Expert Knowledge, Innovative Thinking

Urban Insight

Healthy water cities

From sewer to health booster

Augustijnenstraat, Mechelen © Bram Goots

SWECO

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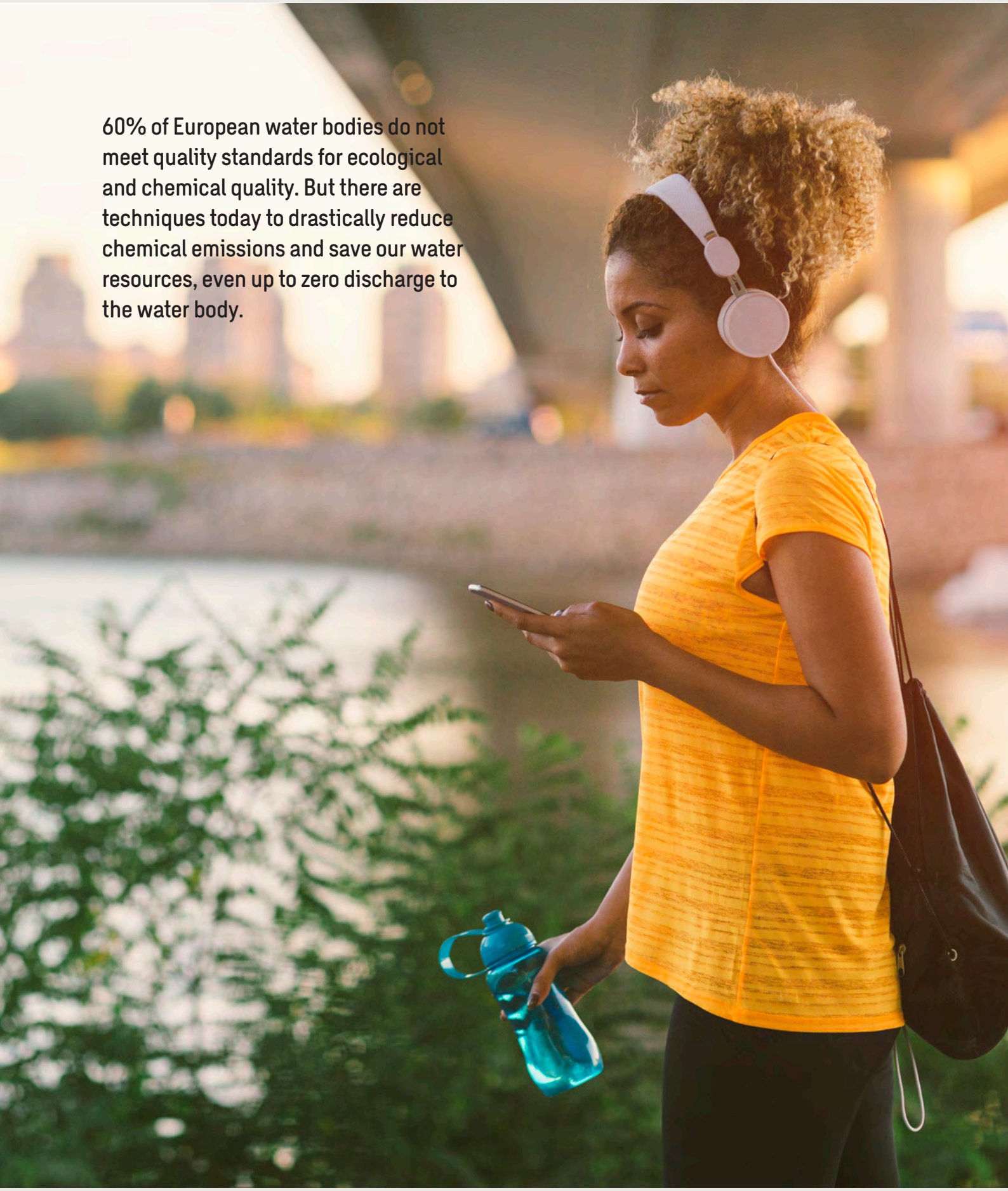
Contents



60% of European water bodies do not meet quality standards for ecological and chemical quality. But there are techniques today to drastically reduce chemical emissions and save our water resources, even up to zero discharge to the water body.

Introduction

We are now witnessing how extensive rainfall and floods have become a reality even in Europe.

In the summer of 2021, catastrophic flooding hit towns across Belgium, Germany, Switzerland, the Netherlands and Sweden. Huge amounts of rainfall caused river levels to rise in large parts of western Europe. The high water and mud flows caused riverbanks to burst, washing away buildings in Belgium and Germany and flooding homes and streets – leading to the deaths of hundreds of people. The deadly flooding and damage to property, infrastructure and urban areas have devastated these communities.

A mix of hilly terrain, non-resilient infrastructure and unprecedented meteorological conditions became the recipe for disaster, unleashing enormous floods through the villages. In rain events this epic, most drainage systems cannot withstand such volumes of water. The sewer systems, many built over 100 years ago, were therefore sorely unprepared for such extensive flooding. Moreover, sewage, grey water and water supply pipes in European cities are deteriorating, and in 10-20 years sewage infrastructure might collapse due to material failure.

Climate change – which according to IPCC's 2021 report is alarming – and urbanisation together pose huge challenges that demand our attention.

"The increased frequency of extreme weather conditions is creating elevated health and safety risks all over Europe. Actions are needed to minimise the risks of flooding, pollution and health hazards", says Tia Savolainen, water management engineer at Sweco Finland.

Pollution is the second biggest health risk in urban areas in the European region. Groundwater and soil pollution due to untreated discharge and cracking wastewater sewer system cause serious health issues. Historically, sewer system failures caused vast swaths of the population to die from cholera, typhoid fever and dysentery, which spread from drinking sewage-contaminated water. To this day, different kinds of pollution – from plastics, chemicals and pharmaceuticals – snake their way into our living environment and food chains, impacting all organic life on earth.

At the same time, water shortages pose a great challenge globally. Without any change in water consumption, the demand for water is expected to exceed available water supply by 40% in 2030 due to the growing population, increased urbanisation, climate change and a shift in our food consumption[1].

Management and maintenance of underground assets are highly challenging and expensive. Political support for single-purpose preventive measures like pipe replacement is hard to find. However, a multi-purpose solution can benefit the health and well-being of the community in both the short and the long term.

To secure a future with sufficient clean water and successful water network management that prevents system failures, we propose three water strategies that address health challenges at the same time: Restore space for water and people, Reintroduce nature in cities, and Reduce, reuse and purify wastewater.

This report highlights the challenges identified by engineers and designers. We also spotlight the water cycle and reveal potential breakthrough innovations in underground and surface water systems that directly impact our health.

DID YOU KNOW?

31% of the groundwater reserves in Europe have a poor chemical status

and 10% are in poor quantitative state[2]

Two-thirds of the European wetlands are lost

Wetlands that existed 100 years ago have been lost leading to a substantial decrease in the number, size and natural habitat of large bogs and marshes, and small or shallow lakes. This has changed both the visual landscape, the water balance of the region and other environmental functions[3]

Over 16 million people still lack access to basic drinking water

in Europe, according to WHO.[4]

14 people die every day

due to disease associated with poor water, sanitation and hygiene in European Region.[6]

This report support multiple UN Sustainable Development Goals, with a particular focus on:

The health challenges of flooding, drought and pollution

Health and safety risks are increasing across the world due to flooding, droughts and polluted water. What can we expect from the future?

IPCC's latest report shows that scientists now have more proof that climate change is causing these changes in weather patterns. "Europe is warming faster than the rest of the world", IPCC says. "No matter how greenhouse gas emissions evolve, there will be more and more intense heat". When IPCC published its report, the earth was already 1.1°C warmer than during the second half of the 19th century and the consequences are becoming more visible with each passing day. At a global warming of 2°C, heat extremes would more often reach critical tolerance thresholds for agriculture and health, the report shows.

DRY AREAS WILL BECOME DRYER, WET AREAS WILL BECOME WETTER

In all possible climate scenarios, the intensity and distribution of precipitation is changing and the risk for heavy rainfall is increasing. Regional differences in Europe show that the Nordic countries will receive more rainfall and wind with a potential risk of flooding. West and Central European regions will see more and longer dry periods during the summer months with an elevated risk of wildfires. At the same time, due to more evaporation and higher temperatures, the air can carry more humidity, resulting in more intense precipitation. With decreasing Gulf Stream activity, the risk for extreme flood events increases.

DROUGHT AND FLOODING

The intensity of precipitation may temporarily exceed the infiltration capacity of the soil, causing flooding and erosion. Together with growing urbanisation and soil impermeability, lower infiltration rates and pumping of natural groundwater reserves leads to water scarcity, lower river levels and drought. In this regard, excess water must be understood in the context of water shortages. Some of the causes of water shortages are related to how we occupy and use the land, cover surfaces and provide for rain drainage before water reaches the natural water cycle.

HEAT-RELATED ILLNESS, WATER SHORTAGES AND POLLUTION

Most of those affected by extreme heat are the elderly and low-income groups, who face consequences like premature mortality due to hyperthermia, heat-related illnesses and fires in the home. Cities are confronting water shortages and deficient public space cooling. Another problem cities face is finding space for water capture and retention, and yet another is how to purify polluted runoff and surface water. On top of damage caused by water, the population in recently flooded areas across Europe must now grapple with sanitation problems including huge volumes of mud, fuel, chemicals and other substances that were released into human habitats and the environment.

ZERO EMISSIONS

We know what we need to do. Climate agreements are being signed by nations worldwide and ambitions are set to reach zero emissions. The IPCC report stresses that the world's current emissions of 40 gigatons per year need to decrease to zero urgently since the earth only has room for an extra 500 gigatons of CO_2 in total. While we need to reduce the consumption of our planet's resources, we also need to adapt. European engineers and designers, as well as city planners and water managers, have been studying and preparing for climate change adaptation for a long time.

Now, this preparation must be intensified. Become more widespread and transferred into rapid adaptation to a changing climate. In this study we want to give an overview of the experience and insights of visionary pilot projects and recent realisations to accelerate future adaptation to ensure a healthy environment.

STRATEGIES:

Restore space for water and people

In this report we focus on three water strategies that address health challenges simultaneously. The first strategy, restoring space for water and people, is linked to the work of scientists, water managers, and landscape and urban designers over the last decade. When space for water is restored in our cities, people's health can be improved at the same time.

To prevent drought as well as flooding, upstream measures are being implemented. Water capture and retention in the landscape, reopening rivers, adding water to public spaces and permeable pavement all represent measures that can bring back water in our living environment, as a part of a healthy water cycle.

MULTIFUNCTIONAL SPACES

Space is scarce in dense urban areas, and city planners and engineers need to look for innovative, creative solutions. But because space for water, nature, people and thriving communities is limited, we need solutions that can combine various functions. These can include rooftops for rainwater harvesting, rainwater tanks as urban furniture, parking lots with underground water storage and squares as rainwater detention basins. Innovations and new technologies will need to take into account the extreme climate scenarios in order to provide safe and health-promoting solutions.

Restoring natural riverbanks with creeks, micro-depressions and marshes in urban areas to collect, filter, infiltrate and store rainwater can help to increase well-being in cities and leverage the positive effects of a natural river ecosystem over artificially irrigated greenery.

EXTENSIVE HEALTH EFFECTS

In the past, rivers were used as sewers and were covered to reduce the negative effects such as sanitary problems and waterborne diseases. However, due to proper sewer systems and wastewater treatment, river systems are recovering. Reopening rivers can improve the dimensions of physical, mental and social health. Reintroducing surface water in the urban context brings thermal comfort, cooling, safety improvements, views of wet vegetation and plants, access to green areas and improved recreation potential, which according to several studies all directly benefit our health.[7] Indirectly they can make major contributions to the quality of the air we breathe through restored wetland vegetation. In the long term, this leads not only to prevention of respiratory diseases, but to climate mitigation. In its turn wetland vegetation has a large impact on the natural buffering and recovery of surface water, the recovery of surface water allows for people to swim in open waters, where that was not possible in the past. It is also proven that a variety of experience values of landscapes can stimulate more physical activity or other behavioural changes, such as more social encounters.[8]

INCREASING LIVEABILITY IN KARLSTAD, SWEDEN

Karlstad's urban peninsula was redesigned to increase liveability and enjoyment for Karlstad's citizens. The idea was to transform this barren peninsula into an attractive city park by developing spatial qualities, plant habitats, seating, recreational areas and water presence. The effect water has on our mind is being studied in neuroscience and environmental psychology, but the success of this project is clear about the impact on our health. This park has changed the lifestyle of many residents of Karlstad giving them a quiet space close to the water facing the sunset, extensive boardwalks, views from multiple platforms and lush valleys in the middle of the city.

Designer: Thorbjörn Andersson, Sweco
Location: Karlstad
Client: City of Karlstad, Sweden
Photographer: Kasper Dudzik.

RIVER JEKER FOR A HEALTHY AND SUSTAINABLE CITY, BELGIUM

Daylighting the river Jeker has given back open space to the inhabitants of Tongeren. In 1954, the Jeker was dammed for sanitary reasons like many other European rivers. This year the Jeker has resurfaced providing opportunities for urban health and well-being thanks to the presence and visibility of pure and natural water flow through the city. The new urban park offers space for the water to swell. Waterplay raises citizens' awareness of the natural water cycle, and it provides spaces for interaction and recreation as well as multiple health benefits including heat stress alleviation. At the same time it gives the city a space to harvest rain water reducing the frequency and pollution of sewer overflows.

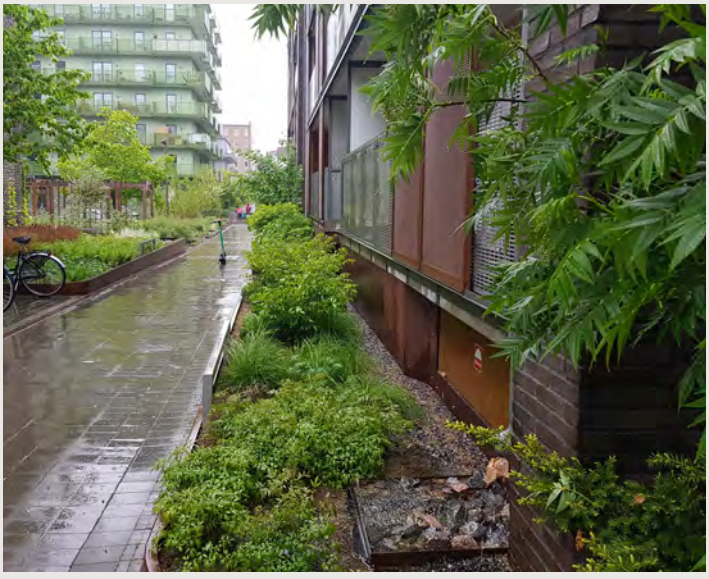
Info: Public Space Prize 2021

Designer: Sweco
Location: Tongeren, Belgium
Role of Sweco: Engineering, design, participation
Client: The municipality of Tongeren
Photographer: Bram Goots

NATURAL WATER SYSTEM, HAMMARBY SJÖSTAD, STOCKHOLM, SWEDEN

The eco-district Hammarby Sjöstad is the most referenced example of implemented initiatives. The integration of sustainable urban drainage systems (SUDS) has not only proven to be an efficient nature-based solution for rainwater detention, which temporarily stores rainwater and slowly releases it back into the natural water system. It is also an essential component of a successful, liveable neighbourhood. The open spaces offer a place for human encounters, recreation and a closer experience with nature. The cognitive, social and psychological benefits of the blue-green elements are the ingredients for a truly healthy neighbourhood.

Designer: Urban Planning and Environmental Coordination Committee, Stockholm Water Company in a collaborative process among municipal authorities, urban planners, developers, architects, landscape architects, engineers at eco-tech businesses, energy company Fortum and the Stockholm Water Company.
Location: Hammarby Sjöstad, Stockholm, Sweden
Role of Sweco: involved since the beginning in 1999 in water management
Client: Environment and Health Committee of Stockholm



HEALTHY BLUE NETWORKS

Blue networks have a multifunctional role in the urban living environment and can provide improved evapotranspiration (heat exchange) and thus a cooling effect. Other benefits of these blue spaces include filtered air, filtered light, reduced urban noise and green networks which provide recreational spaces for people when moving around in the city. Studies have shown the benefits of water views and contact with water on our mental health.[9] In general, researchers found that places located far away from large bodies of water had higher rates of psychiatric disorders, especially major depression and bipolar disorder.[10]

HEALTHY WATER CITIES

Cities as well as citizens should take responsibility in shaping a healthy living environment. From private parcels to the design of public spaces, each element of the city has a role to play in maintaining the balance of the natural water cycle. Decoupling and reusing rainwater as well as decreasing water use and wastewater volumes are part of the solution at the parcel level. Collecting runoff as well as treating and introducing non-potable distribution networks at the city scale remain to be investigated.

By connecting 10% of pavement areas to buffers for rainwater reuse, we could create an equivalent volume of 40% of the water storage

NON-POTABLE (NON-DRINKING) WATER SYSTEM

In urban design practice, the implementation of a water reuse system to cool down urban areas is gaining interest in southern Europe. The city of Nice is experimenting with shell-based paving stones laid in places on the new tramway line. These evaporative pavements with underlying water supply system are completed with road humidification system (sprinklers), both connected to the city's raw water (non-potable) distribution network. As the water quality improves, natural summer bathing in rivers or former harbour basins is becoming more and more popular.

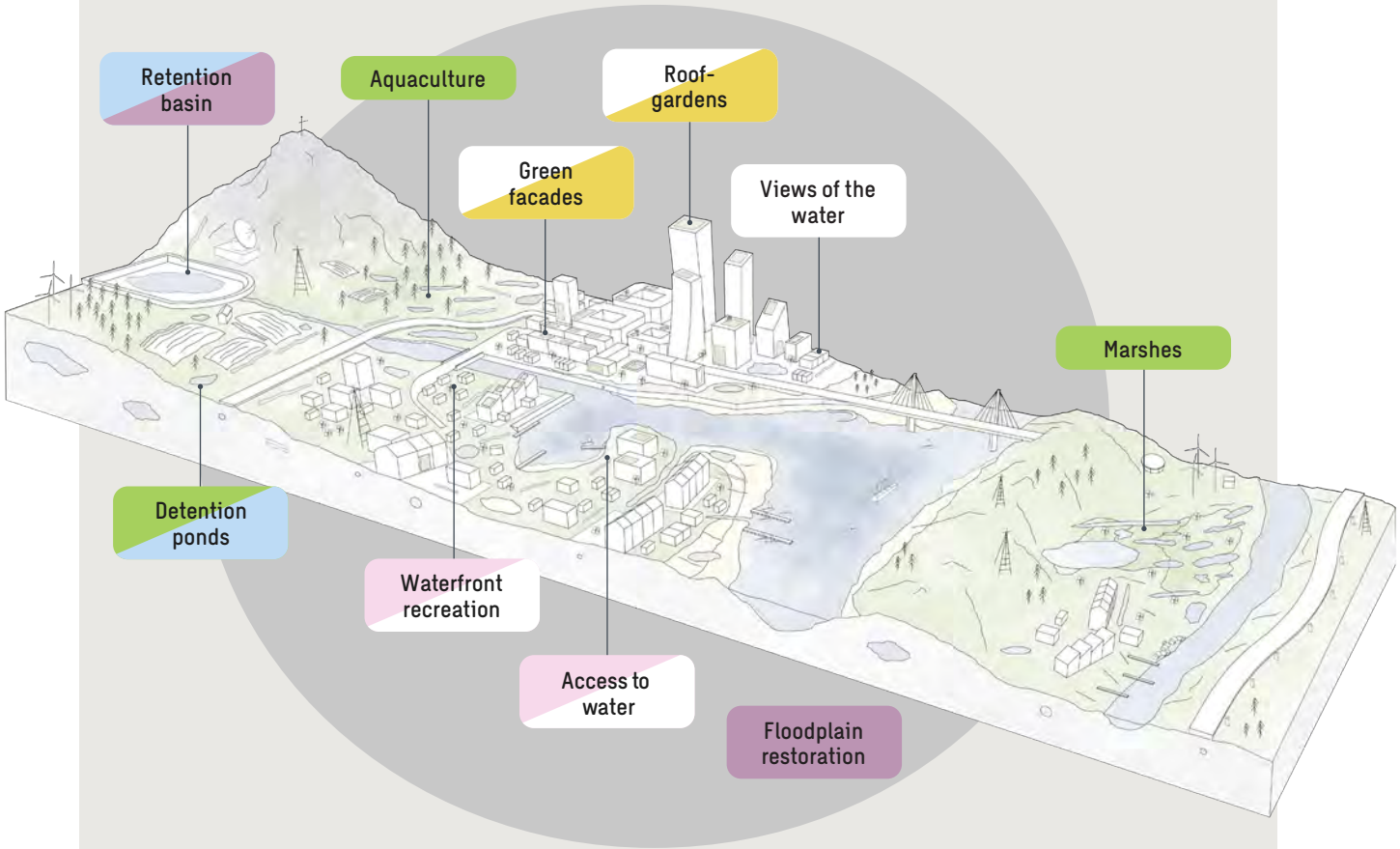
A non-potable network is in use in Paris, as a solution to aging infrastructure, pressure on water supplies, and increasing regulations. Paris' dual network consists of a drinking water and a non-drinking water network. The non-drinking water network has its own lines of production, storage and distribution. It is run in lower pressure which separates it from the drinking water in addition to the quality of the water. While non-drinking water restrictions are lower, it costs less to maintain a functioning network, so it is cheaper and used in large quantities. Non-drinking water is used for hydrants, fountains, street cleaning, irrigation of the public garden and flushing drains instead of drinking water in Paris.[11]

STRATEGIES:

Reintroduce nature in cities

This second strategy is about using nature and soil in urban planning processes to remedy drought and flooding issues. A thorough understanding and a sustainable use of the natural water cycle and natural processes not only benefits nature, but has a positive impact on people and their health. An example of this is the popular concept of sponge cities.

HEALTH BENEFITS IN THE SPONGE CITY



BLUE-GREEN BENEFITS

- for a natural and biodiverse ecosystem
- for water supply
- for connectivity and physical movement
- for thermal comfort (cooling in the city)
- for safety (from flooding and contamination)
- for mental health

HOW CAN WE TURN CITIES INTO GIANT SPONGES?

To answer this question, we turned to Kongjian Yu. A professor of landscape architecture at Peking University, Yu is also an ecological urbanist, urban planner, landscape architect and founder of the planning and design office Turenscape in Beijing. So far, he has been involved in 600 projects of this kind across the world.

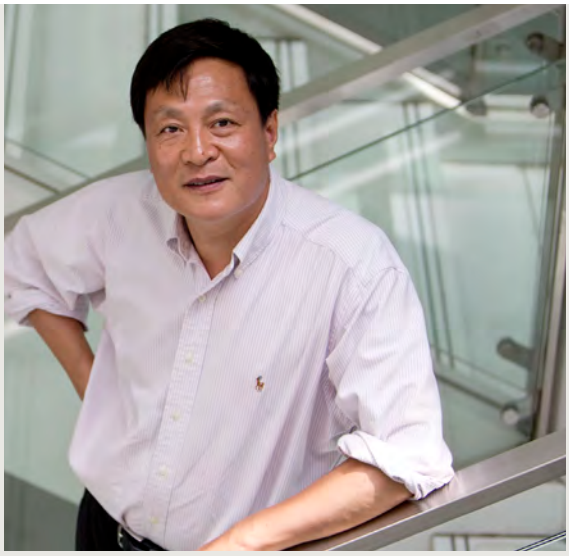
A sponge city is a nature-based solution that retains water as much as possible at the source, slows down the runoff and prevents flooding at the end-of-pipe. It's a holistic and distributed system. It lets nature function as a resilient system that absorbs and cleans water – like a sponge.

Knowledge about managing stormwater has been around for thousands of years, and is particularly advanced with regard to monsoon climates. Chinese agricultural literature states that for every four hectares of land you cultivate, you have to reserve one hectare of land for water.

"People have to have a physical environment that allows us to move freely, to stretch out. We think of nature as a system. The pandemic and the lockdowns stopped us from moving and created physical and mental illnesses. The system we create in the cities allows people to move freely. Placemaking is also an important aspect of our work. For people to meet, create a community, find a cultural identity and sense of belonging", Kongjian Yu says.

Placemaking in our sponge city projects is about making places for people to meet, create a community, find a cultural identity and a sense of belonging.

Kongjian Yu



Kongjian Yu, Professor of landscape architecture.

TIANJIN QIAOYUAN WETLAND PARK

A former heavily polluted site was restored with wetland vegetation to purify the saline-alkali soil. The use of native vegetation allowed for several ecosystem services as well as low maintenance. The park protects the living environment by containing and purifying stormwater and by improving the soil, while providing opportunities to learn about the environment.

Location: Tianjin, China
Designer: Turenscape
Client: Environment Construction and Investment Co., Ltd, Tianjin City
Photograph @ Turenscape

MINGHU WETLAND PARK

The Shuicheng River and its valley were recovered as ecological infrastructure providing ecosystem services to the population in the form of an urban wetland park. The valley was transformed back into the lifeline of Liupanshui city through the use of vegetation, providing a space to wander and wonder on its natural embankments.

Location: Liupanshui City
Designer: Turenscape
Client: Liupanshui Municipality

Our soils are challenged by flooding, water pollution and drought. Due to wear and tear on the existing network, climate change and more intense rainfall, the existing sewer system may become undersized or inadequate, posing a risk to maintain soil quality.

A healthy soil with the right vegetation is not only important for preventing runoff, but also serves as a great water tank thanks to its vast surface and capacity to store water. It should be safeguarded to maintain water quality and the quantity of underground reservoirs, both considered indicators of our health.

Toxic pollution emitted by industries, such as heavy metals, specific pharmaceuticals and chemicals, e.g. PFOS, and waste or agricultural sources of contamination, are exposed thanks to soil monitoring. And as medical research advances, more and more substances are added to the list

REDUCE WATERBORNE DISEASES AND IMPROVE WATER QUALITY, ÅLEBÆKKEN, DENMARK
Designer: Sweco in collaboration with Rambøll, NCC Danmark A/S Civil Engineering
Location: Karlstad
Client: Lyngby-Taarbæk Fors
Visualisation: Ramboll

RESTORING AN OLD STRUCTURE FOR HUMAN USE

The purpose of the project is to reduce the discharge of wastewater to Lake Mølleåen and at the same time improve the water quality in the area. It is an improvement that will help reduce waterborne diseases in the area and help ensure better water quality and better habitats for the river's fauna. The project also includes a plan to open up the area to the city's citizens and create a new landscape park, which will be integrated with the existing structures from a decommissioned treatment plant. Throughout the project, work is being done to recycle concrete structures and technical installations from the abandoned treatment plant. This means that large amounts of CO_2 and resources are saved. Stones and felled trees from the area are kept on site and reintegrated in the new park to preserve the area's history.

of carcinogenic sources. In some cases, eating from your own garden can even be less healthy than buying products in the supermarket.[12] But also drinking from 'clean' natural sources (bore, river or mineral spring) is being questioned in certain areas due to the contamination of surface water and soil in the same catchment with waterborne illnesses (from naturally occurring chemicals and bacteria to viruses).[13]

Technical innovations in water management lie at the basis of shaping new urban structure and prosperous, healthy societies.

EMSCHER – FROM SEWER TO HEALTH BOOSTER, GERMANY

Since the beginning of the industrial development of the Ruhr region, the Emscher River has been consistently used for wastewater disposal. After mining activities in the northern Ruhr area have largely ceased, this river is to be restored to a natural watercourse. This project will finally allow the population of the Ruhr region to enjoy a thriving and healthy water ecosystem. The centrepiece of this task is the new construction of the Emscher, a sewer network approximately 35 km long.

The new sewer separated the wastewater from the river water and enable a thriving healthy water ecosystem in the Emscher region.

Designer: ARGE Emscherkanal (Emscher sewer system consortium members Dorsch International Consultants, Pöyry, Germany; Sweco Germany; Prof. Dr. Stein & Partners GmbH)
Client: Emschergenossenschaft
Department: Water Technology
Project location: Dortmund to Bottrop (Germany)
Role of Sweco (with others): planning, construction management, construction supervision

ORGANISING AROUND WATER AND HEALTH IN ANCIENT SETTLEMENTS

Improved sanitary conditions in city centres have driven urban renewal since the origins of urban planning. From the irrigated terraces of Machu Picchu and the cisterns in Copenhagen's underground to the sewer systems of Paris or London, technological innovations in water management lie at the heart of new urban structures and prosperous, healthy societies. Today, ancient aquaculture is even gaining interest in the realm of integrated water management and climate change adaptation.

SLOWING THE WATER CYCLE

Our soils are challenged by water quality as well as drought. As increasing urban populations demand higher water supply rates, densely populated areas will become more sensitive to water stress. Besides being directly dependent on drinking water, our health indirectly relies on the hydro-ecological status of our living environment. Studies emphasize the health benefits of diverse landscapes,[14] structural diversity and complexity of greenery. Microbiological biodiversity can also potentially strengthen the immune system.[16]

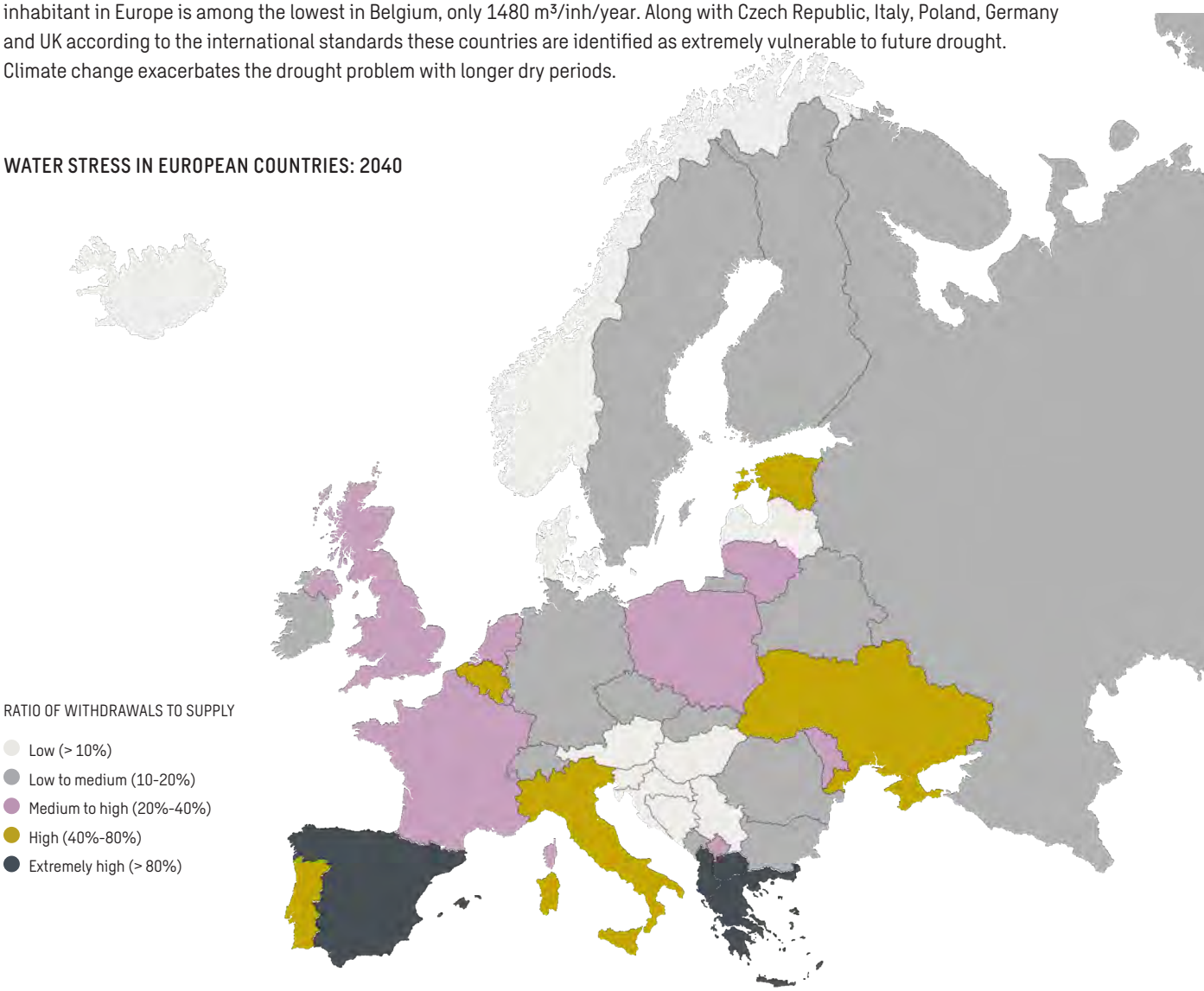
Drought and flooding issues in the European Region have the same cause: an increase in weather extremes due to a changing climate. But they are also an effect of a changing land use pattern due to more drainage and more evaporation.

The combination of a densely built region, high pressure on water resources and high pavement rate creates a shortcut in the water cycle which literally flushes water as fast as possible out to the sea. As the population grows and urbanisation increases, many European governments are looking for solutions that contribute to slowing down this water cycle.

WATER STRESS

Looking at the map of Europe one can notice the correlation between water stress and soil covering due to urbanisation. Water stress is defined as the relationship between total water use and the availability of water resources.[17] Water availability per inhabitant in Europe is among the lowest in Belgium, only 1480 m³/inh/year. Along with Czech Republic, Italy, Poland, Germany and UK according to the international standards these countries are identified as extremely vulnerable to future drought. Climate change exacerbates the drought problem with longer dry periods.

WATER STRESS IN EUROPEAN COUNTRIES: 2040



MOBILISING SOIL TEAMS

To address soil issues, we must first understand regional landscaping features, soil characteristics, groundwater levels and fluctuation, and natural and manmade drainage systems. Therefore, a multidisciplinary team is needed consisting of soil experts, groundwater modellers, ecologists and landscape architects that can consider the characteristics and their interdependence in order to get a clear idea of how the water system works. This is crucial for determining how and whether a certain project (infrastructural, road, nature design, urban development) has acceptable impact or, in the case of unacceptable impact, how to mitigate it.

THE SPONGE EFFECT

Today the urban drainage system exists of a fine-mazed network of gutters, channels, ditches, canals, sewers and pipes. Once they were built to drain excesses of runoff water. Now, we can change their use to transform them into retention volumes to mitigate drought. Industrialised upscaling, such as the large-scale groundwater draining with round ceramic pipe systems used in rural areas in the UK during the 19th century, was a practice that took off in Europe. The sponge effect of the soil and the slow, deep infiltration processes were bypassed. Studies indicate that the potential impact of restoring the sponge effect and replenishing aquifers in rural areas is much larger than in urban areas.[18] However, the multiple benefits in urban areas are just as important. We should harvest our rainwater, or at least slow the urban drainage and infiltrate wherever possible.

For a long time, the proportion of wetlands in Europe diminished due to the need for land in various projects. In recent years, however, the importance of wetlands for biodiversity and reduced flooding has been realized and interest has increased in restoring old areas and also creating new ones.

FIVE RAIN GARDENS DIGTERKVARTERET, DENMARK

Five Gardens in Digterkvarteret is an example of climate-robust and healthy urban design, storing and cleaning rainwater runoff. The sewer systems are not overloaded , and water on roads, by the houses and overflows to the sea is avoided. The project also has a recreational aspect for citizens to relax and explore the many exciting natural sites. The gardens have been constructed as five cascading basins, each with its planting character, and five areas with hills for various activities for both children and adults. The primary function is in fact climate change adaptation towards the rising rainfall.

Designer: Sønderborg Forsyning, the Municipality of Sønderborg and Sweco Denmark collaborated on the project.
Location: Digterkvarteret, Sønderborg
Role of Sweco: Project management, design management, detailed project, tender documents and supervision.
Client: Sønderborg Forsyning A/S (utility company)
Photographer: Niels Nygaard

STRATEGIES:

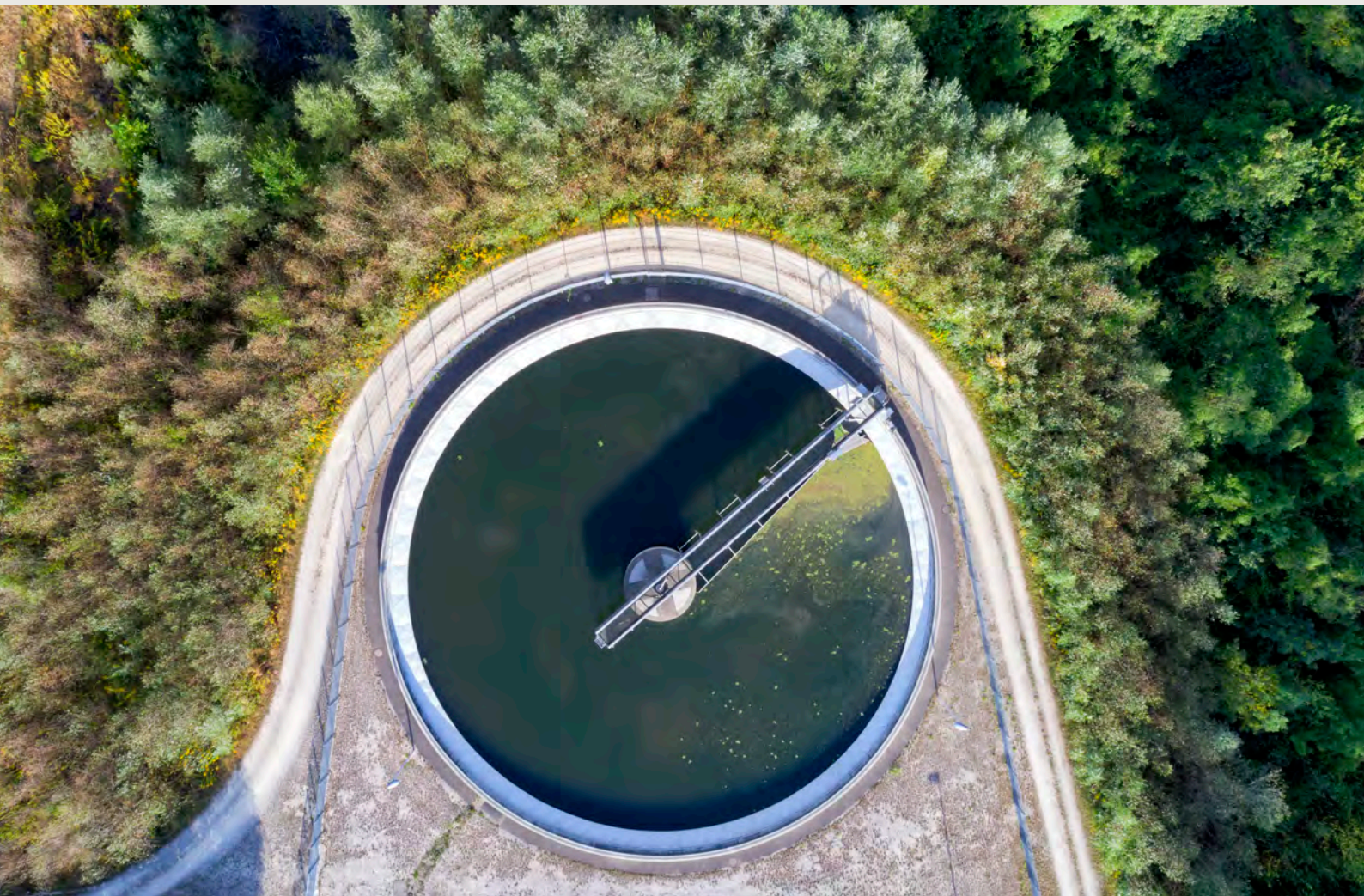
Reduce, reuse and purify wastewater

The third strategy is linked to circular water strategies for reducing the exploitation of natural water resources. As our populations grow, total water consumption is increasing. By reusing water, we can decrease the volumes discharged into rivers, which in turn will prevent flooding downstream. Our safety as well as our health can also be impacted through improved water quality.

Industries that pump up groundwater to use as process water or cooling water are among the biggest consumers and dischargers. Crop irrigation and pumping at infrastructure construction sites, whether permanent or temporal, are other examples.

WULPEN, WASTEWATER FOR WATER PRODUCTION THROUGH NATURAL FILTERS (DUNES)

Drinking water is produced directly from a communal wastewater treatment plant in Wulpen (Belgium). Treated wastewater is injected, after membrane filtration, into the dunes as supply for water production a few kilometres onwards. Captation of this high-quality groundwater only requires simple purification to produce drinking water. The infiltrated volume represents 35% of the production volume of the drinking water company IWVA. The system has been in use since 2002 and creates a sustainable barrier to salt infiltration in this coastal area.



When we use water we pollute it with all kinds of chemicals. Although the total mass of discharged chemicals is relatively small, the effect on the aquatic ecosystems and our health is huge. Nitrogen and phosphorous, as macronutrients, already have huge effects starting from several milligrams per litre of water, but specific chemicals have already a negative effect on our ecosystem and health with concentrations lower than 1 µg/l.

REDUCE OUR WATER CONSUMPTION

To preserve a maximum water quality at an affordable cost, it is important to reduce our water consumption. In our households we can easily reduce our water consumption to a minimum by implementing smart technology in our washing machines, dishwashers, shower systems, toilet flushing and low-flow taps.. But our behavior also has a major effect on our water consumption. Awareness campaigns and a strong price strategy are crucial to give everybody access to good water quality.

REUSE OUR WASTEWATER

Another major impact can be obtained by reusing wastewater. Treated wastewater can be reused locally or from a centralised resource for applications requiring low-grade quality water, such as for toilet flushing. Nowadays, systems are even available for producing drinking water out of wastewater (off grid solution).

Technological developments have made it possible to reuse all types of water. The big challenge that remains is to maximize wastewater production and reuse without complex technology. The residual wastewater will probably be very complex to treat, but the the total volume to be treated will be drastically reduced, so it is still economically feasible. The creation of zero liquid discharge to the environment will indirectly have a huge impact on our health.

REUSE PROCESS WATER ON INDUSTRIAL SITES

New technological developments allow a strong reduction of chemicals. When water reuse is also applied, not only is the total water volume reduced, but the chemical emissions are further reduced.

Instead of using drinking water and groundwater in an industrial company, reused process water can be used to produce demineralised water. Using membrane technology, a minimum of chemical addition can be applied. The small footprint of the installation allows easy implementation and creates an endless source of water. Reusing the wastewater not only leads to a reduction of water consumption and water discharge, but to a reduction in chemical consumption and chemical discharge with a large positive impact on the environment.

18%
reduction in water consumption and discharge

93%
reduction in salt consumption and discharge

EFFLUENT REUSE FOR AGRICULTURE IN KAPELLE, NETHERLANDS
Our agricultural production can have severe implications for droughts. Closing the circle can create a solution to cope with periods of droughts. The food industry creates lots of wastewater from processing all kinds of foods. After treating the wastewater it can be buffered and distributed back to the crop fields for irrigation, securing production. A feasibility study for Impuls Zeeland in the Netherlands, investigated the business case for distributing the treated wastewater to the potential crop fields. Thanks to this solution a vegetable company in Kapelle can reuse 600,000 m^3 each year as a supplier of water.

Reducing water consumption

If we reduce our water consumption by 10% from industry (excluding cooling water) and households, we could obtain an equivalent 23% reduction in groundwater consumption (groundwater is one source of our drinking water), which would create a strategic water buffer during droughts. This effect would be doubled if we achieved a 10% reduction in cooling water consumption.

Salt reduction to reduce pollution

If only 10% of industry used alternative technologies for producing softened water, salt emissions would be reduced by 50%. This would have an equivalent effect on salt consumption of more than 1.3 times our households.

THE EFFECTS OF MICROPOLLUTANTS
Especially in the long-term, a negative impact is expected due to accumulation in aquatic organisms and human bodies, toxicity and resistance to degradation in the environment. Regulations on their emissions and discharge are thus decisive for improving the aquatic environment and surface water quality.

Currently there is no Europe-wide regulation for micropollutants. Switzerland is the first country to legally limit the release of micropollutants from municipal wastewater treatment plants. Proven technical processes for efficient micropollutant removal are based on oxidative, adsorptive and physical methods.

THE RISK OF POLLUTING SEWER OVERFLOWS

Due to climate change, more intense storms will occur more often.[19] Traditional sewer systems are clogging more often, especially in urban areas with vast impermeable surfaces. Pluvial flooding and polluting sewer overflows are an increasing risk for our safety and health. In traditional sewer systems rainwater is discharged into the sewer system and mixed with wastewater. Large quantities of water lead to high economic costs related to the distribution infrastructure and water treatment.

A maximum reduction of rain water runoff and connection to a separate collection system with a maximum reduction of water consumption and discharge would reduce the total volume of water to be treated. A maximum integration of blue-green networks within our cities would make water management more economically feasible and therefore effectively improve water quality in outfalls.

ENHANCED WASTEWATER TREATMENT AT BRUSSELS SOUTH

The Waste water treatment plant Brussels South needed to be renovated to cope with increased waste flow and to meet stricter effluent quality standards. Membrane technology was selected to meet these requirements in the very small footprint that was available. A big advantage of this technology is the high effluent quality that can be obtained which will boost the quality of our aquatic life and indirectly our health.

Designer WWTP: Sweco
Client: SBGE
Location: Brussels, Belgium
Role of Sweco: Concept design, engineering, project management

CRITICAL WATER INFRASTRUCTURE IN THE HEALTHY CITY

A resilient, healthy water city is a place where people have direct contact with water and are safe from flooding hazards and drought. It is a city in which all urban water networks work together to restore the balance in the natural water cycle and minimize the impact of urban growth. A healthy city slows down urban runoff to retain rainwater, recycles and reuses wastewater to minimize groundwater extraction, and installs non-potable water systems. It's a city where people are in contact with water and each other, where natural habitats provide a variety of services to the residents like thermal comfort, filtered air, buffer sound, shade, local food, recreation areas, options for alternative mobility. Protecting water resources and preserving natural environments in urban areas is vital for sustaining life and plays a major role in the fight against climate change.

Integrated water management tools

Besides the three design strategies for cities, two robust tools are available for improving water management. The first is a vision that stems from European water legislation and the Water Framework Directive. The other essential tool that can help us prepare for future challenges is a digital asset management tool, which cities and water managers can use to integrate solutions and make the right decisions on budget, timing and safety.

WHEN VISION IS ALIGNED WITH PLANNING

Cities throughout Europe are crafting policy documents that align their urban planning with water management plans in order to boost resiliency to water risks and better prepare for upstream and downstream impact (basin-sensitive cities). Targeted urban plans like Water Plan Antwerp, Plan Bleu Lyon, Waterplan2 Rotterdam and others have sprung from visions for coping with nearly all water-related issues, such as flooding, water safety and the environment.

A MULTI-LAYERED RESPONSE

In the Netherlands, adaptation is being translated into a multi-layered approach. A first layer provides protection from flooding, with raised dikes and upstream measures. Second, when the dikes break, a bypass should protect the most vulnerable areas. And the final layer involves being prepared and having the necessary infrastructure to safely evacuate an area.

WATER PLAN MECHELEN, BELGIUM

The City of Mechelen expresses its ambition to integrate urban planning, sewer and surface water management in its Water Plan. Based on an interdisciplinary approach the plan aims to retain, store and reuse as much as possible water in public space and as such aim for nature inclusion, climate adaption and health as the main goals. The water plan vision is detailed and quantified; an extensive analysis is made of existing bottlenecks and opportunities regarding sustainable water management.

Designer: Sweco Integrated Water Management Team, Belgium
Location: Mechelen
Role of Sweco: Design, hydraulic modelling, participation
Client: City of Mechelen, supported by EU Interreg 2 Seas, Water Resilient Cities

ASSET MANAGEMENT TOOLS

Water supply assets pose a risk to human health if not properly managed. Leaking industrial and municipal sewer systems, undersized or unsuitable water assets and the increasing effect of climate change might lead to health hazards. Leaking drinking water and sewage networks may cause water-related diseases and trigger severe environmental impacts from soil and water system pollution. And water leaking is a reality in Europe: the mean values for drinking water losses are 23% in member countries of the European water organisation EurEau, ranging from less than 10% to almost 50%.[20]

Urban water systems not only consist of underground pipes and sewer networks, but the blue-green elements above ground. The EU has legislated an integrated approach via its European Water Framework Directive since roughly 1980.[21] Stemming from this legislation cities and administrations have been drawing up water plans, but only the most recent plans include integration with spatial planning.[22]

For a city to be able to structurally and efficiently manage health in complex urban water systems, it needs an integrated vision and an efficient management system.

ASSETS SHROUDED IN OBSCURITY

Many are oblivious to the existence of more than 4 million kilometres of underground drinking water networks and 3 million kilometers of sewer networks in Europe, which correspond to 19 trips from Earth to the moon.[20] Another problem is a lack of understanding about the state of our assets. Some cities lack a database containing key information like the number of kilometres in their networks, or construction year, materials, location, economic value, direction of flow, volumetric efficiency, leaking probability and other metrics.

The actual location of the network might not be digitalised or, in the worst case, even known. This causes problems, for example during construction or when the network lies in contaminated ground. In such cases, the risk of health hazards looms. Drinking water networks need diffusion-protected piping in contaminated ground areas to prevent intrusion via the pipe material. For example, petroleum hydrocarbons can enter the drinking water system this way.

An important question is, how can we optimise the use of existing assets and predict the greatest likelihood of asset failure to prevent harm to human health? Answering this requires an up-to-date database of the assets.

MAINTENANCE AND RECONSTRUCTION

Infrastructure requires maintenance and investments to support healthy cities. Water infrastructure is in poor condition in Europe.[23] Even in Finland, one of Europe's wealthiest countries, it is estimated that 6% of the drinking water network and up to 12% of sewers are rated to be in extremely poor condition.[24, 25] The renewal rates of drinking water assets for EurEau countries vary from almost 0 to almost 10%, and the rates for sewers vary from almost 0 to almost 9%.[20] An increase in the renewal rates of water supply networks is needed, as are other significant investments in the face of intensifying legislation and adaptation to climate change.[25]

FROM REACTIVE TO PROACTIVE ASSET MANAGEMENT

Maintenance of water distribution and sewer systems can no longer be purely reactive. It is vital to proactively manage infrastructure assets to ensure long-term urban health through sustainability, resilience, and security of water assets. Asset management is a systematic process that guides the planning, acquisition, maintenance, operation, renewal and disposal of property as well as information management related to finances and property. It ensures that planned maintenance and repair can be conducted on time. It includes asset inventories, operation and maintenance tasks, and long-range financial planning. Inventories include data on age, condition and criticality of the underground water networks, among other factors.

I see asset management as a tool to minimise risks for pollution and health hazards. Risks decline by maintaining the network and thus keeping the level of reorganisation debt moderate.

Pekka Raukola, water management company Turun Vesihuolto

ASSET MANAGEMENT TOOL FOR CRITICAL RENOVATION

The criticality class of water networks can be determined by calculating the risk for failure. Asset management tools take into account the age, location and material of the pipes. A future estimation of investment costs can then be developed based on data about the pipes and water networks conditions.

INVESTMENT PLANS

By reacting proactively to increasing investment needs, water supply prices stay lower in the long run. This is because it is more expensive to fix an already broken system, the effects of which might be multiplied, than to carry out regular proactive maintenance so the problem will not occur in the first place. The prices can be kept at a moderate level by short- and long-term financial planning with economic modelling, development, strategic and business planning, tariff structure design, life cycle cost and timing optimisation for capital expenditure and reconstruction. This promotes health by ensuring water and sewage treatment for all, regardless of socioeconomic status. It also provides long-term operational efficiency, resulting in a cleaner environment and healthier people.

FINANCING

In Europe, cities are expanding while water and wastewater assets age and water resources become scarce. Ageing assets drive up repair costs. Water infrastructure is expensive and in poor condition in Europe because of insufficient maintenance funds.[23] Capital investments in the sector are below the level needed to maintain the existing infrastructure.[27] Annually, European water services invest approximately €45 billion in water infrastructure.[20] It is estimated that in all EU countries except Germany, the expenses of water supply will increase by at least 25% by 2030.[25]

In Flanders, Belgium, there is a density of the sewer network of about 4 kilometres sewer piping per km² and even more for the drinking water network. Sewer systems are assumed to last for 75 years, resulting in an investment cost of €2 billion over 10 years.[28]

Finland, Sweden and Norway have undertaken long-term water supply investment surveys, identifying the need for an increase in the renewal rates of water supply networks. The investments needed are €480 million/year for Finland and €550 million/year for Sweden.[25] The surveys resulted in an assessment of the need for investment in the water supply networks. The investments needed are €480 million/year for Finland and €550 million/year for Sweden.

THE INTEGRAL AND PROACTIVE ASSET MANAGEMENT TOOL

Pinpointing the exact location of your assets and their status is the first step towards integral, proactive asset management. Obsurv is a good example of an online solution that helps cities to maintain their assets related to water and public spaces. Whether the assets are sewer systems, infiltration facilities for excess rainwater, or natural green zones offering additional and safe water absorption, they can all be maintained in relation to each other. This enables cities to make fact-based choices. Obsurv is used by more than 150 mainly municipal organisations.

A maintenance system like Obsurv also helps planners take the right measures at the right time. Renewing sewer systems, for instance, too early in their lifetime can push up the required annual investment costs 30%. When sewers are renewed too late, this means the old systems remain in operation, so the risk for leakage will increase, leading to induced direct damage of infrastructure and threatening our water quality and health. Renewal of sewers at the right moment is essential to prevent environmental risk and to manage the cost.

Taking calculated maintenance decisions is only possible with a balanced system that fits this challenge. A system like Obsurv enables us to look several years ahead and draw up a realistic maintenance programme.

Anja van der Ven, data management team leader, City of Rotterdam

Likewise, drinking water networks and solutions require digitalised asset management solutions. In the Netherlands, several drinking water companies make use of GeoWeb, a GIS software tool for digitalised and efficient water system maintenance, including problem-solving and emergency closures, as well as for long-term drinking water and drain water calculation models.

Designer: Sweco
Location: Netherlands
Role of Sweco: Provider, design, hydraulic modelling, consulting
Client: 155 cities in NL

CONTINUOUS MONITORING OF WATER QUALITY

Real-time online water quality monitoring is also a part of asset management. It reveals the impact of the network on water quality, providing information on the type of water pumped into the network and how it changes. New technologies are developed for monitoring the water quality remotely and in real time, such as online monitoring of microbial activity in water via ATP (adenosine thiphoshpate). It allows monitoring of water quality both remotely and in real time.[26]

ASSET MANAGEMENT TOOL: ASPECT OF CONTROL BY DIGITAL TECHNOLOGIES

Wastewater supplies experience increasing problems with hydrogen sulfide as a result of centralization of wastewater treatment plants and implementation of long pressure pipes. The purpose of this project is to make an integrated digital control of the prevention of hydrogen where the platform will include integration of: 1) dosing of chemical, 2) physical cleaning of the sediment/biofilm, and 3) control of biofilter for odor mitigation.

Case: R&D project
Consortium: three wastewater supplies and three industrial companies
developing new technologies
Client: The project is funded by the The Danish Environmental Protection Agency.
Role of Sweco: project management and delivering specialized knowledge in the project.

Conclusions and recommendations

Torrential rains and floods during the summer of 2021, together with the alarming report from the IPCC about more extreme weather, are turning even more eyes towards our water supplies and water management in European cities.

Our health and the health of our ecosystems largely depend on the quality of our underground and surface waters. Keeping underground infrastructure in good condition is crucial. In that sense, there is a large role for urban water engineers to play in preventing future health issues.

We need to adopt and strengthen water management in our cities. Yet our underground infrastructure is aging and in poor condition. Cities are facing huge costs in terms of coping with water pollution, droughts and flooding as well as the costs of rebuilding underground infrastructure.

To secure a future with sufficient clean water and successful water network management that prevents system failures, we propose three water strategies that address health challenges at the same time: Restore space for water and people, Reintroduce nature in cities, and Reduce, reuse and purify wastewater.

1. RESTORE SPACE FOR WATER AND PEOPLE

To prevent droughts and flooding, upstream measures are being implemented. Water capture and retention in the landscape, reopening rivers, water in public spaces and permeable pavement construction are all measures for bringing back water to our living environment, with beneficial effects on our health.

Reopening river beds has the potential to store runoff excess during peaks of more frequent storms. In addition to preventing pluvial flooding, multiple health benefits are gained. Reintroducing surface water in the urban context brings thermal comfort, produces a cooling effect, prevents heat-related illnesses, improves safety, provides views of wet vegetation and plants, and offers access to green areas and improved recreation potential, which several studies indicate all create direct benefits for our health.

Reopening rivers and allowing water to be retained above ground make inhabitants aware of water-related benefits such as clean water in urban areas. The presence of water can provide a better living environment for the city's inhabitants, increasing social cohesion and recreation values. When water is locally available it can be easier to also raise awareness of the need of investments for clean water and biodiversity. As rivers return in the visual landscape and provide more interactions, people will become more engaged and form a more intimate relationship with their environment.

In addition, a natural rainwater network (restored water cycle or artificial underground network) can contribute to more useful water management. This leads to a more efficient wastewater treatment system, which again could improve the quality of urban rivers and make water available for the public again.

Space for water, nature, people and thriving communities is limited, so we need solutions that can combine various functions. These include rooftops for rainwater harvesting, rainwater tanks as urban furniture, and squares as rainwater retention basins.

2. REINTRODUCE NATURE IN CITIES

A thorough understanding of the natural water cycle and natural processes not only benefits nature, but has a positive impact on people and their health. Environmental factors such as water quality, air humidity, sound and scents all influence our well-being, physically and mentally.

Let nature function as a resilient system that absorbs and cleans water – like a sponge. Recognising soil as a surface that has a direct impact on our water quality and water management and our most important water reservoirs complements the idea of using nature to solve future challenges

in water management practices. Besides reserving space for natural infiltration, new technologies are also introducing the practice of enhanced infiltration. Enhanced infiltration processes entail capturing rain, or drained or treated wastewater, and diverting it to the groundwater layers or to surface infiltration zones.

3 ways to safeguard soil as water reservoirs:

1. **Minimize groundwater consumption** to keep it as a strategic reserve during peak consumption or droughts.
2. **Refill and restore it.** Pavement and reduced rainwater infiltration today pose a huge challenge. Instead of leading the water through long pipelines directly to the sea, we should return to natural infiltration and keep water local.
3. **Prevent pollution.** We must stop polluting our groundwater, for instance by keeping our sewer systems in good condition.

3. REDUCE, REUSE AND PURIFY WASTEWATER

As our populations grow, total water consumption is expected to increase. By reusing water, we can decrease the volumes discharged into rivers, which in turn will prevent flooding downstream. Our safety as well as our health can also be impacted through improved water quality.

Water consumption can be reduced by using smart new technologies. Reusing wastewater for low-grade purposes or even drinking water production will reduce our emissions and total environmental costs.

We should harvest our rainwater, or at least mitigate urban drainage, through infiltration wherever possible. Rainwater must be part of the architecture of our cities, creating places for recreation and nature experiences and increasing well-being, physical health and cognitive function.

A separate rainwater collection system with a maximum reduction of water consumption and discharge would reduce the total volume of water requiring treatment. It would make water management more economically feasible and therefore effectively improve water quality.

Embracing our relationship with water also involves keeping and using water locally for as long as possible. Rainwater reuse and infiltration in the ground will lead to a major reduction in flow discharge, preventing high economic costs for sewer systems and major buffer systems, but also preventing flooding and water scarcity during droughts.

Reusing wastewater locally helps to directly reduce water capture, production and consumption. Specific waste loads from wastewater can be treated using more enhanced technology, leading to a reduction in surface water pollution and, again, increasing the quality of our environment and our health. Although the technology is currently available, it needs to be used in a smart way to control costs and risks.

Dual networks consisting of drinking water and non-drinking water support the use of water of the right quality at the right place, helping to relieve pressure on water supplies and aging infrastructure and to address tightening regulations. This creates a window of opportunity for enhancing the reuse of rainwater and treated wastewater.

INTEGRATED WATER MANAGEMENT TOOLS

Besides the three design strategies for cities, two robust tools are available for improving water management. The first is a vision as expressed in a water management plan. The other essential tool that can help us prepare for future challenges is a digital asset management tool, which cities and water managers can use to integrate solutions and make the right decisions on budget, timing and safety.

Management software aims to help cities manage their assets, by mapping, visualizing and providing easy access to data.

By reacting proactively to increasing investment needs, water supply prices can stay lower in the long run.

About the Authors

If you have any comments or questions we are happy to help.
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STEVEN RAES, bioengineer in environmental technology, Sweco, has been active in water engineering and management for more than 20 years. He has been involved in all aspects of the total water chain, with water production, water use and wastewater treatment as the point of departure. His practical experience utilises existing technologies in a new challenging and overall sustainable economic context. He starts from the broad context of the problem and determines solutions based on technical possibilities and potential risks. He is involved in projects from scope through to commissioning, all with the goal of realising a vision.

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Urban Insight

Urban Insight is a long-term initiative that provides insights about sustainable urban development, seen from a citizen's perspective. The initiative is built on a series of reports, based on facts and research, written by Sweco's experts. The initiative provides society and decision-makers with facts needed to understand and meet current and future challenges.

This report is part of a series of reports on the topic Urban Health and Well-being in which our experts highlight specific data, facts and science that are needed to plan and build safe and resilient future urban environments.

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