WATER RESILIENT CITIES
NAVIGATING SHOCKS AND STRESSES
City resilience can be described as the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt and grow no matter what kinds of chronic stresses and acute shocks they experience (100 Resilient Cities).

Cities face the increasingly complex challenges of climate change impacts and other natural hazards, as well as population growth and rapid urbanization, aging infrastructure and poverty. As already more than half of the global population lives in cities that are creating 80% of the global GDP, overcoming these challenges is vital. City resilience aims to ensure the safety of urban inhabitants, increase livability and enable economic competitiveness to create a flourishing economy and job opportunities.

For many of the largest, often low-lying cities on earth, dealing with the impacts of climate change should be the first priority. This includes sea level rise, more frequent and intense storms and more frequent and longer drought spells. Recent dramatic flood events as a result of the hurricanes that struck New Orleans, New York and Houston, as well as several devastating typhoons in Southeast Asia, showed the impacts of too much water. Recent droughts in São Paulo, Cape Town and California showed the impacts of too little water, not only resulting in water shortages but also in bush fires threatening urban areas and citizens.

Therefore, cities need to be water resilient. As space in urban areas is often valuable, and funding often limited, an integrated approach linking urban water management, urban development and spatial planning is required. Arcadis has developed a holistic and impactful method to develop water resilience in dynamic city environments are often constrained by the physical and economic landscape. By creating multifunctional solutions that not only protect but also enhance urban attractiveness and livability and ensure an economic climate suitable to investment, we add value for citizens and communities, attracting investors and creating opportunities for bankable solutions.

Arcadis aims to not only help cities cope with their challenges of water resilience, but also transform these challenges into opportunities for economic development and an improved quality of life.
Cities worldwide are increasingly confronting a wide array of water-related shocks and stresses ranging from different types of flooding to water scarcity and pollution. Cities are challenged to take account of increasing risks, both in terms of probability and impact, of the following trends: global climate change, urbanization, water shortages and pollution and vulnerability of infrastructure and businesses.

- **Global climate change** changes the regional distribution of water causing different impacts across the globe. Sea level rise will increase coastal flooding and more frequent heavy rainfall will increase the probability of urban and riverine flooding. Furthermore, the intensity and frequency of hurricanes and superstorms, as well as the occurrence of prolonged dry spells, are predicted to increase.

- **Urbanization** is accelerating as more people move to cities. With growing cities come greater challenges for city water systems. Decreased surface permeability results in less infiltration and faster runoff, which cause flash floods. Cities located in river deltas with soft soils will have to manage land subsidence. Without heavy investments in flood prevention measures, flood damage in coastal cities is predicted to rise to US$ 1 trillion by 2050, according to the World Bank.

- **Water shortages and pollution** cause increasing challenges, as cities worldwide are struggling to supply their growing population with safe drinking water and proper sanitation. The World Bank states that by 2050, urban water demands are predicted to increase by 50 to 70% and 1.9 billion urban inhabitants will have to deal with seasonal water shortages.

- **Vulnerability of infrastructure and businesses** is increasing. Growing populations in cities need access to public utilities like electricity, telecom services and different modes of transportation. Cities have become economic powerhouses with more businesses prone to the consequences of shocks and stresses. With such a high concentration of both people and wealth in one place, the potential impact of floods, severe weather events and dry spells on cities has increased.

To navigate these challenges, cities will have to increasingly invest in adaptation strategies that improve their water resilience and safeguard communities, businesses, utilities and assets against the impacts of shocks and stresses.
SUCCESSFUL URBAN WATER RESILIENCE

Many cities and metropolitan regions around the world acknowledge that improving their water resilience is crucial to keep their cities safe, sustainable and attractive for their citizens and businesses. Based on our global experience, we have identified key factors that cities should consider when tackling water resilience issues.

- **Investing in flood resilience pays off.** For example, Rotterdam’s innovative and proactive approach to water resilience not only consists of a solid flood protection and drainage system, but also includes solutions such as multifunctional flood protection structures, a floating water pavilion and attractive water plazas. Investments like these have helped the city become one of the most water resilient places on earth with a thriving economy and an attractive, functional cityscape. Lonely Planet, the largest travel guidebook publisher in the world, cites Rotterdam as one of the top global city destinations, which recognizes the modern appeal of a water resilient city.

- **In a resilient city, “the show must go on”,** under all conditions, even right after a flood. In addition to providing flood protection for the city as a whole, as New York City exhibits, cities should safeguard undisturbed public services, by making not only their most critical public infrastructure, like public transport, tunnels, water, electricity but also hospitals and other public assets resilient. Additionally, businesses should invest in protecting their premises and production processes to protect business continuity.

- **Including private stakeholders as early as possible** in the planning process increases the chances of financial feasibility of projects. Through incorporating financial engineering at an early stage, cities can move fast from planning to implementation to turn climate challenges into bankable opportunities and breakthroughs. One of the most promising financial mechanisms to strengthen a city’s ability to finance resilience is to capture (via taxation or other means) the increased value of previously neglected waterfront properties after the completion of flood protection, soil remediation, waterfront restoration and projects that increase access to the waterfront.

- **Multifunctional solutions** in water resilience for water storage and flood protection are growing in popularity and impact. Cities like Rotterdam and New York combine these measures with other urban functions such as parking, transport, recreation and tourism, as well as natural functions such as the ecosystems based functions. Doing so increases the value and attractiveness of these costly investments that occupy precious urban space and makes them more feasible for cities to implement.

- **An integrated, multilayered approach** contributes to water resiliency in cities, with intense interaction and knowledge sharing between all public and private stakeholders, as well as community involvement. Because resilience requires redundancy and the combination of large- and small-scale measures, the alignment of decision makers and community leaders at all levels can help accelerate implementation.

- **Involving communities and citizens** using social media and other digital developments is an important component of urban water resilience. Iterative participatory processes, reflexive learning and the use of big data can help steer projects towards the most appropriate solutions. Raising awareness among citizens by investing in education and communication is essential for improving community resilience and increasing preparedness.

- **Ecosystem-based measures,** such as those implemented by Building with Nature, have many co-benefits when applied in the urban environment to develop resilient and eco-friendly waterfronts and improve water storage and flood defenses. Natural ecosystems such as coastal mangroves, beach dunes and wetlands provide ecosystem services for human well-being that generate more sustainable solutions.
OUR APPROACH

An integrated approach at all levels is required to achieve and maintain urban water resilience. At a city level, flood protection for the city as a whole is required, but has to be combined with additional resilience for critical public infrastructure like public transport, tunnels, water and electricity, as well as protection of private companies to safeguard business continuity. In this way, cities can ensure the safety of their citizens alongside undisrupted public services and business continuity.

At a project level, integrating different functionalities in resilience measures can increase overall project feasibility by generating opportunities for co-financing and creating additional revenue streams. To leverage these opportunities, Arcadis applies an integrated approach in which we incorporate different disciplines and involve all relevant stakeholders as early as possible.

Integrating multiple functions into a solution is not only limited to water resilience. The addition of other urban functionalities can provide further benefits for cities and their inhabitants, improving their quality of life. Examples of this approach are combining flood defenses with an underground car park, adding green spaces or other adaptive functions to storm water reservoirs or creating a seawall that not only protects the city against storm surges but also protects the underground against the potential liquefaction impacts of earthquakes. These solutions all deal with shocks and stresses, but are not limited to water resilience; in doing so, we address city resilience in its broadest sense.

We believe that capacity building, stakeholder management and in particular involvement of financial stakeholders at an early stage is critical to the success of implementing water resilience strategies.

Attaining funding for resilience measures is key for implementation. In most cities, it takes a disaster before funding is allocated to reduce the risk of shocks such as flood and droughts. However, at this point, there has already been tremendous damage to people and assets. The mitigation of slow-developing stresses such as sea level rise and water pollution are even harder to fund and the implementation of measures is often postponed as their effects are usually gradual and easily overlooked. Nevertheless, cities need to act now and incorporate water resilience in their urban development to safeguard their safety, livability and economic competitiveness.

To help cities navigate towards water resilience, and making their vision a reality, Arcadis has developed an innovative approach: The Resilient Pathway.

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The Resilient Pathway

To unlock money flows and to raise capacity of stakeholders, ARCADIS has developed and successfully tested a new and unique high level business model, the Resilient Pathway. The Resilient Pathway helps cities to identify the ‘moments of change’ and to define investment opportunities, while creating a marriage between technical, financial and social engineering.

The Resilient Pathway approach entails five different phases of scoping, optioneering, prioritization, deal structuring and project implementation:

**Phase 1 - Scoping:** setting clear targets, clarifying challenges, identifying relevant stakeholders and potential opportunities.

**Phase 2 - Optioneering:** identifying business models and adaptation options around urban developments.

**Phase 3 - Prioritization:** procuring commitment from the full stakeholder community of interest and selection of the prioritized option.

**Phase 4 - Deal Structuring:** transforming the selected investible and prioritized opportunity into a contract with detailed specifications and financial and legal arrangements.

**Phase 5 - Project Implementation:** the projects or developments are realized, managed effectively and monitored.

As a platform partner of 100 Resilient Cities, pioneered by the Rockefeller Foundation, Arcadis organized and facilitated interactive workshops in the cities of Bristol (UK), Pittsburgh (USA) and Vejle (Denmark), applying Phase 2 of the Resilient Pathway approach. The optioneering workshops focused on concepts, methods and tools for creating urban climate resilience and best practices for financing climate change adaptation. The workshops brought together financial experts, planners, engineers, citizens and designers with city leaders and other local stakeholders, to jointly design feasible visions and create strategies. The workshops in the three cities consisted of a variety of issues and solutions. The Bristol workshop dealt with how to manage future flood risk and protect and value green space, the Vejle workshop focused at creating resilient pathways and bankable opportunities for two city districts, and the Pittsburgh workshop dealt with identifying the most relevant constraints and potential benefits of the implementation of green infrastructure in a watershed of the city.
OUTCOMES
WE DELIVER

Arcadis offers a wide range of services to help our clients deal with water-related shocks and stresses and navigate towards water resilience. Building on our unique combination of extensive expertise in water and our worldwide presence in major cities, we are best positioned to deliver the most water resilient outcomes to our clients. From protecting cities against storm surges and reducing the impact of heavy rainfall, to securing potable water supplies for communities, managing the water usage of industries and ensuring a well-functioning drainage and sewage network, we help our clients become more water resilient.

COASTAL AND RIVER MANAGEMENT
We are actively involved in coastal protection, flood risk management, ecosystem restoration and climate change adaptation planning for coastal cities around the globe. We bring significant experience in the planning and engineering of resilient and sustainable coastlines and deltas. Building on our origins and success in The Netherlands, our water experts have planned, designed, assessed, supervised and maintained coastal protection and restoration projects in the USA, Germany, Italy, France, Belgium, Poland, Sweden, the UK, Australia, Brazil, Colombia, Chile, China, Hong Kong, Korea, Malaysia, Myanmar, and the Philippines.

URBAN WATER MANAGEMENT
To minimize the impacts of urban flooding we offer our clients a wide range of tailor-made solutions, such as the implementation of Sustainable Urban Drainage Systems, the “Sponge City” concept and Water Sensitive Urban Design. Solutions include green rooftops, creating parks, swales, basins and ponds, and increasing natural drainage in urban areas. We have helped numerous cities implement sustainable urban drainage strategies. Outcomes we have delivered include reductions in water treatment needs and urban heating, improvement of local ecosystems, surface water quality and air quality, and increases in recreational opportunities. By integrating these functionalities we have realized significant cost savings for our clients, in both the short and long term. We have helped cities worldwide in this capacity, such as Amsterdam, Rotterdam, New York, New Orleans, Sydney, Wuhan, Singapore, Hong Kong and Manila.

WATER SUPPLY AND TREATMENT
Water scarcity is caused by droughts and increased water demand, inefficient water use, pollution and conveyance losses. We help our clients ensure a safeguarded and durable water supply. Through our expert knowledge, we apply leading-edge technologies to meet ever-changing quality needs for drinking water and wastewater facilities. We act within local regulatory requirements and with minimal environmental impact to protect the world’s water supplies for future generations. We also help communities and utilities safeguard, expand and diversify their water supplies in cities such as Los Angeles, Dubai, Doha and São Paulo.

WATER CONVEYANCE
Moving water reliably and efficiently is a major urban challenge as populations increase and put additional pressure on finite freshwater supplies. As cities continue to grow, so too does the need to collect and transport our water supplies and ensure our drainage facilities are effective and will stand the test of time. Arcadis has over a century of experience in assisting our clients to convey and store water, wastewater and storm water. Building on our global experience and water sector expertise, we have delivered impactful outcomes to our clients, including well-maintained water conveyance networks with a reduction of water leaks and pipe breaks, reduced water losses and improved efficiency, reliability and performance of these utilities. In addition, we consistently help water utility companies recover revenue through improved metering and billing.

WATER FOR INDUSTRY
Flooding and water shortages also impact multiple industries. We help protect businesses against the impact of flooding and make smarter use of industry’s resources. It is vital to minimize the demand on the water used in manufacturing and production processes and safeguard business continuity under all circumstances. With water impacting industries more than ever before, it is imperative that companies invest and focus on securing and protecting their supplies as well as address the impacts on their infrastructure and operations.

From providing water assessment and designing moveable flood protection to developing turnkey technology solutions, Arcadis partners with industry to help effectively manage water while making their businesses more resilient.

New York City, USA
Arcadis helps cities worldwide advance their water resilience through increasing flood protection, restoring coastal ecosystems, improving drinking water supply and sewerage systems, reducing pollution and increasing water quality and security, incorporating green infrastructure and drainage in the urban fabric and developing resilient and revitalized waterfronts. This chapter presents a selection of case studies of cities where we have helped make communities, utilities and assets more water resilient.
Amsterdam, home to Arcadis’ global headquarters, is a historic city with an attractive mix of business, culture and creativity, green parks and public space, and educational enterprises. The city aims at continuously improving its housing, sustainability, and infrastructure while maintaining the historic parts of the city. As Amsterdam is a low-lying city which faces rising sea levels, the city is investing in smart sustainable growth to ensure a prosperous and resilient future and strives to upgrade flood protection, increase mobility and update aging infrastructure.

Arcadis is a partner of Amsterdam Smart City, a partnership between companies, governments, knowledge institutions and the people of Amsterdam that develops smart social and technological infrastructures to facilitate sustainable growth.

SOLUTIONS
Arcadis has worked on various projects updating and climate proofing critical infrastructure and transportation hubs, such as the tunnel, highway system and public transport terminal of the Zuidas area and the Second Coentunnel to increase resilient transport and mobility of the city.

Arcadis also planned and coordinated the Drainage Master Plan for Amsterdam Airport Schiphol. We helped upgrade dikes and sluices to mitigate sea level rise, for example strengthening the Markermeer dikes protecting Amsterdam and surrounding areas. Arcadis works on the Dutch Delta Plan to protect the Netherlands against flooding while safeguarding freshwater supplies. We assessed resilient waterfront development of the Westpoort Port District using the adaptation pathway method linking resilience to the creation of new business opportunities.

With nearly 80% of Rotterdam below sea level, the city is protected by an extensive system of dikes, storm surge barriers and closure dams. Rotterdam has a proactive water management approach that promotes integrated, innovative and multifunctional solutions. Two of the most innovative features of the Rotterdam approach are multi-purpose urban storm water storage and multi-purpose flood protection. The city is striving to be completely climate resilient by 2025.

SOLUTIONS
Arcadis has worked on Rotterdam’s strong and multifunctional first line of defense in managing and maintaining the Maeslantkering Storm Surge Barrier, executing the conceptual design studies of multifunctional levees and developing the concept of multipurpose dikes. Arcadis has helped create resilient buildings and strategies for innovative storm water storage, for example, the iconic and high-tech Rotterdam Central Railway Station.

Together with the city, we are exploring smart flood risk management and finance options for climate change adaptation of the Merwe-Vierhavens, an iconic area of the port of Rotterdam. For the Schouwburgplein water plaza as part of the 7 Square Endeavour collaboration, we are exploring innovative and integrated solutions for transport, environment, water, urban planning, existing buildings and quality of life. Arcadis involved the community, conducted research and proactively planned by investigating smart ways to adapt to future floods, including serious gaming and a state of the art decision support system for smart flood risk management.
London is transected by the Thames and its twelve catchment tributaries, and the tidal influence of the North Sea extends through the entire city. The rapidly urbanizing city needs to adapt to extreme weather events, as the intensity and frequency of extreme rainfall events and tidal surges are predicted to increase significantly. To adapt to the demographic, economic and climatic changes, the city needs to heavily invest in improving the current water supply and sewer networks that are not only designed for a much smaller city but also over 150 years old.

**SOLUTIONS**

Arcadis supports London’s pursuit of water resilience in several ways: through updating aging infrastructure, constructing green infrastructure, improving drainage systems, and reducing the risk of flooding from heavy rainfall, the River Thames and North Sea tides. We helped Thames Water achieve a step change in its capital investment programs for essential improvements to London’s infrastructure between 2015 and 2025. We have undertaken vendor due diligence review for the Thames Tideway Tunnel which will upgrade London’s sewerage system to cope with the demands of the city well into the next century.

The 25 kilometer interception, storage and transfer tunnel running up to 65 meters below the Thames will prevent overflow of tens of millions of tons of sewage into the Thames. We are supporting the delivery of a UK wide program of improvements to flood protection. One of these projects is the River Thames Scheme, worth an estimated £500m, which provides a 16 kilometer long and 60 meter wide flood channel to the west of London, reducing the flood risk to over 15,000 homes. Arcadis developed the operating strategies for the Thames Barrier, provided asset investment management and was responsible for engineering services for the Thames Weirs radial gates replacement.

New York City is a global hub of finance and culture and has one of the most iconic coastlines of the world. The city has largely thrived due to its waterfront that has served as a venue for commerce and transportation. However, its location puts it at a high risk of flooding, illustrated by the consequences of Superstorm Sandy. In reaction to the storm, Mayor Bloomberg released in 2013 a US$ 20 billion plan for “A Stronger, More Resilient New York”. The plan is multilayered, striving to reduce impacts whenever possible and improve the capacity of the city to bounce back from disruptions.

**SOLUTIONS**

Arcadis supports the City of New York in many ways. We are involved in various projects in flood resilience, resilient public transportation systems, resilient hospitals and resilient office buildings for business continuity, green infrastructure, flood robust sewer systems and pumping stations. Examples include the flood protection analyses and resilient designs of bus - and subway stations for the New York MTA Metropolitan Transportation Authority and the BIG U project to protect Lower Manhattan.

We developed flood protection measures for the Nassau County Sewage Treatment Plant and were responsible for repair and facility stabilization, funding assistance, flood mitigation planning, design and construction services for the hospitals of the New York City Health and Hospital Corporation. We have carried out projects for improving the resilience of waterfront communities with integrated planning and flood proofing residential areas such as Coney Island and Jamaica Bay. Arcadis developed a comprehensive flood protection solution for Southern Manhattan for the NYC Southern Manhattan Coastal Protection Study. We also identified and assessed flood protection options as well as evaluated various storm surge mitigation alternatives for the NYC East Side Coastal Resiliency Flood Protection Design.
New Orleans was founded in the Mississippi Delta near Lake Pontchartrain 300 years ago. The city's proximity to waterways and water resources holds various economic advantages, but also make the city vulnerable, as Hurricane Katrina illustrated in 2005. In response to the disaster, the U.S. Army Corps of Engineers (USACE) doubled its levee strengthening efforts and constructed a new Hurricane Storm Damage Risk Reduction System (HSDRRS) that proved itself in August 2012 when Hurricane Isaac struck the Mississippi Delta and New Orleans remained safe. However, the city faces increasing challenges with its urban drainage system, continuing land loss in the delta, sea level rise and land subsidence.

**SOLUTIONS**

Arcadis participated in the Dutch Dialogues, a multidisciplinary and multilevel design process in which American and Dutch experts, public servants, stakeholders, scientists and engineers collaboratively helped the city develop new concepts for a more sustainable water system and a greener, more resilient and livable city. Arcadis also played a key role in the subsequent development of the Greater New Orleans Sustainable Water Plan that will reduce street flooding and land subsidence and make the city a more attractive place to live.

San Francisco's location at the coast of the Pacific Ocean and San Francisco Bay makes the city prone to flooding, sea level rise by the year 2100 will put around US$ 64 billion of property value at risk of future flooding. The city has had its share of natural disasters, mainly from earthquakes and fires, and reacted with plans for improved resilience. The new challenges of climate change, including droughts and sea level rise, are approached with the same attention; San Francisco recently developed a city resilience strategy and a climate action plan to protect some of its most vulnerable critical infrastructure.

**SOLUTIONS**

As leader of a team that included U.S. and Dutch engineers and scientists, Arcadis developed climate change adaptation strategies for the San Francisco Bay Area. As part of a multi-consultant team, Arcadis assessed the vulnerability of Bay Area transportation infrastructure to sea level rise and developed adaptation strategies for more resilient transportation infrastructure in the Adapting to Rising Tides project. Arcadis led the award-winning Mission Bay sea level rise resilience study for the City and the Port of San Francisco.
LOS ANGELES

With its Mediterranean climate and distant water sources (over 85% of the water supply is imported from over 100 miles away), the iconic city of Los Angeles is aiming to become more drought resistant. However, drought is not the only water related problem the city is facing, as it is also experiencing degraded water quality and occasional flood events. The city is responding to these challenges by a mandatory 25% water use reduction and is investing in water reuse and water conservation programs. The city introduced the One Water LA framework which strives to increase climate resilience, improve local water supply and integrate water resource management.

SOLUTIONS

Arcadis helped to explore in the “Room for the LA-river” workshop how a blue-green infrastructure approach could alleviate the problems of flooding, drought and degrading water quality of the LA River. Arcadis worked on an urban renewal project adjacent to the LA River to transform the former Albion Dairy plant into a 2.5 ha Albion Park improving the underground storm water quality. The park provides the community with much needed green spaces and recreation areas, including a new multipurpose athletic field, walking and bike paths, and a host of other recreational features. Under the US$ 500 million Proposition O clean water program, Arcadis applied a blue-green infrastructure approach in three park projects that increase drought resistance, flood control and water quality: in Perris Park, Echo Park Lake and South L.A. Wetlands Park. With the Los Angeles Aqueduct Filtration Plant, we supported Los Angeles Department of Water and Power to increase the city’s water sustainable footprint and decreasing its reliance on imported water.

TORONTO

Toronto is a city that lives with the water, with its world-renowned waterfront facing Lake Ontario, transected by three rivers. Toronto is exposed to climate related impacts like increased river and storm water flooding, blizzards and heat stress. In 2017, Lake Ontario reached an all-time water level record, threatening Toronto and other cities in both Canada and the U.S. with flooding. The city also faces aging infrastructure, making failures more likely and possibly exacerbating the impact of other threats. Toronto is challenged to sustain its high livability standard in the face of climate change and extreme weather events.

SOLUTIONS

Arcadis supports Toronto as it increases its resilience by revitalizing its waterfront, reducing the environmental impacts of urban development and reducing riverine flood risk by adopting a nature-based approach. In Toronto’s Future Weather and Climate Driver Study, we have assessed climate change impacts to develop adaptation strategies. We also performed an environmental and resilience peer review for proposed works on the Billy City Airport for the waterfront. For the redevelopment of the 20 hectare West Don Lands brownfield site, located near the waterfront, we conducted environmental investigations and risk assessments. The plan included flood protection measures to protect downtown Toronto from a once in a hundred-year flood event. Arcadis is involved in a project that will transform the existing mouth of the Don River on the city’s waterfront including the Keating Channel, into a healthier, more naturalized environment, while at the same time reducing the risk of flooding. An environmental assessment to support the revitalization of Queens Quay at the waterfront of Toronto was carried out including a combined geotechnical and environmental investigation to identify sources of contamination.
The fast-growing city of Doha, the capital of Qatar, will host the 2022 FIFA World Cup. Water resources are limited and desalination plants are the country’s main source for drinking water, providing a challenge for its increasing numbers of citizens and tourists.

Acknowledging the challenge of meeting the growing demand for water with increased efficiency, the country recognized the need for a national strategic plan to safeguard its future. The current water supply system can store only two days’ worth of water and any drought has the potential to create a serious water crisis in Doha.

**SOLUTIONS**

To increase the city’s resilience and water security, Arcadis is assisting the city in building the first-of-its-kind Mega Reservoir project. The project will allow Doha to store 15 million cubic meters of potable water, increasing the city’s water supply security from two to seven days. Five interconnected sites, each containing four to five reservoirs, are currently under construction and are on course to be completed by 2018.

Additionally, an expansion to nine reservoirs at each site is scheduled to be constructed by 2036, improving efficiency and storage in Qatar’s water system even further. The mega reservoirs will be the largest of their kind in the world. With seven full days of water security, Doha’s citizens and businesses will have a more efficient, secure and resilient supply for the future.

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São Paulo, the most populous city in Latin America, has grown rapidly and mostly uncontrolled. Irregular urban settlements and inadequate housing programs lead to untreated sewage being drained into the river and consequent high levels of pollution. The megacity is vulnerable to weather extremes in general, and pluvial and riverine flooding and drought in particular. From 2014 to 2016, the city experienced a major drought and was not able to comply to its citizens water demands anymore. In 2016, torrential rainfall caused flooding and mudslides in the previously drought-struck city.

**SOLUTIONS**

For decades now Arcadis is the consultant and technical advisor to the São Paulo State Sanitation Company (Sabesp) for improving the water quality of the Tietê River. Since 1992, we have helped Sabesp deliver infrastructure for improving the water quality and access by connecting additional households to the sewer system and increasing the volume of sewage treated. The project aims to increase sewage collection of 19 million inhabitants to 100% by 2024. Arcadis worked on recovering the remaining floodplains of the Tietê River and transforming them into a linear park and recreational area for the urban population. The park also reduces the flood risk of the Tietê River for the East Zone of São Paulo. Arcadis provided management and technical support in the Water Loss Reduction Program, which aims to reduce water loss not only in São Paulo Metropolitan Region, but in São Paulo State as a whole. Furthermore, in order to improve water quality and mitigate the risks of water shortages by reusing treated water, Arcadis developed conceptual and detail designs of the new São Lourenço Water Treatment Plant.

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Hong Kong has a natural deep-water harbor and is an important trading port in the world. The city has grown continuously, while only 25% of its area has been developed due to its mountainous topography. Hong Kong has experienced natural disasters throughout its history. From June to October, typhoons bring rainstorms and strong winds that can cause flooding, landslides, and rockslides. To manage these risks, the government of Hong Kong has invested heavily in mountainside and storm water storage. However, climate change models project an increase in extreme rainfall events and Hong Kong will have to further extend its efforts. Other challenges are related to pollution and sea level rise.

**SOLUTIONS**

Arcadis projects include the vitalization of the central harbor front promenade for Victoria Harbor, one of the busiest harbors in Asia. The water quality of Victoria Harbor has been improved by the Harbor Area Treatment Scheme, including the design of a 12 kilometer sewer tunnel at up to 160 meters depth. Other projects include the development of Pak Shek Kok with a Seafront Promenade and marine facilities, and the Lamma Power Station Extension project, which ensures sustainable energy supply for Hong Kong. For the latter project, Arcadis worked on land reclamation, bridges, and trails, including geotechnical services, detailed design, settlement assessments, and detailed ground treatment design. Furthermore, Arcadis designed the Integrated Waste Management Facilities, making them resilient against shocks and stresses related to landslides, flooding, and sea level rise. Lastly, Arcadis helped connect Hong Kong with mainland China by designing the Mass Rapid Transport (MRT) underwater high-speed rail tunnel.

Wuhan, China

With 11 million residents, Wuhan is the most populous city in Central China. The city lies at the intersection of the Yangtze and Han rivers. Flooding from the two rivers has been strongly reduced by the construction of levees and upstream reservoirs. However, urbanization has reduced the retention capacity of the city and there is a lack of surface water and green spaces.

**SOLUTIONS**

Wuhan was selected as one of the main cities in China to serve as a pilot for the “Sponge City” Program, which aims to address the challenges of flooding, drought and pollution with an integrated system of comprehensive management structures, green infrastructure, an upgraded urban drainage system, water storage and purification facilities throughout the city. The quality and quantity of runoff are controlled through green infrastructure, permeable pavements and small-scale water storage facilities enabling water re-use. Arcadis worked with several partners on the development of the Sponge City Strategy for Wuhan, creating multifunctional green public spaces to absorb storm water, increasing the city’s resilience to climate change and contributing to a more attractive and livable city.

Arcadis acts as the principal consultant providing technical, systematic and legal advice, and has delivered a full range of water management services for over 400 projects over the past years. The Sponge City Program aims to reduce the economic and environmental damage caused by floods in Wuhan and increase safety for its residents. Its goal is to manage 60% of the rainwater and provide an example for other Chinese cities. Some of Arcadis’ projects that are part of the Sponge City Program include the Han River Street Central Green Axis, the Underground Space Design project, and the Donghu Greenway project. The latter project focuses on the East Lake in Wuhan, the largest urban lake in China, and will significantly add to the attractiveness of the city.
Sydney, Australia’s most populous city, is facing significant challenges to sustain a high livability standard for its fast-growing metropolitan population. Future projections for the city entail the increasing risk of flooding due to intensifying storm and sea level rise and simultaneously growing impacts of droughts and heat stress. The city needs to deliver a secure and reliable water supply that meets the demands of a growing urban population, addresses potential prolonged droughts, and provides a healthy ecosystem and a livable environment. The city is emphasizing good urban design and planning to create a sustainable and resilient city that protects the natural environment and has a balanced approach to the use of land and resources.

**SOLUTIONS**

Arcadis is supporting Sydney to become more water resilient with developing Climate Change Adaptation plans and Water Sensitive Urban Design (WSUD) Masterplans. The plans integrate the urban water cycle, and are designed to achieve multiple objectives including water quality, storm water detention and flood management.

Sydney’s waterfront Darling Harbor, Arcadis prepared a water WSUD for the transformation of the iconic International Convention Center and the new city neighborhood Darling Square. The WSUD strategy included green roofs, rainwater tanks, bioretention and rain gardens, tree pits, filtration systems and pollutant traps, resulting in a 6 Star Green Star Community rating, the highest sustainability rating in Australia.

**MANILA**

Manila, the capital of the Philippines, has a very high population density and a greater metropolitan area characterized by extensive informal settlements, which are developed without proper urban planning. This makes the city vulnerable to the impacts of flooding especially since it is in an adverse geographic location with one of the most challenging climates on earth. The Philippines is the country most exposed to typhoons in the world, with Manila being hit by five to seven typhoons annually. Manila is striving to improve its resilience planning for a flood protection program, and to increase the level of drinking water supply and sanitation.

**SOLUTIONS**

Arcadis helps to increase Manila’s drinking water supply resilience by exploring alternative sources of freshwater, improving water quality and upgrading aging infrastructure. We have supported the city in improving the coverage of its drinking water and wastewater network. We conducted studies about water quality, treatment process options, conveyance route optimization, cost estimates and an economic analysis for the Kalawa Water Supply project for Maynilad Water Services. Furthermore, Arcadis carried out a feasibility study on the treatability of raw water in the Laguna Lake as a potential new source for drinking water. We have worked on an assessment of and rehabilitation works for the Angat Dam aqueducts to improve operational flexibility and allow for refurbishment of older aqueducts, without putting the water supply at unacceptable risk. To rehabilitate and restore the quality of water draining to Manila Bay, we conducted a feasibility study on the development of sewerage systems, comparing different sewerage schemes and reviewing different sewage treatment technologies. A Water Treatment Sludge Management Scheme for Manila was developed to determine proper means of treatment, disposal or potential reuse of the sludge with due consideration to the economics, environmental compliance and beneficial applications.

Another example of a WSUD project by Arcadis is the 120 hectare residential sustainable development and town center of the New Rouse Hill. Arcadis realized the integration of urban planning and water cycle management, and extensive reuse of materials on-site in line with sustainability goals. In Sydney’s waterfront Darling Harbor, Arcadis prepared a water WSUD for the transformation of the iconic International Convention Center and the new city neighborhood Darling Square. The WSUD strategy included green roofs, rainwater tanks, bioretention and rain gardens, tree pits, filtration systems and pollutant traps, resulting in a 6 Star Green Star Community rating, the highest sustainability rating in Australia.
We have people and offices around the world. Our global network enables us to bring our knowledge and experience of projects worldwide and apply that expertise to specific local needs and situations. We are based in:

**WHERE WE ARE IN THE WORLD**

Australia  |  Bahrain  |  Belgium  |  Brazil  |  Brunei  |  Canada  |  Chile  |  China  |  Czech Republic  |  Dubai  |  France  |  Germany  |  Hong Kong  |  India  |  Indonesia  |  Italy  |  Kazakhstan  |  Korea  |  Macau  |  Malaysia  |  Mexico  |  Mozambique  |  Netherlands  |  Oman  |  Peru  |  Philippines  |  Poland  |  Qatar  |  Romania  |  Russia  |  Saudi Arabia  |  Serbia  |  Singapore  |  Slovakia  |  Spain  |  Switzerland  |  Taiwan  |  Thailand  |  Turkey  |  United Arab Emirates  |  United Kingdom  |  United States  |  Vietnam  

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Arcadis is the leading global natural and built asset design and consultancy firm and provides services in infrastructure, water, environment and buildings. We deliver services throughout the entire value chain - from strategic advice, project management, planning, design and implementation, to maintenance and total lifecycle operation. For over 125 years, we have worked in partnership with clients around the world to deliver exceptional and sustainable outcomes.

Our reputation is built on a deep understanding of client needs, combined with our knowledge and experience worldwide. With 27,000 people and €3.4 billion in revenues, we have built an international network that enables us to serve our local clients on a global basis. Arcadis works in over 70 countries worldwide and maintains its own city network, connecting colleagues as well as city clients, called the Big Urban Client (BUC) program. The BUC program seeks to help large urban clients become more competitive and livable by providing sustainable urban solutions for challenges in transportation, environment, water supply, urban planning and building design.

Through our Shelter program, Arcadis and UN-Habitat, the United Nations agency for human settlements, have partnered since 2010 with a common goal: to improve the quality of life in rapidly growing cities around the world. We commit our employees, our expertise and skills to help bring the UN-Habitat mission to fruition.

Arcadis is a platform partner to 100 Resilient Cities initiative, pioneered by the Rockefeller Foundation. Arcadis is committed to help cities around the world to navigate towards a more resilient future through supporting the transition from their resilience strategy to implementation.
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