Integrating subsurface management into spatial planning in the Netherlands, Sweden and Flanders

Hooimeijer, Fransje; Tummers, Lidewij

DOI
10.1680/jurdp.16.00033

Publication date
2017

Document Version
Final published version

Published in
Proceedings of the ICE - Urban Design and Planning

Urban Design and Planning
Volume 170 Issue DP4

Integrating subsurface management into spatial planning in the Netherlands, Sweden and Flanders
Hooimeijer and Tummers

ice | proceedings

Proceedings of the Institution of Civil Engineers
Urban Design and Planning 170 August 2017 Issue DP4
Pages 161–172 http://dx.doi.org/10.1680/jurdp.16.00033
Paper 1600033
Received 22/06/2016 Accepted 17/02/2017
Published online 14/03/2017
Keywords: government/knowledge management/ municipal & public service engineering

ice Institution of Civil Engineers
publishing

Integrating subsurface management into spatial planning in the Netherlands, Sweden and Flanders

Fransje Hooimeijer PhD
Chair of Environmental Technology and Design, Department of Urbanism, Faculty of Architecture & Built Environment, TU Delft, Delft, the Netherlands (corresponding author: f.l.hooimeijer@tudelft.nl)

Lidewij Tummers MSc
Chair of Spatial Planning and Strategy, Department of Urbanism, Faculty of Architecture & Built Environment, TU Delft, Delft, the Netherlands

The pressures of climate change, energy transition, the financial crisis and retreating governments, call for a reintroduction of the subsurface into spatial planning. Most urban technological infrastructure, including load-bearing capacity, heat and water, is located in the subsurface. It stores water, plays a role in cooling the city and provides geothermal heat as renewable energy. Yet the subsurface is insufficiently recognised as part of the solution in tackling the current challenges. This paper compares the level of integration of subsurface management in Dutch, Swedish and Flemish (Belgium) planning systems. The criteria for the comparison of the planning systems are based on the format developed in COMMIN, a transnational project within the Baltic Sea Region INTERREG III programme. To establish the guiding principles for spatial planning applicable in all three countries, the principal institutions, legal frameworks and planning documents are studied. These are analysed and connected to subsurface management aspects. The analysis of the main differences and overlaps between the planning systems of the three countries forms the starting point for an approach that integrates subsurface decision making into spatial planning. The conclusions argue that, rather than new regulations, a culture change in planning culture is the key to successful integration of the subsurface.

1. Introduction

The pressures of climate change and the energy transition, as well as the financial crisis and retreating governments, call for a reintroduction of the subsurface into urban planning and development practices. Most urban technological artefacts, such as infrastructure, load-bearing capacity, heat and water, are located in the subsurface. Therefore, the subsurface is part of the solution in tackling the current challenges. Moreover, using the subsurface intelligently can be financially rewarding.

With the increased role of technology, the connections between natural systems and urban development have been lost. Although the Netherlands is famous for making land, it is also a great example of 'forgetting' that the soft and wet soil conditions need special attention (Hooimeijer, 2014). As a result, Dutch cities are now very vulnerable to climate change. Ecosystem services that arise from the subsurface system, such as industrial and drinking water, clean and fertile soil for urban green areas and unsealed healthy soils for rainfall regulation, have become overlooked in urban development. Furthermore, privatisation provides an additional challenge – that is, national and municipal authorities are leaving urban development more and more to the private sector (Heurkens *et al.*, 2014). This new 'bottom-up' approach brings new roles and new flows of information exchange between specialists and private developers, especially concerning the public domain knowledge of the subsurface.

Spatial planning needs to integrate the technosphere of the city in order to create long-term, resilient and sustainable development plans. At the same time, soil legislation and management have become more important when adapting to climate change, the energy transition and foremost to (re-)develop cities with lower costs.

To understand in the ways in which a planning system can include subsurface management, a study 'Balance4P: Balancing decisions for urban brownfield regeneration – people, planet, profit and processes' was conducted into the planning contexts of the three participating countries: the Netherlands, Sweden and Belgium (Norrman *et al.*, 2016). The main research question was 'how to integrate the subsurface better into urban development?' This paper reflects on the results of this study. It first presents the framework and the approach used in Balance4P, followed by short descriptions of spatial planning in the Netherlands, Sweden and Belgium. The criteria for the comparison of the planning systems are based on the format developed in COMMIN, a transnational project within the Baltic Sea Region INTERREG III programme (COMMIN, 2017 and Section 1.1). The sections that follow describe the main features of spatial planning in each country,

including the guiding principles, main institutions, legal frameworks and planning documents, connecting each to the subsurface management aspects. The fourth section provides an overview of the main differences and overlaps between countries. This allows for the identification of the potential strategies to integrate subsurface decision making into spatial planning (Hooimeijer and Tummers, 2015). The conclusions recommend steps to take towards making use of this potential.

1.1 Method and definitions

The Balance4P project studied the 'planning systems' and 'building practices' in the three participating countries, for a better understanding of how the subsurface can be incorporated into urban development. The term 'planning system' refers to the formal processes of planning (Nadin and Stead, 2003), but recognises that the professional structures of planning do not only consist of formal, written procedures and regulations. There are also unplanned territorial interventions, unwritten assumptions and concepts, informal roles of inhabitants, changing reliability of governments and different perceptions of the importance of nature that form the 'planning culture' (Reimer *et al.*, 2014). Both formal and informal influences have to be taken into account when relating planning to subsurface management.

In spatial planning and design, the very general sustainability aspects of the'triple bottom line' consisting of the three P's: people, planet and prosperity (UN, 2002) are translated into territorial interventions seeking balance and synergy. This crucial strategic activity is captured by a fourth P in the 4P tetrahedron theory by van Dorst and Duijvestein (2004) (Figure 1). The fourth P represents both project and process. 'Project' stands for the physical results of the balance between the triple P and represents spatial quality, relations through scales, (bio)diversity, robustness and aesthetics. 'Process' regards the interaction between stakeholders, their skills and the institutional context in realising a balanced design (van Dorst and Duijvestein, 2004).

Figure 2 shows how the planning system is a process in which the spheres of law, regulations, policy and institutions work together at different scales, influence each other and set the planning conditions for urban redevelopment. The urban redevelopment process consists of four phases (Figure 2): (*a*) initiative, (*b*) plan, (*c*) realisation and (*d*) maintenance (Verburg and Dam, 2004; VROM, 2011). Phases (*a*) and (*b*) are considered to be part of the 'planning process', whereas (*c*) and (*d*) are part of the 'implementation process'. Although these phases are variable, this division serves to distinguish planning from actual implementation of the plan. This mainframe is applicable to the three countries in the study.

To understand the possible opportunities or challenges for integrating subsurface management into spatial planning, the COMMIN framework was applied to analyse the planning cultures in the three participating countries. The aim of the COMMIN project was to make heterogeneous planning systems comparable (COMMIN, 2017; Nilsson and Rydén, 2012). Balance4P applied the COMMIN method to create a framework of five categories: constitutional, national scale, regional scale, local scale and participation (Table 1). For each of the countries involved, it identified the guiding principles and objectives defined for planning, and the principal planning

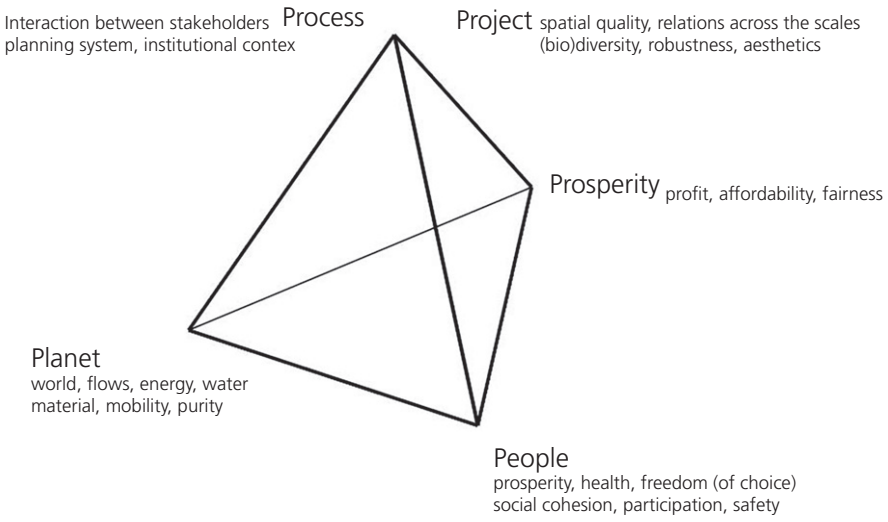

Figure 1. The tetrahedron of sustainable construction (van Dorst and Duijvestein, 2004)

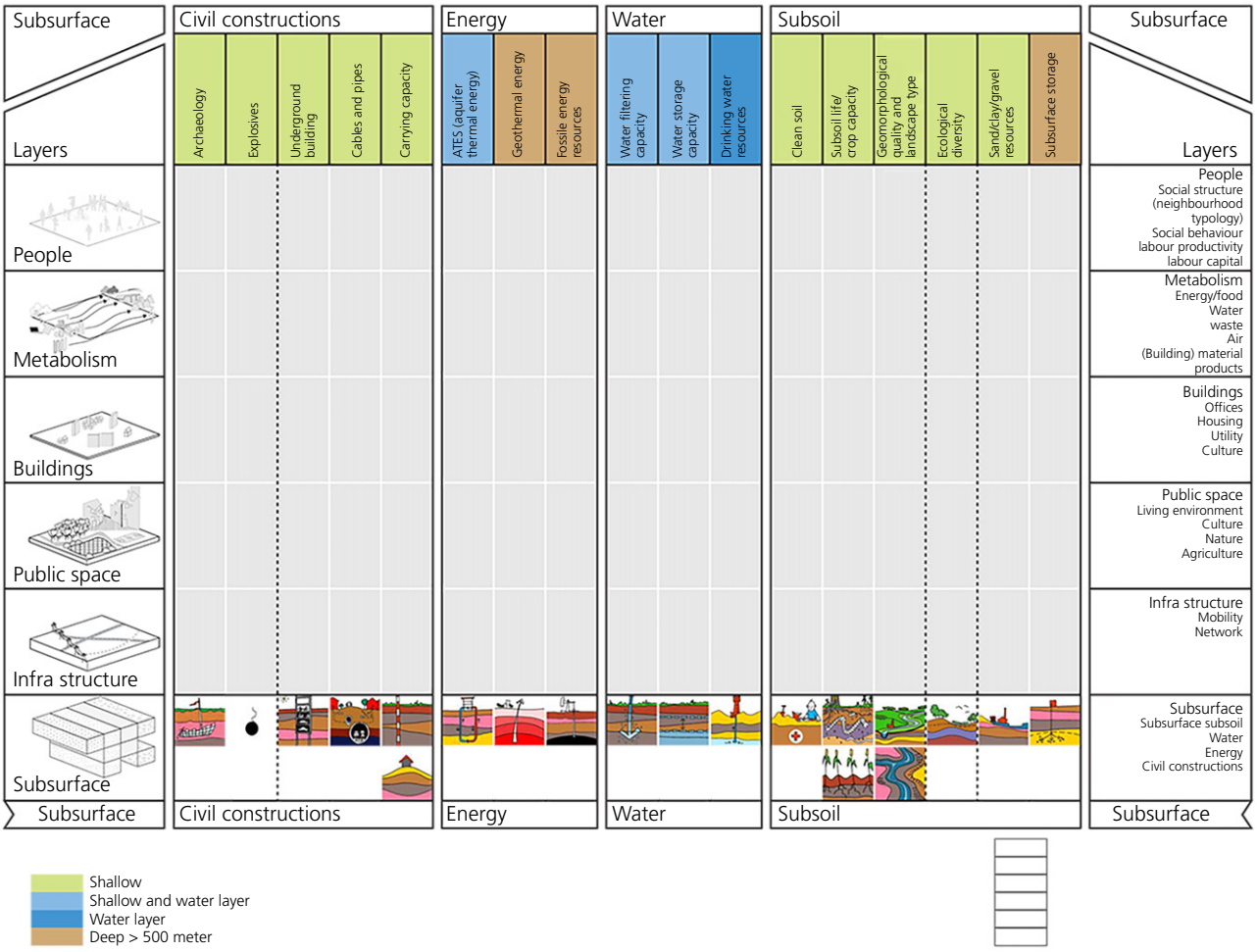

Figure 2. The 'System Exploration Environment and Subsurface' (Hooimeijer and Maring, 2013)

Table 1. Summary of the planning systems in the participating countries (Hooimeijer and Tummers, 2015)

	The Netherlands	**Sweden**	**Flanders**
Constitutional	Planning on three levels: national, province and municipality. Strong constitution; public responsibility; planning for public cause	Municipalities have a monopoly in planning with strong constitution from the state; public responsibility; planning for public cause	State, province and municipality form a strong constitution; public responsibility; planning for public cause
National	Ministry of Infrastructure and Environment; Environmental Act; EIA (independent)	Ministry of Health and Social Affairs; Ministry of Environment Planning and Building Act; Environmental Code; EIA done by municipality	Ministry of Environment Nature and Energy; Planning Decree; EIA done by certified expert
Regional	12 provinces; water boards; structural plan; water assessment; ATES control	21 county administrations; five water authorities; Göteborg and Stockholm	12 provinces; water boards; Structural Plan
Local	Planning and building department; Vision, Master Plan; Zoning Plan is strongly related to building permit	Planning and Building often separate departments; Municipalities (290) develop: comprehensive plans and detailed plans	Planning and building department; municipal structure plan; municipal implementation plan
Participation	Organised	Organised	Organised
Building practice	67·1% private house owners. Top-down changing to bottom-up (urban redevelopment)	69·6% house owners Public–private development	72·3% house owners Bottom-up development

institutions. Second, it summarised the planning acts and other legally binding contexts and planning documents that are commonly used and generally recognised. For each category, the question was raised as to if and how soil management is handled.

Next to the planning system comparison, the Balance4P project also assessed to what extent subsurface management is included in building practices. To capture the drivers and processes of building practices, the following questions were added to the COMMIN framework.

- Who initiates urban development?
- What steps in urban development define the process and related products?
- What role does the government play in development?
- How is knowledge integrated into the planning and design process?
- How is the subsurface taken into account in the development process?

The subsurface includes everything below the (land)surface. The Dutch 'Manual for planning with the subsurface' identified subsurface qualities that are meaningful to the surface (Ruimtexmilieu, 2017). Hooimeijer and Maring (2013) regrouped these qualities into new categories, relating to issues in urban development.

- Civil constructions (archaeology, explosives, underground building, cables and pipes, load-bearing capacity).
- Water (infiltration, storage and drinking water resources).
- Energy (aquifer and underground thermal energy storage, geothermal and fossil energy).
- Soil (clean soil, soil life and ecology, crop capacity, diversity and geomorphology, mineral resources and underground storage).

Figure 3 shows how the model 'system exploration environment and subsurface' brings these categories together (Hooimeijer and Maring, 2013). The categories are used to study the planning systems, focusing on the institutions, laws, policy instruments and regulations, and management of the subsurface (Nilsson and Rydén, 2012).

2. Spatial planning in the Netherlands, Sweden and Flanders (Belgium)

This section presents results of the investigation into the three planning systems. Each country profile starts with a brief description of the planning culture, followed by the main elements of the planning system and ending with the 'state of the play' regarding subsoil management. 'Culture' is formed, among others, by the historical developments, topography of

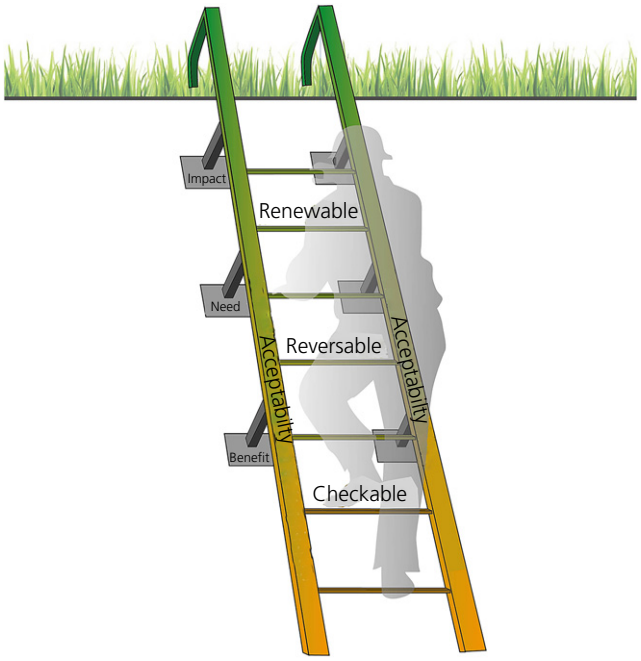

Figure 3. The soil ladder (Province Zuid-Holland, PSH, 2013)

the territory and population density. The Netherlands and Flanders are comparable topographically and geographically – water is an important spatial component in the territorial characteristics of these small countries – whereas in the much larger Sweden, the landscape is dominated by rock.

2.1 The Netherlands: poldering

Due to its wet and soft territory, the Netherlands has an old and strong governance tradition (Hooimeijer, 2014; van der Cammen and de Klerk, 2012). Flood management, in particular, as a main condition for spatial development, has been institutionalised and considered of national concern since the start of the Monarchy in 1814 (van der Woud, 1987). From early on, agricultural, civil and trade interests related to water management, met in regional 'Waterschappen' (water authorities), which exist today alongside three levels of government (local, provincial, national). It is said that the creation of polders brought with it the necessity for collaboration and the resulting 'polder model', the negotiation process of which is the verb 'poldering' (Lendering, 2005).

2.1.1 Spatial planning

Due to its territorial conditions, spatial planning has been perceived as a public task for centuries. Planning in the Netherlands has a long tradition, expressed in its institutions, laws, policy instruments and regulations: the 1901 Housing Act is generally considered to be the first planning law

(van der Cammen and de Klerk, 2012). During the twentieth century, urban development in the Netherlands was government driven and implemented by private or semiprivate developers.

However, in the current neo-liberal era, the Dutch government is reconsidering its central role and devolving responsibilities to lower governments and the market. Deregulation is the trend and private developers are invited to engage in urban development through public–private partnerships. Citizens are invited to develop initiatives to form the so-called 'participatory society' (Heurkens *et al.*, 2014). The tradition in the Netherlands, however, is 'provision' rather than (individual) self-building. Until 2000, home owners were a minority but, as a consequence of national policies, are now more than 60% (CBS, 2015).

Presently, there is an ongoing process of integration across sectors and governmental organisations. For example, at the national level the ministries of water and spatial planning recently merged; at the provincial level, the departments of soil and spatial planning; and at the municipal level, engineering and urban development departments are coming together (Rijksoverheid, 2017). Integration is also taking place at the legal level, notably through the joining of different types of building and environmental licences into one. It is also perceptible when one observes the term 'gebiedsontwikkeling' (integrated area development) replacing 'masterplanning'. Nevertheless, spatial development is still considered primarily a public task, based on land-use regulation.

A longstanding planning instrument is the 'Structuurvisie' (long-term development vision), used at the national, provincial and municipal scale to set priorities and frame spatial development. The implementation of these visions is made specific at the district scale with the use of zoning plans. These are still the only legally binding spatial plans for private initiatives (van der Cammen and de Klerk, 2012).

Typical of the Netherlands polder model is the 'welstandscommissie': the local committees that perform a qualitative check of architectural and urban planning proposals. This mechanism to adjust private plans to the public consensus is viewed as an undesirable controlling body in the current shift towards a more liberal urban development.

Other important instruments are the environmental impact assessment (EIA) (to ensure the environmental quality) and the 'Watertoets' (water impact assessment). The 'Watertoets' is mandatory to ensure that local plans fit the national contingency criteria (Watertoets, 2017). 'Structuurvisies' and zoning plans need to go through the EIA procedure to ensure that important data for the project is available, in order for decision makers to make an informed decision. Even though the advice of the National EIA Advisory Institute is not binding, a negative response is usually a strong base for preventing these plans through a court order. However, when a plan is found to have negative effects on the environment, it may still be built, depending on the decision makers (MER, 2017).

2.1.2 Subsurface

In the Netherlands, the subsurface is increasingly being used for different functions. This instigated the setting up of a 'National Vision on Spatial Planning of the Subsurface' (Dutch acronym: STRONG) (RWS, 2017). STRONG covers the period 2010–2015 and addresses both the deep and shallower subsurface. State, provinces, municipalities and water authorities reached an agreement on ambitions concerning remediation and sustainable use of the subsurface. The agreement encompasses different functions of the subsurface – such as sustainable use of resources (e.g. strategic ground water resources) and energy (shale gas, effects of gas winning, soil energy) – to ensure that the use of the subsurface cannot be considered separately from spatial developments and societal challenges such as climate mitigation, energy transition, clean (ground) water provision and economic development.

In line with general policy development, several provincial authorities have produced 'Soil Visions'. In 2006, the province of Zuid-Holland made soil part of a policy plan about ecology, water and environment and took another 7 years for their Soil Vision (PSH, 2013). Another important step was to merge their departments of soil and spatial planning and integrate the Soil Vision into their new Structural Vision in 2014. One major new instrument in the Structural Vision is the 'Bodemladder' (soil ladder, Figure 4). The vertical beams of the 'Bodemladder' question if the proposed uses are acceptable for the society and the horizontal steps ask: 'Is it controllable? Is there a possibility to change it back? Is it renewable?' In each step the usefulness, necessity and impact need to be discussed before moving further up.

2.2 Flanders: decentralisation

Spatial planning in Belgium has always been a complex balance between local initiative and central liberal government. Until the 1970s, central government created the conditions and supplied the budgets for infrastructure and later also for social housing. The, mostly very small-scale, municipalities were responsible for realisation of the national policy. This situation became even more complicated after the division into three regions – Flanders, Brussels and Walloon – each with a regional government, which together form the federative administration of Belgium. The (then national) Planning Act of 1962 (NGB, 1962) is still present in the background of legislation and district plans at all three levels

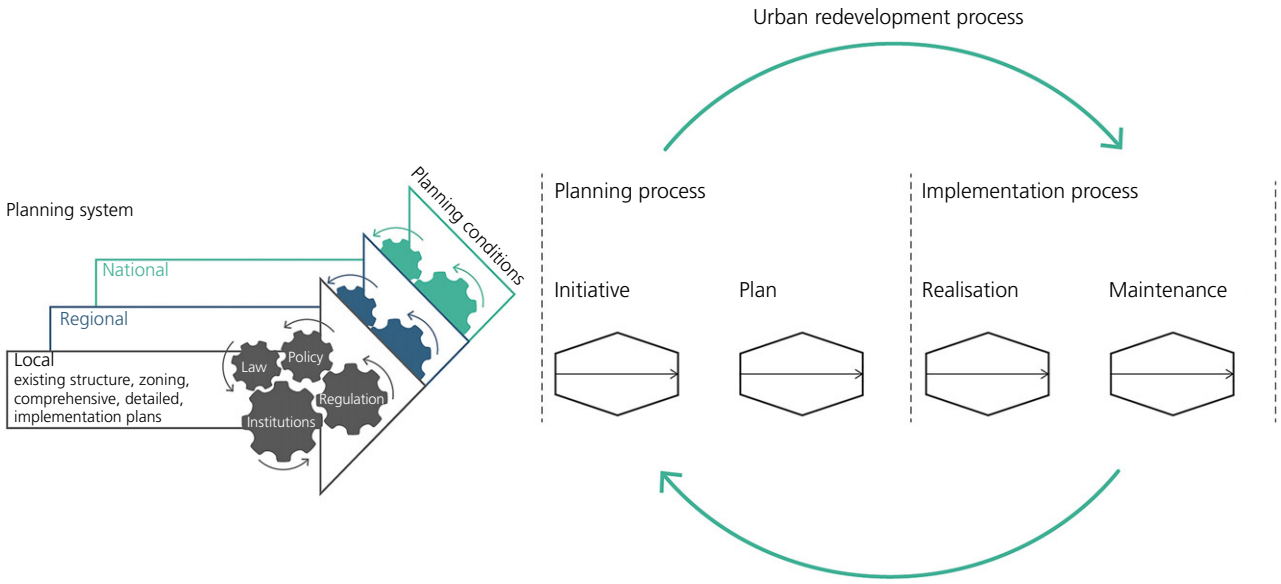

Figure 4. The urban redevelopment process operates within the planning conditions. Illustration by F. L. Hooimeijer, drawn by Janneke van der Leer, ©Chalmers University 2015, reproduced by permission

(Ryser and Franchini, 2008; Verbeeka *et al.*, 2014). Since the state reform in 1980, the federation has no constitutional powers regarding spatial planning, excepting some environmental issues. De facto, today there are three planning systems, based on regional autonomy.

2.2.1 Spatial planning

The Balance4P project took place within the region of Flanders, which is considered comparable to the Dutch and Swedish national context. In Flanders, three planning levels – the region, provinces and municipalities – work together on principles of subsidiarity and top-down framework control, which are translated into RUPs (spatial implementation plans). The institutions, laws, instruments, policies and regulations in Flanders are very comparable to the Netherlands. Like in the Netherlands, spatial plans are subject to EIA procedures; however, in Flanders, only certified agencies can perform EIAs. Unlike the Netherlands, a 'Watertoets' is needed not only for governmental pre-plans but also for private developments that apply for building permission. Even though in their instruments the planning systems of the Netherlands and Flanders are comparable, the elaboration of these is very different, as Flanders traditionally supports private ownership and building, whereas in the Netherlands building is largely institutionalised.

Due to the strong role of the municipalities, the typical small-scale landscape of Flanders was urbanised in a scattered way. From the nineteenth century onwards, citizens were also encouraged to build their own house, with the result that only 6% of households live in rental houses and 75% are owner-occupied (Dehaene and Loopmans, 2003). This practice, known as 'Nevelstad' (urban sprawl), is characterised by scattered urban development over a landscape of urbanised roads, with large gardens at the back of each house.

2.2.2 Subsurface

The main legislation in Flemish soil policy is the Flemish Soil Remediation Decree, drawn up in 1995 and updated in 2006. The guiding principle of the Flemish soil policy is to treat all historical soil pollution by 2036, and to prevent all new pollution or treat it immediately. The most essential directives in the decree are: the land information register, soil certificates (making relevant information available) and remediation. The new Soil Remediation and Protection Decree, together with the adapted VLAREBO (Order of the Flemish Government establishing the Flemish regulation on soil remediation and soil protection) came into force on 1 June 2008. It not only emphasises soil remediation but also soil protection – that is, preventive measures.

The redevelopment of brownfields is stimulated through the implementation of the Brownfield Decree and Brownfield Covenant, which came into force in 2007 (Ovam, 2007). The Brownfield Covenant promotes cooperation and synergy between the various project stakeholders (organised in a brownfield cell) and also provides some financial and tax benefits for redevelopers.

2.3 Sweden: regulating public interest

In 1810, land in Sweden became a tradable commodity through a law granting land ownership rights to Swedes regardless of their social class. However, uncontrolled development of privately owned land led to urban sprawl, low hygiene standards, fire hazards, lack of space for public functions and speculations on the housing market. A planning system was established in the 1900s, in order to balance between public and private interests with respect to land use (Blücher, 2013). Public interests that are promoted and included in planning are: health and safety, cultural and ecological values, environmental and climate aspects, social issues, aesthetics, resource efficiency and growth (Hedström and Lundström, 2013). Historically in Sweden, municipalities have a planning monopoly – that is, spatial plans are formulated, approved and adopted at the local level.

2.3.1 Spatial planning

Swedish national policy documents, like the National Transport Plan, set out the larger scale guidelines. Institutions at the national and regional scale work closely with the municipal scale, where detailed plans (comparable to the Zoning Plan) are made and assessment of the quality of the built environment is carried out. In contrast to the Netherlands and Flanders, an EIA is only performed if the municipality finds that the proposed development may cause 'substantial environmental impact'. An EIA is usually carried out by the municipality, with consultation from the County Administration Board and the adjacent municipalities.

Urbanisation in Sweden took off only after the 1930s; today 85% of the population lives in urban areas (SS, 2007). Between 1965 and 1974, one million houses were built with the aim to provide affordable houses for everyone: the 'Miljonprogrammet'. In the 1970s and 1980s, a strong public resistance arose against this development programme because it lacked context, identity, cultural meaning and diversity. As a result, abandoned city cores were revitalised into working and living environments, which became popular among small households and professionals. Planning and urban development are also connected to property ownership (Kalbro and Mattsson, 1995). In the latest revision of the building and planning legislation (SFS, 2010: p. 900), municipalities may define special regulations in the detailed plan that specifies property subdivisions, land reserves for jointly owned facilities, easements and such.

2.3.2 Subsurface

In Sweden, there is the Environmental Code that applies to issues of soil contamination (SEC, 2017). However, there is no clear link between the Environmental Code and the Planning and Building Act with regard to the development of contaminated sites (SNBH and SEPA, 2006). Furthermore, different authorities are responsible for planning and soil remediation, which complicates redevelopment of brownfields.

Swedish soil policy is focused on the establishment of a 'non-toxic environment', to prevent the negative effects of non-naturally occurring substances on human health and biological diversity. Risks posed to subsurface qualities are usually assessed by screening the concentration of contaminants in the soil.

3. Comparison of planning systems and subsurface management

The results of the investigation into the three planning systems of the Netherlands, Sweden and Flanders (Belgium) are summarised in Table 1. Each country operates within the European Union umbrella of law and regulations. Planning is not a formalised activity at the European level, but other laws and directives steer national policies of the member states in the same direction (Hooimeijer and Tummers, 2015). For example, the EIA is a European regulation issued in all three countries, but assigned a different purpose and role. In addition, in each country the agents who produce these assessments are different, which also affects decision making in urban development.

The Netherlands is a small country with strong spatial planning at a national scale to optimise the use of the land. In Flanders this has been the same, with the distinction that even though planning is top-down, most urban development has been in the hands of private developers supported by local policy. Sweden is a large country and municipalities are in control. Presently, the Netherlands is moving towards a more bottom-up governmental system, similar to Sweden, and also a more bottom-up development practice, as used in Flanders.

The comparison of subsurface management in the three participating countries was done with the same method of analysis and is represented in Table 2. As the subsurface is a large field and fragmented through the planning system, the comparison can only be made by establishing what is specifically done for the subsurface. Here it can be established that there are significant differences between the three countries. The geography is quite leading: the Netherlands and also large parts of Flanders are quite wet, thus the water issue is very well organised and, in the last years, integrated into urban planning and development. In the Netherlands, this is increasingly included in its policies and visions, and instruments to make the subsurface better integrated into surface planning are under development. This new focus comes from the former attention to soil pollution, which is still the main emphasis in Flanders.

Table 2. Summary of subsurface management (Hooimeijer and Tummers, 2015)

	The Netherlands	Sweden	Flanders
National	Subsurface policy and regulations: National Structure Vision Subsoil (STRONG) soil covenant; SV shale gas; basis registration subsoil (EU INSPIRE). National responsibility is >500 m, mostly considering oil and gas winning. For cables and pipes there is KLIK info-system. Archaeology is also steered on a national level	Subsurface policy and regulations: (*a*) 'soil and ground water quality': Environmental Code; (*b*) 'archaeology': Heritage Conservation Act of 1988; (*c*) 'use of natural resources': Water Act of 1983, Mineral Act of 1991, Peat Deposits Act of 1985, and Continental Shelf Act of 1966; and (*d*) 'underground installations': Pipelines Act of 1978, the Water and Sewerage Act of 1970, Public Heating System Act of 1981, Electrical Installations Act of 1985, and Telecommunication Ordinance of 1985	Subsurface policy and regulations: Brownfield Decree (Ovam, 2007) and Covenant promote co-operation and synergy between the various stakeholders and provide some financial (tax) benefits for redevelopers Additionally, a 'brownfield cell' was installed in 2008. This is a board advising the Flemish Government. Archaeology and KLIP registration (cables and pipes) are part of planning
Regional	Provinces: Soil Vision; Soil Ladder; extraction permits for ground water; contamination and archaeology. Water boards are responsible for water management	The archaeological and soil remediation procedures are coordinated by the County Administration Boards. The County Administration Boards also oversee hazardous activities, such as energy facilities, quarries and mines	Provinces have supervision over extraction permits for ground water, contamination and archaeology. Water boards are responsible for water management
Local	Through the Zoning Plan some categories of the subsurface are touched on at the municipal level. However, next to water, remediation, archaeology and cables and pipes there is no active management or vision. Rotterdam is working on a Master Plan for the subsurface	Archaeological concerns are integrated into the planning process (early stage); soil remediation also integrated (late stage). Contaminated soil related issues are handled on both municipal and regional levels. There are special regulations in the detailed plan defining land reserves for jointly owned facilities, easements and utility easements	Through the RUP (spatial implementation plans) some categories of the subsurface are touched on at the municipal level. Next to water, soil remediation, archaeology and cables and pipes there is no active management or vision. 'Wateringen' are water boards on municipal level
Building practice	There is now no common practice concerning introducing the subsurface into development, this works through experts who enter late in the process	There is now no common practice concerning introducing the subsurface into development, this works through experts who enter late in the process	There is now no common practice concerning introducing the subsurface into development, this works through experts who enter late in the process

In Sweden, the subsurface – even pollution – is not an urgent matter, probably because there is less claim for space.

Despite the relative similarities in the formal planning systems and urban development processes, some intangible elements of planning culture lead to different outcomes (Table 3). The cultural aspects of planning become clear when noting that, for example, although formally the Netherlands and Flanders have very comparable laws, regulations and policy, these are applied differently with various results, due to the informal culture of perception and interpretation of these various instruments.

The comparative analyses in the three participating countries show that planning and the subsurface are still two separate domains (Hooimeijer and Tummers, 2015). The experts in one domain have no overview of the other and vice versa. In planning, subsurface elements are predominantly perceived as nuisances for development that should be solved technically, setting boundaries in a financial and spatial sense. When

Table 3. Cross-analysis overview of planning and subsurface management (adapted from Hooimeijer and Tummers, 2015)

B4P integration subsoil in planning	Planning system	Planning culture	Building practice	Subsurface
The Netherlands	Top-down > bottom-up	Collaborative, poldering	Top-down > bottom-up	STRONG = top-down instruments for integration in planning
Flanders	Bottom-up > top-down	Self-provision	Bottom-up	Pollution/remediation oriented
Sweden	Bottom-up	Local autonomy	Top-down	Sectoral, dispersed

reconstructing an existing urban area or brownfield, it is important to realise that the subsurface is already being used in many ways. In particular, restoring nature in such areas demands a completely different approach towards (urban) development.

4. How to integrate subsurface management into spatial planning?

This section presents the most opportune ways to integrate subsurface management into spatial planning and building practices. It exploits the latent potential in current policies and practices, building on existing considerations of the subsurface identified in Section 3.

Looking from the European level through to building practices (by way of the national, provincial and municipality levels), four existing fields in surface planning were found to hold this potential to mainstream the subsurface: heritage, environment, nature and water (Table 4). These fields could easily integrate subsurface management by amending the following: law and regulation, policy and visions, knowledge exchange, and design and construction in urban development (Hooimeijer and Tummers, 2015). If legal regulations regarding subsurface aspects were in place, and their implementation was demanded in policies and visions, then professionals in charge would include the subsurface in the planning process. The following paragraphs provide examples of concrete opportunities that could be realised in the short term.

4.1 Law and regulation

The domain of law and regulation offers opportunities to include the subsurface when considering the heritage, environment, nature and water in the redevelopment of cities. Heritage protection is set by law and is part of the planning process through specific paragraphs dedicated to heritage in structure and zoning plans. This can be expanded to archaeology and other human remains in the subsurface. In Sweden, law and regulation is already strong with regard to the protection of archaeological remains. The benefit of including archaeology as early as possible is that it gives more clarity during the planning process, leading to better management of budgets and time. Moreover, it could bring more legibility of local identity into the design of public space.

The EIA is secured in all three countries. Since this is the only formal review carried out by decision makers before implementing a project, there is the chance to integrate a requirement for subsurface information. During the resulting process of information gathering, which would include different specialists, synergies between the natural system, the (civil constructed) conditions of the site and the development plans can be identified, thus promoting integrated planning.

Surface water, namely the river system, is a well-organised topic in planning, starting on the European scale with the Water Framework Directive, which is consequently developed into regional plans for each country and regional water basin. There is also a ground water framework directive but that is much less mainstreamed into planning. Considering surface water and ground water as one system should support more integrated planning and design in which trade-offs and synergies between the natural and the artificial system are exploited.

Finally, nature protection is organised at the European level with Natura 2000 and at national planning scales. Considering

Table 4. Potential for mainstreaming subsurface in existing planning topics (Norrman *et al.*, 2016)

Topics in surface planning		Heritage	Environment	Nature	Water
Chances for enhancing the subsurface by	Law and regulation	Chances for ■ including the subsurface in planning regulations about heritage, environment, nature and water ■ including the subsurface in EIA and water assessment test ■ subsurface in zoning plans through paragraphs about heritage, environment, nature and water			
	Policy and vision	Chances for ■ visions on the subsurface in local and regional plans, local policies, as well as in individual projects			
	Knowledge exchange	Chances for ■ interdisciplinary co-operation ■ developing new knowledge by co-operative learning			
	Design/construction	Subsurface in plan and design process needs ■ better frame of reference ■ better instruments (subsurface potential map)			
Categories of subsurface qualities		Civil constructions soil	Civil constructions soil water energy	Water soil energy	Water soil energy

the subsurface as part of this natural system is a small step, but opens up the possibility for strong connections with existing nature-related laws and regulations. The benefit is mutual because the quality of the natural areas depends heavily on water and soil conditions. Adding reliable information makes nature development plans more robust.

4.2 Policy and visions

The Dutch case shows that visions for the subsurface can be integrated into the structure plans. It also shows that integrating the subsurface at a policy level successfully stimulates early and explicit consideration in the planning process. Such visions could emphasise different qualities of the subsurface at different scales and set the agenda for structure plans. Subsurface visions would also allow plans to connect to the planning themes of heritage, environment, nature and water.

4.3 Knowledge exchange

Knowledge exchange is the key for better integration of subsurface management into spatial development of the surface. It enhances interdisciplinary cooperation and leads to new insights that make it possible to handle uncertainties in a qualitative manner. In traditional planning practice, knowledge exchange is often practiced by means of documents, reports and formal meetings. Direct and conscious knowledge exchange is more effective when more active instruments such as workshops and dialogues are used. However, it takes a culture change to organise such communication differently. The three cases in the Balance4P project made use of system exploration environment and subsurface (Norrman *et al.*, 2016), a method which supports and registers the knowledge exchange between experts of different fields. The method gives an overview of the urban system and, by relating the 'above-ground' layers to 'subsurface qualities', guides the dialogue between respective specialists (Hooimeijer and Maring, 2013).

4.4 Design/construction

Most of the options for integrating the subsurface into the design can be found during the design and construction phase (Hooimeijer and Maring, 2013). In each of the four phases in Figure 4, and most articulated in the plan phase, two modes can be observed: a diverging mode – opening up the field of choice to consider as many relevant options as possible and a converging mode – narrowing down this field of choice through various decisions (Friend and Hickling, 2005). The diverging mode is an exploratory process to outline the project. Ideally it includes identifying subsurface options and defining system boundaries for the decisions to be taken in the final design. In this mode, various designs are made and tested. In the next step, the converging mode, that complexity is reduced to allow for progression through the (re)development process, resulting in the most optimal design. This type of intensified collaborative planning produces less sectoral frictions and more effective long-term results.

5. Conclusions: no spatial plan without the subsurface

This paper reports on the results and experiences of the Balance4P research project, a European collaboration addressing the integration of subsurface management into spatial planning. The main reason for integrating the subsurface into urban (re)development is to achieve sustainable urban renewal, respond to climate change and energy transition, and to mainstream smarter development. Analysing and comparing the planning systems of the Netherlands, Sweden and Flanders (Belgium), identified the bottlenecks and also showed that the lack of integration can quite easily be solved. Integration is still rudimentary in all three countries but in comparing the three systems it made it easier to identify gaps or successful implementation of policy. Second, the opportunities for better integration of the subsurface into existing instruments used in planning and urban development have been revealed.

Spatial planning is a dynamic field involving interrelating governmental fields and institutions. Even when formal systems look quite similar, informally they work out very differently. Integrating subsurface management into spatial planning requires primarily a change of culture. It requires another approach to mitigation and adaption, for example, when facing issues due to climate change.

Given the current trend of liberalisation, decentralisation and (attempted) deregulation of spatial planning, a plea for more regulation between subsurface and surface would be counterproductive. More importantly, the existing instruments offer sufficient opportunities to begin integration into the existing structures and plans. Therefore, rather than new regulations, it is the planning practice that must support the culture change.

Decision makers and professionals need to realise that integrating the subsurface into spatial planning and urban development supports a range of objectives. It can help achieve energy neutrality targets, adapt to the changing hydrological system, reduce air pollution and urban heating (smart planning leaves more open soil for green which is an important factor in this), and finally is also more cost effective. It requires a culture change that follows the strategy of action captured in the 4P tetrahedron theory. When balancing out the triple bottom line, the result is the 'Project' P; the city as a construction of human and natural systems. The 'Process' P concerns interdisciplinary working and changing common behaviour to be able to respond to climate change, the energy transition and densifying cities.

Governments can take action in several ways: (*a*) set the right example in their projects, (*b*) promote interdisciplinary collaboration and (*c*) facilitate knowledge brokerage. This would create a frame of reference for issues and plans at the local and regional scales, which not only serves public departments but also private partners involved in spatial development.

Acknowledgements

The authors acknowledge the larger research team of the project Balance4P: Linda Maring (Deltares, Unit Soil and Groundwater systems, Department of Urban Water and Soil Management), Yevheniya Volchko and Jenny Norrman (Chalmers University Goteborg Department of Civil Engineering), Jaan-Henrik Kain (Chalmers University Goteborg Department of Architecture), Kaat Touchant and Steven Broekx (Flemish Institute Technological Research). The SNOWMAN Network and the national funders in this network are acknowledged: SNOWMAN (SN04-01), Formas (Dnr 216-2013-1813), Stichting Kennis Bodem (SKB, D3146), and OVAM. In addition, the Municipality of Rotterdam, Port of Rotterdam, Gebiedsteam M4H, Programmabureau Stadshavens Rotterdam and Gemeentewerken Rotterdam are acknowledged for their willingness to invest both money and time into the work, providing the case study within the research project and being enthusiastic about it. Hanna Kaplan, Christian Carlsson from the City of Gothenburg and Elisabeth Forsberg representing the private developers HSB and Balder are acknowledged for investing time and effort in the work with the Fixfabriken case study, always having a positive attitude, and being co-explorers, despite limitations in time. All students and stakeholders are acknowledged for contributing with their time, skills, experiences and knowledge. Finally, the authors thank Kate Unsworth for her English editing and support in presenting this broad and complex topic in a clear manner.

REFERENCES

Blücher G (2013) Planning legislation in Sweden – a history of power over land-use. In *Planning and Sustainable Development in Sweden* (Lindström MJ, Fredriksson C and Witzel J (eds)). Swedish Society for Town & Country Planning, Stockholm, Sweden, pp. 32–42.

CBS (Central Office for Statistics) (2015) http://www.clo.nl/indicatoren/nl2164-woningvoorraad-naar-eigendom (accessed 06/03/2017).

COMMIN (2017) http://www.commin.org (accessed 06/03/2017).

Dehaene M and Loopmans M (2003) De argeloze transformatie naar een diffuse stad. Vlaanderen als Nevelstad. *Agora* **19(3)**: 4–6 (in Dutch).

Friend J and Hickling A (2005) *Planning Under Pressure: The Strategic Choice Approach*. Routledge, London, UK.

Hedström RT and Lundström MJ (2013) Regional planning in Sweden. In *Planning and Sustainable Urban Development in Sweden* (Lundström MJ, Frederiksson C and Witzell J (eds)). Swedish Society for Town & Country Planning, Stockholm, Sweden, pp. 167–178.

Heurkens E, de Hoog W and Daamen T (2014) *De Kennismotor, Initiatieven tot Faciliteren en Leren in de Rotterdamse Gebiedsontwikkelingspraktijk*. TU Delft, Delft, the Netherlands (in Dutch).

Hooimeijer FL (2014) *The Making of Polder Cities: A Fine Dutch Tradition*. Jap Sam Books, Heijningen, the Netherlands (in Dutch).

Hooimeijer FL and Maring L (2013) Ontwerpen met de ondergrond. *Journal Stedebouw & Ruimtelijke Ordening* **94**: 52–55 (in Dutch).

Hooimeijer FL and Tummers L (2015) *Harmonizing Subsurface Management in Spatial Planning: The Netherlands, Sweden and Flanders*. Repository University of Technology Delft, Report. See http://repository.tudelft.nl/view/ir/uuid%3A5eb5b44a-7c94-4fa2-b3ae-fdd55065ca17/.

Kalbro T and Mattsson H (1995) *Urban Land and Property Markets in Sweden*. UCL Press, London, UK.

Lendering J (2005) *Polderdenken. De Wortels van de Nederlandse Overlegcultuur*. Athenaeum, Amsterdam, the Netherlands (in Dutch).

MER (2017) http://www.commissiemer.nl/english (accessed 07/03/2017).

Nadin V and Stead D (2003) European spatial planning systems, social models and learning. *disP – the Planning Review* **44(172)**: 35–37.

NGB (National Government Belgium) (1962) *Wet "houdende organisatie van de ruimtelijke ordening en van de stedenbouw"*. Belgium parliament, Brussels, Belgium (in Dutch).

Nilsson KL and Rydén L (2012) Spatial planning and management. In *Rural Development and Land Use* (Rydén L and Karlsson I (eds)). The Baltic University Programme, Uppsala, Sweden, pp. 215–227.

Norrman J, Volchko Y, Hooimeijer F *et al.* (2016) Integration of the subsurface and the surface sectors for a more holistic approach for sustainable redevelopment of urban brownfields. *Science of the Total Environment* **563–564**: 879–889.

Ovam (2007) http://www.ovam.be/brownfields (accessed 07/03/2017).

PSH (Province South Holland) (2013) *Bodem Visie*. Province South Holland, The Hague, the Netherlands (in Dutch).

Reimer M, Getimis P and Blotevogel HH (eds) (2014) *Spatial Planning Systems and Practices in Europe. A Comparative Perspective on Continuity and Change*. Routledge, New York, NY, USA.

Rijksoverheid (State Government) (2017) http://www.rijksoverheid.nl/ministeries (accessed 07/03/2017).

Ruimtexmilieu (2017) http://www.ruimtexmilieu.nl (accessed 07/03/2017).

RWS (Rijks Water Staat, State Water Department) (2017) http://rwsenvironment.eu/subjects/soil/policies-and/ (accessed 07/03/2017).

Ryser J and Franchini T (eds) (2008) *International Manual of Planning Practice*, 5th edn. ISOCARP, Den Haag, the Netherlands. See http://www.isocarp.org/index.php?id=141 (accessed 16/12/2013).

SEC (Swedish Environmental Code) (2017) http://www.government.se/legal-documents/2000/08/ds-200061/ (accessed 07/03/2017).

SFS (Swedish Code of Statutes) (2010) *Plan- och bygglag. Resource Efficient Use of Mixed Wastes*. Swedish Code of Statutes. See http://rkrattsdb.gov.se/SFSdoc/10/100900.PDF (accessed 07/03/2017) (in Swedish).

SNBH (Swedish National Board of Housing) and SEPA (Swedish Environmental Protection Agency) (2006) *Naturvårdsverkets Föreskrifter om Miljörapport*. NFS 2006:9. SNBH and SEPA, Stockholm, Sweden. See http://www.naturvardsverket.se/Documents/foreskrifter/nfs2006/nfs_2006_9.pdf (accessed 07/03/2017) (in Swedish).

SS (Statistics Sweden) (2007) *Yearbook of Housing and Building Statistics 2007*. Energy, Rents and Real Estate Statistics Unit, Stockholm, Sweden.

UN (United Nations) (2002) *UN Report of the World Summit on Sustainable Development, Johannesburg, South Africa*. United Nations, New York, NY, USA.

van der Cammen H and de Klerk L (2012) *The Selfmade Land. Culture and Evolution of Urban and Regional Planning in the Netherlands*. Uitgeverij Unieboek | Het SPectrum BV., Houten – Antwerpen, Belgium.

van der Woud A (1987) *Het Lege Land. De Ruimtelijke Orde van Nederland 1798–1848*. Meulenhof, Amsterdam, the Netherlands (in Dutch).

van Dorst MJ and Duijvestein CAJ (2004) Concepts of sustainable development. In *The 2004 International Sustainable Development Research Conference* (s.n. (ed.)). University of Manchester, Manchester, UK, pp. 176–183.

Verbeeka T, Boussauwa K and Pismana A (2014) Presence and trends of linear sprawl: explaining ribbon development in the north of Belgium. *Landscape and Urban Planning* **128**: 48–59.

Verburg J and Dam J (2004) *Het Besluitvormingsmo del Ruimtelijke Plannen Rotterdam*. OBR and dS+V, Rotterdam, the Netherlands.

VROM (Ministry of Volkshuisvesting, Ruimtelijke Ordening en Milieu) (2011) *Reiswijzer Marktpartijen in Gebiedsontwikkeling*. Ministry VROM, The Hague, the Netherlands (in Dutch).

Watertoets (2017) http://www.dewatertoets.nl (accessed 07/03/2017).