CITY + WATER

An international showcase of innovative urban stormwater management and flood mitigation

Prepared by:

SHOAL CREEK CONSERVANCY

CITY + WATER: An international showcase of innovative stormwater management and flood mitigation.

Shoal Creek Conservancy
Shoal Creek Conservancy is a 501(c)(3) nonprofit organization dedicated to the improvement of Shoal Creek for all Austinites – present and future.

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The Shoal Creek Conservancy would like to acknowledge all the architects, engineers, designers and contributors involved with these inspiring projects. Imagery and media credit for each of the Innovations is provided on the individual Innovation page.

Cover: The eighteen 'Supertrees' of Singapore's Gardens By The Bay are at once vertical gardens, solar power generators and stormwater management features, harvesting rainwater for irrigation and use in architectural fountains. (© Erix2005 | Dreamstime.com)

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Image: Sand Hill Property Company's proposal for the world's largest green roof in California includes trails, orchards and vineyards. (© Sand Hill Property Company)

FOREWORD

Can Shoal Creek be the *World's Best Watershed*?

Officially, there is no such award. There's no glitzy ceremony or gilded statue to collect. In fact, watersheds are difficult to compare at all, each a unique unit of space defined by topography and possessing particular character. But great urban watersheds exist. Like great cities and great neighborhoods, you know when you are in one.

And Shoal Creek can be one.

In early 2017, the City of Austin and their consultant team embark on a $900,000 study, seeking solutions to Shoal Creek's myriad of flooding challenges. These solutions have the power to infuse significant capital into our watershed's health; redefine how it looks, feels and functions; and springboard to other advancements with trails, public space and historical preservation. This is a great opportunity for our community. The Shoal Creek of the future takes shape with the discussions we start today.

We Are Shoal Creek

Watersheds encompass all natural and constructed elements which drain to a single point. (Upend a glass of water anywhere in Shoal Creek's watershed and, in simple terms, that water will drain to the mouth of the creek at Lady Bird Lake.) What elevates an urban watershed like ours into the discussion of "world's best" may be how well natural and constructed elements are allowed – or designed – to comingle.

Can each flourish without negatively impacting the other? Can a city's river top its banks without its citizens missing a step?

Show me a healthy urban creek and I'll show you a healthy community.

Living With Water

Staring down rapid urbanization and the effects of climate change, cities around the world are now racing to "resiliency." Flood resiliency – the ability to adapt to or bounce back from extreme events – is being achieved in numerous ways. Some municipalities choose to build mega infrastructure to hold back or divert flood waters, others are trying to return heavily developed watersheds to more natural states, while others still build amphibious cities and let the flood waters in. The Shoal Creek Conservancy created *City + Water* to showcase innovations in these methods and to inform our resiliency discussions.

A Showcase of Innovations

Every watershed is different and every community unique. Their solutions will not be ours, but as we come together in the next months to examine the challenges of

living with water, we hope inspiration for our Austin-made solution is found somewhere in the discussions these innovations spark.

In 1991, the US Army Corps of Engineers released a report detailing potential solutions for Shoal Creek's flooding, including most notably the Shoal Creek Tunnel. Many of the solutions in that report will continue to be discussed. *City + Water* aims to broaden the spectrum of consideration by spotlighting recent innovations in stormwater management and flood mitigation which have been developed across the country and around the world. Including case studies in this showcase does not warrant their viability for the Shoal Creek watershed, nor does it suggest these are the only solutions available. The creativity of the Shoal Creek solution is limited only by the creativity of the Shoal Creek community.

Including 10 case studies here is just a start; more will be added as our discourse develops.

Shoal Creek of the Future

What does the Shoal Creek of the future look like to you? We want to know! But even more important than the manifestation of our collective *World's Best* vision is the act of striving for one together.

The *World's Best Watershed* is a grand vision for Shoal Creek. Soon, I hope, it will be our bold statement.

Joanna Wolaver
Executive Director
Shoal Creek Conservancy

COMING SOON

Shoal Creek Flood Mitigation Study
2017-2018

This City of Austin-led study will assess various approaches to flood mitigation; how well they may work at reducing flooding; implicit challenges with their implementation; and cost. The first public meeting as part of the study is scheduled for March 9, 2017.

http://www.austintexas.gov/shoalcreekfloods/

Shoal Creek Watershed Action Plan
2017-2019

The Shoal Creek Conservancy leads a public-private coalition seeking to create a community-driven plan which restores, providing a path to a resilient, healthy and safe watercourse. The plan will build on findings from the City's *Flood Mitigation Study* and also address water quality, erosion, habitat and spring flow challenges. It will be the first watershed-specific plan in the City of Austin and serve as a model for urban watershed restoration.

www.shoalcreekconservancy.org/water/

Watershed Stakeholder Group

Join our *Watershed Stakeholder Group* email list and be the first to find out about opportunities to learn, get involved and have your say on the future of Shoal Creek.

www.shoalcreekconservancy.org/water/

Photo: New York City's Dryline proposal includes a "reverse aquarium" which helps redefine the city's relationship with water. (© Bjarke Ingels Group)

INTRODUCTION

(Re)Defining Austin's relationship with water.

On the south side of Cesar Chavez Street, in the morning shadow of the Buford Tower and steps west of Congress Avenue, stands a squat, stone obelisk, weathered grey by years of exposure. Its simple inscription, split by an unadorned arrow, reads, "Flood 1869 Elev 466.38"; the marker's austerity betraying the import of the event it was erected to commemorate.

Some believe the flood of 1869 was Austin's worst. Standing here 147 years ago on July 7th – at 9 p.m. to be precise – Frank Brown, a city and Travis County official for much of the 19th century, would have been knee-deep in the Colorado River, its peak flood waters rising over 40 feet to breach the floodplain banks.

> **"Early in the first week of July, rain commenced falling and so continued at short intervals for several days. The (river) commenced gradually rising, but no apprehension was felt of the heavy overflow. On the 6th, a tremendous flood suddenly came down in solid walls, overflowing all the lowlands and spreading over the valleys to the hills. The river rose to the bluffs. The people thought the highest was reached, but the water continued to rise rapidly, and much alarm was felt. . . The rise was estimated at forty-six ft. The mass of waters rushed down from the narrow and confined channel between the mountains above, to the wider one below, with such fearful velocity that the middle of the stream was higher than the sides, and the aspect it presented was appalling.**
>
> - Frank Brown

Early Austinites long battled the scale and surprise of Colorado River flooding. Situated in Central Texas' infamous "Flash Flood Alley" – a crescent of steep slopes and shallow soils buffering Hill Country, and reaching from San Antonio to Dallas – the river escaping its banks was common occurrence. In his *Annals of Travis County and of the City of Austin*, Brown notes significant events in 1833, 1836, 1843, 1852 and 1870, but none compared to the flood of 1869. "(They) did not approach it in volume within 8 or 10 feet," he writes.

Austin's relationship with water has been difficult. Flooding here, as everywhere, is a process as old as the Earth, a process which in the natural context possesses a certain beauty, regenerative quality and purpose. But in the human context, flooding has been nothing short of devastating. When life and property are consumed by it, flooding assumes that menacing persona with which most are familiar. It's Mother Nature at her worst.

Efforts to control Mother Nature were, in part, successful. Decades after Brown's death in 1913, the Colorado River would be tamed, relief provided by Roosevelt's New Deal and construction of the Highland Lakes dams it funded. The six dams in the network, and specifically the Mansfield Dam, collect and store upstream runoff, allowing managers to release it at rates which downstream landscapes can accommodate. But in urban areas where mega control projects weren't possible and development pressured tributary creeks like Shoal Creek, Waller Creek and Onion Creek, flooding continued.

In fact, this history and perception of water has influenced the way Austin was built. Like most American cities which grew up in the twentieth century, booming in decades following WWII, suburban sprawl pushed out the city's boundaries with infrastructure constructed to whisk stormwater away, to hide it, to get rid of it. Shoal Creek, and watercourses like it, became nothing more

Image: The vision for Copenhagen's Tåsinge Plads includes converting tarmac to absorbent park.(© Tredje Natur)

than a conveyance channel. Stormwater was a waste product, and floodwater – any runoff which could not be conveyed by the infrastructure – a danger.

The Effects of Climate Change

But climate change is changing everything. As extreme storms and drought become more frequent and more intense, cities are looking to redefine their relationship with water in a time when much of the twentieth century infrastructure is up for renewal. The twenty-first century reality is stormwater in urban spaces can have immense value.

World–class cities are defined by how they interact with water. In his 2014 book, *Blue Mind*, Wallace Nichols investigates the neuroscience behind human interactions with water. As it turns out, for evolutionary and biological reasons, we as a species are happier, healthier and more productive around water. When we connect with water we connect with each other. Water drives community.

Looking to delicately balance resilient flooding solutions with cultural opportunities, cities are contemplating what the watershed of the future looks like. *City + Water* examines case studies from around the world demonstrating innovative approaches to stormwater management and flood mitigation.

Some cities are choosing to remain on the historic path of building mega infrastructure to store or divert stormwater. Other cities are reversing development in an attempt to return watersheds to more natural states. Other cities still are building amphibiously and letting the flood waters in. The approaches these case studies highlight, from Japan to Denmark and locations in between, are as distinct as the cities themselves.

The methodologies to reducing the costs of flooding, building urban water resilience and creating water-related value are many. As Austin and the Shoal Creek community consider how best to achieve these goals within the Shoal Creek watershed, these international examples can provide inspiration. Presentation of these case

studies in this showcase does not warrant their direct applicability in the Shoal Creek context, but the lessons learned and discussions sparked will be valuable as an Austin-made solution is developed.

A Past, Present and Future with Water

On West Cesar Chavez Street, the Buford Tower's dedication plaque reads: "In memory of Captain James L. Buford." Built in 1930 as a training facility for firefighters, the tower was restored in the 1970s and dedicated in honor of Buford who died in 1972 attempting to save a boy from drowning in a swollen Shoal Creek. Memories like these, and of the 1869 flood, the twin Memorial Day floods and others won't – and shouldn't – fade. Water has played and continues to play such an important role in the history of Austin.

When Edwin Waller surveyed the original 640-acre city in 1839, he laid out his plan fronting the Colorado River and bounded by two creeks – Shoal Creek and Waller Creek, forever tying Austin's course to its

relationship with water. Austin came to be because of that relationship, and celebrates it today in our most valued places, while swimming in Barton Springs or Deep Eddy, boating in Lady Bird Lake or enjoying the escape of a hike along Shoal Creek.

With the future of Shoal Creek in the balance of discussions today, a watershed can be designed which honors the past and celebrates the future, a watershed with reduced flood risk and restored health – a watershed all Austinites can enjoy.

How to Reduce the Costs of Flooding

Austin's 1981 Memorial Day flood is reported to have caused $35.5 million in damages. In Travis County, more than $80 million in damages to public property alone were estimated as a result of flooding on Memorial Day in 2015.

Reducing the costs of flooding can be accomplished in many ways. These can include:

Protect People & Property

» Remove people and property from the floodplain
» Improve flood forecasting
» Improve flood warning
» Improve flood response
» Improve structural floodproofing
» Improve neighborhood floodproofing

Reduce Flooding

» Reverse climate change
» Optimize runoff conveyance
» Reduce runoff quantity
» Increase runoff storage
» Optimize subwatershed runoff timing

Many of these methods are presented in the following innovation case studies.

Image-Left: Rabalder Parken doubles as a stormwater management feature and skatepark.
(© Soren Nordal Enevoldsen)
image-Right: The main chamber of Las Vegas' Poreform includes a floating stage for cultural performances.
(© Water Pore Partnership)

WATERPLEIN BENTHEMPLEIN

Rotterdam's 'Water Square' breathes new life into old public space.

Image: The Waterplein Benthemplein has been painted in shades of blue to loosely represent the isobars on a weather map and relate where areas will be flooded. (© De Urbanisten)

Rotterdam sits exactly zero feet above sea level.

It's no wonder flooding is such a significant concern in the Netherlands' second largest city. Not only is there an ocean-side threat with rising sea levels due to climate change, but inland rain is hard to drain as well. As such, Rotterdammers are persistently on the hunt for any urban space they can turn into stormwater storage. One of their latest projects, the Waterplein Benthemplein, happens to be one of their most innovative and was the world's first full-scale 'water square.'

The Waterplein is a series of three multipurpose concrete basins which provide stormwater attenuation during rainfall events and public amenity – especially for youth – during dry periods. Interspersed with self-irrigated native plants and "green infrastructure" elements, the basins have made better use of what was an under utilized and dreary 2.3-acre, WWII-era public space, creating opportunities for sport, art and even religious ceremony.

When dry – which is most of the time – the largest and deepest of the three basins is a court for basketball, volleyball or soccer; the medium-sized basin provides a landscape

for skateboarders to enjoy; and the third basin is an amphitheater with a tiered stage as its focus. An open air baptistery is also nestled near a 19th-century church at the edge of the square for parishioners to use with water trickling back into the basins.

When storms arrive, rainwater from adjacent building roofs and the impervious square is directed into the two smaller and more shallow basins through stainless steel gutters (which have been sturdily constructed to accommodate skateboarders when not full). In extreme weather, rain enters the biggest basin through two creative inlets: a Water Wall and Water Well, which gush influent into the space in a fun and whimsical manner.

The first runoff from storm events, especially following prolonged periods of dry weather, tends to be dirtier as it entrains particulate matter, oils and other debris which collect on the surfaces. This "first flush" flow from the Waterplein's contributing catchment is pumped directly into the sewer system for treatment, while the cleaner secondary runoff is directed to the basins for storage and infiltration or until the downstream canals have capacity to take it. Under design storm conditions, the basins would retain water for 36 hours while providing 450,000 gallons of storage – roughly two thirds the volume of an Olympic swimming pool.

Like the Shoal Creek watershed, Rotterdam is densely populated and largely impervious. In both locations, there is a struggle to find opportunities to implement stormwater management controls. Whereas at one point the Dutch focus went underground, it has resurfaced with projects like the Waterplein Benthemplein because they have determined the approach is a better investment into residents' quality of life. In a 2014 interview with Fast Company, Waterplein's lead designer, Florian Boer of De Urbanisten, suggested money solely spent underground to solve the occasional problem of flooding could find better use: "For the same amount of money, we can not only solve a problem but create an opportunity."

Critical Thinking

Where in the Shoal Creek watershed can we tackle flooding while creating opportunities to improve our community?

Project Details

» Location:
Rotterdam, The Netherlands

» Design Lead:
De Urbanisten

» Awards:
2013 Dutch Water Board Prize

» Mitigation Type:
Runoff Storage

» Status:
Constructed 2013

» Cost:
$4.7 million

Learn More

» Story:
Fast Company: "This Sports Field Also Helps Save The City From Flooding"

» Photos/Video:
SCC Digital Showcase

POREFORM

Rapid collection systems a solution to flash flooding.

Image: The Poreform “skin” capping the main tank reduces evaporation of collected runoff. (© Water Pore Partnership)

For a time, Amy Mielke and Caitlin Taylor lived in Las Vegas’ municipal office. Poring over flood records and historic maps, Mielke told Metropolis Magazine in 2015, they sought to understand the downtown district’s raw dichotomy with water – a world away from Bellagio’s fountains or The Venetian canals on the glamorous Strip.

Water scarcity and flash flooding were new challenges to tackle for these two New York City architects who, at the time, were only one year removed from graduate school. “I didn’t know the first thing about (them),” said Mielke. “I’m pretty sure I Googled ‘water issues Las Vegas.’” But the partners wanted to demonstrate the civic and cultural importance of infrastructure, and their thoughtful approach in Las Vegas yielded a surprising solution – and international acclaim.

Poreform, Mielke and Taylor’s take on permeable paving, is a concrete surface capable of rapid and large-scale water absorption. Coupling Poreform with a network of 10 underground tanks, they calculated, could provide an additional 75,000 megaliters (19.8 trillion gallons, or 30,000 Olympic swimming pools) of flood storage. Las Vegas’ downtown area has 72% impervious cover and little surface capacity

to store flood water. The Poreform proposal showed how runoff from large storms could be absorbed and retained for future use, solving scarcity and flooding challenges simultaneously.

The concrete Poreform, or what Mielke and Taylor call the "skin," is formed in place using a poly-blend fabric framework. The cobblestone-like final product allows water to drain through interstitial spaces, or pores, and can be customized for a variety of scales and sites, including as sidewalks, curb drains, foundations or storage basin caps. The tank network includes nine satellite basins all connected to the municipal storm sewer and a central 3.6 million-cubic-foot main tank, 75 feet wide, 100 feet tall and 480 feet long.

A significant advantage of Poreform is its retrofit application. For most of the 20th century, cities have viewed stormwater not as a resource, but as a liability or waste product to be quickly expelled. Infrastructure grew up to service this mentality. Now, for cities in arid climates which suffer from water scarcity issues, flash flooding is a cruel and dangerous irony because most cities are not equipped to safely retain the water and use the momentary bounty for future water supply purposes. Rapid collection and storage strategies like Poreform can change this dynamic.

Mielke and Taylor believe Poreform can also improve the public realm and help revitalize the downtown. Poreform's concrete skin can be applied artistically to create unique gathering places and the largest of the tanks doubles as performing arts space during rain-free periods, replete with a floating stage to maximize use even when water is being stored.

In 2014, Poreform won the LafargeHolcim Foundation's $100,000 North American Gold Award ahead of New York City's renowned Dryline project. In acceptance of the award, Mielke said: "As architects, we typically think of infrastructure as being in service to us. Instead we're trying to explore how these types of systems can benefit from an architectural way of thinking." Mielke and Taylor are using the prize to further materials testing and advance the development of water-permeable concrete structures.

Critical Thinking

Where in the Shoal Creek watershed can we tackle flooding while creating opportunities to improve our community?

Project Details

» Location:
Las Vegas, Nevada

» Design Lead:
Water Pore Partnership

» Awards:
2014 Holcim Gold Award - North America
2015 Holcim Global Award - Finalist

» Mitigation Type:
Runoff Storage

» Status:
Proof of Concept

Learn More

» Story:
Metropolis Magazine: "Game Changers 2015: Water Pore Partnership"

» Photos/Video:
SCC Digital Showcase

HILLS AT VALLCO

Looking up for stormwater management solutions.

Image: Proponents of Vallco's 'world largest green roof' suggest the roof is not unusually heavy, in line with some projects which use concrete. (© Sand Hill Property Co.)

In Cupertino, California, in the shadow of the world's leading technology companies, there exists a stark juxtaposition. On one side of the road, the steel and glass cathedral that is the Apple Campus, on the other, 1.2 million square feet of the outmoded Vallco Shopping Mall awaiting demolition. Both Apple and Vallco launched in 1976. Apple built computers quietly in Steve Jobs' garage four miles down the road, and Vallco opened its doors to fanfare during America's indoor retail boom. But trends change. Now, as with everything in Silicon Valley, the Vallco Shopping Mall is looking to reinvent itself (in local vernacular, pivot) with a world-renowned result.

With the 58-acre Vallco site, owners Sand Hill Property Company hoped to create a new town square for Cupertino and, following a 2014 design competition, hired `starchitect' Rafael Viñoly to bring that vision to bear. Viñoly's design called for 16 mixed-use, LEED Platinum buildings. These would include over 2 million square feet of office space, 800 residential units, parking for over 9,000 vehicles and 625,000 square feet of commercial, retail and civic space. In true Silicon Valley spirit, a 10,000-square-foot high school innovation center designed to "incubate" student-led projects and businesses was also integrated. Topping off the plan was the world's largest green roof.

At 30 acres, it would also be Cupertino's largest park.

Viñoly saw the roof as an opportunity to bring to the city the nature and culture from the surrounding hills of the Santa Clara Valley. The roof design includes 3.8 miles of trails, 1,282 new trees, demonstration vineyards, sloping orchards, an organic farm and a wide array of public space. The Vallco Shopping Mall was to be remade as The Hills of Vallco – with actual hills.

The landscape plan focused on native, drought-tolerant plants which largely wouldn't require irrigation. In areas needing help, landscape architects planned to quench the demand through aggressive site-wide rainwater harvesting also designed to minimize runoff. In a 2016 interview with The Mercury News, Laurie Olin, chief landscape architect for the project, describes the drive to 'catch every raindrop': "Catch it, keep it, use it, keep it clean," she said.

This site management philosophy can provide critical relief in watersheds with flooding issues while positioning the roof as an important stormwater management tool. Retrofit or new-build green roofs increase evapotranspiration of water through plants and slow down the rate of runoff. "Blue" roofs, which are also gaining popularity in North America, store stormwater like a traditional yet elevated pond with controlled release to downstream natural or sewer systems. With enough distribution, Olin's philosophy and roofs can help mitigate downstream flood elevations.

However, some in the community believe The Hills at Vallco is a "fantasy." Indeed, it remains an ambitious yet still two-dimensional concept on hold after a November ballot measure vote. But the proposal highlights the importance of utilizing every corner of a compact urban environment. In a space-starved watershed searching for stormwater management opportunities, looking up can yield significant results.

Viñoly and Olin's vision for the world's largest green roof – a park built atop a small town – may not immediately come to be, but

Critical Thinking

Can flat roofs in the Shoal Creek watershed be used to store stormwater and help reduce peak runoff rates?

Silicon Valley seems like a natural place to push the boundaries of technology – even green technology.

Project Details

» Location:
Cupertino, California

» Design Leads:
Rafael Viñoly Architects
OLIN Landscape Architects

Mitigation Type:
Reduce Runoff

» Status:
Concept design

Learn More

» Story:
Mercury News: "Hills at Vallco: Cupertino preview gives details of green roof"

» Photos/Video:
SCC Digital Showcase

SUPERTREE GROVE

Blurring the lines between art and infrastructure.

Photo: Stroll through the Grove's canopy on an elevated skyway and dine at a bistro atop the tallest of the Supertrees for a commanding view of the gardens below and adjacent Marina Reservoir.(© Grant Associates)

In 2006, Andrew Grant won a design competition worth $750 million. His UK-based landscape architecture firm, Grant Associates, and a collaborative team of engineers, architects, planners and designers, had pitched Singapore's National Parks Board on a beyond-futuristic vision for the 130-acre Bay South portion of the their Gardens By The Bay project. Included were the world's largest columnless greenhouse, a Flower Dome and Cloudforest and 18 Supertrees which would become an iconic part of the city-state's new downtown skyline.

Ranging from eight to 16 storeys tall, the Supertrees are at once vertical gardens, solar power generators and stormwater management features, harvesting rainwater for irrigation and use in architectural fountains. Grant's inspiration for Bay South Garden was Singapore's national flower: the orchid; his inspiration for the Supertrees were trees themselves. Where natural trees convert sunlight to energy through photosynthesis, absorb water, improve air quality and moderate temperature, so too do the Supertrees.

Each Supertree has a hollow concrete core to provide ventilation for the Flower Dome and Cloudforest below. Over 160,000 native

and exotic plants, including ferns, vines, orchids and bromeliads, hang in planting panels from a steel frame. The frame clads the concrete core. The Supertrees' canopies sit like up-turned umbrellas and capture sunlight through photovoltaic cells and rainwater, the latter directed to and stored in the water tower-like core. By day, the Supertree Grove is an exaltation of South East Asia's tropical beauty; by night it turns simply magical with colorful light displays and a "Garden Rhapsody" which plays softly throughout.

Gardens By The Bay (including Grant's vision of Bay South Garden) opened to the public in 2012 with cost estimates ranging between $750 million to more than $1 billion. But with a calendar full of festivals, concerts, movie screenings, sports and community events, educational workshops and school programmes, the Gardens have become a local nexus and global attraction, to date drawing more than 25 million people.

Supertrees and similar rainwater harvesters would not typically be used to directly mitigate the impacts of flooding (i.e., floodwater would not be directed to them as a form of control), but the underlying principles of harvesting, reuse and infiltration can be critical elements of stormwater management in a healthy watershed. Employed with great distribution, they can significantly reduce the urban overland runoff which contributes to flooding. The Supertrees simply underscore how artistically this can all be accomplished.

"The (design) brief at some levels was very simple," Grant said in a 2012 interview. The National Parks Board, he noted, wanted to create the most amazing tropical gardens in the world and Singapore's best outdoor recreation space. Grant's team added cutting-edge environmental technologies and contemporary thinking about how to manage natural resources. "On a plate," Grant said, "this is what Singapore is all about."

Critical Thinking

Can Austin's rainwater harvesting incentive program be improved to have a meaningful impact on flooding in Shoal Creek?

Project Details

» Location:
Singapore

» Design Lead:
Grant Associates

» Awards for Gardens By The Bay:
2013 Royal Institute of British Architects Award
2013 President's Design Award
2013 International Architecture Award
2013 Landscape Institute Award
2013 Skyrise Greenery Award
2012 Design For Asia Award
More

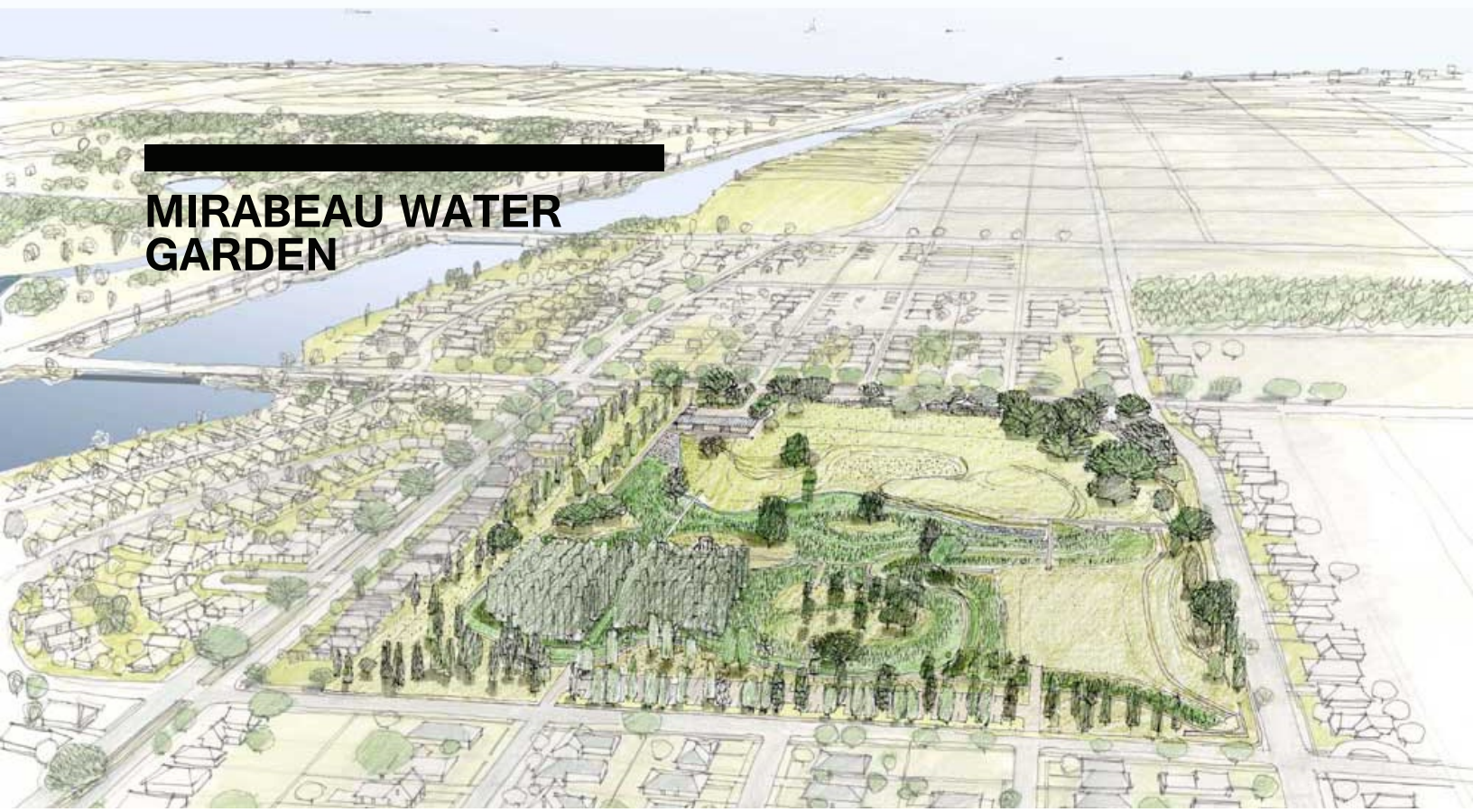
» Mitigation Type:
Reduce Runoff

» Status:
Completed 2012

Learn More

» Story:
BBC: "Singapore's 'supertrees' spark green thoughts"

» Photos/Video:
SCC Digital Showcase



MIRABEAU WATER GARDEN

How 'wet' parks can provide multi-level benefits.

Image: Vacant lots are being used for stormwater management in the Gentilly Resilience District, but the 25-acre Mirabeau Water Garden allows for neighborhood-scale control. (© Waggonner & Ball Architects)

Building a water garden in America's city most susceptible to flooding might seem cheeky, but for David Waggonner and the residents of New Orleans' Gentilly neighborhood, it wasn't only logical – it was inspired. In 2010, Waggonner and a team of architects, engineers and designers were commissioned to create the new Greater New Orleans Urban Water Plan. It turned out to be a philosophical about-face in the city's approach to water management, and Mirabeau Water Garden is playing a central part.

For over 300 years, New Orleanians have lived with water unlike any other community on the continent – often at its mercy. Water management for both rainwater leaving the city or Gulf water entering it was a complicated system of pumping and levees in an attempt to keep basements and feet dry when some would argue they had no natural right to be. As with The Netherlands, much of New Orleans sits one to two feet below sea level. Unlike The Netherlands, New Orleans receives a hurricane once every 2.8 years.

Waggonner's plan: let water in and live with it instead of building against it. His vision, drawing on an earlier collaboration with the Dutch, was to transform New Orleans with

a series of functional yet attractive canals and absorbent parks. By retaining rainfall in place inside the levees, Waggonner hoped to slow down runoff making it inherently easier to store and manage. In the process, flooding would be reduced. Allowing for a wet landscape would also help the city battle subsidence, a problem caused by the pumping out of every drop of water – from the sky or ground – as it appeared. The implementation challenge for Waggonner was finding enough land to make the plan work, a challenge which had him scouring aerial photos for any sliver he could transform. The 25-acres which will become the Mirabeau Water Garden was a gift in every sense of the word.

As the jewel of the plan in the Gentilly Resilience District, the Garden design includes a mix of sports fields, wetlands, green spaces and trails. Before its reinvention, the property was a vacant lot home only to a building previously destroyed by a lightning fire. Unused since 2007, the owners, The Nuns of The Congregation of St. Joseph, offered Waggonner the land. Their lease terms? One dollar per year for 99 years.

"After Hurricane Katrina, we were keeping a vigil waiting for a vision on how we could best use the property to fulfill our mission and benefit the people of New Orleans," Sister Pat Bergen said in a 2016 interview with The Lens. "Then an architect came to us with his plan for the Mirabeau Water Garden, and we knew right away it was the vision we had been praying for."

The land was situated in prime location to provide stormwater management for the entire Gentilly neighborhood. Engineers estimate the wetland terraces proposed for the Garden could remove up to 9.5 million gallons of runoff after heavy rainfall and eliminate neighborhood flooding during the 10-year storm. Flooding during the 100-year storm would also be reduced by 72%. Of course, when dry, the garden returns to being a centerpiece public amenity.

New Orleans' new Urban Water Plan has been a revelation. However contrary to centuries of history, embracing stormwater in this water-logged city could be the key to a successful, natural coexistence between residents and the water they used to fear.

Waggonner's team received a $12 million FEMA grant to tackle the Garden's initial design. The grant and design, in turn, helped the city win $141 million in funding from the U.S. Department of Housing and Urban Development as part of the National Disaster Resilience Competition.

Critical Thinking

What are the pros and cons of converting green space in the Shoal Creek watershed to 'wet' parks?

Project Details

» Location:
New Orleans, Louisiana

» Design Lead:
Waggonner & Ball Architects

» Mitigation Type:
Runoff Storage; Reduce Runoff

» Status:
Concept Design

Learn More

» Story:
Pacific Standard Magazine: "Changing Tides: How the Mirabeau Water Garden could shift the way New Orleanians think about water"

The Lens: "A Water Expert`s Vision Was Sign From God Nuns Were Looking For"

» Photos:
SCC Digital Showcase

RABALDER PARKEN

A place where water collects and people gather.

Photo: When built in 2012, Rabalder Parken was the world's largest outdoor skateboard facility. (© Søren Nordal Enevoldsen)

Stormwater management features rarely have their own Facebook page, but invite a skateboard enthusiast to design a drainage project and you might end up with one. That's what happened when Søren Nordal Enevoldsen – also an architect – brought his signature fascination with play and movement to a traditional sewage project in Roskilde, Denmark, 20 miles west of the nation's capital.

Getting his first board in 1988, Enevoldsen has almost 30 years of riding experience and is well known in the Copenhagen skate community. His Shredders Lodge profile suggests a love of "street" and preference for skating in the city's Red Plaza. The movement of skating found its way into Enevoldsen's practice too, as he has been designing skate shops, skate parks, and playful urban spaces since 2006. When invited to design the project for the local municipality in Roskilde, it felt like a natural extension. Designing for water and designing for skating, he would tell WIRED magazine in 2013, both require consideration for flow and fluid movement. He welcomed the challenge.

The project was earmarked originally as a simple drainage initiative as part of Roskilde's climate change adaptation.

The site was located at the center of a major development, MUSICON, which was converting a 62-acre concrete factory into an economic and cultural hub complete with residential areas, museums, studios, commercial spaces and schools. Traditional grey infrastructure – underground sewers and a storage pond – would have sufficed, but, in the spirit of the area's redevelopment, the municipality and Enevoldsen believed the project could offer a unique focal point and better return for the community on project funds.

Enevoldsen's creation, Rabalder Parken, a 2.75-acre stormwater management feature and skatepark, was the first combined facility of its kind in the world. When wet, runoff is collected from the surrounding area via 1,500 feet of 30-foot-wide asphalt or concrete swales. Three cascading concrete basins provide the storage equivalent of 10 Olympic-sized swimming pools and fill completely during the 10-year storm.

When dry, water is replaced by skateboarders, rollerbladers and BMXers, as all corners of the facility were designed with dimensions and surfaces to accommodate wheeled exploration. The basins drain quickly after rain and sweepers remove debris from the basins when needed to maximize use. When built in 2012, Rabalder Parken was the world's largest outdoor skating facility.

The Dane's world-leading quest for climate change resiliency was accelerated in large part by an early-July storm in 2011 which inundated much of the country. Copenhagen received six inches of rainfall in three hours causing widespread flooding and a reported one billion dollars in damages. Rabalder Parken was one of the first projects to result from a mindset influenced by this storm. It shows climate change adaptation and a move to 'life with water' can be done in a multi-functional way, improving not only environmental resilience but also aesthetic, recreational and cultural opportunities. At last count, Rabalder Parken has 1,593 Likes on Facebook, but whether they are for the quality of skating or the innovative stormwater management is not clear.

Critical Thinking

Can more funding for flood mitigation projects be secured if they provide multi-functional benefits?

Project Details

» Location:
Roskilde, Denmark

» Design Lead:
Nordarch

» Awards:
2013 INDEX Award - Finalist
2013 Danish Town Planning Prize

» Mitigation Type:
Runoff Storage

» Status:
Constructed 2012

Learn More

» Story:
WIRED: "Ingenious Architecture: A skatepark that prevents flooding"

Gizmodo: "This Submersible Skatepark is Drainage in Disguise"

» Photos/Video:
SCC Digital Showcase

THE DRYLINE

Reinventing the flood wall to include public space.

Image: The Dryline, also known as the BIG U, will protect Lower Manhattan's $500 billion business district from flooding. (© Bjarke Ingels Group)

Hurricane Sandy was a uniquely powerful storm. It transformed into a 'superstorm' because of a number of conditions in rare combination. For example, high winds and the phase of the moon reportedly caused the water level at The Battery in Lower Manhattan to reach a record height, 13.9 feet above the average low tide elevation. On October 29, 2012, the storm flooded much of the lower island, caused New York City $19 billion in damages, and ranked as the second costliest hurricane in American history behind only Hurricane Katrina.

Manhattan flooded simply because its flood protection was inconsistent and, ultimately, too short. As part of the U.S. Department of Housing and Urban Development's Rebuild By Design competition eight months after Sandy, Denmark's Bjarke Ingels' proposed an equally simple solution: fill in the gaps and build up the flood protection with impervious public amenity. In effect, Ingels was creating a bow of public space on the leading edge of Manhattan to crash through the surge of future storms. Ingels' solution won the competition and New York's BIG U is now moving past concept and into reality.

Officially proposed as the BIG U but commonly known as the Dryline (a

nickname sampling the same excitement and intrigue as namesake public space projects, the Highline and the Lowline), Ingels and his team designed a 13-mile flood protection system which wraps around the lower end of Manhattan from West 57th Street to East 42nd Street. His innovation is sewing the system together as a fabric of public space based on the needs of each adjacent community, something his team learned through an extensive process of public consultation.

In the East River Park neighborhood, the flood "wall" is barely noticeable as grade gradually increases from river to inland maximum height in an intertwined network of parkland and bike paths. On the west side, colorful floodgates flip down from below the elevated FDR Drive to protect dry-time markets and programmed space. In various locations along its length, seating, stairs, terraced benches, skateboard ramps, elevated walking platforms, berms and planter boxes can all be found linking together to provide flood protection. Ingels described the Dryline to the Guardian in a 2014 interview as "an uncompromising seawall that also wants to give you a hug."

In a unique twist speaking to the change in city-water relations Ingels' team wants to affect, renovation of an existing Coast Guard building is proposed, converting the space into a new maritime museum and environmental education center set partially below sea level. In the "reverse aquarium," visitors will be able to view passing wildlife or observe rising water levels against graduated markings during storms events.

The simplicity of the Dryline belies its importance. Flooding in Lower Manhattan would affect 220,000 people, and the Battery Park measures alone protect $1.9 billion in property. With a $500-billion business center towering just beyond the Dryline's border, incapacity here due to flooding could cost the world economy billions of dollars by the day.

Through the Rebuild By Design competition, New York City was awarded $335 million to initiate Phase 1 of the project. This phase includes the East Side Coastal Resiliency and Lower Manhattan Coastal Resiliency projects which span between the East River Park and The Battery. Funding contributions from HUD ($511 million) and the city ($305 million) mean over three quarters of the expected $1-billion project can be completed.

Critical Thinking

Can the development of the Shoal Creek Trail attractively improve neighborhood floodproofing?

Project Details

» Location:
New York, New York

» Design Lead:
Bjarke Ingels Group (BIG)

» Awards:
2014 Rebuild By Design Competition
2014 Holcim Silver Award - North America
2015 Holcim Global Award - Bronze

» Mitigation Type:
Neighborhood Floodproofing

» Status:
Under Construction (2017)

Learn More

» Story:
The Guardian: "Bjarke Ingels on the Dryline"

» Photos/Video:
SCC Digital Showcase

G-CANS

Tokyo sends the 200-year storm underground.

Photo: At 581 feet long, 256 feet wide and 82 feet tall, the main storage tank of G-Cans is known as “The Temple.” (© Dddecco | Flickr)

The entrance to the world’s biggest sewer is through a single metal door in a squat, nondescript concrete bunker. Tours are available in Japanese only (bring an English translator if you like) but once on the floor of the system’s main storage tank, 165 feet underground, words are irrelevant.

Tokyo has always been a flood-challenged city. With over development criss-crossed by many rivers and tributaries, a dense population and often-violent rainy season, parts of the world’s largest city have found itself routinely underwater. In 1991, Typhoon Mireille became Tokyo’s costliest storm, flooding 30,000 homes and killing 52 people.

In response, the Japanese government started construction on Shutoken Gaikaku Hōsuiro, or the Metropolitan Area Outer Underground Discharge Channel, as a means to control the city’s 200-year storm and prevent further disasters from happening.

Colloquially known as the G-Cans project, the facility includes five 105-foot-diameter silos which bore 213 feet into the ground, each connected by four miles of 33-foot-diameter pipe. The tops of the open silos are at grade, like catchbasins, so when floodwaters build in the adjacent Edogawa River, they spill into the silos and are

conveyed by the pipes to the main storage tank, "The Temple."

Complete with 59 columns, each weighing 500 tonnes, the scale of The Temple is enormous, its style a modern interpretation of Turkey's Basilica or London's Victorian-era cisterns. 78 pumps – including four turbines the size of jet engines – evacuate water from the system and back to the Edogawa River at a suitable time and place downstream which minimize flooding. At peak performance in 2008, the system was able to divert 9,500 acre-feet of runoff, the equivalent volume of 7,196 football fields being flooded by one foot of water.

Stormwater management in a monsoon environment is not easy or cheap. G-Cans required 17 years to fully build out and a price tag reportedly near ¥230 billion (USD$2.9 billion). Due to the enormity of the project – physical, financial and chronological – it's likely not to be replicated, but G-Cans' legacy includes influencing excavation and tunneling techniques which are still employed around the world today. More importantly, the Japanese government reports flood damage in the city – particularly in the low-lying eastern neighborhoods – has been reduced by two thirds with the system being used 85 times as of 2014.

Despite its spectacle, G-Cans is a traditional infrastructure approach to flood control and is almost entirely invisible to the millions of Tokyo's residents it protects. The few who experience on tour its grandeur get a glimpse of the scale – and price – of that protection.

Critical Thinking

What are the challenges of building mega-infrastructure underground in Austin?

Project Details

» Location:
Katsukabe, Japan

» Mitigation Type:
Runoff Storage

» Design Lead:
Government of Japan
Japan Institute of Wastewater Engineering Technology

» Mitigation Type:
Runoff Storage

» Status:
Completed 2009

Learn More

» Story:
Global Citizen: "Japan Could Hold The Key to Surviving Floods"

» Photos/Video:
SCC Digital Showcase

BUOYANT FOUNDATION PROJECT

Photo: A Styrofoam-buoyed sub-frame lifts homes out of harms way during flooding events. (© Buoyant Foundation Project)

Retrofit flotation technology allows homes to ride out the storm.

Dr. Elizabeth English is leading a movement. After studying at Princeton (urban planning), MIT (engineering) and the University of Pennsylvannia (architectural theory), she now teaches at the University of Waterloo in Canada, professing the floodproofing benefits of amphibious architecture. Her theory? Houses can ride out storms – literally.

Amphibious architecture is a buzzing term which describes the ability of a structure to prevent inundation during flooding events. This can be achieved with waterproof coverings which roll out over doors or windows, or flood walls in combination with floodgates – anything which prevents floodwater from getting inside. With her Buoyant Foundation Project, English and her colleagues have devised a system which allows homes rise with floodwaters, floating out of any danger for people and property.

The buoyant foundation approach includes constructing a sub-frame under the existing main floor of a home and installing buoyancy blocks, typically Styrofoam, underneath to float the house as floods build. Guiding posts are bored into the ground around the home to ensure it returns to the same resting place when floods abate.

Homes that float – not house boats, but homes designed to occasionally float during flood events – are becoming increasingly popular. Innovative designs such as the Amphibious House and the FLOAT House are two examples of how amphibious architecture can effectively be incorporated into a new build. But these assume permission to build in a floodway or floodplain. For existing at-risk structures, technology like English presents allows for retrofit application and a level of resiliency only limited by the height of the tether. Unlike structures on fixed stilts, which are commonplace in many flood-prone areas, floating houses can adapt as the effects of climate change worsen (or are relieved). When there is no flooding, structures return to grade and blend back into the neighborhood unnoticed, especially important for neighborhoods attempting historical preservation.

The inspiration for English's approach came 1,200 miles away from Waterloo in New Orleans when Hurricane Katrina battered the city in 2005. At the time, English was an associate professor at Louisiana State University's Hurricane Center and she founded the Buoyant Foundation Project in 2006 to help promote long-term resiliency solutions in the hardest hit communities. Her buoyant foundation approach is roughly a third the cost of constructing homes on stilts, English told The Record in a 2017 interview. Because of the cost, simple design and universally available materials, she sees the technology as being highly transferable with applicability in a wide range of landscapes. Initially developed for urban centers like New Orleans, English believes buoyant foundations could also help in remote First Nations villages in Ontario's north, like Attawapiskat and Kashechewan, which are subject to flooding from rivers draining into James Bay.

The challenge in many jurisdictions, English said in the interview, is floating houses are frowned upon by building codes and insurance policies. To battle the uncertainty of regulators, she's building a pilot project outside her office in the Grand River and inviting the world for an inspection. English and the University of Waterloo host the 2nd International Conference on Amphibious Architecture, Design and Engineering June 25-28, 2017.

English acknowledges changes to building codes and in the insurance industry are often slow. But with each successful local project, she hopes the efficacy of amphibious architecture becomes evident and it can be adopted as floodproofing on a global scale.

Critical Thinking

What types of retrofit floodproofing can be applied to the ~275 structures in the Shoal Creek floodplain at risk of inundation during the 100-year storm?

Project Details

» Location:
Waterloo, Canada

» Mitigation Type:
Structural Floodproofing

» Design Lead:
Buoyant Foundation Project

Learn More

» Story:
The Record: "A Local Solution to a Global Problem"

» Photos/Video:
SCC Digital Showcase

SANKT KJELDS CLIMATE DISTRICT

The world's first climate-resilient neighborhood.

Image: The revitalization of Tåsinge Plads into a stormwater management park rallied the community, prompting 170 volunteer-led improvement projects in the area. (© Tredje Natur)

Copenhagen's Climate Adaptation Plan won a major design award. Up against 3-D printable housing, a melanoma-detecting smart phone app, and 58 other ingenious candidates, the prestigious INDEX Award was bestowed to Denmark's capital in 2013 for promoting a "massive influx of sustainable design solutions" for flooding and other climate-related challenges. The €100,000 award prize was used by the city to help, in part, create the Sankt Kjelds Climate District.

With its unnecessarily wide roads and over-paved public spaces, the neighborhood of Sankt Kjelds was a prime candidate for a climate-ready makeover. Copenhagen's Plan required a revisioning of urban space, keeping stormwater out of sewers and adding "green" and "blue" layers to the community to support grey infrastructure. Climate scientists in Denmark are predicting an increase in rainfall of up to 30% in the coming years, so "making room" for stormwater seemed like a prudent approach as grey infrastructure becomes increasingly undersized with the effects of climate change.

The vision for Sankt Kjelds, developed by landscape architects Tredje Natur, called for meticulous consideration of all hard surfaces

in. Those assessed as unnecessary were depaved.

Streets accounted for 67 acres of the neighborhood footprint, 12 acres of which were converted to rain gardens, bioswales and other absorptive features, all without impacting traffic flow or parking capacity. 2 acres of the 43-foot-diameter Sankt Kjelds Square turning circle was depaved and the Tåsinge Plads tarmac, two blocks west, was converted into a community park which fills with runoff during large storm events.

One of the most progressive aspects of the Plan, both in Sankt Kjelds and throughout the rest of Copenhagen, was the promotion of "cloudburst boulevards." The concept calls for existing rights-of-way to serve the community with more than one function, redeveloping their profiles and cross sections to better convey stormwater as well as traffic. This approach included raising sidewalks to create more conveyance capacity in the roadway, lowering dedicated bike lanes to act as stormwater channels during storms and, when appropriate, incorporating green features to increase absorption.

The classification of these cloudburst boulevards included: 1) stormwater roads, which would be redesigned without green spaces in strategic locations to maximize conveyance, 2) detention roads, which would include rain beds, roadside beds and permeable surfaces, and 3) green roads, which would drain and detain water locally, typically on small and/or private roads. In Sankt Kjelds, the network of cloudburst boulevards is expected to control runoff from the 100-year storm and convey it safely out to the North Harbor about half a mile away.

Implementing these green and blue layers in Sankt Kjelds created a wide range of benefits, from improved local air quality to increased real estate values and the expanded tax base which followed. One-off projects, the city and Tredje Natur said, would not have created the same scale of impact or had as much effect in controlling floods as the neighborhood-wide approach.

With Sankt Kjelds setting the example, Copenhagen is hoping to apply the lessons learned here, in what some are calling the world's first climate-resilient neigborhood, to the rest of the city. With the full cloudburst boulevard program approved as policy in 2015, 300 surface projects will be rolled out over the next 15 years putting Copenhagen's award-winning plan into use and the city on the road to its climate-proof goals.

Critical Thinking

What areas in the Shoal Creek watershed – large or small – can be depaved?

Project Details

» Location:
Copenhagen, Denmark

» Design Lead:
Tredje Natur

» Awards:
2013 INDEX Award

» Mitigation Type:
Reduce Runoff; Runoff Storage

Learn More

» Story:
Source Magazine: "Copenhagen Unveils First City-wide Masterplan for Cloudburst"

Cityscope: "Why Copenhagen is building parks that can turn into ponds"

» Photos/Video:
SCC Digital Showcase

WE ARE SHOAL CREEK

Shoal Creek is in the heart of Austin.

In 1839, it was the city's original western boundary, and today, it is an artery into the urban core. With two significant planning initiatives underway, 2017 will be an important year for the future of Shoal Creek. The Shoal Creek Conservancy would like you to be a part of that future.

Help us transform Shoal Creek into a world class watershed:

» Attend a public meeting

» Subscribe to our *Watershed Stakeholder Group* email list

» Donate to the Shoal Creek Conservancy and help support our Watershed Action Plan

Learn more:

www.shoalcreekconservancy.org/water/

APPENDIX

Photo: Singapore's Supertree (© Joshua Wong | Flickr)

HOW TO SURVIVE A FLOOD

Lessons from Hamburg's watertight HafenCity.

Hamburg is a river city. Built on an estuary of the River Elbe 70 miles inland from the North Sea, its residents have battled to keep river and tidal flooding out of their streets and cellars since the ninth century. In 2000, staring down climate change, the prospect of rising sea levels and increasingly frequent flooding, they gave up and welcomed the water in. The strategy appears to be working.

Hamburg's 593-acre HafenCity project is redeveloping a low-lying harbor area into a thriving urban neighborhood immune but not impervious to flooding. Billed as Europe's largest inner-city redevelopment, the concept had been in incubation since the fall of the Berlin Wall but only received masterplan approval in 2000. At a cost of $13 billion – mainly borne by the private sector – HafenCity is now serving as a model for municipal flood adaptation and resiliency planning.

The historic approach to flood abatement here in Germany's second largest city was to build walls and dykes. The city has over 60 miles of them protecting the main city. But in HafenCity, dykes around the district's perimeter were not desired as planners wanted to preserve the island's river connection and waterfront character. Building flood walls would also have required significant up-front public capital and years to complete, delaying the first developer from punching shovel into ground and the city realizing any return on investment.

The solution was to welcome the flood water into HafenCity and build waterproofed structures which poked out above the anticipated flood elevations. Buildings were constructed on 8- to 9-m plinths made of compacted dirt – "Warften," in German – with promenade-facing lower levels employing aquarium-grade glass and watertight windows and doors. Flood waters, which usually invaded a couple of times every winter, could course through the development but with damage to health or property kept to a minimum if it occurred at all.

Transportation corridors, including roads, bikeways and walkways, were all built at the same elevation – 8 to 9 meters above sea level and above anticipated flooding elevations. Flood doors were implemented inconspicuously and can be shut quickly to protect retail space located along the promenade close to the water. These features allow the district to keep at the pace of life during times of high water and fully utilize public amenities during normal flow.

Since floodproofing is being incorporated directly into the structures, the total flood mitigation costs for the district are distributed

and being born entirely by each building developer, meaning development of HafenCity can proceed at a reasonable rate without the lagging influence of politics or public budget debates.

Today, 17 years after its genesis (and 30 years since its ideation), HafenCity is still under construction. In late 2016, development in the last large un-built quarter got underway with two soon-to-sprout condominium towers and seven seven-story apartment buildings – a total of 500 residential units. This construction dug in just as HafenCity's Elbphilharmonie – a stunning 2,100-seat concert theater complete with luxury hotel, 50 apartments and a 121-foot-high public plaza – prepared for a January 2017 opening.

An Elbphilharmonie is (likely) not in the plans for Shoal Creek's flood mitigation strategy but HafenCity's philosophy can be. Flooding is a natural process. Advancements in architecture, engineering, science and design, as exhibited with the HafenCity project, now afford us the opportunity to be better water managers and build resilient communities. Not only can we 'live with water' but we can live well with water.

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Image: HafenCity promenade. (© HafenCity)