate change into account, in combination with increasing surface sealing, the City of Hamburg has to face an increase of sewer overflow and flooding of streets. A broadly discussed approach for flooding problems caused by sewer overflow and surface run-off during extreme precipitation events among urban drainage planners is the implementation of multifunctional spaces as a risk prevention measure. Within the project RISA – Rain InfraStructure Adaption, HAMBURG WASSER and the State Ministry for Urban Development and Environment of Hamburg initiated pilot projects to analyze chances and opportunities for multifunctional spaces under existing conditions.

1. Introduction

The City of Hamburg is facing, like any other growing metropolis, the challenges of increasing surface sealing by redensification and new site development and changing precipitation pattern as a consequence of climate change. Both aspects lead to more stormwater runoff in the city which has to be managed in quality and quantity. Furthermore, legal and quality demands concerning stormwater management (SWM) and flood management due to heavy rainfall have risen in the last decades.

Therefore, the project RISA – Rain InfraStructure Adaption (www.risa-hamburg.de) aims at developing adequate responses concerning stormwater management in order to avoid flooding of streets and properties as well as further water pollution from sewer overflow and street run-off on the technical and administrational level. The main objectives of RISA are to maintain the common drainage comfort and to guarantee and improve flood protection, waterbody protection and to achieve near-natural water balance.

The technical level of the project focuses on the development of technical tools (e.g. GIS-based maps for flood risk analysis, infiltration and space capacity analysis), the implementation of technical measures for urban flood management during heavy rainfall and the development of design requirements, e.g. to determine the necessity of stormwater treatment. All these approaches are tested in pilot projects.

On a more administrational level, the project seeks to integrate water management measures into urban and regional planning and to adapt the institutional setting correspondingly. Furthermore, the necessity of joint municipal tasks concerning stormwater management is realized by RISA which incorporates interdisciplinary of different domains (e. g. spatial planners, traffic planners, urban drainage and water body planners, civil engineers). The project seeks to create the appropriate conditions enabling the implementation of a forward-looking and sustainable stormwater management in Hamburg.

The holistic communication concept of RISA ensures the information and education of all relevant stakeholders (citizens, municipal and political administration, operating companies for drainage system and water body, consultant and engineering companies, universities, etc.).

The results of the project will support the development of a so called "structural plan stormwater". In doing so, a guidance document for administrations, experts and property owners for the implementation of a new stormwater management is given. Hence, the project RISA contributes to the climate protection concept and the climate change adaptation strategy of the Senate of Hamburg.

This article focuses on urban flood management due to heavy rainfall, which is one of the main topics of RISA as mentioned above. Within this topic, RISA works

e.g. on concepts of "multifunctional spaces" as adaption approach to better flood management. This concept will be presented in theory and by means of a pilot project.

2. Needs and Reasons for Multifunctional Spaces for Flood Management

In general, combined as well as separate sewer systems are designed for defined return periods of precipitation events according to different types of area, e.g. city centre, urban area, rural area [1, 2]. If design criterion is exceeded, sewer overflow and flooding of streets and properties with tremendous damage can be the consequence.

As mentioned in chapter 0, the City of Hamburg has to face an increase of stormwater runoff in the city and therefore more sewer overflows including the risk of flooding. Economic and pragmatic solutions for this problem can only be realized as a joint municipal task, since construction of additional retention volume within the sewer system is inefficient/uneconomic and free spaces in dense urban areas are rare.

The joint municipal task means that planners of any infrastructure, like traffic planners, drainage planners and landscape architects, have to work together to develop suitable and affordable solutions. Furthermore, the idea of a joint municipal task incorporates the fact that urban flood protection does not lie within the sole responsibility of the sewage system, as shown in **Figure 1**.

To fulfill the needed design criterion and to ensure a defined drainage comfort, all common measures of urban water management can be installed / used, like sewers, decentralized stormwater management measures, retention ponds etc. If design criterion is exceeded, overflow is likely to occur and has to be managed at the surface, e.g. by using streets for the discharge of overflow water. During extreme precipitation events or under special local conditions, additional object protection like flood protection barriers etc. are required.

A broadly discussed approach for flooding problems caused by sewer overflow and surface run-off among urban drainage planners is the implementation of multifunctional spaces as a risk prevention measure. That means that traffic, recreational or other appropriate urban areas are activated as flood control measure for short-term storage, retention or infiltration of (surface) runoff to avoid flood damage at sensitive urban infrastructure.

3. Definition of Multifunctional Spaces in Hamburg

The definition of multifunctional spaces for Hamburg was established within the Competence Network HAMBURG WASSER in 2009 [7].

Multifunctional spaces like streets, parking places, green spaces, sports and playgrounds are temporarily used for short term retention and/ or transportation of runoff peaks during extreme precipitation events. These extreme precipitation events occur once every five years, for streets the occurrence is limited to once in ten years. Therefore, the multifunctional usage of spaces is not the rule but the exception. According to the risk potential of flooding and according to the utilization intensity of space, the usage as a multifunctional space has to be decided individually.

More details, information and a documentation of project examples are given in [7].

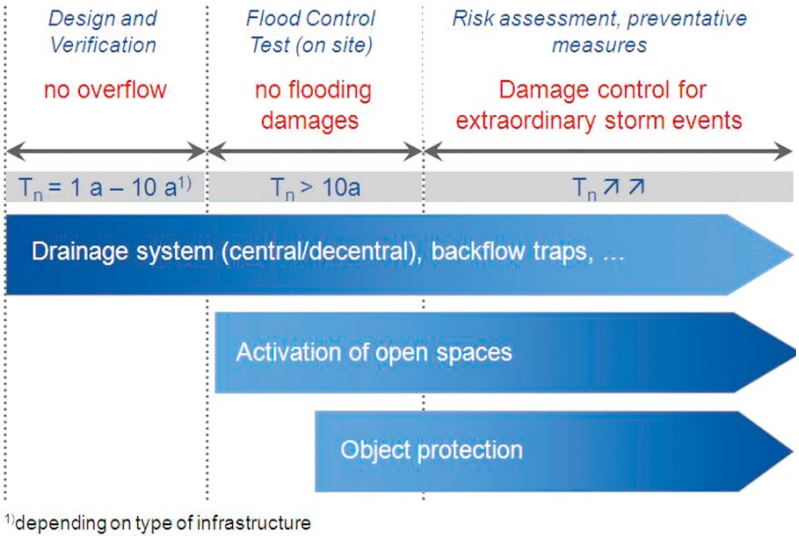


***Figure 1**. Design and verification of urban drainage systems, source: DWA-AG ES 2.5 (modified).*

4. Pilot

Street flooding reoccurred in the past in an urban district in the north of Hamburg, as shown in **figure 2**. Besides the obvious reduction of road and traffic safety, a nearby basement garage is highly at risk of being flooded.

The detailed analysis of the event, using hydrodynamic drainage simulation, digital terrain model and aero photos combined with site visits showed that rainwater from upper streets is flowing on the surface to the low point of the affected traffic area. The dimensioning of the existing drainage system (separate system) in that area, especially in the affected street, is sufficient according to [1, 2]. The implementation of additional manholes would lead to a partial solution of the flooding problem.

Nevertheless, the additional manholes will not lead to permanent flood protection in the case of extreme precipitation events.

To increase flood protection of the traffic area and the basement garage, the following unconventional solution was developed. The solution is based on the idea to use the existing retention volume of the street to store the stormwater and to implement a "flow path" which discharges the water to a nearby situated public

park. In the park, which is designed as a multifunctional space, the water can infiltrate without causing damage. The following figure (**figure 3**) demonstrates the principle parts (retention, flow path, infiltration) of the solution.

The dimension of the multifunctional space within the public park (i.e. the portion of the park which is needed as infiltration area) in case of a two-year (left) and a thirty-year rain event (right) is illustrated in **Figure 4**.

Figure 5 gives a more realistic impression on how the public park could look like during dry and wet weather. During dry weather, the multifunctional space can be used for leisure activities like soccer and other games. During heavy rainfall, stormwater runoff is guided by the flow path (integrated in an existing footpath) to the soft deepening of the green area which already exists. Maximum water level is up to 30 cm as it is illustrated in Figure 4 for a thirty year event. The activated retention / infiltration volume in the public park is up to 330 m^3.

For the adaption and transformation of the traffic area, more technical aspects have to be taken into account. Technical details of the affected traffic area are shown in **Figure 6**.

The adaption and transformation of the affected traffic area can be accomplished with minimal changes in the existing street composition. To ensure the accumulation and guidance of the runoff water on the surface to the flow path, new profiling of the road surface is required. At the same time, additional manholes are implemented in the low points to improve the drainage situation of the traffic area.

The additional manholes and the new profiling of the road pavement within the range of centimeters ensure the hydraulically required longitudinal gradient. Maximum water level on the street will be less than 10 cm. In total, a storage or retention volume of 12 m^3 can be realized with these minimal structural measures on the street. By changing the roof profile of the street to a unilateral profile at the connection sector between street and flow path, the discharge of surface water from the whole traffic area is guaranteed. The planning process takes the relevant rules and standards for traffic areas into account [3, 4, 5, 6].

In conclusion of the planning process, the existing technical and design questions could be solved. The relevant hydraulic information like available and required storage capacity, needed gradient and existing soil conditions in the park could be determined. Furthermore, a possible and suitable alignment profile for the flow path from the traffic area to the public park was found, including a topographical survey and the detection of cables, pipes and possibly existing warfare materials. A survey report ensures that the existing trees within the public park will not take any damage by infil-

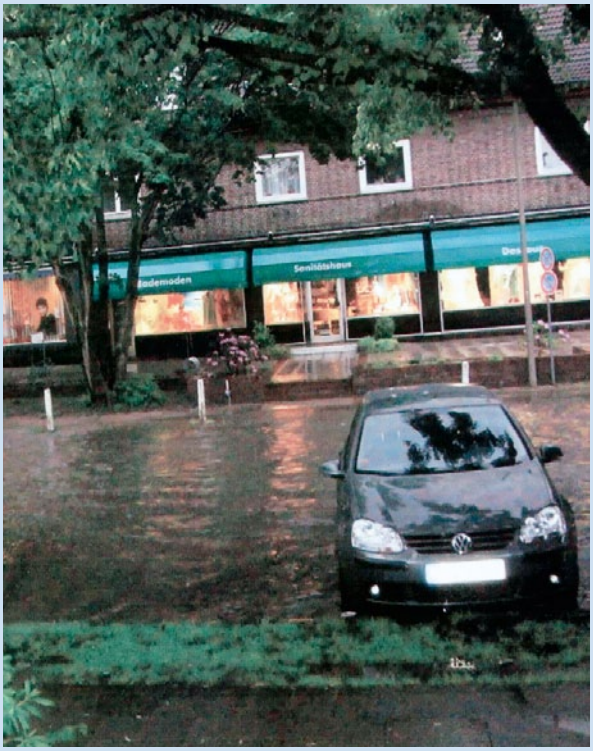


***Figure 2**. Street flooding after heavy rainfall (Tn = 30a), source: HAMBURG WASSER.*

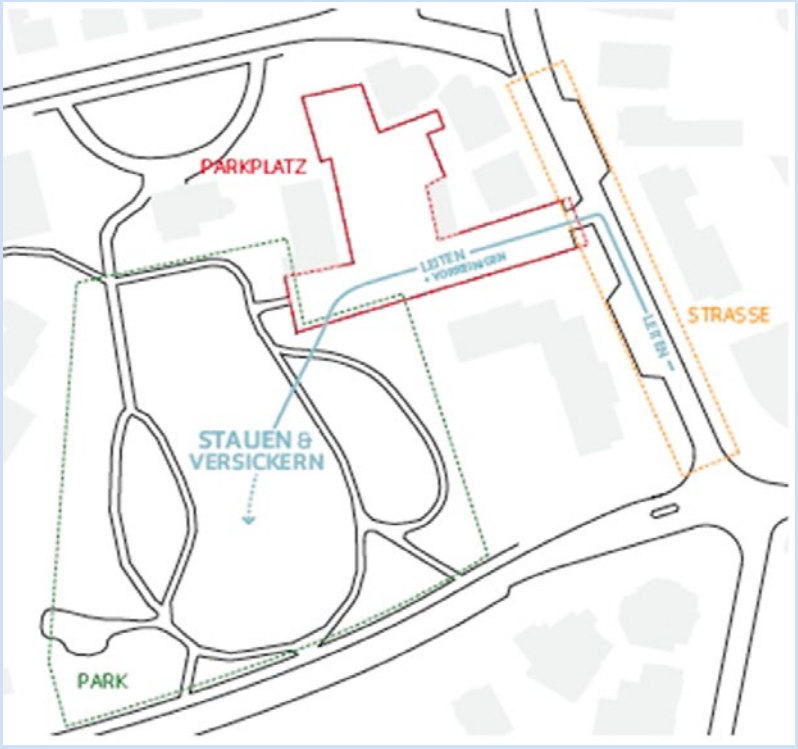


***Figure 3**. Schematic diagram of flood solution, source: osp urbanelandschaften.*

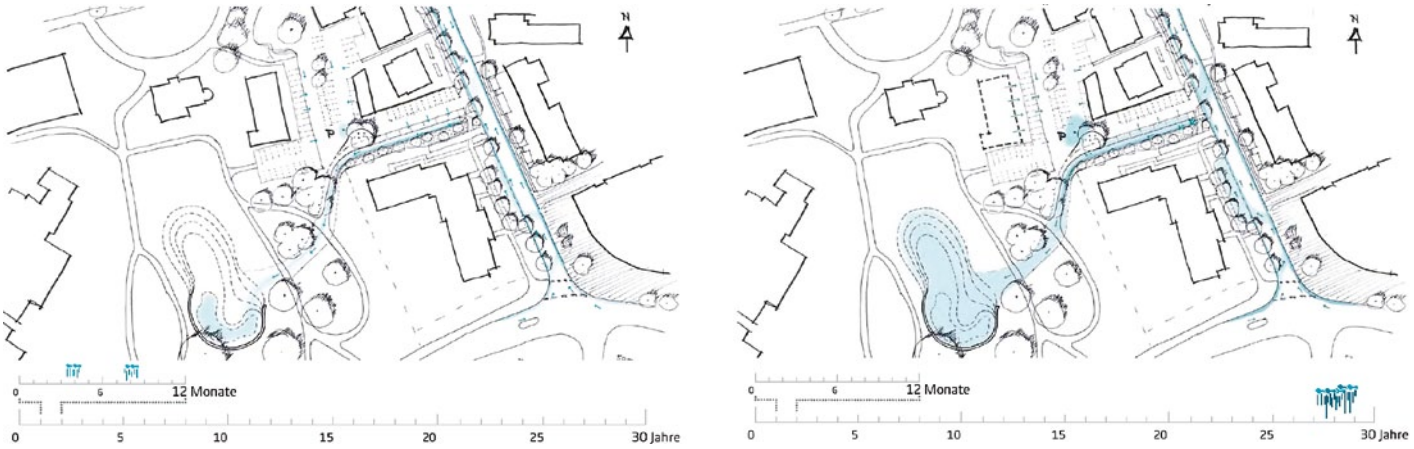


***Figure 4**. Dimension of the multifunctional space for a two-year and a thirty-year rain event (draft), source: osp urbanelandschaften.*

trating stormwater. In summary, the drainage planning for the pilot project is completed. The draft plans concerning the landscape architecture of the public park and the technical design of the traffic area have reached a basic design level.

The integrated planning approach, combining drainage, traffic and landscape planning right from the beginning of the project, offers the chance to implement a water sensitive urban design into the existing urban district.

At the moment, a communication concept for the implementation of the described pilot project is developed.

5. Conclusions

From a technical and design based point of view, the project can be realized. The close cooperation between the different disciplines was a benefit for the whole planning process and a new experience for all participants. Within the process, new design criterions and

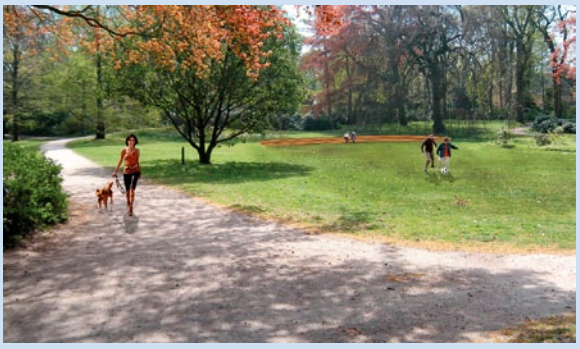
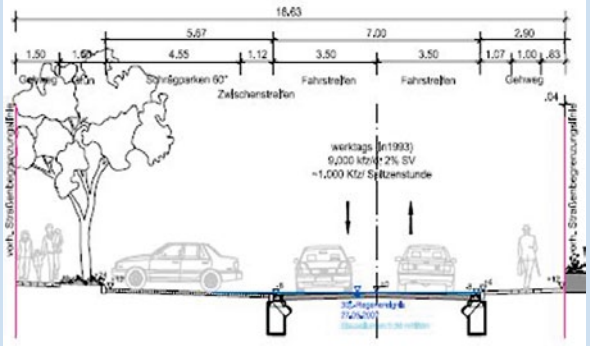


***Figure 5**. Illustration of the park during dry (left) and wet weather (right), source: osp urbanelandschaften.*



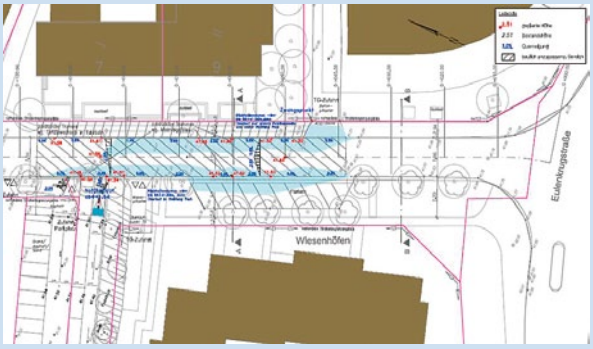


***Figure 6**. Technical details for traffic area, source: ARGUS.*

restrictions could be developed and elaborated and feasible solutions were achieved. The main restrictions the project focuses at the moment are based on financing and the fact that the public park is under preservation order that leads to specific design requirements.

The proposed drainage and flood protection solution is a special and specific solution, strongly characterized by water sensitive urban design and an integrated planning approach. Therefore, the proposed solution offers more an improving potential for the whole district in an architectural sense than a feasible drainage solution. Furthermore, the project has shown that the implementation of multifunctional spaces under existing conditions is facing a high variability of restrictions. These restrictions lead to a very complex planning process, even in a rather small project as the mentioned one.

Based on the overall experiences of the pilot and former projects, the authors come to the conclusion that the implementation of multifunctional spaces can only be a special solution approach for flooding problems under existing conditions. The transferability of results and conclusions of projects are highly limited. Every project has to be managed in particular.

For new developments, multifunctional spaces can be a suitable and interesting approach if the integrated planning starts at the beginning as mentioned within the joint municipal task of flood protection. By doing so, economic and pragmatic solutions incorporating the principles of water sensitive urban design are possible.

References

[1] Deutsche Vereinigung für Wasserwirtschaft, Abwasser, und Abfall e.V.. Arbeitsblatt DWA-A 118 – Hydraulische Bemessung und Nachweis von Entwässerungssystemen. Hennef 2006.

[2] DIN Deutsches Institut für Normung e.V.- Normenausschuss im Wasserwesen (NAW). DIN EN 752 – Entwässerungssysteme außerhalb von Gebäuden. Berlin 1996.

[3] Forschungsgesellschaft für Straßen- und Verkehrswesen FGSV, Arbeitsgruppe Erd- und Grundbau, Richtlinie für die Anlagen von Straßen RAS, Teil Entwässerung RAS-EW, Ausgabe 2005.

[4] Forschungsgesellschaft für Straßen- und Verkehrswesen FGSV, Arbeitsgruppe Straßenentwurf, Richtlinie für die Anlage von Stadtstraßen RASt 06, Ausgabe 2006.

[5] Freie und Hansestadt Hamburg, Behörde für Stadtentwicklung und Umwelt,
Entwurfsrichtlinie 1: Standardisierter Oberbau mit Asphaltdecken für Fahrbahnen, Ausgabe 2006, Fassung 05/10.
Entwurfsrichtlinie 2: Standardisierter Oberbau mit Pflasterdecken, Plattenbelägen und sonstigen Decken für Fahrbahnen und Nebenflächen, Ausgabe 2006, Fassung 05/10
Entwurfsrichtlinie 3: Einfassungen von Straßenverkehrsflächen, Ausgabe 2005, Fassung 2006
Entwurfsrichtlinie 4: Ableiten des Oberflächenwassers von Straßenverkehrsflächen, Ausgabe 2006.

[6] Freie und Hansestadt Hamburg, Planungshinweise für Stadtstraßen in Hamburg (PLAST), Stand 05/2012.

[7] KometenzNetzwerk HAMBURG WASSER, Projekt Regenwassermanagement für Hamburg, Abschlussbericht 2010, www.risa-hamburg.de.

Authors

Dr.-Ing. **Axel Waldhoff**
(corresponding author) |
E-Mail: axel.waldhoff@hamburgwasser.de

Dipl.-Ing. **Juliane Ziegler**
Dipl.-Ing. **Gerrit Bischoff**
HAMBURG WASSER |
Billhorner Deich 2 |
D-20539 Hamburg

Sabine Rabe
osp urbandelandschaften |
Kastanienallee 9 |
D-20359 Hamburg