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Water Sensitive Urban Design – results and principles

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Abstract
Based upon a best practice analysis on regional, city and project level a definition and principles for successful planning and implementation of 'Water Sensitive Urban Design' are made within WP 5.1 in Hamburg. 'Water Sensitive Urban Design' is defined as the interdisciplinary cooperation of water management, urban design and landscape architecture which considers all parts of the urban water cycle, combines water management function and urban design approaches and facilitates synergies for the ecological, economical, social and cultural sustainability.

Keywords: Water Sensitive Urban Design, design manual, best practice analysis, definition, principles

1 Research of Water Sensitive Urban Design

1.1 Best practice analysis of Water Sensitive Urban Design

The research based on case study analysis of best practice examples of Water Sensitive Urban Design (WSUD) on different spatial levels. The documentation and analysis of case studies is focused on three spatial levels:

- City and regional-wide level: Urban planning strategies, methods and instruments, which are appropriate to integrate WSUD-solutions and concepts in city or regional level are evaluated. The requirements of the overall spatial planning for water management and vice versa are described. The management function of the city-wide plans and their objectives and guiding principles is illustrated.
- District level: The interaction between the water management system and the urban structure of districts is described. For the analysis a wide understanding of sustainability with ecological, economical, social and cultural demands is considered.

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- Project level: Innovative small-scale solutions of WSUD and their urban, landscape and water management design are documented and analysed. Single measures and elements and their integration in superior levels are described.

The investigation mainly relied on interviews with experts and site investigations but also on the interpretation of planning documents. The results are united and summarised in continuous descriptions. In the following basic findings of the case studies are described.

Municipality of Hamburg

In the municipality of Hamburg a case study analysis on city level, district level and project level are carried out. On city level the requirements of the overall spatial planning for water management and vice versa are described. Several tools for spatial planning and water management on city-level are used. For water supply one general and long-term master plan exist. For sewer system and sewerage treatment several city-wide construction programs are used. For stormwater management a city-wide planning and coordination is missing. The storm water management is limited on project-level. Similarity of all water management concepts is that they are focused on maintenance, rehabilitation and advancement of the existing infrastructure. Also the spatial development is focused on inner city development and brownfield redevelopment. Beside the city-wide analysis five small scale case studies on district and project level are completed.

- In the quarter 'Neuallermoehe West' a network of canals was developed which is connected with the surrounding traditional drainage system. The canal network serves for decentralized stormwater management and the development of attractive locations. The function as well as the urban design of the canal network is well adapted on the local conditions of the marshland. This is an important precondition for ecological, economical, social and cultural sustainability.
- In the residential area 'Trabrennbahn Farmsen' a ditch network with two central retention ponds was realized. The ponds are located in the green centre of the settlement – the former oval of the racetrack. The green centre serves for several uses, decentralized stormwater management, conservation of nature, recreational uses, children's games etc. The multifunctional use of the open space enables several synergies. Because the stormwater is collected in existing ponds, which are worth of natural protection, it was necessary to attach importance on a good quality of storm water. To guarantee good water quality a combination of different measures is necessary: exclusion of car traffic to prevent pollution, treatment of storm water in sedimentation basins, improvement of autopurification etc.
- 'Merkur Park' is documented as a case study of decentralized stormwater management in commercial areas. Also in commercial areas storm water management enables the development of an attractive open space.
- The case study 'Dorfanger Boberg' illustrates, that some elements of stormwater management enables an emphasised design (e.g. water bodies with a good water quality). On the contrary other elements (e.g. non permanent water bodies or small ditches) require an inconspicuous integration in the surrounding landscape. The suitable adaptation of the existing design vocabulary is necessary. In 'Dorfanger Boberg' a water association takes over responsibilities for operation and maintenance of the water management systems. Water associations are a tried and tested form of organization.
- The residential area 'Heidberg Villages' illustrates the importance of handling altitude differences caused by storm water management. The dwelling mounds which protect the buildings and the infrastructure were constructed with steep embankment. These embankments and missing possibilities for access obstruct the multifunctional usage of the remaining open space. The problem is caused by a one-to-one implementation by sectoral planning. The non-

sensitive handling of the topography and the missing interdisciplinary cooperation affects the sustainability of the case study.

Emscherregion

In the Emscherregion a region-wide analysis of WSUD is realised. In the region all water management activities are focused on one important project, the redevelopment of the whole Emscher river system. The former Emscher was an open sewerage system. Objective of the redevelopment is the construction of a semi natural river system. An ecological, economical, social and cultural sustainability of the Emscher system is aspired. The superior project includes several parts of the urban water cycle, water pollution control, water resource management, flood protection, sewerage treatment, stormwater management etc. Furthermore the concerns of urban and landscape design are considered. The redevelopment facilitates the implementation of several water management innovations. The Emscherregion serves as best practice analysis for WSUD on regional level. Furthermore five small scale case studies of WSUD on district and project level are documented.

- The mixed residential and commercial site 'Bochum-Wattenscheid Zeche Holland' is a typical example for brownfied redevelopment of an old coal mine complex. For the site a decentralised stormwater management system with an appropriate landscape design was realised. The stormwater management system was integrated in the ensemble which is protected as a historic monument and contributes to the development of an attractive location.
- The landscape park 'Duisburg Landschaftspark Nord' is a key element of the regional park project 'Emscher Landschaftspark' which started 15 years ago and is still under construction. The landscape park is a redevelopment of a former iron and steel works. Decentralised stormwater management as well as the renaturation of a part of the Emscher river are constituents of the landscape park. Several urban and landscape design solutions for storm water management are realised.
- The residential site 'Gelsenkirchen Küppersbusch' has an enclosed decentralised stormwater management system. The stormwater management system contributes to the development of a settlement with an unique identity. Problems are the missing connection with the adjacent areas as well as the expressive urban design.
- The residential site 'Gelsenkirchen Schüngelberg' was an important research and demonstration project of the 'IBA Emscherpark' for decentralised stormwater management. In this area one of the first trough-trench systems for stormwater management was developed. The stormwater management was realised in an existing as well as a new developed part of the settlement.
- The residential site 'Bottrop Welheimer Mark' is an up-to-date example of stormwater management in the Emscherregion. The project is included in the different current master plans. The stormwater management system is implemented in an existing site and contributes to social redevelopment of the settlement.

Municipality of Zaragoza

The municipality of Zaragoza is documented as case study on city level. Because of the lack of water and the efforts to limit the expansion of the dessert the region Aragón requires an effective water management. So one of the first integral bodies for river management in the world, the 'Confederención Hidrográfica del Ebro' is located in Zaragoza. The present 'Ebro Riverfront Project'‘ serves for the regeneration of the riverside as well as the development of a main green corridor. The

connection between urban and landscape planning (e.g. EXPO Zargaoza) and large-scale water management projects (e.g. Ebro river restoration programme) is illustrated.

Progress

Further case studies are planned in demonstration cities on international scale. The results of the case studies are accurately assessed in relation to their ecological, social, economical and cultural advantages and disadvantages. As result principles for WSUD as well as a design manual of WSUD are developed.

1.2 Design Manual 'Water Sensitive Urban Design'

Based on the results of the case study analysis a draft version of a design manual of WSUD is developed. The design manual presents sustainable solutions for the water management and the urban and landscape design on city, district and project level. The design manual illustrates the results of the research in a way which is suitable for every practice. The design manual is subdivided in following chapters. As introduction the method and the objectives of 'Water Sensitive Urban Design' are described. The design manual is structured based on the urban water cycle. Solutions for single parts of urban water cycle like collection and runoff of water, retention of water, infiltration of water, treatment of water, use of rainwater, flood protection etc. are illustrated. The urban water cycle also serves as common medium of communication for the interdisciplinary cooperation of urban design, landscape architecture and water management. Furthermore case studies of WSUD with different scales and thematic priorities are presented. The case studies demonstrate how the single elements of WSUD are combined to sustainable concepts.

2 Principles of Water Sensitive Urban Design

Based upon the research the method WSUD is defined as:

'Water Sensitive Urban Design' is the interdisciplinary cooperation of water management, urban design and landscape architecture which considers all parts of the urban water cycle, combines water management function and urban design approaches and facilitates synergies for the ecological, economical, social and cultural sustainability.

Furthermore principles of WSUD were set up. The principles serve as interim results and have to be discussed and concretised in the remaining life span of the project.

WSUD-solutions require an interdisciplinary cooperation of urban design, landscape architecture and water management

The extensive, early and interdisciplinary cooperation of the different affected sectoral and overall planning is aspired. The isolated possibilities of the different specialities to solve the current problems of water management are often exhausted. New solutions possibilities could be developed by interdisciplinary cooperation. To solve the current and future problems of water management (changing environmental conditions, challenges of the climate change etc.) the synergies of the cooperation of urban and landscape design, water management and ecological planning should be

used. Also negative interactions between the different concerns should be prevented by interdisciplinary cooperation. The integrated cooperation requires several organisational measures, in particular an adequate communication between the several institutions involved.

WSUD-solutions require the combination of the city-wide, district and project level

The analysis demonstrates that many WSUD-concepts are limited on borders of the planning site. As a consequence several isolated WSUD-solutions are tried and tested but the establishment of superior and transboundary WSUD-concepts is missing. The limitation on planning sites is inadequate. Several challenges of the water management could not be solved only on the local level. Rather it is required to consider drainage areas on city and regional level. The interaction between the three spatial levels city, district and project level has to be guaranteed. On the one hand WSUD-solutions on project level should consider the goals of the overall spatial development and should coordinate the concepts of adjacent development activities. Because of the missing embedding in superior concepts it is not possible to tap the full potentials of synergies for urban and landscape design. On the other hand concepts are required which combine large-scale (river basins), interdisciplinary cooperation, strategically objectives, consideration of local demands and the coordination of different planning activities. Tried and tested is the development of strategic concepts and the implementation as small single projects.

WSUD-solutions should consider all parts of the urban water cycle

Objective of WSUD is to overcome the constraints of the sectoral splitted water management. Hence WSUD-solutions should consider all component parts of the natural and artificial urban water cycle. Synergies should be target and negative interactions prevented. The WSUD-solutions should be integrated in overall water management concepts. The problems caused by the sectoral areas of responsibility should be solved. The whole natural and artificial urban water cycle should be considered. Many synergies could only be reached with an integrated perspective.
The local urban water cycle could also serve as standard for the development of water management objectives. The aim to follow the natural water balance is practical, comprehensible and easy to communicate. The aim considers the local basic conditions and reduces the objections that WSUD-solutions are desirable in general, but are not fitting to the special local conditions. The aim could easily be translated to an indicator. There are two possibilities to define the natural water balance. On the one hand the natural water cycle could be defined as the conditions right before the present WSUD-project (including the already existing prior charges). On the other hand the natural water cycle could be defined as the conditions before any settlement activities. The urban water cycle could also be used as an instrument for the interdisciplinary communication and the sharing of information.

WSUD-solutions should consider the flow of natural resources

Beside the water cycle also the flow of natural resources like energy-consumption, need of space, consumption of construction material or nutrient balance has to be taken into account. The consideration of these additional benchmarks enables a comprehensive understanding of sustainability with ecological, economical, social and cultural demands. So the energy consumption should be minimised, as contribution to save the global climate change. It has to be surveyed what energy consumption is required for water management solutions. The energy consumption could also serve as standard of comparison for the different indicators. Furthermore the space, which is required for water management infrastructure should be limited. A solution to avoid additional space demand could be

the multiple usages of areas. Additional flows of natural resources like pollutions, nutrients, construction material etc. has to be considered according special part of the urban water cycle which is affected.

WSUD-solutions have to be adapted to the local basic conditions

WSUD is not possible with a schematically implementation of solutions. Objective of WSUD is the turning away from engineering standard solutions and to develop solutions which are customised to the local basic conditions. The morphology of the location has to be taken into consideration. The general objectives of WSUD should be customised for the local basic conditions. The structure of the surrounding surface waters (dimensioning, spatial distribution etc.) and typical elements of the landscape (hedgerows, small woods etc.) have to be used for the design and dimensioning of the WSUD-solutions. Also the surrounding topography should be considered to minimise the interventions in the topography. The successful integration in the surroundings does not require a one-to-one implementation of the characteristics. Rather the structures have to be seized and adapted to the current conditions. The consideration of the characteristics of the surroundings is a tried and tested approach to develop an appropriate urban and landscape design of WSUD-solutions. The commitments of the surroundings are used for the development of an urban and landscape design with a unique identity.

WSUD-solutions should facilitate social multiple use

Water management should contribute to the development of an attractive public or private open space. Social multiple uses like recreation, leisure time, children games or sport at, with and on the water could be realised. The requirements of water management and the needs of residents should be considered equally. A different intensity of multiple uses is required which reaches from the visibility of the water, the accessibility of the banks to the usability of the water body. The multiple uses create new alliances between sectoral departments and facilitate synergies and advantages for all involved parties. The urban design should emphasis the combined solutions to illustrate the value of the cooperation. In particular the urban and landscape design determines the quality of the social and cultural multiple use of water management solutions.

WSUD-solutions should facilitate ecological multiple use

The WSUD-solutions should facilitate an ecological multiple use and contribute to development and protection of nature. Elaborate concepts for the protection and development of habitats should be implemented. The current requirements of nature conservation demand a development from a preservative conservation of nature towards the development of nature. Because of the habitat connectivity function of surface waters the combination of nature development and water management gain in importance. Objective is the achievement of the local aims of nature conservation. The existing habitats as well as local development potentials have to be taken into account.

WSUD-solutions should facilitate economical synergies

Objective of WSUD is, to combine the functional synergies with economical benefits. WSUD based on the expectation, that multifunctional solutions are cheaper than sectoral solutions. The economical sustainability includes different goals which are considered combined. The investment costs as well as

the consequential costs (e.g. external investment costs, operating costs etc.) of WSUD-solutions should be reduced compared with the costs of conventional solutions. Because different organisations are responsible for the different types of costs a fair allocation of costs has to be guaranteed.

WSUD-solutions should facilitate innovations

WSUD-solutions should facilitate the implementation of water management as well as urban design innovations. The possibility for experiments as well as learning processes should be enabled. WSUD requires learning processes to facilitate the transfer of experiences, to scrutinise habits etc. Identified mistakes should be avoided and strengths supported. Furthermore it should be guaranteed that the learned experiences are not limited on single persons but are shared within groups or organisations.

WSUD-solutions should consider the time aspect of spatial planning

WSUD-solutions have to consider the time aspect of spatial planning in two ways. On the one hand the WSUD-concepts should not be limited on the development of constructional solutions but take the operation and maintenance into account. On the other hand the possibilities to adapt the WSUD-solutions at uncertain and changing basic conditions should be considered.
The features of water have to be taken into account not only in the planning and construction phases but also in relation to a long-term future after the construction is finished. In particular with planting and water being no statical system the development is not finished with the completion of the construction phase. Continuous maintenance mainly contributes to a long-term existence and the future performance related to functions.
The natural life of the water management infrastructure averages 50 – 100 years for pipes, sewer system or ditches and 20 - 30 years for retention basins, infiltration measures or treatment plants. Because of this long natural life of the infrastructure it is conceivable that the basic conditions for the design of the infrastructure will change during their life time e.g. global climate change or changes of the legal basis. The adaptability of WSUD-solutions to future and uncertain conditions should be supported. On the one hand WSUD-solutions are required which are robust against changes. So WSUD-solutions should offer an ample scope for operability. Robustness does not automatically mean the over sizing of the infrastructure, because over sizing could affect the operability for the declining volume of water. On the other hand the flexibility of WSUD-solutions is required. For this reason additional space for possible extensions or the usage of management solutions instead of constructional solutions are adequate. Because the open space is more flexible for redevelopment than the built up areas, the open space carries a great weight for the adaptability of infrastructure. There is the danger that flexible measures lead to a trivial urban and landscape design without any possibilities of identification. Because of this reason adaptable solutions should combine two attributes. The WSUD-solutions should have a characteristic urban and landscape design and the solutions should have the possibilities for further developments so that they are not limited on the present conditions.

WSUD-solutions require the combination of function and design

Objective of WSUD is, to use the potentials and commitments of the water management measures as basis for their urban and landscape design. It is improper to separate the functional design (dimensioning, technical principles etc.) from aspects of the urban and landscape design. In urban and landscape design a trend for a new handling of the element water is noticeable. On the one hand there are technical measures which were prettified by urban and landscape design. Elements of the water management infrastructure like pumping station, flood protection barriers, retention basins, waste

water treatment measures etc. are used as elements of urban and landscape design. On the other hand there are measures of urban and landscape design which also have a function of water management. With the combination of water management and urban design the landscape and the urban space serve have an infrastructural function. A basic idea of WSUD is, to seize the potentials and requirements of the water system and use them as basis for the urban and landscape design. There is a paradigm shift from water as a problem to a potential of urban and landscape design.
The WSUD-solutions target an interaction between the function and the design. The urban design of WSUD-solutions should base on the functional demands of water management. The functional, sustainable and aesthetical dealing with water management solutions should facilitate two objectives of urban and landscape design. On the one hand the WSUD-solutions should contribute to the development of attractive locations and emphasise water as an element of urban and landscape design. On the other hand WSUD-solutions should be integrated inconspicuous in the surroundings. To facilitate the inconspicuous integration the encroachments of the WSUD-solutions should be minimised. Both contra positive objectives intended a functional, sustainable and aesthetical dealing with water management.