



Seminar Cultural Heritage and Water Management

Bergen, Norway, June 8-9, 2010

Programme and abstracts





The seminar Cultural heritage and Water Management is organised in the context of the Interreg IVB North Sea project SKINT. The seminar is part of Workpackage 3:

"Placing water earlier in the planning process"

The seminar is hosted by the Norwegian Directorate for Cultural Heritage (Riksantikvaren) and organised in close cooperation with the Geological Survey of Norway and other partners in the Norwegian partnership of SKINT.



SKINT is partly financed by the Interreg IVB North Sea Region Programme. Lead partner is the Dutch water authority Hoogheemraadschap Hollands Noorderkwartier.

SKINT website: www.skintwater.eu

SKINT partners:



hoogheemraadschap
**Hollands
Noorderkwartier**



**Hochschule für Angewandte
Wissenschaften Hamburg**
Hamburg University of Applied Sciences



**The
University
Of
Sheffield.**





Programme seminar "Cultural Heritage and Water Management"

Day 1, June 8

12:00 **Arrival and registration**

12:30 **Welcome addresses**

The Commissioner Lisbeth Iversen (deputy chair of the City Government of Bergen, responsible for urban development, environmental affairs, climate, cultural heritage, roads and transport, water and sewerage and social housing (Christian Democratic Party, NO)

12:45 **Introduction**

Sjur Helseth, Director of Department, Norwegian Directorate for Cultural Heritage

13:15 **The SKINT Project**

Arjen Grent, leading partner SKINT (Hoogheemraadschap Hollands Noorderkwartier, NL)

Session 1, chaired by Hans de Beer

13:30 **Introduction to Bryggen**

Ann Christensson (Norwegian Directorate for Cultural Heritage)

13:45 **Cultural heritage: what are we trying to preserve, why water?**

Henning Matthiesen (Senior Research Scientist, National Museum of Denmark, Copenhagen, DK)

14:05 **The Bryggen Project; need for water (management)**

Hans de Beer (Geological Survey of Norway, NO) and Jann Atle Jensen (Multiconsult, Bergen, NO)

14:25 Fruit and Coffee Break

14:50 **York archaeological preservation and water management issues**

John Oxley (Chief Archaeologist, York City Council) and Ian Panter (York Archaeological Trust, UK)

15:10 **Heritage Waterways; the role of Leeds-Liverpool canal in Bradford, UK**

John R. Hogg (Design and Countryside Manager, Bradford City Council, UK)

15:30 **In situ preservation and water management in the Netherlands**

Michel Vorenhout (Researcher, Institute for Geo- and Bioarchaeology, VU, Amsterdam, NL)

15:50 **Discussion**

16:30 Break

17:00 **Excursion to Bryggen**

19:00 Dinner at Nøsteboden (Nøstegaten 32)





Programme seminar "Cultural Heritage and Water Management"

Day 2, June 9

Session 2, chaired by Prof. Walter Leal

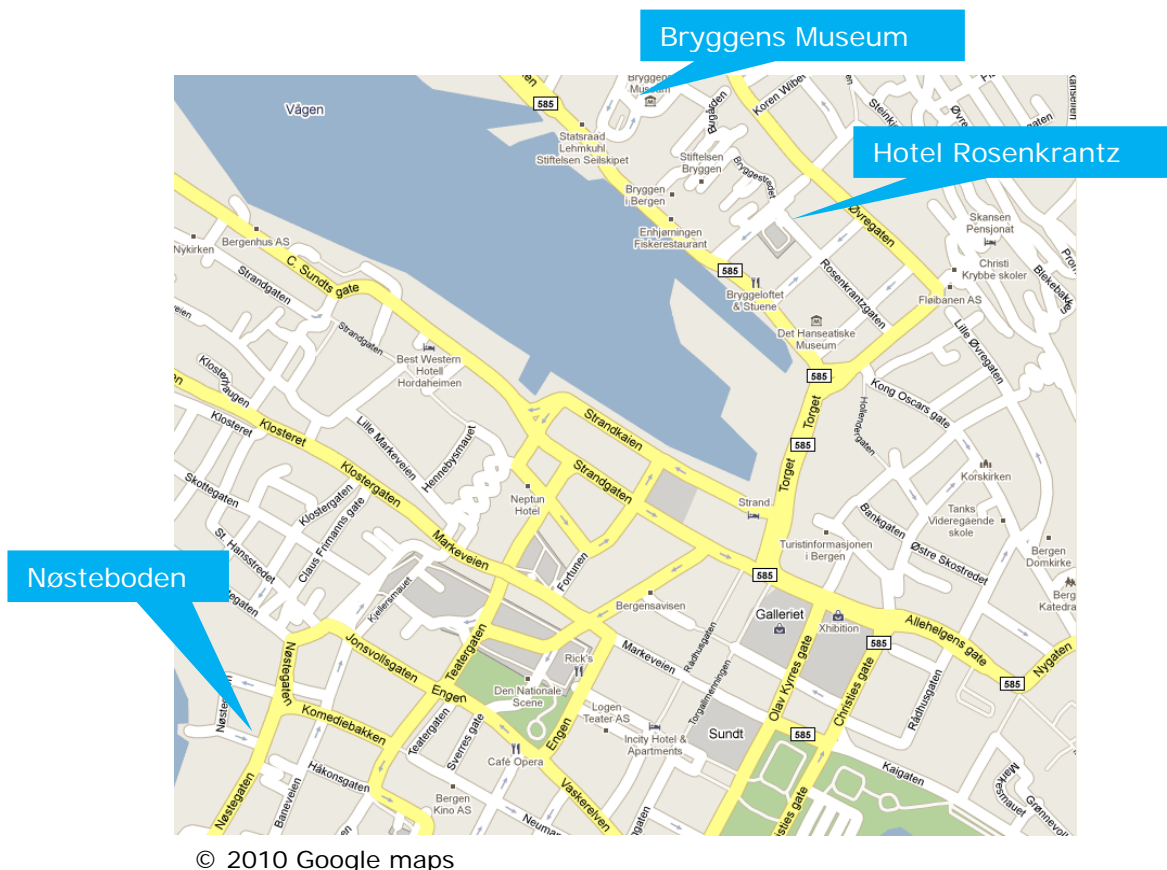
- 09:00 **Urban drainage and climate**
Prof. Maria Viklander (Professor and Head Urban Water Research Group, University of Luleå, SE)
- 09:30 **Embedding cultural heritage protection and sustainable water management in urban planning**
Margrethe Tviberg (Section Head, Planning and Building, Norwegian Directorate for Cultural Heritage, NO)
- 09:50 **Surface water management requirements for the mid 21st Century City**
John Blanksby (Senior Research Fellow, PWG, University of Sheffield, UK)
- 10:10 **Implementation of regulations in the real world**
Louise Walker (Research Associate, PWG, University of Sheffield, UK)
- 10:30 Break
- 10:50 **Local effects of global climate change on the urban water system of Hamburg**
Klaus Krieger (Head of Water Management/Drainage Planning, Hamburger Stadtentwässerung AöR, Hamburg Wasser, GER)
- 11:20 **Groundwater management in urban planning**
Hans de Beer (Hydrogeologist, Geological Survey of Norway, Trondheim, NO)
- 11:40 **The use of "WOLK" in Bergen, Norway**
Floris Boogaard (Group Head Water and Sewage at TAUW, PhD Research Scientist at TU Delft, NL)
George Stockell (Civil Engineer, Bergen Municipality, NL)
- 12:00 Lunch





Session 3, chaired by Prof. Chris Jefferies

- 13:00 **SUDS in dense urban areas**
Prof. Chris Jefferies (Head of Urban Water Technology Centre, University of Abertay Dundee, UK)
- 13:30 **Challenges in modelling storm water runoff and infiltration**
Tone Merete Muthanna (Research Scientist Water Supply and Sanitation Technology, Norwegian Institute for Water Research, NO)
- 13:50 **Managing the ground-surface water nexus in urban areas: Oslo case**
Jadranka Milina (Researcher, City of Oslo, Water and Sewerage Works, Oslo, NO)
- 14:10 **Discussion**
- 14:45 **Concluding remarks**
- 15:00 **End of seminar**





The SKINT project

Arjen Grent

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Rationale for the SKINT project

The Water Framework Directive (WFD) and the Floods Directive (FD) have clear goals to improve water quality and to regulate water quantity. When coupled with the effects of climate change and increased urbanisation these create increasing pressures on water management, especially in urban areas.

Objectives of SKINT

The use of appropriate spatial planning processes can address many urban water management problems. SKINT facilitates the implementation of sustainable urban land and water management by improving the integration of water management in spatial planning processes. SKINT gathers knowledge and experience from successful initiatives and provides (communication) tools for water managers and spatial planners. These will provide an improved skills base to enable effective integrated management of ground and surface water quality and quantity.

SKINT will:

- Facilitate the involvement of water managers and spatial planners in multidisciplinary processes by improving communication;
- Create and apply an international knowledge base of excellent processes and practices of water management integrated with urban land use;
- Integrate water management in urban land use processes to facilitate the implementation of technical water solutions;
- Provide information to professionals to help decision makers to select more sustainable solutions;
- Share the findings from SKINT with water and urban land use professionals in ways specified by those professionals;
- Conduct a specially developed training programme for water and urban land use professionals.

Results of SKINT

SKINT raises awareness amongst decision makers about sustainability in general and the environment in particular to help ensure that better decisions are made about measures to improve water quality and reduce flood risk in urban areas.

The results from the project will be used for a permanent water web-portal and a web-based face-to-face training programme for water and urban land use professionals. The permanent portal for urban water and land use in Europe will be complementary to, and will interact with portals developed by other projects. After the completion of the SKINT project, the water portal will continue to be a dynamic user-driven website for multidisciplinary stakeholders and a source of communication about truly sustainable urban water management.

The training programme will increase the ability of professional staff in key public bodies to manage the built environment of existing urban areas so that the needs of integrated land and water planning are better met. The target group for the training will be a range of disciplines involved in water management and spatial planning / development control who as end users will be the champions of sustainability.





Monitoring Bryggen

Ann Christensson

Senior advisor at the Norwegian Directorate for Cultural Heritage (Riksantikvaren)

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Riksantikvaren (The Directorate for Cultural Heritage) is responsible for:

- the management of all archaeological and architectural monuments and sites and cultural environments in accordance with the relevant legislation,
- ensuring that a representative selection of monuments and sites of all periods is preserved for present and future generations. The selection of monuments and sites must provide an overview of historical development, the way of life and the range of works of art and craftsmanship of each period.
- ensuring that cultural heritage considerations are taken into account in all planning processes.

The Directorate aims to ensure the effectiveness and quality of its heritage management work through the application of interdisciplinary cooperation, high-quality scientific documentation, and increased use of information technology coupled with relevant geodata. There are special programs for the Norwegian World Heritage Sites. Riksantikvaren took in 2001 the initiative to start Project Bryggen, in close cooperation with Hordaland County and Bergen Municipality. The aim for the program is to restore the buildings and this work is done by the owners at Bryggen.

Systematic monitoring of archaeological deposits – the hidden parts of the World Heritage Site – is also part of Project Bryggen. The monitoring work started in 2002, while monitoring of the rate of settling of the buildings themselves started in 1999. Thanks to the monitoring work at Bryggen, we have been able to document that lowering of the water-table represents the greatest threat, since it drastically increases the rate of decomposition of the organic cultural deposits. As a result, in some places the World Heritage Site is literally disappearing beneath our feet. Our task is to find ways to address the critical situation, a situation we at the moment find out of control and unfortunately accelerating.



Figure 1 Former quay (photo: Herteig, 1969, source: Riksantikvaren)

In recent years *Riksantikvaren* has been funding systematic monitoring, and the results show that the decomposition of the cultural deposits is accelerating.

The aim is to make the sheet piling as watertight as possible in order to reduce the dewatering. Multiconsult Bergen and The Geological Survey of Norway have proposed a set of possible solutions to stop the leakage. These proposals are currently undergoing quality control. The monitoring at Bryggen has consisted of several approaches: archaeological assessment of the cultural deposits' state of preservation; biochemical investigation of preservation conditions in the deposits; and hydrogeological mapping of the watertable, water flow and other given parameters. The knowledge and methods developed at Bryggen have already been applied to similar archaeological deposits in other Norwegian towns. Furthermore a standard for monitoring in medieval cities has been compiled based on the work on Bryggen.

The researchers at Bryggen are:

Rory Dunlop, Norwegian Institute for Cultural Heritage Research,
Henning Matthiesen, National Museum of Denmark,
Hans de Beer, Geological Survey of Norway,
Jann Atle Jensen, Multiconsult AS.



Cultural Heritage: what are we trying to preserve, why water?

Henning Matthiesen

Senior research scientist National Museum of Denmark, Copenhagen

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Increasingly, newly discovered archaeological sites are being preserved in situ, as opposed to being excavated. Many factors are influencing this trend, including the high costs of recovery coupled with the conservation and subsequent curation and management of recovered remains. Furthermore, it may not always be desirable, or necessary, to excavate a site. Yet as part of the cultural resource it should be preserved or managed in situ.

Some of the most spectacular archaeological finds come from waterlogged conditions, for instance in wetlands and urban deposits. Where a dry site mainly contains inorganic material – such as for instance stone and pottery – a waterlogged site may also contain organic material such as wood, leather, textiles, and even insects, food remains and human tissue, making the site much more informative. If such finds shall be preserved in situ it is extremely important to keep the site waterlogged, ideally with stagnant anoxic water. A change in the environmental conditions, for instance caused by drainage, heating, or a changed water quality, may lead to increased decay of the organic materials. Apart from the loss in archaeological information, the decay may cause shrinkage of the deposits and settling of the soil surface and buildings. The collaboration between archaeologists and conservators on one side and hydrologists on the other side is therefore crucial in the urban planning.

This presentation shows some examples of waterlogged archaeological sites, where organic artefacts have been preserved for hundreds or thousands of years. It also shows the dramatic consequences, when such a site is drained. The conditions at Bryggen are briefly discussed.





The Bryggen Project; need for water (management)

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Jann Atle Jensen

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As introduced by Ann Christensson and further elaborated by Henning Matthiesen, an intensive monitoring scheme at the World Heritage Site of Bryggen in Bergen has shown damaging settling rates caused by deterioration of underlying, anthropogenic, cultural deposits. Low phreatic groundwater levels caused by redevelopment of the area next to the heritage site in the late '70s have led to an increased flux of oxygen in the subsurface. This currently threatens the heritage site due to decomposition of organic material and consequent settling. The strategic Bryggen Project aims to bring Bryggen to a state of repair that is in accordance with its status as a World Heritage Site, and where only regular maintenance is necessary.

The standing historical buildings rest on the extensive archaeological remains, cultural deposits that are highly degradable and dependent on the natural environment and especially the water content. Both mechanical settling of the terrain and oxidation of organic material occur, thereby not only destroying archaeological values, but also removing the very foundation of the historical buildings above. One of the main goals at Bryggen is therefore to establish a stable hydrological environment, so that the heritage site will be safeguarded for posterity.

Preservation conditions of archaeological remains preserved in situ are thus dependent on both the natural environment and changes to this environment caused by urban development, agriculture or climate changes (Holden et al., 2006). Therefore it is necessary for any archaeological site to be placed within its wider natural environment and to understand the natural hydrological balance and possible changes that are being forced upon it by nature or humans. Safeguarding cultural deposits in urban areas thus requires a proper integration of urban land and water planning, including cultural heritage.

This presentation will show how a holistic approach and multidisciplinary cooperation has led to an improved monitoring programme and better understanding of the preservation conditions at Bryggen, which in turn has led to new general requirements for other sites in Norway. Alternative ways forward to safeguard Bryggen will be presented.





Heritage Waterways: the role of Leeds-Liverpool canal in Bradford, UK

John R. Hogg

Design and countryside manager, Bradford City Council, United Kingdom

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The presentation will look at the history of the canals development from its early development with particular reference to how it influenced the growth of industry, towns, villages and agriculture. The decline of the canal for commercial transport as rail and road became more economic saw the re-birth as a pleasure cruising waterway and an important heritage asset.

The canal designated as a Conservation Area ('an area of special architectural or historic interest the character or appearance of which is desirable to preserve and enhance') has led to the sensitive restoration of many former mills for residential and commercial purposes which has been an important part of Bradford's Regeneration. Leisure and tourism has continued to increase with the designation of Saltaire as a World Heritage Site, and further restoration of the canals natural and built heritage.

Improved water quality has led to the canal becoming important for biodiversity with notable protected species such as otters, crayfish, kingfisher and bats now colonising the water and its immediate environment.

Walking and cycling along the towpath are now a major part of green transport and health policies with the canal a major artery linking town and City centres.

Future major Regeneration is planned around the re-opening of the Bradford Canal which links to the Leeds-Liverpool Canal involving a direct investment of £86m. The Canal Road Corridor proposal aims to have a £1.2 b development value consisting of £470m waterside development, 5,000 new homes all set in a high quality green corridor alongside the re-instated Bradford canal.





In situ preservation and water management in the Netherlands

Michel Vorenhout

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The link between groundwater quantity and quality and in situ preservation of archaeological remains is well established in recent years. The importance of good water management is also established in other fields, like (wet) nature management or safety in low lying areas. The Netherlands are a low lying country, with profound problems related to water management. Large interventions have been planned and are currently under development. A large program is the 'space for water' program, which allows for more space for rivers, enabling naturally, but controlled flooding of areas. This program is mainly nature oriented. Another large program is emergency flood controlling, resulting in for instance large emergence flooding areas. One of these is the area of Peizermade, in the Northern part of the Netherlands. Similar project exist in the UK.

In many developing areas for living however, groundwater is still seen as a problem, rather than a real need. Therefore in these developing areas, the groundwater level is under serious threat. In some cases, archaeology that is found can lead to adoptions to plans, as such leading to equal or even raised groundwater tables. To keep the homes dry, several measures then need to be taken. A popular method is raising soil level by adding an additional layer of soil in the area. This happens for instance in the community of Almere, in the low lying polder of Flevoland. When the surface level is heightened, the groundwater table can raise as well. Another can be the increase of intrusion of rainwater, thus conserving water in the building area itself. This is managed by high infiltration areas like open waters, infiltration tiling and de-coupling of sewage channels from rain surplus water.

The preservation of groundwater is important for in situ preservation of archaeological sites, but can also lead to some disturbances. New nature areas can enhance damage by roots, or make areas inaccessible. Raising soil levels with a layer of sand or clay can enhance damage by inclination of the lower laying horizons. The challenge for archaeological management is to find ways to combine the best methods, and to define better what the limits are for developers. When these challenges are met, a fruitful integration of water management with archaeological management can be established.





Urban drainage and climate

Prof. Maria Viklander

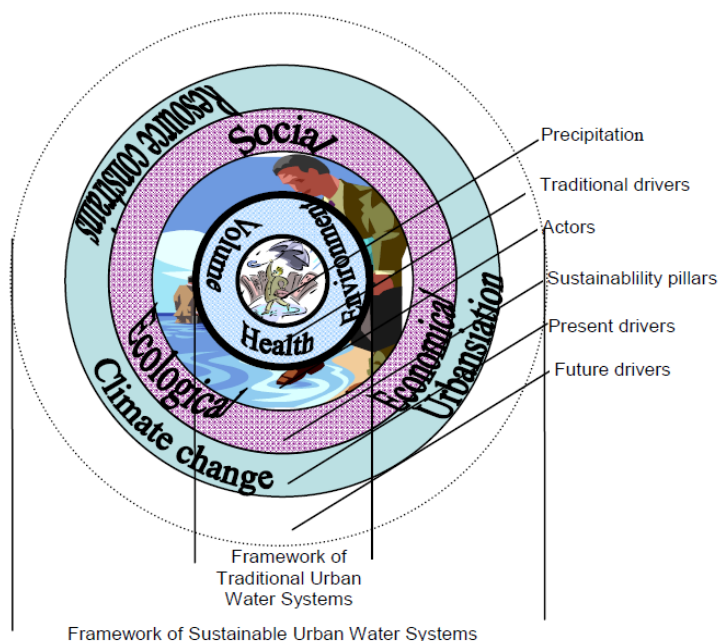
Professor Urban Water Research Group, University of Luleå, Sweden

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Water is essential for nature and living organisms as well as a functioning society. Today's urban water systems are based on large technological systems designed in the 19th century. Thus, a paradigm-shift towards a more holistic approach of the urban water system is required to achieve a more sustainable urban water system. If water is handled in an improper way, this might result in significant problems such as great stress at our water resources due to chemicals or at our infrastructure due to flooding. Thus, given the changing conditions nowadays (such as effects of climate change, new chemicals used in our society etc.) there is a need for more research to prevent negative effects as e.g. flooding and resources constrains. In order to cope with these future demands there is a need of a paradigm shift in urban water management towards a more holistic approach.

When addressing adaptation actions a sustainable approach requires a whole of system approach as different components of urban systems are integrated. A sustainable approach is also essential in order to develop strategies for the future that are both flexible and resilient.

Our urban water systems are affected by impacts from more long-term variations of the climate as well as short-term, seasonal variations and extremes, are important for the understanding of water systems in the future, and are relevant to decision making. Short-term variations in the climate, i.e. seasonal variations have a major impact on the quantity and quality of water in an urban setting. In addition, it is many times concluded that the urban hydrological cycle becomes much more complex in cold climates as compared to areas with warm or temperate climate. Due to higher energy and fuel usage in cold climates, some pollutants are found in higher concentrations. In a cold climate, there is a need for slipperiness control and consequently, the choice of de-icing chemical or anti-skid material can have a major impact on the quality of runoff as well as drinking water reservoirs. Other problems connected to cold climate and water are snow processes and runoff in river basins, and ice-covered lakes. The complexity of urban water system is illustrated in the figure below.





Embedding cultural heritage protection and sustainable water management in urban planning

Margrethe Tviberg

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The urban development and urban planning are both formally governed by the municipality and city council through the mechanisms of the planning and building act. However, the initiative for an urban transformation is just as likely to be a private investment, as a municipal master plan.

The municipality is obliged to involve the public and official authorities in the planning activities, and managing the full scope of interests within an urban situation is a challenge. The urban transformation is also driven by the interests of investors and property developers, who have their own rights to initiate plans and projects within the law. Embedding sustainability and protection into these planning processes is vital, but not necessarily easy.

My presentation will point out how one should act to get a handle on the planning processes – what the formal and procedural “must do”-s are, and what sort of competence and tools are required.





Surface water management requirements for the mid 21st Century City

John Blanksby

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A common perception of water sensitive urban design is that it is only applicable in areas of low density development. However the drivers and pressures acting on 21st Century cities may often result in densification of the existing urban areas rather than expansion into the surrounding countryside. Using the City of Bradford in the UK as an example, the presentation concludes that many surface water management measures which can be classed as water sensitive urban design are appropriate to the needs of the modern city. However, the way in which they are presented needs to change in order to make them appear relevant to those striving to reshape our cities to meet the demands of climate and demographic changes whilst shielding valuable historic urban and rural landscapes from damage.





Implementation of regulations in the real world

Louise Hurley Walker

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During the course of my research career many people have told me of their disillusionment with sustainability, which felt depressing until I realised that it is not the concept but the terminology that has fallen out of favour. People often say that the word is used without care to give a positive spin to rhetoric without substance. Some have turned towards resilience as an alternative term to prevent the glassy eyed response of hard pressed practitioners just trying to do the best job possible.

This cynicism is no surprise when many efforts to do the right thing are thwarted because of lack of funding or the push to fulfil short term political gains. Sustainability is also seen as nebulous, immeasurable and a portent of additional tasks to add to an already packed schedule. It is no surprise then, that often what start out as lofty ideals handed down from executive level end up as boxes ticked and filed away until just before the next review of practices, despite a common wish to make things better.

The world is changing fast. It is moving beyond its environmental capacity to sustain current (developed countries) lifestyles. The practices that we have trained for and become excellent at are no longer enough to make what we do work in the long term. It doesn't matter whether we call it sustainability, resilience, the triple bottom line or anything else, we cannot become disillusioned with the concept. We need to find a way to embrace its principles into everyone's every day working practices so that they become a societal norm.

SKINT addresses one part of this, it is about implementing more sustainable land and water management by improving integration of these two areas and thereby contributing to the application of the Water Framework Directive and the Floods Directive. Whilst we strive for more sustainable management we must remember the principles of the sustainability embrace equity, between disciplines and between generations. The way in which directives are interpreted can mean the difference between a sustainable (or resilient) solution and one that is doomed to failure.

"While policy sets the direction of a community endeavour, those doing the day to day work in carrying out the mission hold the keys to its success" (Larry Matel, US Engineer & LID expert, 2010)

For SKINT the important factors are economic, social, environmental, cultural and energy use. We have a snapshot of how these factors are taken into account in decision making across the partner countries and within our partner projects. The integration in SKINT comes from finding ways of learning from each other and sharing best practices.

Land and water management practices need to interlink in order to remain resilient in a changing world. They must sustain the rigour of engineering whilst embracing the frame of reference of local communities and their custodians. SKINT cannot change practices overnight but it can discover how to train the champions of change and how to cultivate the enabling context needed for change to happen.





Local effects of global climate change on the urban drainage system of Hamburg

Klaus Krieger

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The HAMBURG WATER group owns and operates a sewer network with a total length of more than 5,400 km. Every year, more than 60 Mio € are invested for rehabilitation and renewal of this important infrastructure. With regard to the predicted climate changes, increasing attention is focused on the effects of possible changes in precipitation patterns on the present sewer infrastructure as well as on the question if the present dimensioning criteria are still valid for future planning.

The primary objective of the presented study is an estimation of the hydraulic impacts of the climate change on the Hamburg drainage system. Based on the regional climate model REMO and under assumption of the IPCC scenario A1B, first of all the simulated rainfalls were compared and validated with long term precipitation measurements. Furthermore, a comprehensive trend analysis was realized for the REMO rainfall data.

Based on simulated long term rainfall series for the period 2000 to 2100, the hydraulic effects on the combined inner city sewer network of Hamburg have been analyzed by hydrodynamic modelling. The simulation results showed a significant increase in combined sewer overflows by 50 %. A significant increase in manhole surcharges could not be observed for the Hamburg drainage system.

So far, there seems to be no sound basis for the implementation of an overall climate factor for sewer dimensioning for the Hamburg region. Once climate models with higher spatial and temporal resolutions become available further investigations should be undertaken. Nevertheless, possible effects of climate change should be taken into account within the planning process for major sewer extensions or modifications and the possibility of upgrading the existing system should be considered even now.





Groundwater management in urban planning

Hans de Beer

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Urbanization modifies underlying groundwater systems. This often leads to adverse hydrological-, water quality-, geotechnical, and socio-economic effects which jeopardize sustainability. In the Nordic countries, more than 75% of the population live in cities, and as the urban population is expanding rapidly, the adverse effects are important and becoming increasingly urgent. Urban groundwater is currently largely neglected in the Nordic countries except Denmark, primarily because of the fact that drinking water production is surface water based, outside of the urban areas or geologically isolated from the city. In some other European countries that need to take care of urban groundwater to avoid wet feet, especially the Netherlands, the knowledge and awareness on the adverse effects of urbanization are more eminent and dealt with accordingly.

In Norway, some dramatic consequences of a lack of awareness and knowledge on groundwater in urban areas are becoming visible. In Oslo, groundwater levels are steadily sinking over the last decades. Isostatic uplift may be one of the causes, whilst urbanization is seen as probably a more severe cause, consisting of a complexity of different factors like tunneling, impermeable pavements, drainage, leakage in sewage systems, fillings, etcetera. Heritage buildings protected by law are showing dramatic signs of instability caused by unequal settling. In addition, archaeological organic deposits are disappearing due to low groundwater levels. Bryggen in Bergen is another striking example, where substantial amounts of this non-renewable cultural resource are literally disappearing in thin air, in addition causing settling damage to the heritage buildings above. These examples are very likely only an indication of what is happening in our urban areas due to uncontrolled draining of groundwater.

To reduce the negative effects that urbanization has on groundwater, active management is required, irrespective of whether the groundwater is to be used or not. This management must be based on a sound technical understanding of the interacting processes involved and proper monitoring of groundwater quantity and quality. As groundwater is directly dependent on surface water management, urban planning should always consider the total urban water balance, above and below the ground. This is especially the case in areas that are vulnerable for settling and contain cultural heritage buildings or deposits that are non-replaceable.

A good management of urban groundwater will be of benefit to overlying cities, but it is currently inhibited by the lack of knowledge, awareness and management tools. Insight into groundwater issues for other urban specialists than earth scientists, including urban planners and cultural heritage managers, is required: without communication between the disciplines involved, progress towards acceptable urban sustainability will be slow.





Flood mapping and SUDS to prevent urban storm water flooding in the Netherlands and Norway.

Floris Boogaard

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George Stockell

Civil engineer, Bergen Municipality, the Netherlands

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Due to climate change, urban areas will flood more frequently. Short peak rainfall intensities will exceed the storm water drainage capacity and cause flooding of urban areas like the municipalities Bergen in Norway and the Netherlands. In order to make cities more resilient to flooding more space for water is needed and the infiltration capacity should be restored.

There are more than hundred types of sustainable urban drainage systems (SUDS) to choose from. To support prioritizing of cost effective SUDS for a typical situation a GIS-based method for mapping urban storm water has been developed. Due to its straightforward concept the method is easily understandable for all stakeholders in the urban management.

For the city of Bergen in the Netherlands, which suffered flooding from extreme rainfall more than once, this method has been used to search for cost effective measures against flooding. The rainwater is stored in basins above and under ground and the infiltration capacity is partly restored by: permeable pavement, infiltration shafts and sewers and in so called 'wadis'.

This method can be applied for the situation in Bergen Norway which resembles, apart from the name, in many aspects to the situation in the Netherlands. In order to improve international knowledge exchange the method is applied to the Norway situation and solutions are presented which will make Bergen more resilient to flooding.





SUDS for high density locations

Prof. Chris Jefferies

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The drainage of higher density areas within cities presents problems which are not of such concern in less densely urbanised zones. Most areas currently have combined sewer systems, there is very little undeveloped space and values are very high. SUDS solutions must either make extensive use of whatever space is available on, in and around the buildings themselves or they must make use of the public open space of the city centres such as ponds in public parks or wooded areas.

The design of a SUDS system embeds long term environmental and social factors throughout the life of the system within the functional requirements of controlling the quantity and quality of runoff and the inclusion of the amenity value of surface water in the urban environment. A wide range of technical guidance is available but unfortunately, while many describe the suitable design of SUDS, few provide advice for practitioners involved in the design or appraisal of buildings and roads within higher density and city-centre areas. Early in 2008 the SUDS Scottish Working Party (SUDSWP), guided by practitioners, took ownership of this disconnect developed SUDS guidance for roads. This is aimed at roads in urban areas and provides specific and detailed advice for designers and also a scoring system whereby different SUDS options can be compared and is intended to be the basis of a negotiation between the different stakeholders involved in the planning of new roads and developments particularly in high density areas.

This paper reviews the options available for implementing SUDS in such locations and gives information on their performance. The presentation will give technical details and show examples from range of international locations.



Challenges in modeling stormwater runoff and infiltration in urban water management

Tone M. Muthanna

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The relationship between surface water runoff and groundwater recharge is complex because the surface water system is coupled with the underlying groundwater system. Urbanization creates changes in the landscape and subsurface that alters these relationships. The effects of urbanization are non uniform and non linear in response. Soil infiltration and base flow is the link between the two systems, and Figure 1 (below) graphically illustrates what happens to infiltration as a watershed is urbanized.

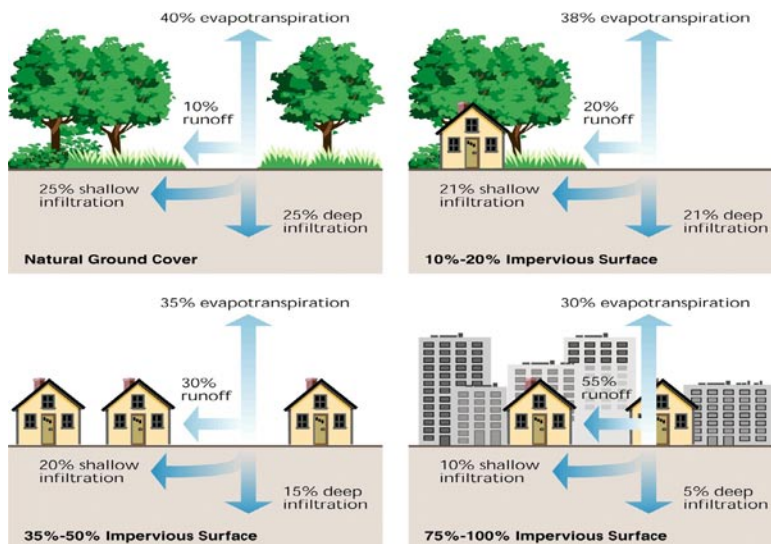


Figure 1: The effects of urbanization in the natural water balance FISRWG (2001)

Hydrologic models are mathematical and numerical representations of a very complex natural system; the hydrologic cycle. Most the commercial and non-commercial models are designed to focus on parts of the system in a higher time or spatial resolution or on the whole system on a lower resolution. The scaling issue is two dimensional; there is a time scale issue and a spatial resolution issue. The temporal resolution is important for an accurate estimation of the runoff volumes and peaks. Hourly observations will cut off the peaks and underestimate the volumes, as the time of concentration in urban watersheds are much shorter than natural watersheds. The spatial resolution is important to capture the stormwater management practices, change in land-use that affects infiltration. Many of the stormwater practices, especially typically distributed practices, like disconnecting roof drains, small garden sized bioretention facilities, are difficult to accurately represent in spatially distributed models with a routing network (i.e SWMM, MOUSE). The models developed for surface water management also lacks the connection between infiltration and baseflow making accurate modeling of groundwater recharge challenging.

This presentation explores some of these issues in creating a physical model that accurately represents the two interlinked systems; surface water and groundwater in an urban context. Some examples of how it can be done are used to illustrate the challenges and look at the best practice of today.





Managing the ground-surface water nexus in urban areas: Oslo case

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Oslo city's water resources portfolio primarily consists of surface waters. The city receives its water from the surface sources in the 330 km² large forest areas surrounding the city. The areas which consist of forty lakes are drained by eight major city's watercourses that flow into the Oslo fjord. The rocks that underlie the watershed and form the surrounding mountains are primarily consolidated rocks of marine-sedimentary and metamorphic origin. The drainage basin is filled with unconsolidated and semi-consolidated marine deposits. The layer of clay and silty clay is a confining unit of which thickness ranges from less than 1 meter to 100 meter.

Rapid urban development and the accompanying underground mining associated with extensive tunnel constructions and increased drainage of organic soils resulted in declines in pore-water pressure in the clay/silty clay soils as well as in the system of cracks in fractured rocks and the compaction of surficial deposits. As a consequence, significant subsidence occurred in the Bjørvika area, parts of Grünerløkka, Majorstuen, Ullevål and Bislett, various locations along the fjord as well as the Alnabru area to the north. In order to control the problem related to subsidence-related damage of the blocks of flats from the nineteenth century, which are founded on wooden rafts which "float" in the clay, a monitoring system of groundwater level and pore-pressure fluctuations was established in the critical area in the early 1970s. The decline in artesian head was halted and reversed by artificial recharge using infiltration wells. Based on the recovery project in the Majorstuen area, a system and procedures for monitoring water infiltration into the subsurface, pore-water pressure and the rate of subsidence were defined by the Geotechnical section at Oslo Water and Sewerage Works, Oslo Vann- og avløpsetaten (VAV). The groundwater data have been used to provide information related to the remedial measures and new project development.

The critical need for a solution to the subsidence problem brought about coordinated management of ground- and surface water in the drainage basin. Different studies have been carried out in order to better understand the details of the processes involved, and predict and prevent future problems related to water level falls caused by excavation and drainage activities. This triggered the use of new technology and new requirements in construction and maintenance of the city's new wastewater tunnel system in the Bjørvika area (subsidence 25 mm/year) and conservation of the cultural strata which lie at a depth of 2,5-4,5 meter under surface in the Medieval park in Oslo's Gamlebyen (Old Oslo).

A new Mapping and GIS section at Oslo municipality building authority, Plan- og bygningsetaten, will form the basis of the watershed management program for urban catchment basins. Starting in 2008, the Plan og bygningsetaten replaced the contour data with LIDAR data and beaklines to construct DTMs for surface and subsurface water modelling. The new geographic watershed information system will contain LIDAR data for topographic mapping, the subsidence measurement based on PSInSAR technique, as well as underground geologic and hydrogeologic mapping as a basis for future surveillance and operational monitoring and construction planning.





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