Cultural Heritage

A review of good practices in cultural heritage management and the use of subsurface knowledge in urban areas

TU1206 COST Sub-Urban WG2 Report

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TU1206 COST Sub-Urban Report
TU1206-WG2.7-008

Published  October 2016

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Acknowledgements

This report is based on work from COST Action TU1206 Sub-Urban, supported by COST (European Cooperation in Sciences and Technology), and itself, a component of the European Union’s Horizon2020 programme. Sub-Urban is a network to improve understanding and the use of the ground beneath our cities (www.Sub-Urban.eu).

Many participants of the Sub-Urban COST Action have contributed to this report and to the Action as a whole, each with their own experience and expertise. This evaluation would not have been the same without their presentations, comments, and discussions; they are all thanked for their contributions.
Acknowledgements

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In addition to dedicated workshops within the framework of COST, the use cases described in this report have been derived from activities organized in the framework of the following research projects:

- “Cultural Heritage and Water Management in Urban Planning” (2012-2015), funded by the Norwegian Research Council;
- “Groundwater and Cultural Heritage” (2010-2015), funded by the Geological Survey of Norway (NGU) and the Directorate for Cultural Heritage in Norway (Riksantikvaren).

On 16 March 2015, a dedicated workshop on "Cultural Heritage and the Urban Subsurface" was organised in cooperation with COST Action TU1206 in Oslo. During this workshop the topics in this report were discussed among a group of international scientists with backgrounds in heritage, environmental and geoscientific sciences. Participants at this workshop were prof. H. Kars (VU University Amsterdam, NL), prof. G. Gianighian (University of Venice, IUAV, IT), dr. H. Matthiesen (National Museum of Denmark, DK), dr. F.C. Boogaard (University for Applied Sciences, Groningen, NL), dr. S. Musa (University of Mostar, Mostar, BA), R. Stuurman (Deltares, Utrecht, NL), R. Stenbro (NIKU, Oslo, NO), D. Kreminska (NIVA, Oslo, NO), A. Seither (NGU, Trondheim, NO), dr. T. M. Muthanna (Norwegian University for Science and Technology NTNU, Trondheim, NO), dr. G. Ganerød (NGU, Trondheim, NO) and J. de Beer (NGU, Trondheim, Norway).

Contributions from individual researchers and practitioners are highly appreciated. Floris Boogaard and Michel Vorenhout are acknowledged for reviewing the use cases. Ola M. Sæther is acknowledged for quality control.

Trondheim, 15 March 2016

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1. Introduction

1.1. Rationale

City growth threatens sustainable development - a pattern of growth in which resource use aims to meet human needs while preserving the environment for present and future generations (The Brundtland Commision, 1987) - of cities. Over the past decades increased urbanization has created more pressure - not only on the suburban outskirts - but also in the inner core of the cities, putting important environmental issues, such as water management and cultural heritage, under stress.

Figure 1. Urban development legacies.

Historic city centres face the challenge of new developments. This (re)development is typically part of a planned renewal, but at the same time directs attention to how historic buildings and archaeological deposits in the inner city should be managed (Harvold et al., 2015). In contrast to the attention given to the visible (above-surface) expressions of cities, there is a marked lack of appreciation of the subsurface among those who plan, develop and manage cities (Malim et al., 2015). This is manifested in a lack of co-ordinated policy on the subsurface. As a consequence, the area beneath the cities is used inefficiently at best and unsustainably at worst; safeguarding of subsurface ecosystem services, such as “stewardship” for archaeological heritage, lacks robustness and conflicting uses of the
subsurface are largely unaddressed. Conflicts with prior uses and unappreciated impacts on other subsurface resources, amongst them archaeological heritage, make use of underground space in cities suboptimal. In terms of ecosystem services, the subsurface environment acts either as a carrier of archaeological heritage in situ (stewardship) or supports above-ground cultural heritage. Often, it’s not enough to protect the heritage site or monument itself: new developments outside a specific protected area can lead to changes in groundwater level, and cause serious damage to heritage buildings and archaeological deposits (De Beer and Seither, 2015).

Management of cultural heritage, both in urban or rural settings, is often related to surface- and groundwater management. Dewatering is one of the greatest concerns for those managing waterlogged archaeological sites, as well as a great danger for wooden foundations of above-ground monuments. To ensure their long-term survival, waterlogged organic material needs to remain waterlogged year-round as this significantly reduces the diffusion of oxygen required for most bacterial decay and aerobic corrosion reactions (Williams, 2016, in prep.).

1.2. Aim and context of this report

This report provides an overview of current practices in cultural heritage management and integration of subsurface knowledge. The main aim is to enhance awareness of cultural heritage as a driver for urban subsurface knowledge development and sustainable urban water management. A secondary aim is to develop guidance for other cities.

1.2.1. Within COST TU1206 Sub-Urban

Cultural heritage can be regarded as one of the fields of application of subsurface knowledge acquisition, interpretation, management and modelling. In the context of WG2 (Evaluation of practices and techniques), urban planning tasks and policy themes are formulated in WP2.1 (Subsurface urban planning and management). WP2.2 considers data acquisition and management, whereas this work package (WP2.3) considers 3D modelling and visualisation of the data. WP2.4 (Groundwater, geothermal modelling & monitoring), WP2.5 (Geotechnical modelling and hazards), WP2.6 (Geochemical modelling) can in line with this reports’ WP2.7 (Cultural heritage) be regarded as application fields.

We constrain the topic of cultural heritage to physical heritage, i.e. buildings, monuments, archaeological remains and artefacts. Other types of cultural heritage, such as traditions, are not considered.
1.2.2. Beyond COST TU1206 Sub-urban

In recent years, the field of cultural heritage preservation, and particularly archaeological heritage preservation, has seen a significant progress towards a more holistic approach, involving a range of different disciplines. This progress has also been triggered by some international examples of alarming developments where environmental changes, caused by urban development, resulted in accelerated decay of archaeological deposits as well as in damage to above-ground heritage buildings. The European Convention for Archaeological Heritage (Malta Convention, 1992) states that archaeological heritage preferably should be preserved in situ, within the subsurface environment. A proper understanding of the natural and man-made subsurface environments that affect heritage is essential for in situ preservation, mitigation design as well as management of heritage sites.

In autumn 2015, under the Horizon 2020 work programme for 2016-2017, the European Commission has launched new calls for large-scale demonstration projects in cities as living-labs for nature-based solutions for climate and water resilience and cultural heritage as a driver for sustainable development. The fact that both topics are considered integrally in new calls, illustrates the need for a more holistic approach in research and development on cultural heritage management at a European level.

1.3. Report structure

This report has been structured according to two main cultural heritage topics, each illustrated by two use cases:

1. Standing cultural heritage; monuments and historic buildings and sites
2. Subsurface cultural heritage; archaeological deposits and artefacts in situ

Finally, a thematic chapter describes the overarching interconnection between urban water management and cultural heritage management. Water management is not only central in both topics, it also represents a significant cultural heritage value by itself in many historic cities across Europe and beyond. Since ancient times, the urban subsurface has provided ecosystem services for water management, such as a source for drinking water and space for wells, cisterns and other infrastructure. Physical remains of these subsurface functions are an important cultural legacy of the city contributing to their identity and also providing lessons for current subsurface management practices.
2. Topic 1: Standing cultural heritage: monuments and other historic buildings and sites

2.1. Introduction

Many historic cities in Europe and beyond contain important monuments, historic buildings and other standing remains of human activity. Depending on the historic city development, it is a collective good ranging from the infancy of the city, to evidence of trade, industrial and pre-modern development. The protective management of standing monuments and historic sites depends on knowledge of geological and man-made subsurface conditions and processes affecting the stability and degradation of this cultural legacy. In this section, the Vondelpark case illustrates this dependency and how subsurface knowledge contributes to improved protection of standing monuments and sites.

2.2. Case: Vondelpark Amsterdam, the Netherlands

*Case introduction*

The Vondelpark (Figure 2) is one of the largest city parks in Amsterdam, and certainly the most famous park in the Netherlands, which welcomes more than 10 million visitors every year. In 1864 a group of prominent Amsterdam citizens formed a committee to found a public park. They raised money to buy 8 hectares of land and the landscape architect Jan David Zocher was commissioned to design the park in the fashionable English landscape style. The park was opened for the public in 1865 as a horseback riding and strolling park named Nieuwe Park. The name Vondelpark was adopted in 1867 when a statue of Dutch poet Joost van den Vondel was situated into the park. The committee soon raised money to enlarge the park and by the year 1877 it reached its current space of 45 hectares. At that time, its location was on the edge of Amsterdam, but since then it has become central in the city, close to Leidseplein and Museumplein. Since 1996 the whole park has been designated as a National Monument (www.amsterdam.info/parks/vondelpark).

![HET VONDELPARK](image)

*Figure 2. Vondelpark map (source: project.waag.org/parq/vondelparkmap).*
Being constructed on a muddy dump area, the Vondelpark has to go through a total renovation every 30 years. This is because the actual ground level of the park constantly lowers itself. If these renovation works would not be done, the whole park would be covered by water. This problem is visible after heavy rainfalls towards the end of the 30-year period before the next renovation, when whole parts of the park become vast ponds. The water cannot be simply pumped out as this would lower the groundwater around the park and endanger the wooden foundations of the buildings situated nearby. The park has existed now for almost 150 years and includes many old plane trees, horse chestnut, Dutch red chestnut, catalpas and different sorts of birch trees. Numerous bushes and herbs complete the park’s landscape. Vondelpark is also a home to many birds including wild ducks, blue herons and many smaller birds.

Subsidence of the Vondelpark with an average rate of 1 cm per year during the last 150 years has resulted in 1.5 meter lower terrain levels. This is clearly visible at the Vondel statue which is founded on wooden piles (Figure 3).
Subsidence leads to serious problems not only for the maintenance and water management within the park itself, but particularly along the borders of the park, where monumental houses founded on wooden piles are located. The wooden foundations are threatened by the lowering groundwater levels necessary to keep the park dry. A series of geotechnical and hydrogeological investigations have been carried out to find good solutions.

As an example, one of these solutions was developed in the area called “Slurf”, a narrow entrance section of the park. Different disciplines have reached agreement on an almost perfect solution. A historic small creek was revived using a water circulation plan to improve water quality with a waterfall, cascades and natural seepage (Figure 5, Verhoog, 2007).
A combined system with a dry swale with soil passage, constructed wetland, drainage, infiltration and a hydrological barrier now secures improved groundwater conditions and supply of clean surface water that is circulated over a constructed wetland to improve the water quality. This has resulted in more durable paths and lawns, trees are growing older and wooden pile foundations are no longer threatened by low groundwater levels. All stakeholders in this old city area have co-operated in a fruitful way, which has resulted in a solution where the historical park design and modern requirements are considered. The dedication of all stakeholders shows that the Vondelpark is really a valuable cultural heritage asset, and not only a “green” area in the urban environment.
3. Topic 2: Subsurface cultural heritage; archaeological deposits and artefacts in situ.

3.1. Introduction

There are quite a few good examples of how archaeological heritage depends on subsurface conditions and processes, particularly related to hydrological conditions. In this section, two examples on how archaeological heritage and earth sciences disciplines can interact and benefit from each others’ techniques and competence are given.

The first case is a technical study on mapping, leading to guidance to planners. The second case is a good example from the planning perspective.

3.2. Case 1: The hidden heritage at Nantwich and York

This is an excerpt from “The hidden heritage at Nantwich and York: Groundwater and the urban cultural sequence” by Tim Malima, Ian Panter and Mark Swain, Quaternary International 368 (2015) 5-18 (SLR Consulting Ltd, UK, York Archaeological Trust, UK).

Although waterlogged deposits in Britain have revealed spectacular archaeology over the past century, the interest in characterizing the kinds of environment in which these survivals occur, and methods for their management have only recently developed a more strategic approach (e.g. Christensson et al., 2008; Reed and Martens, 2008; de Beer et al., 2008; Petersen and Bergersen, 2012).

The scale of development within urban centres over the past two generations has raised awareness of the particular depth and diversity of archaeological deposits within urban contexts (e.g. Holden et al., 2009; Reed and Martens, 2008; Matthiesen et al., 2008), and the need to investigate alternative strategies rather than continuous excavation in response to development. National policy in the United Kingdom (SHEP 2010; NPPF 2013; PPW 2012) is to conserve remains, preferably in situ, but no systematic approach has been developed to understand and manage these types of waterlogged deposits.

In 2007, English Heritage and Cheshire Council commissioned a pioneering study of Nantwich, a historic salt-production town located on the western and eastern sides of the River Weaver, and situated half-way between Chester and Manchester. The study was carried out by SLR Consulting, supported by York Archaeological Trust. The centre of Nantwich is a conservation area, designated for its built heritage, much of which is constructed on top of 3-4 m of archaeological deposits. The aim was to characterize the physical and chemical nature of the burial environment, to map its extent, to interpret the cause of preservation and current threats, and to design a management strategy for the waterlogged deposits which enabled economic growth and new development.
The first stage in the investigation was a desk-based assessment (SLR, 2007) to map the extent, depth and location of previously identified waterlogged deposits beneath Nantwich. This study aimed at utilising non-archaeological data from borehole logs recorded by the British Geological Survey (BGS) and local development schemes, but unfortunately very little usable data was available from the 103 locations and from these sources. This was due to the fact that borehole logs had not been retained once the application had been determined. Instead, data from previous archaeological investigations was used to establish the areas where waterlogged deposits had been recorded and to provide target areas for investigation as part of the characterization project.

After the desktop study, a range of field- and laboratory studies were carried out, such as borehole coring, laboratory soil analysis, palaeoecological assessment, groundwater level and quality monitoring, groundwater sampling and laboratory analysis, permeability testing and gas monitoring. Figure 6 provides an overview of borehole and monitoring well locations (dipwells).

![Figure 6. Nantwich with monitoring well (dipwell) locations (source: Malim et al, 2015).](image-url)
Results

Nantwich is located on Mercian mudstone capped by glacial till, overlain by sands and gravels deposited by the River Weaver, and ranges in altitude from 40 m AOD at the church down to 31 m at the river. GIS modelling of natural drainage paths showed several minor historic water courses cutting through the hillside on the eastern bank of the Weaver and extending up to the church. Over time these had become infilled with organic remains, and it is this area as well as the salt-working zone on both sides of the river to the west, in total 12 ha, in which up to 4 m of waterlogged deposits have accumulated. Organic remains were well preserved adjacent to the river, but even on top of the hill the preservation of organic remains was extremely good. Evidence of organic remains surviving in this area includes structural timbers of 11\textsuperscript{th} - 12\textsuperscript{th} century date found \textit{in situ} and human remains with hazel rods found surviving in shallow graves near the church. The interpretation as to why this has occurred is attributed to the underlying superficial geology, in that the sands lying above the impermeable glacial till became saturated, inhibiting decay of organic remains and leading to a gradual growth of the archaeological deposits.

The coring programme confirmed the presence of ground conditions anticipated in the desk study. The natural superficial strata included alluvium, river terrace deposits and glacial till. These sediments were overlain by made ground in the developed areas around the town centre. Norwegian protocols had been used in recording the core samples, but in order to simplify the borehole logs, the deposit sequence was classified into four broad categories to aid comparison and deposit modelling. The four categories were as follows:

- Made ground: man-made fill material from the higher part of the borehole which included brick, mortar, modern materials, or identifiable inclusions datable to the 18\textsuperscript{th} - 20\textsuperscript{th} centuries.
- Archaeological deposits: silts, clays and sands, black - light grey in colour, which contained evidence of human activity such as ash, charcoal, pottery, bone etc., but without organic remains evident in cores (first part of “waterlogged deposits”).
- Non-carbonized organic-rich deposits: plant-microfossils, wood, leather, plant debris and sulphide odours, archaeological deposit containing evidence for organic remains in cores (second part of “waterlogged deposits”).
- Mineral-rich deposits: grey clays, silts and sands that contained no inclusions of archaeological origin.

In addition, the natural geology was defined as fluvio-glacial deposits: records from the lowest part of the borehole describing superficial deposits of sand that form the top of the natural geological sequence (Figure 7).
The coring programme suggested that the waterlogged deposits were not as uniform or widespread as expected, even though these deposits are known from previous archaeological excavation to have contained organic remains. This demonstrated the variable nature of the deposits, and the inherent complexities in their formation processes and preservation within an urban environment.

The Nantwich study is the first systematic attempt to assess the sediment geochemistry in an urban context in the UK and has adopted an approach that is broadly similar to that applied in Bryggen, Norway (Matthiesen, 2008). Geochemical soil analysis suggests that reducing conditions exist in the floodplain sediments in hydraulic connection with the river, and that these reducing conditions increase with depth. Nutrient levels were low, and therefore indicative of potentially good preservation conditions.

Dating of organic remains showed that the earliest waterlogged deposits were grouped between 118 BC and 111 AD. Roman organic remains of 2nd century date have been found outside the historic centre, whilst the initial onset of waterlogged conditions within the town centre is represented by roundwood near a brine spring dating from the 8th century onwards. It appears that the main period of accumulation of organic remains has begun in the late Anglo-Saxon period (10th - 11th centuries), continuing into the 13th century.
Preserved remains include timber structures, wooden conduits, corduroy roadways, salt ships, barrels and other items.

The results of the groundwater monitoring indicate that groundwater is present at depths between 0.7 m and 3.5 m below ground level. As expected, the general direction of groundwater flow is towards the River Weaver. Preferential groundwater flow pathways exist within the shallow deposits that are probably related to the historical water courses and drainage channels that are now buried beneath the town. This is reflected in the presence of local highly permeable granular fluvial deposits and the difference in the depth to the water table. There is evidence that the most reducing conditions are located in the area within 100 m reach of the river. However, the water table in these boreholes is generally located below the archaeological deposits due to the draining effect of the river, which is situated at a lower level than the cultural horizon. This suggests that the reducing conditions in this area are potentially due to the location of the deposits within the capillary zone; otherwise more oxidizing conditions would be expected if the deposits were actively drying out. A comparison between rainfall and redox-potential levels within the groundwater appears to support the hypothesis that the influx of oxygenated rainfall increases the levels of oxidization within the waterlogged deposits beneath the archaeological deposits.

The combination of soil types and measured hydraulic conductivity values indicates that there is an area of high hydraulic conductivity in the vicinity of St Mary's church which may have a significant drainage effect on the surrounding locality. The saturation of shallow sands overlying till is a contributing factor to the waterlogging of deposits, whereas areas with greater thicknesses of sand deposition contribute to increased drainage. Therefore, the monitoring wells in the area around St Mary's Church tend to have a lower water table and this is also confirmed in the groundwater monitoring data. In general, the inverse is true at other locations where less permeable sediments are present, and the monitoring wells in these locations tend to have a water table at a shallower depth.

The baseline conditions for preservation showed that all monitoring wells had reducing conditions, but that these values were clustered above the sulphide/sulphate boundary. The water was more acidic than samples from sediments, and a comparison of conductivity to salinity suggested that recharge was largely through surface water (groundwater from deeper horizons showed higher levels of conductivity due to the effect of brine springs). Based on the sedimentary geochemistry and water quality, two zones were identified; Zone 1 with good preservation potential characterized by high methane readings, low levels of phosphate and nitrate, sulphate and ferric iron, whilst in Zone 2 (which was located uphill from Zone 1 (Figure 8), the conditions generally suggested past and active decay.
However, there were also isolated boreholes which showed contradictory results to the general pattern in both zones, and the water table varied between 1.4 m and over 3 m below existing ground surface. Where desiccation of the deposits is occurring, this is attributed to the changes introduced during Victorian times following cholera outbreaks, to improve sanitation through paving streets and building drains. The natural percolation of rainwater was diverted into the River Weaver, resulting in 150 years of gradual drying out. Incidences of subsidence to buildings and other structures have been noted, and might be due to the shrinkage of the waterlogged deposits. A supplementary planning guidance document has been produced to try to influence spatial planners, highway engineers, drainage engineers, and others so that the hidden heritage of Nantwich is better appreciated and can begin to become incorporated in strategic planning.

York
A similar situation exists in York, where over forty years of excavations have revealed the presence of substantial archaeological remains dating from the first century AD onwards. York is located at the confluence of the Rivers Ouse and Foss, where the Ouse cuts through a moraine composed of sand and gravel left by the retreating glaciers at the end of the last Ice Age. This moraine forms a ridge of high ground that would have acted as a dry access route.
running east-west across the low-lying Vale of York. Excavations and other interventions have revealed the extent of the waterlogged archaeology throughout the urban core of York, particularly in the valleys of the two rivers as well as the “Kings Fishpool”, an area in the south-east quadrant of the city that was created when the River Foss was dammed in the year 1069 to form a moat around the new Norman castle. Much of this material can be considered as “well-preserved” because the deposits continue to be hydrologically connected with the rivers. A recent intervention adjacent to the south-west bank of the Ouse (York Archaeological Trust, 2001) led to the release of methane gas which was carbon-dated to the 10th Century AD, indicating that the source of the gas was from deposits accumulated in the historic past, the organic Anglo-Scandinavian archaeology and suggesting that elements of the archaeological deposits remained anoxic (methane gas is formed during microbial activity under anoxic conditions). However, threats to the continued preservation include the construction of improved flood defences as and when the full impacts of climate change become apparent.

Surprisingly, there are large areas of well-preserved organic archaeological remains within the historic core that are effectively disconnected from either river. Although the very early Roman features, often situated between 6 and 8 m below the current ground surface, may be recharged by groundwater flow from the Ouse. Later deposits may be located within the capillary zones whilst perched water tables account for other pockets of preservation. These deposits are more at risk than those connected with the rivers and over the years attempts have been made to identify and monitor such threats.

The investigations completed at Nantwich and York prove that soil coring programmes combined with monitoring well installations can provide the information required to assess and monitor the in-situ preservation conditions of archaeological deposits. This approach allows the waterlogged archaeological deposits within our constantly evolving historic urban environments to be monitored and preserved for future generations, particularly in locations where traditional excavation techniques are not feasible due to physical or financial constraints. Following the investigations at York, the responsible City Archaeologist (John Oxley) frequently requests deposit monitoring as a component of the archaeological evaluation for commercially funded schemes. These typically involve the installation of a small number of monitoring wells with regular measurements of redox potential, water levels, conductivity and methane gas. A problem occurs when it is attempted to monitor post-construction, as there is usually neither funding available nor anyone or nobody identified to carry out the procedure. But the procedure has led to the installation of a network of monitoring points around the historic core as well as additional data pertaining to water levels, geochemical characteristics of the sediments and baseline data about the level of preservation of certain material classes.
To complement this initiative, and in recognition of the complexity of urban hydrology, the York Hydrology Study was commissioned by English Heritage and carried out by Joseph Holden and Ellie Maxfield, two hydrologists from the University of Leeds. The project adopted a systems analysis approach and considered the range of factors that determine the amount of water entering and exiting York (Holden et al., 2006). The three major recommendations from the study were:

− Improved recording of soil and water characteristics and classification of the preservation state of organic remains;
− The development of a 3D model of the natural land form and the archaeological deposits;
− Implementation of a programme of characterisation, monitoring and modelling of selected sites leading to the production of a vulnerability map for the historic core.

The conducted work in Nantwich has followed these lines and will be rolled out nationally. Subsequently to the first phase of the Nantwich project, English Heritage has commissioned five further projects in urban centres with known waterlogged potential: Berwick, Boston, Bristol, Carlyle and Droitwich. At these locations, as well as in York and Nantwich, organic remains have been found in a variety of unexpected locations (including the unsaturated zone), which are presumed to be the result of favourable micro-environments formed by factors such as perched water tables or capillary action. TDR probes fitted with remote dataloggers have just been installed in Nantwich for a more detailed study of soil moisture in these deposits.

Proactive engagement, and even an evangelical approach, will be required from archaeologists in order to influence urban planners so that they realize the value and threat not only to the buried archaeological heritage, but also to the historic buildings that are constructed above. It is this cultural heritage that continues to promote the economic viability of the town by making it an attractive place to live, work, shop and visit.

3.3. Case 2: Sustainable urban water management in medieval Tønsberg

This is an excerpt from “Sustainable urban water management in Tønsberg” by Kjell Harvold, Norwegian Institute for Urban and Regional Research (NIBR), published in: NIBR Working Paper 2012:10. The case was produced within the framework of the Interreg IVB NSR Project “Skills Integration and New Technologies (SKINT), July 2012.

Over the past decades, regulations concerning improved water quality, coupled with climate change and increasing urbanization, have created increasing pressure on water management, especially in urban areas. This leads to a more integrated approach related to
ground and surface water in urban areas, compared to conventional drainage of surface water. Currently, innovative water solutions are available, but implementation is hindered by barriers to multidisciplinary working. Especially since many innovative water solutions have a much higher surface demand than conventional drainage systems, the integration of water management in spatial planning processes is important.

The urban development and planning process involves different stakeholders that often represent different disciplines. Usually the stakeholders’ perspective is limited to their own discipline. Technical experts (water managers, urban drainage engineers, road engineers, etc.) often speak a different “language” compared to spatial planners, city architects and project developers. Their perception of the problem and their expectations can be very different. With changing conditions and new challenges it will be important that different stakeholders understand each other’s positions and are capable to communicate in the right way in order to come to most sustainable solutions. Especially when they are working together in a multidisciplinary urban development and planning process it’s important that they are able to understand and speak each others’ language.

Urban archaeological deposits are among the more challenging phenomena confronting heritage management authorities, town planners, property owners and town developers alike, particularly in relation to building and infrastructure projects (RA/NIKU’s Monitoring manual, 2012). Norwegian authorities have stated that it is an aim to “preserve the underground archives” and, at the same time, to establish conditions for continued use of the pertinent areas and the development of the vital inner cities (Parliamentary Report no 16: 2004-2005). In the municipality of Tønsberg, local authorities have decided to revitalize the town centre. In this revitalizing process the authorities face a lot of challenges – not at least when it comes to water management, drainage and preserving the archaeological deposits: As it is a medieval town most of the urban centre has such deposits. In this section we focus on the planning process in Tønsberg: How do the authorities and other planning actors solve the challenges connected with the development of an urban area, where drainage, water management and cultural heritage management are key factors?

Tønsberg is the oldest urban settlement in Norway, founded as a town during the Viking Age in the year 871. Many famous Norwegian archaeological finds – such as the Oseberg ship – have been found not far from the centre of the town. Tønsberg remained an important centre for the Oslo fjord region throughout the Middle Ages: from the 13th to the 16th century, it was one of three Norwegian Hanseatic towns, with its own Hanseatic trade office. In the 17th and the 18th century, Tønsberg became an important shipping town – and later (in the 19th and the first part of the 20th century) whaling made businessmen from Tønsberg very rich (see also http://www.visittonsberg.com).
Systematic archaeological investigations of the medieval town were carried out more or less annually from 1971 to 1991. After 1991 only smaller excavations were carried out, with the exception of one major excavation in the year 1999. The latter was followed up with a monitoring program to record possible detrimental effects of new building constructions on the archaeological deposits left intact around and under the buildings. Figure 9 indicates the areas with archaeological deposits that are automatically protected according to the Cultural Heritage Act.

The municipality has now decided to revitalize the centre of the town. This is considered to be a key element for creating a new framework for the development of the urban centre, as
it’s formulated in a new Master Plan. The plan emphasizes that the town centre has, like very few other Norwegian towns, still a part of the street structure from medieval times. Tønsberg has a central town square - and this square, with its surrounding streets, has a potential for revitalization. However, to reach the goals for revitalization, the town has to organize traffic in new ways - and has to try to connect different parts of the city closer to each other, for instance by connecting the harbour with the town streets and the town square. The process of revitalizing the historic centre of Tønsberg includes numerous challenges - not least when it comes to preservation of the urban archaeological deposits - and how this should be coordinated with other considerations like drainage and water management. However, since systematic investigations have already been carried out, a good baseline is given. The overall aim for the authorities being responsible for protecting cultural heritage assets is not to stop all new development. The Directorate for Cultural Heritage in Norway states that the goal is to protect the medieval towns and to "find ways of fulfilling this goal at the same time as allowing the modern town to develop".

The revitalization of Tønsberg historic centre is ambitious, and one of the first challenges that the main actors in the project realized was that the organisation of the process should be taken into close consideration. As one informant in the project stated:

“Dialogue with all actors is a cornerstone in the revitalization process of Tønsberg. This project would be impossible without cooperation and coordination with a lot of different people. This includes – among others things - involving actors for different public sectors, private enterprises and property owners and - not least - the ordinary people of Tønsberg.”

To deal with the different challenges, such as drainage and water management, different organizational approaches have been put into action. The overall responsibility for the project is linked to the City Council (the highest elected body in the municipality). A special enterprise “Tønsberg Development” (Tønsberg Utvikling) has been established by the municipality to deal with challenges that involve cooperation with the private sector in Tønsberg historic centre. Tønsberg Utvikling (TU) is led by a board with eight members. The board consists of leading politicians (from the City Council) and representatives from the private sector. The town mayor is the leader of the board. In addition, four other politicians participate in the board (representing different political parties). Two board members come from private enterprises, and finally the chief administrative officer of the municipality (Rådmannen) is member of the board. Key-figures in the community are thus members of the TU-board. For the development project for the historic centre, this is considered to be very important. One of our informants stated that:
"The TU-board is very “action-oriented”: They want things to happen. And because they are leading politicians and represent important private enterprises they know what is possible to do, and what’s not possible to do. This may have led to a faster decision making process, compared to process where everything had to be given clearance through a formal political process."

The project manager for the historic centre-project reports to the board. It has also established a special project group to solve ongoing challenges in the project. This project group consists of one representative from The Directorate for Cultural Heritage, one representative from the archaeological research institute that perform the actual excavations, one representative from a private consultant (hired by the municipality to take care of the planning process) and one representative from the municipality's water and sewerage department. The group is led by the project manager from Tønsberg Utvikling.

The project group has meetings at different time intervals, depending on what kind of issues need to be solved. Typically, the group meets one time per month. The group members gather to discuss practical challenges concerning the development, such as how to solve problems when it comes to ground work, ground heating, terrain surface development, electrical (re)constructions, etc. One instance has usually the responsibility for the specific field of work – but necessary coordination is taken care of by the project group.

The members of the project group seemed to be satisfied with the internal cooperation; as one member stated:

"I think that the group functions very well. We have an open dialogue and we are focused on solving the problems as they come by. The representative from the Directorate for Cultural Heritage is very open-minded. As the rest of us he is interested in finding solutions that can bring the project forward."

The project group has numerous different specific tasks to work with as the development of the historic town progresses. To maintain a momentum in the development project, it is important that alignment of different tasks is coordinated. The work has not been without problems, as the members of the project group pointed out during the interviews. The main problem has without doubt been new archaeological findings. The project leader stated that:

"When we started up this new development project in the historic centre, we had faith in the assessment from The Directorate for Cultural Heritage: Their valuation was that there would be little need for new excavating work now, since there had been systematic excavations in the town from 1971 to 1991. The assessment was also based on an archaeological
research report from 1997. However, on the second day of ground work in the main square, the workers hit unknown archaeological objects. The work had to be stopped, and archaeologists took over.”

The new archaeological findings significantly delayed the whole project. When work started (spring 2010) the plan was to finish construction in the same year (fall 2010). However, this time schedule could not be realized, mainly because of the new, not expected archaeological findings and required mitigation measures to preserve the archaeological heritage. A revised plan from Tønsberg Utvikling indicated that the work would be delayed by one year. In addition to the delay, the municipality has to pay for the excavations, following the given principle in Norway that developers have to pay for archaeological excavation costs.

Even though the development of the town was lagging behind the original time schedule, the members of the project group seem to be relative patient. One of the members formulated it like this:

“When we are dealing with archaeological deposits, we have to be aware that things can take much longer time than first anticipated: Archaeological work takes time.”

It should also be pointed out that the new findings had positive effects: the local newspapers wrote articles about the archaeological findings. This led to larger interest from the inhabitants and created a new awareness among the citizens about Tønsberg’s medieval history. Tønsberg Utvikling has tried to build on this interest by publishing information leaflets and also by placing information boards on the town square, where the archaeological excavation is taking place.

It’s also important to emphasize that there was a high awareness and knowledge within the project group about how the constructions influenced the water balance and, therefore, the archaeological preservation conditions. During the whole process there has been a high willingness to change constructions plans in order to preserve archaeology.

The members of the project group emphasized that it was a significant advantage that the municipality itself - and not a private contractor - had the responsibility for the conducted ground work. When the development had to stop because of the archaeological excavations, the municipality could reassign its workers elsewhere. If a private contractor had been hired, this would not have been possible, and the municipality would have been faced with high labour costs even when the work was temporarily halted.

The project group is of key importance for the whole development project. However, for Tønsberg Utvikling it is also important to ensure participation and involvement from groups
outside the project group. The project leader emphasized two main categories of groups outside the public sector:

“First of all it’s of course important to have a close cooperation with the private property owners with properties around the town square. There are 12 such owners. They were all invited to participate in the development project when we started up. Nine of the owners responded positively to the invitation – and have participated since the start. However, three owners have turned down the offer of participation, due to economical reasons.”

It should be emphasized that the bulk of the development costs is financed through public funding (from the municipality). The estate owner portion of the financing was clarified from the beginning of the project. In other words; when the total project costs increased (as a result of the archaeological excavations), this had no effect on the estate owner’s financial contribution to the project.

All the three interviewed members of the project group underlined the significance of a good dialogue with estate owners. One of them formulated it like this:

“A very important part of the project is to maintain a good relationship with the estate owners: They have to know what is happening when, so that they can plan their own businesses”.

The property owners are invited to meetings where they are informed and have a possibility to discuss the project with representatives from Tønsberg Utvikling and the project group. NGOs and the inhabitants of Tønsberg are also important groups for the development project that were informed through brochures, pamphlets and specific meetings. In addition, Tønsberg Utvikling has put up banners and information boards on and around the town square itself. The citizens have been invited to public meetings where the project has been presented and where it has been possible to discuss the development progress.

The project leader underlined the importance of reaching out to the public:

“The remains of The Maria Church were uncovered during the archaeological works last year (2010). This created a tremendous interest among the inhabitants of Tønsberg. People became really interested in the medieval settlements. I think it is very important that we build on this positive interest in the project: It can create a positive attitude towards the whole development project of the historic town.”
The main lessons learned from the planning process in Tønsberg historical centre can be summarized in six points:

a) **Putting water early in the planning/development process.** Different stakeholders have been involved in the project from the start. Water managers participated in the project group from the start, which ensured that considerations related to water and archaeological preservation were timely included in the project.

b) **Organisational model.** When it comes to the organisational model, the Tønsberg approach had many advantages. First of all, the strategic organisational model has given the project a firm foundation: Leading actors - both in the public and in the private sector - are linked to the project, facilitating direct handling of challenges in the development process with little bureaucracy.

c) **Archaeological excavation may take time.** Due to the cooperation within the project group, the damage to the archaeology has been minimized. However, the redevelopment of the historic centre took much longer time than first anticipated: archaeological excavation takes time, and this must be reflected in the work schedule.

d) **Prioritization of archaeology may lead to lower priorities for other environmental considerations.** The development in the town square illustrates that the prioritization of archaeological deposits can mean that one has to give less priority to other environmental considerations. Some of the larger trees in the historic centre had to be cut down, because their root system could damage the archaeological deposits. New trees had to be planted in separated “pots” or tanks, resulting in smaller trees, needing more care, and having a shorter lifespan than trees under ordinary conditions.

e) **A direct contact forum between representatives from water and drainage departments, heritage management representatives and other developers can give good solutions.** Within the project group it is easy for heritage representatives to contact actors that implement new developments, such as the municipal water and drainage department. Problems concerning subsurface conditions, stormwater and drainage issues could easily be identified and solved directly in these meetings. The project group was also a forum for dialogue between (cultural heritage) protecting interests and development interests.

f) **Open dialogue can create positive involvement.** Tønsberg Utvikling formed a model for dialogue with the public and with the involved property owners. An open information and dialogue strategy towards the public is probably of vital importance for a project like this. In Tønsberg the strategy resulted in a positive public interest for the new development of the historic centre.
4. Sustainable urban water management and cultural heritage

4.1. Introduction

This section considers two relations between water management and cultural heritage. The first is regarding historic subsurface urban water management systems that have heritage value by themselves; they tell a story about how man during thousands of years has made use of the subsurface as a resource. It is illustrated by the historic development of the City of Venice and how its inhabitants have used, and still do use, the scarce subsurface space for storage and supply of fresh water.

The second relation is the use of sustainable urban water management techniques to preserve subsurface archaeological heritage and historic cultural landforms. It is illustrated by the case Motte Montferland in the Netherlands; the highest man-made hill in the Netherlands.

4.2. Case 1: Water management in the historic city of Venice.

This is a summary based on a keynote presentation "Venice and Fresh Water" at the final seminar of the project “Cultural Heritage and Water Management in Urban planning”, by prof. Gianighian at the UIAV, Venice. The full presentation is available at www.sub-urban.eu.

The city of Venice has been growing by steady land reclamation from shallow sea and marshes (Figure 10). Land reclamation took place by driving wooden piles into the mud around the area to be reclaimed and by constructing brick quay walls on top of this. The area was subsequently filled with rubbish, old building material and soils (Figure 11). The subsurface of the city is characterized by this legacy of land reclamation, resulting in a rather unstable foundation base.
Surrounded by the brackish lagoon, Venice was always aiming at fresh drinking water. The groundwater is primarily brackish and naturally produced groundwater for drinking water purposes is rare. To make use of their rain, Venetians built thousands of rainwater cisterns below the pavement of the public squares and palace courtyards. A unique system of water harvesting situated below the surface (Figure 12).
In its original form, the access to fresh water was taken care of by the construction of square sand-filled "boxes" placed above ground at the harbour front. These so-called Aquatas provided fresh water for Roman ships. Only later this system was adopted to the Venetian land forms by constructing the cisterns below ground, normally down to about 3 meters below the surface. Each cistern began as a large void excavated into the island mud. They coated the hole with a 4'-thick layer of locally produced clay. In the center, they built the well column: a wide stone "pipe", perforated at the base with special permeable mortar. Around the well column, the clay bowl was packed with layers of cleaned sand, pebbles, and gravel, which provide water purification and stabilisation of the subsurface. At the corners of the hole, just inside the clay perimeter, they embedded four permeable galleries into the sand. On top of these galleries, special perforated slabs were placed to channel down rainwater towards the subsurface galleries (Figure 13). The rainwater directed to these slabs infiltrates slowly towards the central shaft by force of gravity. On top of the shaft, typical wellheads were placed, often beautifully designed. They call this whole assembly a pozzo or well (Figure 14). The sand and clay combination is the key to this system. The impermeable clay keeps the brackish lagoon water out, separate from the fresh water sand filter on the inside. The clay membrane functions like an aquiclude layer bounding a sand aquifer. The sand filters the rainwater and its compression strength obviates the need for a structural system below.
The typical depth of a cistern was about 10 feet, as it was considered a risk to extract deeper than this level due to the risk of ingress of dirty, salty waters into the system, which would be difficult to remove after the completion of the cistern.

Figure 13. The pilella, stone perforated slabs to channel down the rainwater into the cistern (source: G. Gianighian, IUAV).

Bianco investigated all cisterns in Venice in 1858-1860. He documented the depth, capacity and quality of the water as well as the connected roof area. Rainwater channels were constructed along the roof and inside the masonry of the buildings to channel the water to the courtyard and into the cisterns. Stone gothic gutters are examples of this.
Some cisterns have in later times been restored and raised to avoid seawater entrance during high tides. It has been documented that a special squad was established to flush the cistern systems in case of pollution with brackish or salty seawater. The brackish water was pumped from the cisterns and transferred through temporary wooden gutters to the sea.
The cisterns were then filled with fresh water from the rivers and emptied again. This process was repeated 6-8 times until the water regained a satisfying freshwater quality.

The use of cisterns in the courtyards in the city required space. This became a problem from the year 1633 onwards, when the urban area of Venice was growing steadily, with the given limited availability of building plots. More double buildings were therefore constructed on top of cisterns, to more effectively use the available building areal. Those newer, internal cisterns do not have the traditional galleries as those that were constructed in the original courtyards. They are just subsurface "water boxes" with only internal well heads. These newer systems were built under the building foundations, using the foundation structures as framework.

The Venetian water harvesting system was abandoned by the introduction of the aqueduct in the year 1884, and water was transported into Venice from the hinterland. It was the "death" of the traditional Venetian water harvesting system. But still today, every courtyard of the city in Venice, public or private, has at least one cistern, public or private. The shallow subsurface of Venice can thus be described as a sort of large sponge; 6 km long, 3 km wide and with a large number of holes in the ground for harvesting fresh water. With the 6,000 sand cisterns in Venice (not including terra firma), the city was formerly a dense collection of small fresh water aquifers, sitting in a saltwater lagoon.

In light of the current focus on sustainable urban development, the possibility to reuse the original cisterns in the subsurface for secondary water supply services has become tangible. All historic information on the Venetian cisterns collated by Bianco (1858) was entered into a GIS database (Gianighian, 2010, Figure 15) and several old cisterns have been re-investigated to assess the possible re-use of the system. Although this project was halted due to financial issues, a success has been achieved at the Marciana Library. At this location, the old system proved to be considerably larger than originally documented by Bianco. The old subsurface cistern is now used for flushing toilets, using the rainwater harvested from the roofs of the Marciana Library building.
4.3. Case 2: Motte Montferland, the Netherlands

This is an excerpt from “Implementation of sustainable urban drainage systems to preserve cultural heritage – pilot Motte Montferland” by Floris Boogaard, Michel Vorenhout, Johannes de Beer and Ronald Wentink (in press) for publication in Conservation and management of archaeological sites in situ (Spring 2016).

Introduction

It is well described that groundwater quantity plays a crucial role in preservation conditions for archaeological deposits (e.g. De Beer et al., 2012; Smit et al., 2006; Tjelldén et al., 2012). Be it degradable remains that need to stay in a permanently anoxic environment (e.g. Matthiesen et al., 2015; Vorenhout, 2015), or be it materials that require low water flow such as bone (Hollund et al., 2012; Huisman et al., 2009). Urban areas often exhibit large areas with solid surfaces, making it difficult for rainwater to infiltrate. Low infiltration means lower groundwater tables and higher water flows along roads and structures, which in its turn can cause erosion. Implementing water management structures in archaeologically important areas can be challenging (de Beer et al., 2012b). Any local structure used to manage the water flow can potentially damage archaeology (de Beer et al., 2012a). Most of these structures require groundworks, and some are placed completely under the surface. This trade-off requires special attention and experience (Rytter and Schonhowd, 2015).
Establishing a stable hydrological environment is the main goal. Green infrastructural solutions such as Sustainable Urban Drainage Systems (SUDS) are the applied methods for preservation of cultural deposits. Some Dutch pilots show that implementation of SUDS can be performed in an archaeological setting, and that they are in general cost effective. Subsurface green and blue solutions have been adapted in order to prevent the use of underground infrastructure (storage volumes, pipes, cables, etc.) and as such minimize the effect on archaeological layers.

In Boogaard et al. (2016), several solutions in water management at archaeological sites are discussed, followed by general information of different case studies. In this section, the example of the Motte Montferland is excerpted from Boogaard et al. (2016). At Montferland, a variety of SUDS are implemented to preserve the water balance and thus the archaeological heritage.

**Motte Montferland**

The Motte Montferland is the highest man-made hill in the Netherlands. It is surrounded by a double canal system. Since 1000 AD, it has been inhabited by royals, and was used as a fortified living place. The Motte is a listed monument, and its shape has been defined as the most interesting feature. This shape is quite remarkable. A physical calculation study showed that in fact the sides of the hill are basically unstable as they are too steep. There is a small road on the side of the Motte which is going up to the plateau. The apparent cracks in the road and visible small landslides aside raised an alarm in the 1990s. Several parties have described the problems, and all agree that the increasing amount of rain over time is the largest threat. The hill slopes can be protected by dense vegetation with roots, but this vegetation has changed into a small wood, currently seen as an undesirable situation. The most ideal vegetation cover is short and should show the complete form of the mound.

The threat of erosion of the hill slopes will increase when the vegetation is not dense enough, especially during the period of wood cutting. Several consultants gave ideas to divert the water flow caused by rain from the slopes and road towards local storage. The initial plan entailed large-scale stormwater storage and infiltration at one central place in the higher area. This, however, would mean ground disturbances below the first archaeological layers, thus greatly increasing costs for installation as this would include a relatively large excavation of the area and therefore a considerable loss of in-situ preserved remains. Due to the high total costs and possible damage to cultural layers, the plan was halted.

**New problem assessment**

The Motte is located in a forested area (Figure 15). The encroachment of vegetation is large, and unwanted in the eyes of the monument maintainers. The preferred setting is that the Motte will stand out of the area and have a good visibility. Removal of the trees will,
however, create a bare soil, susceptible to local gully formation by water erosion. Due to the steepness of the hill, the general use of the upslope road by cars and small sized lorries is detrimental to the general stability of the hill. This use is however very difficult to change as the Motte is in use by a small hotel and restaurant, which in turn generate a need for maintenance.

![Aerial photograph of the Motte Montferland (source: Globespotter) and mapping of heights and water flow in this area to construct structural measures of decentralised storing and infiltration of stormwater (source Boogaard et al., 2016).](image)

The current runoff is rather high and future predictions show an increased intensity of rainfall events due to climate change. The main problem for a good preservation of the Motte is therefore the lack of slow water runoff and the lack of storage of rainwater on the plateau. After flood modelling of this area (Figure 16), it was decided that the runoff should be stopped as much while not going deeper than needed, preventing the need for an archaeological excavation. Rainwater should be stored on the plateau and other areas and infiltrate on a decentralised level. Local infiltration should not take place too close to the sides of the plateau. That would decrease the stability of the top layer on the sides after removal of the trees and replacing the vegetation with a grass mixture. Access water on the Eastern side will be directed along the current road into the original canal. The road will be equipped with enforced sides.

Different SUDS were used to help preservation of the Motte:

1. Surface discharge to the canal downhill
2. Swales
3. Discharge to an infiltration basin
4. Storage and infiltration of stormwater in grassed swales

In the coming years the implemented measures will be monitored and evaluated to optimize the water management system. Lessons on the design, construction and maintenance will be exchanged with other sites in the Netherlands where the aim is to preserve archaeological deposits in situ.
5. Discussion

Cultural heritage protection is often related to surface- and groundwater management. This poses a threat, certainly in view of climate change and the current need to adaptation in urban water systems.

A city has, commonly, developed from a historical city into an (unsustainable) industrial city with subsurface resource exploitation to a modern development. The challenge today is to consider all aspects given by this growth, from preservation of historical heritage to pollution and further need of space.

There is a large risk of heritage deterioration by unforeseen circumstances. The reasons for these are plenty; natural, political or management decisions, characteristics of the soil, historical activities, (ground) water circulation, human action or just the wrong location. The field of cultural heritage preservation, and particularly archaeological heritage preservation, has seen a significant progress towards a more holistic approach, involving a range of different disciplines (Holden et al., 2006). This progress has also been triggered by some examples of alarming developments where environmental changes caused by urban development resulted in accelerated decay of archaeological deposits as well as in damage to above-ground buildings (e.g. Schonhowd and Rytter, 2015). A significant part of our cultural heritage in cities is and may be damaged in the future by changes in hydrological processes. A proper understanding of the natural and man-made environment and processes that affect heritage is essential for in-situ preservation, mitigation design as well as management of heritage sites. Cultural heritage resources have to be considered as an integral element in urban planning processes if they are to be preserved for future generations.

In general, the current status in urban planning shows a lack of co-ordinated policy on the subsurface. In urban development processes, conflicts with prior uses and unappreciated impacts on suburban resources, amongst them archaeological heritage, are either unaddressed or taken care of too late in the planning process. This makes the use of underground space in cities suboptimal. In terms of ecosystem services, the subsurface environment acts either as a carrier for archaeological heritage (stewardship) or supports above ground heritage. Often it is not enough to protect the heritage site or monument itself; new developments outside a specific protected area can lead to changes in groundwater level, and cause serious damage to heritage buildings and archaeological deposits.
On the other hand, climate adaption measures that are primarily aimed at local water dispersal and flood mitigation may offer opportunities to cultural heritage preservation and protection. Use of sustainable water management solutions may hinder erosion of cultural landscapes, such as shown in the case of Motte Montferland, and may also provide a more stable hydrological environment, supporting preservation of archaeological heritage, e.g. by local rainwater infiltration.

The multiple benefits that modern sustainable water management systems may provide, including heritage preservation support, are not yet fully recognized by those who can benefit most from them; heritage managers, water managers as well as urban planners and decision makers. A knowledge gap exists in terms of awareness of the option to include (retrofit) modern climate adaption measures in historic cities. Similarly, it is necessary to develop further technical modifications to established sustainable water management systems if they are to be applied in areas with vulnerable cultural heritage. Implementing new infrastructure for sustainable water management in archaeologically important areas can be challenging (de Beer et al., 2012b). Any local structure used to manage surface - and groundwater flow can potentially damage archaeology (de Beer et al., 2012a). Most of these structures require groundworks, and some are placed completely under the surface. This trade-off requires special attention and experience (Rytter and Schonhowd, 2015).
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Monitoring manual

