On the road to a new stormwater planning approach:  
from Model A to Model B

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ABSTRACT
Traditional models for planning urban water systems are to great extent based on technical 
and economic considerations (Model A). This approach is adequate for planning isolated and 
well-defined water systems. With the introduction of the concept of sustainability, the water 
systems interact with societal processes in the urban environment. We are not any more 
dealing with an isolated water system but with a complex adaptive system. For such systems 
the traditional planning models are not good enough. A more integrated planning approach is 
needed (Model B). An important characteristic of this new approach is that the complexity of 
the planning process is not combated but made manageable. As a result, during the process 
different space scales are handled parallel, time plays a more important role and more actors 
are involved. It is an open process. Also more values of water are taken into account. 
Different techniques for sustainable stormwater drainage are described. Based on experiences 
in the city of Malmö in Sweden a practical approach for integrated planning of these types of 
management systems has evolved (Model B). As a result multiple use of stormwater facilities has 
today been general practice in Malmö. The outcome of some sustainable stormwater projects 
is presented.

KEYWORDS
Complex adaptive system; implementation; integrated water management; planning; 
stormwater management; values.

INTRODUCTION
The Rio declaration and the Agenda 21 from the early 1990’s introduced the concept of long-
term sustainability of our environment. One important ingredient in the new approach is that 
technical, economic and social aspects of the development are handled integrated. There is 
today a consensus that urban water systems should be approached in an integrated way. 
Surface water, groundwater, water quality, water quantity and ecology should be looked upon 
in relation to each other. We also know that integrated approaches can give inspiration to new 
solutions to water problems. Thus, the introduction of the concept of sustainability has in the 
field of urban water systems among others led to an increased interest for source control and 
open drainage of stormwater within the urban environment (Stahre, 2002).

Although an integrated approach sounds good, there are many obstacles under way. In recent 
years many integrated urban water plans have been drawn up. Interdisciplinary teams develop 
plans, formulate optimum packages of measures and create beautiful reports with nice 
better. The local politicians often enthusiastically receive these plans. However, many of
On the road to a new stormwater planning approach: from Model A to Model B

the suggested measures are never implemented. As some people say: “Integrated urban water plans die from their own beauty.”

Urban water managers have become aware that it is not sufficient to restrict an integrated approach to surface water, groundwater, water quality, water quantity and ecology. They also require measures that are attuned to spatial planning, traffic, maintenance and management of public areas, urban renewal, etc. A town displays a great deal of dynamics, in which a large variety of professionals intervene. Traffic engineers adapt roads and streets, architects make new designs for buildings in the city centre, green belts are changed, programs are initiated to improve social safety, and town planners implement urban renewal plans where significant parts of the town are redesigned. It is essential that water management fit into these dynamics. However, that is not always the case today.

TWO PLANNING APPROACHES

Traditional planning models for urban water systems are to great extent based on technical and economic considerations. These urban water systems are mostly regarded as controlled systems that have to be optimised: we measure, define objectives, compare measurements and objectives, remove bottlenecks and apply techniques to improve the water system. Finally, the system will attain the objectives.

Figure 1. Schematic illustration of the traditional (Model A) and integrated (Model B) planning approaches.

The traditional planning approach is adequate for isolated and well-defined systems, such as underground pipe networks and end of pipe treatment facilities. However, for water systems, where there is an interaction between water and society, the traditional planning approach is not sufficient. To be able to handle the social dimensions in an appropriate way we must find alternatives to the traditional planning models. This means that integrated systems must be approached as complex adaptive systems with positive and negative feedback loops.

In the following the traditional planning approach (“Model A”) and the new integrated approach (“Model B”) will be discussed in some more detail. In Figure 1, Model A represents the traditional way of thinking. It assumes that the water manager controls the water system, so it will function properly. When the water manager detects deficiencies, he or she will compose an optimum package of corrective measures. The planning process in this model can be described in consecutive steps, which are passed through cyclically.
Model B represents a new way of thinking. The water system is regarded as an integrated part of the city, which display a lot of dynamics. The model focuses on the interactions between the water system and society. These interactions are complex by nature, because many actors are involved in the process, a large variety of structures exist and different scale levels and many policy fields are covered, like traffic, spatial planning and housing. It is also a meeting between technical and social sciences. The whole of processes is assumed to be a complex adaptive system. The system has the ability to adapt its structure when the environment changes.

CHARACTERISTICS OF THE NEW INTEGRATED APPROACH
At first sight there seem to be only minor differences between the two planning approaches. However in practice the differences are huge. Some of these differences will here be explained in more detail.

System complexity
Urban water systems, which interact with societal processes, are complex adaptive systems. The complexity that characterizes such systems should not be combated but be made manageable. Complexity must not be looked upon as something nasty that has to be reduced or avoided, but as a precondition for innovation and transition. When a complex adaptive system is tamed and totally controlled, it loses its ability to adapt and to innovate (Geldof, 2002a).

Disputing complexity (as in Model A) means in practice that the integrated systems are reduced to such an extent that they show predictable behaviour that can be controlled. This means that only part of the system is in focus, i.e. the part that shows linear behaviour and which falls under negative feedback loops.

Managing complexity (as in Model B) means that we try to understand the value of the interwoven processes. The whole system then comes into view. This is when we discover that the system is not static but undergoes constant changes. In that, time plays an important role. With model B we illuminate subsystems with negative and positive feedback loops. Due to the positive feedback loops, processes accelerate and may show chaos, part of the time. Complex adaptive systems exhibit patterns on which we can reflect during planning. In that, we have to strengthen the bond between science and practice. Science offers new insights and tools for practice, and practice offers experience for science (see also Schön, 1991).

Switching between scales
In complex adaptive systems processes happen at many organisational levels (aggregation levels). The nature of the processes can differ greatly, which is the case in integrated stormwater planning. There are three scale levels in the process: (1) municipality and region, (2) estate or neighbourhood and (3) street, house or company.

With Model B it is less important to achieve planning at one ideal scale level. Plans are made and implemented at various scale levels, while considering other kinds of processes and structures at each scale level. This way, less information is lost. Especially the dissolution of information at the smaller scale levels is prevented. After all, plans are also made on the smaller scale level of street, home and tree. These plans are of a different nature than the plans at the higher scale levels, but they are no less valuable. They are often more integrated than plans at higher scale levels because the integration of local plans often costs a great deal of effort, sometimes resulting in complicated multicriteria-considerations, while integration is
On the road to a new stormwater planning approach: from Model A to Model B

more a matter of course at the smaller scale level. Real integration takes place on this scale level and it can even be hard for many people not to consider integration. Everything is connected to everything else. People have stories at the smaller scale level. It is a fascinating scale level, because of the huge diversity in forms, colours, and views. Culture becomes visible at this scale level and inspiration is bubbling to the surface for poems when the confrontation is sought with the environment and with time. Not everything is equally valuable to everyone, but there is a spontaneous order at the micro-level, which is worth understanding.

Time perception
In complex adaptive systems time plays an important role. Looking at planning processes in integrated urban water management, where insights and techniques have evolved dramatically in the last decades, we see that there has not really been a dignified place for time. Model A still dominates. In the following the importance of time will be discussed.

In systems with positive feedback the past does not fade away (Geldof, 2002b). A lot of values attached to water systems, especially surface water, have their roots in history. In plans we make with model a, the history of an area is not taken into account. We recognize the present and the future, where the future should present a better state than the present. So – measures are planned. History does normally not influence the process of selecting appropriate measures.

In traditional planning (Model A), the difference between the present and the future in many cases is artificial. Goals are formulated for the future (e.g. “by 2005, emissions from the sewer system have to be reduced by 50%”). Later, when these goals have been reached, the state of the system will have improved. For that to happen, however, the goals have to be both rigid and verifiable. Today we often apply standards as goals.

How do we cope with the goals and standards in Model A? We compare the present state of a system to its desired future state. By doing that, we beat down time and confront ourselves with a pile of bottlenecks – problems – in the present. Time has disappeared. To reduce these bottlenecks we identify measures. After that, we use complex planning strategies to prioritize the measures and reintroduce the eliminated time. The result is a measuring rod of time, with measures neatly organized alongside. This time structure is the result of a bargaining process, in which ambition and costs are important variables. Glasbergen and Driessen (1993) analysed several integrated planning processes in the Netherlands. They concluded that: “Defining rigid project goals beforehand… will discourage actors from participating in the process.” They observed that in successful planning processes goals are formulated during the process and sometimes even afterwards. The goals emerge from the process.

Time is a rich concept. At the level of integrated water management plans, time manifests itself in a creative manner, i.e. as the carrier of change. Sometimes we can predict change, but often we cannot. Time produces surprises and if we do not like them we experience time as an obstacle and an enemy. It is an obstacle when it separates us from goals in the future and an enemy when it reveals our inability to control environmental problems. By means of advanced models we create the impression that complex processes can be predicted and controlled. When it does not work out the way we expect, we feel guilty or we blame someone else. A cyclic pattern of problem, solution, control, failure and guilt develops.

Open process
Figure 2 takes up a central position in the interaction between water and society. People are working on a water system. Water professionals want to take measures to have the system function better. However, the water system is embedded in an environment in which many processes take place and in which water only plays a partial role. The environment – the context – continuously changes and it is important that the water system adapts to these changes. This adapting is all about a middle path. If the environment (society) is listened to too much, water plans will become “any which way the wind blows”. On the other hand, if the environment is not listened to enough (Model A), there will be no support and the various disciplines in the living environment will work at cross-purposes from each other.

Figure 2. System and context.

In the history of water management, roughly three stages can be distinguished. They are described by Lems and Valkman (2003) as basic water management, functional water management and contextual water management. Basic water management characterises the way in which water management was dealt with up until the mid-eighties. Back then, water managers had relatively little interaction with people from other disciplines. There was no need for such interaction, because they had complete control over the objects they were managing. In the mid-eighties the principle of functional water management was introduced, which means that more people can have a say in water management. Functions are laid down in interaction with the environment. Functional water management fits the control system approach well and is the model for water management to date (Model A).

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<thead>
<tr>
<th>Table 1. The nature of issues in water management (indicative)</th>
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</thead>
<tbody>
<tr>
<td>Basic water management</td>
</tr>
<tr>
<td>• Water level management</td>
</tr>
<tr>
<td>• Tackling point sources</td>
</tr>
<tr>
<td>• Traditional management of river banks and watercourses</td>
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<td>• Sewer system and sewage treatment</td>
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<td>Functional water management</td>
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<tr>
<td>• Spatial planning programmes</td>
</tr>
<tr>
<td>• Nature development</td>
</tr>
<tr>
<td>• Sewer system and water quality</td>
</tr>
<tr>
<td>• Drinking water catchments</td>
</tr>
<tr>
<td>Contextual water management</td>
</tr>
<tr>
<td>• Tackling diffuse sources</td>
</tr>
<tr>
<td>• Integrated stormwater planning</td>
</tr>
<tr>
<td>• Water and urban renewal</td>
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<tr>
<td>• Flooding policy</td>
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We now find ourselves in the transition phase to contextual water management, which has a real interaction between system and context and also takes into account its nonlinear
On the road to a new stormwater planning approach: from Model A to Model B

dynamics. This is necessary because the new water policy can only be implemented successfully if water professionals can influence the environment. Diffuse sources can only be combated if a large field of actors is involved. The working method of Model B is related to this kind of issue (see Table 1).

PRACTICE OF STORMWATER DRAINAGE PLANNING
Storm drainage is the city’s Drainage department responsibility. As traditional stormwater facilities (pipes and detention tanks), are located underground the planning, design and the construction is normally carried out without involvement of any other technical department in the city (Model A). Figure 3 schematically illustrates the traditional planning of measures to upgrade an existing urban stormwater system.

As a base for the planning a goal is set up for those runoff standards that are to be fulfilled. With the help of advanced hydraulic modelling tools alternative measures to improve the system are identified. A cost benefit analysis is carried out to select the optimal set of improvement measures. When the measures have been implemented the result is evaluated by monitoring the system. The typical feature of the planning is that it in practice is fully controlled by the Drainage department (Model A). Model A is still the prevailing approach for planning measures in urban stormwater systems.

Figure 3. Illustration of traditional planning of stormwater facilities (Model A)

To succeed with the implementation of the concept of sustainable urban storm drainage it is of utmost importance to consider the societal aspects that are associated with an integration of the stormwater facilities in the urban environment. The introduction of sustainable stormwater drainage leads to more complex planning (Model B) compared to planning of traditional stormwater facilities (Model A). An active involvement is needed of several departments in the city. This involvement is seldom problem-free. Most cities do not have the tradition to cooperate in the planning and the implementation of jointly owned and operated water facilities.

The institutional barriers for such initiatives are often unexpectedly high. In the city of Malmö in Sweden it took many years to overcome these barriers (Stahre, 2001).
On the road to a new stormwater planning approach: from Model A to Model B

During 10 years experiences of sustainable stormwater drainage in the city of Malmö a new planning approach for this type of facility has evolved. In Figure 4 this approach is outlined for a typical example of integrated planning (Model B).

When sustainable stormwater management is applied in Malmö at least three departments in the city administration typically take active part in the planning process. One important element in the planning is the involvement of citizens, schools, and pressure groups, which can have an interest in the planned facilities.

The departments of Drainage and City Environment develop their common vision together with representatives from the City Planning department. Depending on the nature of the suggested drainage facilities other city departments are involved in the discussions of the implementation of the vision. If for example the suggested facilities are to handle polluted runoff from roads and other trafficked areas the Street department is involved in the discussions. If the facilities are to be used for recreational purposes the Department of Recreation is involved.

Figure 4. Schematic illustration of integrated stormwater planning in Malmö (Model B).

At the earliest possible stage the developed vision must be introduced in the city’s physical planning process. The concept of sustainable stormwater drainage can in practice often become the driving force for developing the plans. Potential additional partners are approached in order to broaden the economic base for the implementation. Private developers and the city’s own real estate department are partners that might see a benefit in taking part in the project. One incentive for them could be that the prize of the land might increase if a “blue-green” corridor including open water is introduced in or around the development.

It is important with public participation in the planning process. The visions should therefore at the earliest possible stage be introduced to citizens, schools and other pressure groups in the
area. A humble attitude to public demands and requests will facilitate the public acceptance of the facility. Local media can play an important role in the promotion of the planned facilities.

**EXAMPLE FROM MALMÖ, SWEDEN**
The residential area Augustenborg, in Malmö, has a combined sewer system. The area has suffered from frequent basement flooding. In order to reduce the risk of flooding different source control techniques have been introduced. The primary goal with these was to reduce the stormwater runoff to the overloaded combined sewer system. Model B was applied during this process.

In the Augustenborg most buildings here have flat roofs. To reduce the stormwater runoff from these roofs it was decided to apply a vegetation cover of sedum grass on top of 9,500 square meters (0.95 hectares) of the roofs. An evaluation of the structural strength of the existing roofs showed that no extra reinforcement was needed to carry the extra load.

The green roof installation was designed as a full-scale research facility, where the effect of different grass species, thickness of the soil substrates, the sloop of the roof etc could be investigated.

The main reason for applying green roofs was their capability to reduce the stormwater runoff from the roofs. Among the other advantages with this technique can be mentioned that the green roof serve as an effective insulation of the building and thus contributes to savings of heating energy. In addition the green roof protects the roof construction. Calculations show that the lifetime of the roof construction can be prolonged quite considerably.

To reduce the speed of the stormwater runoff, an open drainage system was constructed through the residential area of Augustenborg. In an existing park the open drainage system was designed in the form of a shallow drainage ditch (swale). This is only fed with water during wet-weather conditions. During dry weather conditions the drainage ditch is totally dried out. One advantage with choosing an open drainage ditch was that the construction cost was very low and that is easily could be integrated in the park environment. The new drainage ditch in the park is shown in Figure 5.
On the road to a new stormwater planning approach: from Model A to Model B

The idea to form an open drainage ditch originally came from the residents within the area. Some of them had experienced an old open creek in the park, which was culvertized when the area was developed several decades ago. No doubt the link to the “historic” creek through the area was very much appreciated by the residents. In addition the City Environment department considered that the new open drainage ditch added to the aesthetic value of the park.

The schoolyard in residential area of Augustenborg has a very high percentage of impervious surfaces (roofs and pavements). Almost all runoff from the schoolyard was connected to the combined sewer system. As part of the upgrading of the sewer system, the impervious surfaces were remodelled so that most of the runoff was diverted directly to the new open drainage system in the area.

To slow down the peak flows of runoff, an open detention basin was constructed in the schoolyard. After discussions with the school authorities it was decided to design the basin in the form of an open amphitheatre, see Figure 6. The ambition was to be able to use the basin for outdoor lectures.

In Augustenborg plans were not only made, they are also really implemented. In a learning process where the complexity was not combated but made manageable, enthusiasm emerged gradually. By doing things and making things visible, it was easier to get people involved. At least two planning scales were handled parallel: the scale of Augustenborg and the total area and the scale of a house, engineering workshop or schoolyard. It is impossible to proof, but actors involved are convinced that an Augustenborg Model A process would be far less successful.

CONCLUSION

The introduction of the concept of sustainable stormwater drainage has led to that stormwater not any longer can be looked upon as just a technical service that is supplied by the city’s Drainage department. Stormwater has become a positive resource in the urban environment for the citizens. This has led to that many of the city’s departments must take more active part in the planning.

A close co-operation between the different technical departments in the city and an active involvement of the public has proved to be of utmost importance for a successful implementation of the concept of sustainable stormwater management. This integrated approach (Model B) is much more complex and time-consuming than the traditional approach to stormwater Model A is still the prevailing approach for planning measures in urban stormwater systems. This is all right as long as the measures are limited to the construction of facilities, which do not directly intervene with the urban environment. However, the introduction of sustainable stormwater drainage has changed the prerequisites for the planning. Because the measures are integrated in the urban environment in quite another way than traditional underground stormwater facilities, Model A is not adequate any longer. The planning cannot be carried out by the Drainage department alone, but must be carried out in co-operation with other city departments and with involvement of the citizens.

Planning (Model A).

Many cities tend to continue to use the traditional approach (Model A) for planning sustainable stormwater solutions. As this approach is not very well suited for planning stormwater solutions, which are closely interacting with the societal processes in the urban
On the road to a new stormwater planning approach: from Model A to Model B

environment, the result will often be unsuccessful. For planning sustainable stormwater systems one should apply Model B.

Experiences show that sustainable stormwater drainage is a most efficient way of handling stormwater from both existing and new developments. It must be emphasized that time plays an important role in the integrated planning. To obtain public and political support for a plan, it is necessary to include among others history, timing and uncertainty in the planning process.

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