## What's next in making cities resilient?

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<u>1 flood</u> cost <u>1 city</u> council <u>half a billion</u> dollars.



# What's next in making cities resilient?



## brilliant

AECOM was created to design, build, finance and operate infrastructure. Whether we serve clients at one phase of the project life cycle or throughout, our role is to apply creative vision, technical expertise, interdisciplinary insight and local knowledge to address complex challenges in new and better ways.

We are currently working across a number of programs to generate ideas and tools to better understand the risk that disasters pose to our clients and their communities. We have designed and delivered adaptation and resilience projects at local, regional, national and international scales, looking at climate hazards, risk, vulnerability and sustainability.

Resiliency is an important issue, but it is not an insurmountable one. We are uniquely able to simplify and prioritize risks and investments for clients in both public and private sectors drawing upon our extensive network of technical and creative expertise.

We work in and for cities both large and small. We partner with a wide range of organizations, including the United Nations Office for Disaster Risk Reduction (UNISDR), Rockefeller Foundation, CDP and C40 Cities, to help build the resilience of communities around the world.

Previous spread One flood in Brisbane cost the city government around half a billion Australian dollars. We're now working on standards to ensure more cities are better prepared in the future.

client Australian Department of the Environment

## Contents

#### Introduction What's Next in Making Cities Resilient?

Mike Burke **7** 

### Resilience Defining our Times

Gary Lawrence 17

#### Re-frame Eight Steps to a Brilliant City

Stephen Engblom 22

## Prioritize

Capital asset reliability: Getting infrastructure right. 35

## Plan

Climate adaptation: Minimizing tomorrow's risks today. 47

## Protect

Secure systems and cities: Staying safe for the long term. 61

## Provide

Economic development: Enabling sustainable growth. 71

#### In Partnership Making Cities Fit for the 21st Century

Claire Bonham-Carter **87** 

#### Resilient Infrastructure Assessing the Challenges

Vahid Ownjazaryeri **91** 

## The Long View **Best of Both Worlds**

Jason Prior **95** 

## A whole-systems approach to better <u>prioritize</u> projects, <u>plan</u> ahead, <u>protect</u> vulnerable assets and <u>provide</u> sustainable growth.

#### Introduction What's Next in Making Cities Resilient?

<u>Mike Burke</u> Chairman and CEO Cities have become the front line for many of the world's most pressing challenges, from climate change, water scarcity and air quality, to economic disruption, public health and social instability. The scope of these issues extends beyond individual departments or agencies, beyond city boundaries and beyond the public sphere or private sector.

Yet it's essential that cities find solutions. In the next 20 years, the world's urban population will grow by more than two billion people. We are in the midst of the urban century.

Fortunately, cities have the capacity to address these global challenges—and meet local demands. At their best, cities have a density that makes transportation and housing more efficient, reduces per capita resource and energy use and lowers carbon emissions. They boost individual mobility and opportunity and drive economic growth. They foster diversity, creativity and social progress. Building successful cities is essential to creating a more sustainable world.

Which is why we're asking the question, what's next in making cities resilient? How do we plan for healthy urban growth?

The answer lies in a new approach: a whole-systems approach to better prioritize projects, plan ahead, protect vulnerable assets and provide sustainable growth. At AECOM we're pursuing ways to connect the best ideas and insight, from across communities, professions and regions and from public and private sectors, to help cities overcome their challenges and build a brilliant future.

## Prioritize

With constraints on funding, cities will need highly sophisticated evaluation techniques to prioritize their spending and maximize the benefits from social and physical infrastructure.



In 2012, it took just six hours for Superstorm Sandy to transform from a tropical storm in the Caribbean to a catastrophic weather event that struck the American Eastern Seaboard. The continuing cost of the recovery to the U.S. federal government is in excess of \$60 billion.

### Plan

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Because nature pays no regard to how we manage and maintain infrastructure, city leaders must understand the interrelatedness of city systems and the broader networks in which they operate.



In the aftermath of the 2011 earthquake, 45% of the buildings in central Christchurch were deemed to be unsafe. A detailed analysis of a city's building stock can identify where base-isolated design, which enables structures to absorb seismic shock, can be used for future building.



### Protect

We often take for granted the high-tech systems that underpin our urban lives. What happens if they stop working? With the ability to effectively monitor their security, vulnerable networks can be future proofed against threats so they are always reliable.



In March 2015, a massive blackout struck Turkey. Five major cities, including mega-city Istanbul and the capital Ankara, were brought to a standstill. Metro, tram services and road traffic systems all stalled resulting in huge costs and disruption to business and residents. The source was identified as a malfunction at just one or two power plants, potentially a cyber attack.



## Provide

It's just not megacities that can flourish in a competitive global economy. Places, regardless of size, which capitalize on knowledge infrastructure and are attractive to investment, can secure long-term benefits for local people and business.



The typical metropolitan area in the United States produces 299 patent applications per year. The San Francisco Bay Area creates 15,000 annually, more than any other region in the country. Likewise, the city of San Francisco is the <u>second</u> <u>highest receiver city of foreign</u> <u>direct investment in the U.S.</u>, just behind New York City, but with only a tenth of the population.



#### Resilience Defining our Times

We live in times of great and accelerating change; in human capability, population growth and societal upheaval. In response, we can choose to carry on as before, or seize the opportunities on offer, says <u>Gary Lawrence, Chief Sustainability</u> <u>Officer</u>.

Left Skyline of Manhattan from the Brooklyn Bridge Park, which has been redeveloped by AECOM.

<sup>Client</sup> Brooklyn Bridge Park Development Corporation Attempts to define the greatest challenge of our age have slipped in and out of fashion, trailing confusion and polemic in their wake. We have moved from the ecological movement of the '70s through the sustainability movement of the '90s (leapfrogging the global party that was the '80s) to the more immediate issue of today resilience.

In recent years, we have witnessed largely consistent patterns of growth and development within increasingly unpredictable and differentiated contexts. As a result, the desire for resilience is felt more urgently than its ecology and sustainability counterparts.

#### 18 AECOM

#### Making connections for resilience

To start integrating climate resilience into our businesses, cities and communities, the solutions require three things they must be technically feasible, economically viable and politically acceptable.

Each region's challenges and responses will be unique; yet every decision must happen within the context of the interplay between the natural, human, economic and social systems that support it. Expect great benefits when we understand the connections between water, food, energy and security.

A resilient community is one that recognizes that at some time it will need to adapt to new and unexpected circumstances. The key to our collective future in relation to population growth, urbanization, unpredictable natural patterns and constrained resources, is pragmatism. Hoping the worst doesn't happen is not a sound investment strategy.

#### Anticipate, or ignore the risks?

While we cannot predict the right route to pursue, it is possible to anticipate risk. We can take an inclusive, integrated approach that brings together depth and breadth of knowledge and different stakeholder perspectives to afford the possibility of more flexible solutions that can adapt to change.

We can design communities to fail at those points where recovery can happen most quickly, with reduced threat to human life, physical assets and business continuity. The opportunity costs associated with resilient design can seem high. But they are even higher when individuals, institutions and investors choose to ignore the risks.

Resilience is not an alternative to ecology or sustainability. It is an inclusive approach that brings together the best thinking from all of these frameworks.

#### The added value of resilience

AECOM works with clients to promote the understanding that disaster preparedness is a fundamental element of the core investment strategy. We know that a unit of planning will reduce response actions by 4 to 7 units of expenditure. Every investment we make in infrastructure or assets is an opportunity to improve our resilience to unpredictable disasters and to improve the quality of life for our citizens through slight changes in scope.

No sprache house



## One unit of planning will reduce response actions by <u>4 to 7 units of</u> <u>expenditure</u>.

Pictured Montmorency Metro Station in Montreal.

client Société de transport de Montréal 40% of the world's population lives in <u>coastal</u> <u>areas</u>.

#### New ways with infrastructure

The best mitigation and adaptation strategies are not stand-alone investments, but are part of a broader consideration of cumulative benefits. This approach maximizes the value of every dollar spent and often creates access to additional sources of funding by aligning common goals among multiple stakeholders.

For example, investments in water can be part of a broader solution to the availability of energy, raw materials, and water for business processes as well as the health and security of the workforce and their families. Responsible water solutions require the technical expertise of businesses, effective government policies and regulations, and the engagement of civil society in responsible water management practices. They also require improved energy efficiency for extraction, movement and refrigeration.

#### Left

San Diego's regional beach sand replenishment will help to safeguard the city region of 3.2 million people from coastal erosion. <sup>Client</sup> San Diego Association of Governments

#### **Reasonable and resilient**

Resilient design considers reasonable probabilities and anticipated changes in the behaviors of the systems in which our cities and populations exist.

It integrates natural landscape elements with built solutions to protect human life and physical assets in ways that reduce costs. It designs supply chains less vulnerable to interruption that can come back online more quickly. It builds in capacity for critical energy, water and communications infrastructure to function detached from citywide, regional or national grids so they can still serve community and business needs when large systems fail.

Critical buildings and infrastructure are designed to fail "gently" rather than cataclysmically, and at specific points to minimize damage and facilitate quick repair. Design solutions embrace performance rather than prescriptive regulatory schemes to encourage innovation and realize clear benefits for owners and tenants.

#### The power in our hands

Those with vision are looking at unparalleled opportunity.

Successful businesses and communities will embrace the challenges of population growth, urbanization, unpredictable natural events and constrained resources as a catalyst for innovation, new business models and future success. They will anticipate the risk of mismanaging their response to climate threats, but also create opportunities by integrating responsible stewardship into longterm business plans.

As ever, since time began—we live in an age of uncertainty. We also live in an age of expanding creativity, invention, technology, knowledge and possibility.

The power to change, adapt and improve lies in our hands.

#### Re-frame Eight Steps to a Brilliant City

Knowing that AECOM can help cities to prioritize, plan, protect and provide, <u>Stephen Engblom, Senior Vice</u> <u>President, Global Director of AECOM</u> <u>Cities</u>, observes that successful cities think differently about the challenges they face. These steps to the brilliant city look at immediate challenges in the round, recasting them as long term strategies for success. Cities have never been more important, nor the competition between them more intense. Those positioned to excel through this time of global change are pursuing broad, integrated strategies to tap hidden value, celebrate ecology and culture, attract people and investment and overcome financial and operational inefficiencies to define success.

As one of the world's largest urban design and civil infrastructure consultancies, AECOM does more than answer questions, we help cities re-frame them. The chapters of this book outline our signature, pragmatic underpinning to visioning and delivering successful urban environments: Prioritizing capital asset reliability; Planning for climate adaptation; Protecting assets—with physical measures as well as cyber security; and Providing for sustainable economic development. We see this as building resilience while achieving brilliance.

Brilliant exudes character and confidence. Brilliant works across boundaries in support of a greater vision. Brilliant finds the common ground between private and public to close funding gaps. Brilliant performs technically while achieving broader social and economic benefits. Brilliant overcomes obstacles to get essential projects delivered.

## <u>8 steps</u> to a brilliant city:

Start at the end: Secure a legacy with strategic planning.

#### Draw a crowd:

Energize the center through compact urban design.

#### Get there together:

Upgrade transportation to move people and business faster.

#### **Change the flow:**

Get more from innovative energy and water infrastructure.

#### Make green pay:

Take environmental action that provides an economic boost.

#### Ignore borders:

Collaborate across agencies and regions for bigger results.

#### Act now:

Identify and address physical and cyber vulnerability.

#### Finish ahead:

Get projects funded, built and operating sooner.

#### Start at the end

Secure a legacy with strategic planning What will your city be like in 50 years? Understanding where your city is headed—and how you want to shape its future—should guide how projects and infrastructure are prioritized today. Smart long-term planning anticipates social, economic and environmental changes and builds the strategic direction to secure a positive legacy, for cities and leaders.

#### Draw a crowd

## Energize the center through compact urban design

People come to cities to be near other people. Cities need places where people can come together, places that resonate, inspire and excite; a waterfront promenade or central park, a distinctive district or event center, a signature tower or downtown area. A well-planned project can turn the tide and change a city's fortune. Cities that work to boost business and celebrate life are positioned to compete and succeed.

#### Get there together

## Upgrade transportation to move people and business faster

A city's economy moves at the pace of its transportation network. Efficient transportation speeds the flow of people, ideas and commerce. Airports and seaports are global gateways. Roads and rail establish regional connections. Bike and walking routes make mobility healthy, inexpensive, and fun. In a great city, access is built into the fabric.

#### Change the flow

#### Get more from innovative energy and water infrastructure

We depend upon civil infrastructure to meet our daily needs, but the investments we make for these essential functions can yield wider value when we take new approaches. Stormwater managed naturally can improve the urban landscape, increase property values and protect our waterways. Recycled wastewater can green our parks and neighborhoods. Solid waste treated organically can reduce landfill and produce energy for homes.

#### Make green pay

## Take environmental action that provides an economic boost

Investments in the environment can yield financial and social dividends. As cities take measures to mitigate and adapt to climate change, remediate contamination, and protect and restore natural environments, they are finding a wealth of benefits, from energy savings and cleaner air to rising real estate values and healthier people. It creates a better climate for business and community.

#### Ignore borders Collaborate across agencies

#### and boundaries for bigger results

Challenges do not follow the boundaries of departments and municipalities. Neither should solutions. To compete at a global level, cities need to advance in step with their supporting regions. This means collaborating across disciplines and jurisdictions, and cooperating and planning at the regional level, to see the bigger picture, connect better ideas and find smarter solutions.

#### Act now

## Identify and address physical and cyber vulnerability

Buildings and bridges are joining the internet of things. This increases the need for cyber security, along with security against physical attacks, violent weather, earthquakes, and decay over time. Proactive solutions begin with a comprehensive vulnerability assessment. Anticipating the most likely points of attack or failure lets a city know where to invest to prevent or mitigate disaster before it strikes.

#### **Finish ahead**

## Get projects funded, built and operating sooner

Public budgets are stretched. Roads, bridges, water systems, hospitals, schools and courthouses need maintenance or new structures, but there are new ways around old obstacles. Partnering the public and private sectors and linking the phases of a project's life cycle can speed construction, reduce cost, increase performance and manage risk. It's time to take advantage of the alternatives.



## <u>Start at</u> <u>the end</u>

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**Start projects with the end state in mind.** Rather than design a masterplan for a single event - the Olympics in 2012 – we designed a masterplan for 2040. Our work on a myriad of projects in East London, including the original vision that secured London's Olympic bid, are bringing to life what has long been the UK's most deprived urban area.

Queen Elizabeth Olympic Park, London Clients: London Legacy Development Corporation, Greater London Authority, UK Olympic Delivery Authority, Thames Gateway Development Corporation, London Development Agency, London Boroughs of Hackney and Newham

## Draw a crowd

**Embracing compact urbanism to attract talent.** Our award-winning masterplan for the revitalization of Doha's city center represents a pivotal moment for urban planning and architecture in a region known for hasty expansion. The project draws on the vernacular patterns of Gulf settlements to redress the trend for inner city decline and decentralization by giving Doha a vibrant, walkable place for commercial development, residential living, recreation, culture and retail activity, to make it an attractive and authentic destination in this hyper-competitive Gulf economy.

> Mshiereb, Heart of Doha Client: Qatar Foundation



#### Using natural systems as infrastructure. Green

infrastructure naturally filters urban pollutants from stormwater runoff and can help prevent flooding. It also brings much needed green space to under-served communities while being part of a tightly woven network of systems that underpin the resilient city. Jeddah, which in recent years has faced flash flooding on an unprecedented scale, is ensuring it's better prepared next time.



<u>Jeddah Structural Plan</u> Client: Jeddah Municipality



## <u>Make green</u> pay

#### Pro-environment projects are good for the

economy. The Calligraphy Greenway, designed by AECOM, has brought new energy to the heart of Taiwan's third largest city, Taichung, while also providing a crucial new piece of green infrastructure. As a new green lung that has activated the center of this congested city, the Greenway has increased land values in the surrounding area by at least 20% in just two years.

<u>Calligraphy Greenway</u> Client: Taichung City Government





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Feel a sense of urgency. In Orange County, California, AECOM has been working with the Santa Margarita Water District to upgrade dams, identify risks and provide construction plans and design specifications for a reservoir critical to the urban water supply. The effort will ensure this vital piece of infrastructure can flourish even in 100-year return period rainfall.

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## Finish ahead

**Get creative with design and delivery.** The new courthouse in the city of Long Beach for California's Los Angeles County, offers new potential for the delivery of social infrastructure in the U.S. The project is the first of its kind in the country delivered through an availability payment-based publicprivate partnership. AECOM served as architect and engineer of record in a consortium led by Meridiam Infrastructure for the State of California. 34 AECOM

## Prioritize

## Capital asset reliability: Getting infrastructure right

Balancing the maintenance and rehabilitation of aging infrastructure with the need for sustainable growth requires effective planning and decisionmaking, especially considering the challenges of funding large and complex projects. From maintaining physical assets, delivering longterm value to your staff, customers and clients, or keeping in step with the shifting ground of economic and regulatory environments, we apply the skills and knowledge of our team to strive for optimum performance throughout every stage of the asset life cycle and minimize unexpected failures.

Pictured Inundation mapping showing extent of 100-year storm surge with 66-inches of sea level rise in Bayview, San Francisco.

#### San Francisco

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850,000 people today. Urban since the early 19th century.
### The Long-term View with the San Francisco Public Utilities Commission

To upgrade San Francisco's wastewater infrastructure, protect it from the effects of climate change and improve service, the San Francisco Public Utilities Commission (SFPUC) is implementing a multi-billion-dollar investment for the city. The 20year program will be informed by a climate adaptation plan, and includes upgrading existing and constructing new infrastructure.

In preparing for a century of potential change, the SFPUC is undertaking a comprehensive climate change vulnerability and risk assessment, which will culminate in a climate adaptation plan. This plan informs design and operational strategies, manages climate change-related risks, and identifies trigger points for implementing adaptation strategies to increase the likelihood that a consistent level of service can be provided in future decades.

This project includes coordinating with other city departments and agencies to foster the use of consistent climate science data for city-wide planning. As part of this, we played a key role on the Mayor's Sea Level Rise Committee, which culminated in the landmark Capital Planning Commission Guidance for incorporating sea level rise vulnerability and risk within the capital plan. The detailed sea level rise and storm surge inundation maps we developed are now the recommended standard for all sea level rise planning within the city and county of San Francisco.

One of the most important tasks was completing the inventory of SFPUC wastewater assets within the sea level rise vulnerability zone. We compiled readily available and existing GIS data layers of assets, and linked these layers to additional data on condition, age, criticality, materials, lowest adjacent grade, elevation of critical electrical equipment, maintenance history. Where data gaps were found, we developed targeted surveys as an efficient means of gathering information from departmental staff. The survey approach minimized the burden on busy staff schedules, and prevented the need to schedule and host large working group meetings.

We are developing a series of vulnerability and risk profiles, focused on individual assets, as well as groups of assets which function as systems. The profile approach also captures the interdependencies within the system, and helps prioritize adaptation strategy development and implementation – within existing projects currently in the design process, and within future projects that are likely to move forward to construction within the next two decades.

Working with an agency that provides water to 2.6 million Californians. PARKIN ANY TIME

<u>Water System Improvement Program</u> Client: San Francisco Public Utilities Commission

## <u>This is</u> infrastructure

The Burger

Incorporating water sensitive urban design features in all elements of the cityscape, at large and small scales, can create meaningful benefits. These include natural rainwater treatment and enhancing biological diversity. There is more than sidewalk planting—it is an integral part of the SFPUC "living machine" that treats rainwater and greywater from buildings for reuse inside.



# Our tool measures potential climate change impacts.

### Understanding Risks and Increasing Resilience

To ensure long-term operational resilience, achieve cost and resource savings, and to help organizations fulfill their responsibilities under climate change legislation, we created the Adapting to Climate Change Application (ACCA) tool to identify potential future impacts of climate change on assets and operations, and to find ways of effectively responding and adapting to these impacts.

Designed to help users understand the risks from climate change and prioritize adaptation responses to reduce these risks and maximize opportunities, the ACCA has been used on buildings, transportation, water, energy and environmental projects. The ACCA is designed to:

- Provide a summary of the most likely impacts of climate change on a particular project or asset(s);
- Estimate the likelihood and severity of each impact through a structured risk and probability assessment;
- Facilitate the selection of the optimal and cost-effective adaptation through the application of a robust and proven multicriteria analysis methodology.

We have extensive and continuously evolving expertise and experience in developing and implementing regional, sectoral, organizational and asset-specific climate change risk assessments. This expertise is being developed through our sustainable innovation program and projects for multi-sector clients in anticipation of continued disruptions to business and supply chains caused by natural hazards, and an increasing number of legislative drivers relating to future climate change and its potential impacts.

### Raising Resilience with Port of Houston Authority

We used ACCA to carry out an analysis of the potential impacts of future climate change and extreme weather events on the assets and operations of the Port of Houston Authority's Bayport Terminal. The project identified the potential risks with highest probability and greatest consequence, and established a prioritized adaptation action plan for the port so it could raise its resilience to future climate change risks. Findings from the study have supported the establishment of a long-term climate change strategy, which the authority is considering as part of its ongoing competitiveness, investment, and risk and vulnerability assessments.

### A Strategy for Change for Yorkshire Water

The U.K. utility company, Yorkshire Water, commissioned us to undertake a strategic climate change risk assessment to assist the organization's long-term aspiration to further enhance the resilience of its assets. and to maintain high levels of service in a changing climate. The ACCA and its associated methodology were used to develop the assessment and to identify, prioritize and, as far as possible, quantify Yorkshire Water's vulnerabilities to climate change and extreme weather events. The risks and adaptation recommendations identified will help Yorkshire Water maximize its level of strategic and operational resilience to climate change and extreme weather events.

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Sheffield

560,000 people today. Urban since the 8<sup>th</sup> century.

<u>A region's</u> water supply The military is planning for the impact of climate change on security in the year 2100.

### In Defense of Defence with Australia's Department of Defence

To support the long-term durability of its operations and facilities at key sites, the Australian Department of Defence (Defence) wanted to understand the potential risks to assets as a result of climate changeinduced sea level rise, storm surge and coastal erosion.

Studies on risk assessment of 38 sites around the country were commissioned. We began this work by prioritizing the sites at greatest risk across three time frames: 2040, 2070 and 2100. The initial assessment established a framework to guide future studies and enabled Defence to select sites for further investigation and adaptation planning.

With 14 detailed site assessments, the second stage included physical inspections to assess current asset condition and to facilitate local stakeholder engagement. This work also addressed anticipated impacts associated with sea level rise, storm surge, flooding and coastal erosion, together with issues noted in the initial study. These assessments provided an analysis of the risks and identified measures for adaptive planning.

To inform the site assessments, we performed detailed modeling of coastal erosion and flooding from storm surge and extreme rainfall. Input from the Commonwealth Scientific and Industrial Research Organisation, Antarctic Climate and Ecosystems Cooperative Research Centre, together with the Met Office informed and validated the selection of climate inputs for this assessment. We used existing climate change projections for sea level rise and extreme rainfall to inform the detailed assessments of marine flooding, estuarine flooding and coastal erosion.

We also supported Defence's internal engagement by developing site-based visual summary sheets and animations for use in stakeholder workshops and internal branch briefings. We also facilitated engagement with external stakeholders to discuss broader regional risks and adaptation opportunities. A suite of reports was produced to address the project's multiple audiences.

#### Sydney

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4.8 million people today. Urban since the 18<sup>th</sup> century.

# 85% of the population

With around 85% of its population living in Australia's coastal areas, climate change with its actual and potential impacts on public infrastructure are significant issues for the government.

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Pictured A navy ship in Sydney Harbor.

Protecting Critical Assets for Australia's Department of the Environment

Australia's coastal region is of critical economic, environmental and social importance. Research shows that between 150,000 and 250,000 buildings could be at risk of inundation from sea level rise, and that the replacement value of these buildings would be more than AUD \$60 billion.

In response to this challenge, a new set of federal standards—called

150,000-250,000 buildings in flood risk zone. <u>Brisbane</u>

2.3 million people today. Urban since the mid 19<sup>th</sup> century.

Considering Climate Risks when Managing, Owning and Funding Coastal Assets—has been adopted by the Australian government. It is used for all types of public assets, from airports to defense bases and major highways. In compiling these standards, our scientific report focused on key hazards, exploring the relationship between climate variables and these hazards. It also described past and future trends, level of confidence, current knowledge gaps and available resources for each variable and hazard. We also developed a detailed riskmanagement process that can be applied by any government agency considering works on assets – from management of existing assets to funding and building new ones. The risk management process was aligned with ISO standard risk managementprinciples and guidelines. It provides a detailed step-by-step approach and a new paradigm for risk management of public assets based on a hierarchy of risks. The level of immunity desired for public assets, and therefore investment in risk management measures, is directly proportional to the criticality of the assets and the services they deliver.

While the standard was developed for the federal government, a range of institutions from local government to private sector companies can now use this process to guide their decisions and investments in key assets.

> Pictured View of central Brisbane during the 2011 Queensland floods.

46 AECOM

# Plan

### Climate adaptation: Minimizing tomorrow's risks today

Increasingly volatile seasonal storms, higher temperatures and deeper droughts in some areas are leaving residents, municipalities and businesses vulnerable to property losses, infrastructure damage and even loss of life. By analyzing the potential threats from climate change, it is possible to develop efficient and effective solutions to protect people and preserve resources in the face of the most destructive extreme weather events.

# Making it easier to enjoy the beach while also protecting an entire city.

### Inspired by Nature for Blackpool Council

With its distinctive serpentine shape, sculptural detailing and massive scale, Blackpool's new seafront has become an iconic feature in this U.K. seaside resort town. It provides a contemporary-style setting for the world-famous Illuminations, an expanded promenade, an enhanced relationship between the urban center and its beach and improved sea defenses. This work was undertaken in the broad context of creating economic resilience for the town. Replacing the imposing Victorian, basalt-faced sea wall that rose steeply from the beach, our design of the new defenses has involved radically rethinking the traditional approach to such structures. While the old sea wall was a rigid vertical barrier intended to withstand the full force of waves, the new structure takes its inspiration from the organic shapes of local sand dunes. It is designed as a sweeping flight of steps that acts as a massive revetment (breakwater) and it improves the visual and physical links between beach and town.

The use of computer modeling created the structure's sequence of serpentine curves and the graceful flight of shallow steps between beach and town evolved with each step acting as a small breakwater. Scale models of the designs were tested in water tanks to observe and record how they responded to waves of varying strengths.

Pebble smooth and sculpted into round shapes, concept images showed the evolution of seating designs for the seafront. Integrated into the promenade and sea defenses, the curved shapes make comfortable and sheltered places to sit, and they have the dual function of being designed to redirect seawater back to the sea and away from the town during storms and high tides.

From technical drawings, 3-D scale models of a portion of the wall and headland were constructed directly from the digital models using a computer numerically controlled cutting system. The sections were then tested in a water tank with waves of varying strengths up to the force of a one-in-100-year storm event. With the action recorded on video and then analyzed, the designs were refined to form the smoothly rounded headlands. It was found that by combining steps with a serpentine shape, it was possible to significantly reduce the wave impact. To withstand even the most ferocious seas, the steps are crowned by a wall with a concave face designed to redirect the waves and turn them back towards the sea. Curved railings and sculptural seating details echo the organic design theme.

Because of the challenges of pouring concrete in a saline environment, the wall units were precast off site in a nearby temporary factory and fitted together like a vast 3-D jigsaw on site. Computer modeling was used again to calculate the optimum size, weight and shape of each precast unit, some of which weighed more than 16 tons. Working between the tides ensured maximum on-site building efficiency using cranes to lift each piece and slot it into place. To complete the attention to detail, and ensure the new structure looked at home on the beach, the concrete was colored to be an exact match with the famous Blackpool sand.







#### Anchorage

300,000 people today. Urban since the early 20<sup>th</sup> century.

## <u>Will the snow</u> always be there?

### Extreme Climate Expertise

for the U.S. Federal Emergency Management Agency and the Kenai Peninsula Borough

The Kenai Peninsula is a popular tourist destination and includes several of the most populous towns in southern Alaska, including Seward on the Gulf of Alaska coast. To help protect the area against potential climate change effects, we used a strategic resilience approach in the 2013 Local Hazard Mitigation Plan for the Seward-Bear Creek Flood Service Area that emphasized current flood threats and developed future climate change impact modeling scenarios to guide future land use initiatives.

Our contribution included project managers, plan development and editing, and activity coordination provided locally in Alaska; hydraulic and hydrological analysis, mapping, and Hazards United States-Multi-Hazard (Hazus) modeling, GIS oversight and modeling quality control and climate change impact and adaptation analysis oversight for future land-use scenario development. Our work also included facilitating public meetings and presenting materials to each jurisdiction for evaluation, validation and implementation. The team used the U.S. Federal Emergency Management Agency's (FEMA) Hazus damage estimation software to develop multiple climate change related hazard impact scenarios. They acquired newly available University of Alaska-Fairbanks' Scenarios Network for Alaska + Arctic Planning (SNAP) climate change weather data along with visual real-world flood hazard event impacts experienced during their field visit.

The plan fulfills the need for local governments to have a FEMAapproved, local government-adopted hazard mitigation plan for FEMA grant programmatic eligibility. Special service areas are encouraged to participate with jurisdictional mitigation planning activities or to develop independent plans across an area that spans multiple jurisdictions.

The plan update enables citizens and decision-makers to implement sustainable climate change resilience actions. These would reduce or eliminate future and potentially damaging natural hazard event impacts to their jurisdiction's critical facilities, residential structures and population. Enabling local governments, wherever they may be, to comply with national standards and global best practices.

# 207 cities working together to reduce emissions while growing their economies.

## Preparing Cities for Risks with CDP and C40 Cities

Helping cities and companies to develop a strategic approach to climate change, we are working with CDP (formerly the Carbon Disclosure Project), an international, not-for-profit organization that provides a global platform for measuring, disclosing, managing and sharing vital climate change information.

Pictured Scenes from the global launch of CDP Cities 2013 at AECOM's London office.



Supporting CDP's focus on reducing greenhouse gas emissions and drive toward sustainable water use, we volunteer our expertise in data analysis and visualization techniques to gather and organize information about greenhouse gas emissions, anticipated physical infrastructure risk and exposure to weather events, climate adaptation and mitigation actions and sustainability trends in urban areas. CDP then uses this data to identify trends and themes to help municipal governments benchmark their progress with their peers as they develop procedures for preparing for possible risks associated with a changing climate.

Our partnership with CDP on its global annual reports has seen a rise in the number of participating cities from 73 in 2012 to 207 in 2014. The latest report for 2014, entitled Protecting our Capital, outlines how these cities are protecting their populations from the effects of climate change and creating resilient places to do business.

In the 2014 CDP report, 207 cities participated, with the majority disclosing that climate change presents a physical risk to the businesses operating in their cities. This real and current threat is driving local governments to take concrete action in response.

Learn more about the CDP Cities program and download the reports at cdp.net/cities





Cities are

responsible for

4/5

global GDP

Cities not only have direct influence over greenhouse gas emissions, but also face the greatest concentration of physical, social and economic risks associated with climate change.





Statute Contanuous



22 million people. 3 states, 25 counties. GDP equivalent to Spain.

# <u>Up and running, rain or shine</u>

With three states across the Greater New York city region, multiple public agencies involved in the management of its infrastructure, more than 20 million people calling it home, and the head offices of a tenth of Fortune 500 companies concentrated on a small island, one bridge across a single river takes on a global role, no matter the weather.

R



### In the Wake of Superstorm Sandy with the U.S. Federal Highway Administration and Cambridge Systematics

Learning from extreme weather events such as Superstorm Sandy, the Federal Highway Administration is developing an initiative to enhance the tri-state region's long-term resilience to climate change and extreme weather.

Working with partners in Connecticut, New Jersey and New York, the agency is surveying the damage and disruption wrought by recent storms and hurricanes on the region's transportation systems. The project partnership will use lessons learned from these events, along with future climate projections, to develop feasible, cost-effective strategies to reduce and manage extreme weather vulnerabilities amid the uncertainties of a changing climate. We helped to develop a four-step adaptation engineering assessment process and helped the partner agencies to identify 10 regionally significant transportation facilities that had suffered in previous extreme weather events to use as case studies for the assessment process. These ranged from roadways, bridges and tunnels, to rail, and a port. For each of these assets we are completing engineering-based assessments that include an evaluation of future climate impacts and the development of a number of engineering-based strategies to help improve resilience to these impacts. The strategies range from updating design guidelines for drainage systems to incorporating sea level rise and storm surge protection, to evolving the approach to a bridge structure. Results from the engineering assessments will inform a multimodal transportation vulnerability and risk assessment for the region.

The project will provide guidance to agencies in the tri-state region—and nationwide—which seek to plan and invest for long-term climate resiliency while addressing today's transportation challenges.

# Defending a city from a 1-in-200-year flood.

### Protecting and Enhancing for Scottish Water

To help prevent repeated and damaging flooding in the Scottish capital Edinburgh, U.K., we designed a flood prevention scheme that involved creating reservoirs and the use of a natural flood plain together with making the most of opportunities to enhance the waterside. Based on achieving a 1-in-200-year standard of defense with an allowance for climate change, our design for the Braid Burn watercourse included improvement or replacement of several culverts and bridges, new flood embankments, flood walls, strengthening of existing barriers and the creation of two flood storage reservoirs. Maximum use is made of the natural flood plain where this is practical.

In parallel with the flood alleviation objectives, our designs responded to feedback from public consultation and has also enabled the council to improve the visual, amenity and environmental quality of the river corridor. An Environmental Statement and Environmental Action Plan were prepared to identify and assess the impacts of the scheme, achieve appropriate mitigation measures and seek maximum enhancement potential.





## Securing a Gateway for Global Trade with the Port of Long Beach

As part of the largest port complex in the United States, and a critical gateway to global trade, the Port of Long Beach is an important economic engine vital for Southern California. Strategies for climate adaptation measures are being developed for its maritime infrastructure and operations. Adaptation is integrally linked with the port's triple-bottomline responsibilities of economic, environmental and community stewardship.

To understand and manage the challenges ahead for the port, we are undertaking a multi-year study to understand the vulnerabilities faced by the port's infrastructure and operations and to develop a climate resiliency strategy to address those vulnerabilities. Our work started with a climate impacts study to assess vulnerability to changes in climate and the potential impacts to port infrastructure and operations. We evaluated the potential exposure of each part of the port to sea level rise and storm surge and carried out an overtopping analysis to identify the locations in the port where inundation will first occur. In addition, we looked at the potential impacts associated with extreme heat events and changing precipitation patterns. In particular the overtopping analysis enables a more precise identification of where to focus shoreline protection efforts.

Interestingly, the most vulnerable parts of the port can be the most unexpected—not the open oceanfacing wharfs, but the piers within the port and the backlands facing the channelized Los Angeles river. The climate resiliency strategy under development is likely to include adaptation strategies that consider the range of effects of climate stressors, including on coastal infrastructure, transportation networks, energy, water use, water quality and coastal ecosystems.



#### Long Beach

470,000 people today. Urban since the early 19<sup>th</sup> century.



CMA CGM

60 AECOM

# Protect

### Secure systems and cities: Staying safe for the long term

The number of successful cyber attacks on integrated control systems at power generation, petroleum production, nuclear energy, water treatment and other facilities has increased dramatically in recent years. These intrusions have resulted in extensive damage to and disruption of facilities. Our expertise in intelligence, information technology and cyber security—with a strong, diversified base of government relationships in key areas—is helping to minimize potential damage.







#### Left

AECOM has been working on a number of projects enhancing the sustainability of U.S. military assets, including basewide sustainable infrastructure assessments for six air bases with more than 8.5 million ft<sup>2</sup> across 450 buildings.

### Making Connections and Saving Energy for the U.S. Army Corps of Engineers

Helping the U.S. Army to make more efficient use of energy and water at its sites, our teams have connected vital industrial control systems for the U.S. Army Corps of Engineers in Fort Belvoir, Alabama.

Following the introduction of legislation requiring metering in all federal buildings, the Army Central Metering Program involves installing a network of advanced meters that report remotely to a central database located at Fort Belvoir. Sites with exceptionally high energy and water consumption can be targeted for reductions in use. This work encompasses some 6,700 Army, Army Reserve and Army National Guard facilities at more than 480 sites worldwide. The meter system provides army installations with the capability of measuring and tracking electricity, water, natural gas and steam consumption at individual facilities.

The army is also undertaking the installation of advanced utility meters on all military construction projects and for renovation or energy projects with a programmed cost of \$250,000 or more that include electrical, natural gas, water or steam components.

The U.S. Army Engineering and Support Center at Huntsville, Alabama, is responsible for managing the execution of the metering and other energy programs for the Office of the Assistant Chief of Staff for Installation Management and the Installation Management Command.

Our cyber security team worked to establish vital links between the Army Meter Data Management System and the front-end server for metering data. We troubleshot configuration settings and network designs, and developed a solution enabling the full integration of vastly improved meter data reporting. The successful project established good communications to facilitate the collection of data from multiple sites to meet legislative requirements.

### Keeping the water flowing for Chicago's Department of Water Management

The Chicago Department of Water Management operates the two largest capacity conventional water treatment plants in the world. Together the two facilities process almost a billion gallons of water every day, supplying water to the city of Chicago and 125 suburban communities in Illinois.

To help ensure continuity of this critical service, we completed a threat and vulnerability assessment update for the department using the American Water Works Association's risk and resilience standard J100, Risk Analysis and Management for Critical Asset Protection Standard for Risk and Resilience Management of Water and Wastewater Systems. This project was one of the first full-scale applications of the J100 methodology for a large water utility.

During the work, we identified critical assets; determined appropriate threats and hazards; estimated consequences, effectiveness of existing mitigation measures, and threat likelihood for critical threat-asset pairs; calculated the baseline risk; and applied mitigation measures and evaluated the cost benefit of implementing various mitigation suites. We evaluated the resiliency of the supervisory control and data acquisition hardware and software, system access vulnerabilities, malware prevention and control and performed penetration testing and rogue wireless testing.

We led several group meetings and workshops throughout the project with DWM staff, as well as the Chicago Police Department, FBI, Coast Guard, Office of Emergency Management and Communications, and the Joint Terrorism Task Force. These workshops provided for knowledge sharing and served as a tool for achieving consensus on tough issues and making everyone involved feel that they participated in the solution. We customized several components of the J100 methodology to meet the client's unique needs. For example, we modified the methodology used to estimate the likelihood of terrorist threats, and developed methods for estimating other threats and hazards such as the likelihood of proximity hazards and workplace violence incidents. We then completed an economic analysis to estimate the regional economic impacts of a major water disruption or contamination event.

After completing the assessment, we worked with the Chicago utility to develop a security and preparedness capital improvement plan that prioritizes the investments that the city will make to improve the security and resiliency of their critical infrastructure.

> Right The Stickney Water Reclamation Plant; AECOM provided overall project management and administration, data collection and analysis, alternative evaluation, preliminary design, final design, and service during bidding for improvements for the Metropolitan Water Reclamation District of Greater Chicago.



<u>Who can access a city's data?</u>

66

AECOM

## Cyber Security and Infrastructure: a Hidden Threat

Our work in cyber security and infrastructure illustrates that electronic systems permeate every aspect of modern life. This is especially evident in our critical infrastructure and the processes that surround it. The unfortunate reality is that the electronic systems that improve our business, communication and operating efficiencies also create vulnerabilities in our infrastructure.

Cyber threats continue to increase in number and sophistication, and the results of breaches can be wideranging in severity and impact. A cyber attack can have significant consequences on the financial and competitive health of an organization. Over the past 15 years, there has been a drastic increase in the number of successful cyber attacks against industrial control systems at power generation, petroleum production, nuclear energy, water treatment and other facilities. These intrusions have resulted in damage to and disruption of facilities. Examples include intentional discharge of millions of gallons of sewage, opening breaker switches, tampering with boiler controls, and shutdown of combustion turbine power plants.

### Understanding the controls

Operating more than a dozen transportation and commercial facilities, a large U.S. port authority wanted to understand what industrial control systems existed across the enterprise, and catalog key information. At each facility there are numerous systems providing a level of automation and control over building management, access control, intelligent transportation, HVAC, power and security systems.

We worked with the authority to create a full inventory of all systems and created a central repository of control system information for integration with existing asset management.

We developed a custom inventory schema and associated questionnaire from existing standards, such as the National Institute for Standards and Technology Asset Identification standard, existing client inventory efforts, and industry best practices. The inventory is designed to collect system-level and device-specific information. A key component of our approach is a custom data collection application for the inventory database. This not only provided a standardized entry form, but also has functionality that enables the user to mark questions for follow-up with the interviewee. This custom application allows for a streamlined and continuous follow-up for dozens of stakeholders across the enterprise and makes obsolete cumbersome email communications. We are now developing custom prioritization criteria to assign criticality to all industrial control systems across all facilities.

From building management to power generation, infrastructure is increasingly managed in the digital realm.

## <u>This keeps a</u> city running



### Cyber disruption planning

As part of a large U.S. city region's preparedness for catastrophic events, we helped create a multi-jurisdiction cyber attack coordination plan. With a director from each jurisdiction sitting on the executive committee for this regional entity, the project has been awarded a Regional Cyber Attack Coordination Planning Program grant.

Our team provided management, technical, and operational expertise, headed by the project executive committee and led by staff at the city mayor's Office of Emergency Preparedness. The project provided a wide range of deliverables including:

- A comprehensive inventory and prioritization of cyber assets for the participating jurisdictions;
- A capabilities assessment of critical cyber assets to absorb and respond to a large scale cyber disruption;
- A regional risk and vulnerability assessment of identified critical cyber assets;

- A resiliency plan with a complete step-by-step guide to developing and implementing a cyber disruption response capability within a jurisdiction;
- A regional catastrophic cyber disruption response annex detailing the creation of multidisciplinary cyber disruption teams;
- A Cyber Disruption Team Training Plan recommending training courses for each member of a Cyber Disruption Team;
- Jurisdictional Cyber Disruption Response Templates and Plans for each jurisdiction.

We also developed and conducted a series of six Homeland Security Exercise Evaluation Program compliant exercises to develop, refine, and test the cyber disruption response Annex with city and state emergency management, IT and law enforcement representatives. 70 AECOM

# Provide

### Economic development: Enabling sustainable growth

In the coming 15 years, \$90 trillion will be invested in infrastructure in the world's cities, agriculture and energy systems. This spending provides unprecedented opportunities to drive low-carbon growth that can bring multiple benefits to the world's population in the form of jobs, health, business productivity and quality of life. Our experts identify, plan for, implement and manage these plans and programs, making real the visions of economically strong and resilient communities while protecting investments.

### AECOM's Sustainable Systems Integration (SSIM)™ Model Measuring Sustainable Costs and Benefits

Drawing together the expertise of planners and environmental experts, SSIM provides a holistic approach to measuring environmental, social and economic sustainability.

Designed around the themes of energy, water, transportation, green building, ecology, carbon footprints and sociocultural factors, we developed this land-planning tool to measure the costs and benefits of different planning strategies. For example, in evaluating a number of alternative masterplans for new development, the SSIM makes it possible to measure components such as projected water consumption, energy use and greenhouse gas emissions and then identify the most sustainable plan option.

The tool can also be used to achieve higher performance infrastructure and building systems, and calculate their different costs and benefits. The overall result is a blueprint for new development ranging from the plan of streets and open spaces, along with the type and extent of public transport through the entire spectrum to the most detailed considerations of which light bulbs to use in street lights and the performance of plumbing fixtures. For each component of a masterplan, the SSIM provides a rational basis for deciding how masterplan forms, primary infrastructure systems, building designs and ecological footprint should be configured to optimize sustainability within given cost and budget frameworks.

### A sustainable extension for Tianjin

This masterplanning project for the Tanggu District New Town in Tianjin, China, used the SSIM land-planning tool to assess different options on route to creating a benchmark eco city. Total project calculations were provided for energy and water consumption, vehicle kilometers traveled and total greenhouse gas emissions generated. The results showed that up to 50 percent energy and water savings were possible depending on the acceptable cost impact. The project will help accommodate Tianjin's growing population.

### A new Smart City for Samsung

Just south of Samsung's semiconductor plant at the historic city of Xi'an, the technology and electronics company is developing the 500-hectare Samsung Smart City. The new town is located at the center of the new Hi-Tech Industries Development Zone in Xi'an's Gaoxin District. The extensive zone is being developed to house more than 2,100 high-tech companies.

Samsung and AECOM conceived this pilot project to set new standards in sustainable urban systems. Samsung Smart City is planned to be sustainable first, and smart second, Planners initiated a "Smart Plus" program to combine smart initiatives with sustainable goals: a smart framework plus sustainable development for economic innovation. environmental responsibility and social harmony: smart infrastructure plus highperformance systems, focusing on water, waste, transportation, energy and technology; and smart places plus liveable spaces to produce comfort, convenience, health, and safety.

To meet these goals, we adapted the Samsung Smart City Platform—which will be used in Xi'an and in future Samsung smart cities—from our SSIM tool. We customized a four-stage, sixteen-week process to guide our efforts.

In the first stage of the process, SSIM allowed comparisons between the Xi'an government's existing planning standards and an initial Samsung plan, showing, for example, better connectivity to pedestrian walkways and lower population density in the Samsung plan. In the second stage, SSIM was used to compare two new options that we designed for the new town. The process enabled all parties involved to review new town plans with design drawings and hard data.
Pictured Tianjin's increasingly busy Binhai International airport.

### <u>A growing</u> middle class



11.5 million people today. Urban since the 6<sup>th</sup> century. 19.0



### Low-carbon Future

SSIM appears again in land-scarce Singapore, where development that maximizes opportunities to spur continuous while sustainable growth ranks high on the nation's agenda. To meet these objectives, we are working on a range of projects to help secure a vibrant and resilient future for the country. As part of the goal to raise Singapore's international profile, we are working on an extension of the central business district at the Marina Bay/Greater Southern Waterfront area.

Our multidisciplinary team partnered with the Urban Redevelopment Authority of Singapore to provide a sustainable development framework and plan for Marina Bay and the adjacent Greater Southern Waterfront. Features of the long-term conceptual study include the addition of unique waterfront districts, incorporating a network of walk-able public space, a new reservoir for rainwater harvesting, a continuous 30km waterfront pathway for walking and cycling and an ecological corridor for people and wildlife.

SSIM was used on these developments to assemble and assess various development scenarios, to identify the optimal scheme for the project in terms of sustainability and cost.



### <u>A financial hub,</u> but also an ecological corridor

anne.

### Building Resilience for the San Francisco Bay Area

The San Francisco Bay Area is expecting significant housing and employment growth in the coming 30 years. Many areas of anticipated growth, particularly those along the bay shoreline, are at risk from earthquake-induced liquefaction and sea level rise. In the wake of a major disaster, homes in the region are likely to be seriously damaged and residents displaced.

Our recent work has included delineating the process for conducting vulnerability assessments and identifying adaptation strategies into a guidance document that the Association of Bay Area Governments (ABAG) and the U.S. Environmental Protection Agency (EPA) have shared with other communities in the Bay Area. This has created a model which other regions or communities could use to assess the vulnerability of their housing and residents and develop strategies to make development safer.

The long-range integrated transportation and land use/ housing strategy, called *Plan Bay Area*, provides a blueprint for how growth will be accommodated in the region. This plan is aimed at reducing greenhouse gas emissions from land use and transportation sectors by concentrating growth in core areas, and preserving natural resources and open space. Some 80 percent of new housing and 66 percent of new jobs are expected to be in locally designated Priority Development Areas.

To mainstream resilience to earthquake and sea level rise risks into regional/local land-use planning, decision-making and implementation, we worked with the EPA and ABAG under the Smart Growth Implementation Assistance Program. Our remit was to develop adaptation strategies addressing the vulnerability of new and existing development to sea level rise and earthquake hazards.

Using our assessment results, we developed more than 20 resilience strategies to help local jurisdictions reduce the vulnerability of new and existing residential development to earthquake-induced ground shaking and liquefaction, as well as to current and future flooding hazards. We considered existing policies, plans and programs in the Bay Area, as well as existing federal and state legislation, and designed strategies that would exceed these basic safety standards. Our goal was to create a new set of safe growth strategies that would

increase regional resilience and ensure that people could either remain in their homes, or return to their homes more quickly after disasters. We also designed the safe growth strategies to ensure that local development is affordable, transit-accessible, and beneficial to the economy and environment. ABAG and the San Francisco Bay Conservation and **Development Commission incorporated** these strategies into a manual to support action at the local level that will help the entire region become more resilient in the face of earthquakes and flooding.

In the final stage of the project, we compiled the process for conducting vulnerability assessments and identifying adaptation strategies into a guidance document. The strategies included those that could be implemented at various scales, such as local, regional or statewide. The class of strategies included changes to local plans, regulations and building codes; protection/creation of natural systems; and structural and infrastructure projects. The strategy descriptions included funding and implementation options. They also addressed potential synergies and conflicts between earthquake risk mitigation and sea level rise adaptation. The strategies are aligned with smart growth approaches and therefore will not encourage dispersed, low-density development or cause negative environmental impacts.

### <u>This is not</u> <u>San Francisco</u>

It's Berkeley, one of more than 100 separate cities that make up the larger San Francisco Bay Area. The Bay Area has provided fertile ground for AECOM to innovate its urban resiliency work. The area provides a unique laboratory and many distinct challenges in that it is a sprawling and diverse region with several large cities (San Francisco, San Jose and Oakland), a few medium ones (such as Berkeley) and many smaller ones, spread across nine counties. More of this kind of "city region" approach will ensure resiliency strategies are increasingly joined up and don't duplicate efforts.



**Berkeley** 

115,000 people today. Urban since the early 19<sup>th</sup> century.





Pictured A roadside sign warning flood risk in Efate, Vanuatu.

### Island Communities Managing their Futures

With their high levels of vulnerability to rising sea levels and other damaging effects of climate change, the Pacific island nations and territories were seeking help in assessing and managing future risks. We delivered technical analysis, ran a series of workshops and provided tools to assist local practitioners undertaking risk assessments and economic analysis. This work formed part of the Pacific-Australia Climate Change Science and Adaptation Planning Program supported by Australia Aid and managed by the Australian Government Department of the Environment.

While there is widespread concern about climate change across the islands and some work has been done, there are still significant gaps in understanding the likely timing, nature and extent of impacts and the types of effective adaptation actions available. Economic analysis of climate change impacts and adaptation options is particularly limited. The program assisted central agencies and decision-makers in making better informed development and investment decisions given competing priorities and constrained resources. Our work was focused on two areas - food security in the Solomon Islands and coastal infrastructure in Vanuatu. For the Solomon Islands, cost benefit analysis was used to manage climate impacts on food production in the Sepa and Loimuni communities in Choiseul Province where food security challenges are particularly severe. Meanwhile, in Vanuatu, there was growing concern that local communities in North Epi Island were becoming increasingly inaccessible by road following heavy rainfall and storm events. Recognition of this led to the need for an investigation into available options to improve road access. As part of this investigation, we objectively compared the merits of different options.

We conducted workshops that explored these case studies and showed how the assessment and analysis toolkit were applied. Along with the areas of food and infrastructure, the tools can be used to test vulnerability in a wide range of risks from human health and disaster management, to fresh water availability, agriculture, fisheries, forestry, marine ecosystems and tourism. Equipped with the right information, communities can plan better and even flourish in the face of climate change risks.

### R!SE to the Challenge with the United Nations

Promoting collaboration between the public and private sector to take leadership of disaster risk reduction, the United Nations has established the R!SE program. Founded by the U.N.'s Office for Disaster Risk Reduction (UNISDR) and PwC, R!SE aims to make all development investments risk sensitive and ensure that it contributes to building the resilience of local communities and the global economy as a whole.

AECOM has joined UNISDR and PwC to build a broad alliance in support of the program with others, including the Economist Intelligence Unit, Willis Insurance and Principles for Responsible Investment.

We are a partner organization leading one of six work streams that make up the initiative. Our stream focuses on supporting local business communities and government departments to increase disaster resilience in their municipalities and cities. We use a quantitative scorecard to measure city-level disaster preparedness and resilience and facilitate public and private sector engagement on disaster risk reduction, response planning and recovery.

A city resilience scorecard has already been piloted in about 20 cities globally and we have recently published a handbook on resilient business. We were a key player in the recent United States launch of R!SE and worked to further promote the collaboration at the third World Conference on Disaster Risk Reduction in Sendai, Japan.

### Partnering with IBM

Partnering with IBM, we have developed the Disaster Resilience Scorecard—a tool that helps cities assess and respond to the risks they face in potential natural or human disasters. Based on the UN's checklist called the 10 Essentials for Making Cities Resilient, it is the first tool to provide a single, holistic, cross-sector evaluation of any city's ability to adapt, respond and recover in the face of a disruptive event.

Combining AECOM's climate adaptation science and engineering data with IBM's big data and analytics capabilities, the scorecard reviews policy and planning, and the engineering, informational, organizational, financial, social and environmental aspects of disaster resilience.

The creation of this tool responds to the growing imperative for all cities to become resilient in the face of many types of threat. While mortality is down from disasters, capital losses are rising, largely due to increasing frequency of disasters and rapid urbanization. Responsible for about 80 percent of total investments in a city, the private sector has a significant stake in making sure cities are more resilient. Our goal was to facilitate public-private engagement so city stakeholders can respond to disasters together, rather than individually. AECOM's Dale Sands, Vice Chair of the Private Sector Advisory Group for the United Nations' International Strategy for Disaster Risk Reduction (UNISDR), spearheaded the collaboration with fellow advisory board colleague, IBM.

The scorecard project combined our strong architectural and engineering knowledge across a broad spectrum of sectors from water, energy, and transportation to land-use planning, ecology and economics.

Cities have already discovered the power of this tool to inform future plans and investments. It is in use in cities in Africa, Australia, India, Indonesia, the Philippines, Vietnam and the United States. Many more cities around the world are adopting it this year including in the countries of Portugal, Sweden, the U.K., Mexico, Brazil, Colombia, Jamaica, Jordan and Ghana. The UNISDR target is to have the scorecard in use in 500 city plans in the coming five years through R!SE and a variety of other initiatives.

### How it works

Because each system has different owners and stakeholders, resilience is a multi-organizational endeavour. The scorecard produces numerical and visual assessments for 81 areas of activity and demonstrates the connections and interactions between different systems and activities. Each of the criteria has a measurement scale of 0 to 5, whereby 5 is regarded as best practice. Data is compiled in a single overview that cities can use to establish a baseline, identify gaps, inconsistencies and weaknesses and set priorities for moving forward. It is custom fit to the local exposures and risks.

This systematic assessment increases economic investment potential by reducing exposure or vulnerability to natural disasters and communicates a clearer understanding of potential risk. The scorecard provides a basis around which to identify and engage the many organizations on which a city's resilience depends—ultimately saving lives, reducing losses to property, infrastructure and economic activity, and improving post-disaster recovery.

With the development of the Sendai Framework for Action (2015-2030) and subsequent acceptance by the U.N. General Convention, we will update the scorecard in connection with a revision to the U.N.'s Ten Essentials. With IBM, we are actively involved in the next generation "Ten Essentials" development.

## A scorecard for cities developed with the United Nations.

Pictured AECOM's Michael Nolan (pictured below left) and Ben Smith participated in the UNISDR Third World Conference on Disaster Risk Reduction in Sendai, Japan, March 2015.





The Disaster Resilience Scorecard is available at no cost through UNISDR, AECOM or IBM. IBM and AECOM are members of UNISDR's Private Sector Partnership and the Making Cities Resilient Steering Committee. For more information, see <u>UNISDR.org/campaign</u>

# 100 cities, 9 counties, 1 coastline.

# Thinking (and Planning) Regionally with multiple stakeholders across different sectors

The potential devastation and disruption caused by rising seas is leading many coastal authorities to focus on developing adaptation measures to keep their region mobile and their economy healthy long term. In the U.S., to support the San Francisco Bay Conservation and Development Commission's (BCDC) larger Adapting to Rising Tides project, we led two climate change pilot projects in Alameda County. The goals included increasing the preparedness and resilience of Bay Area communities to sea level rise and other climate change-related impacts. Our clients were the Metropolitan Transportation Commission, California Department of Transportation (Caltrans) District 4, Bay Area Rapid Transit and BCDC.

In one of only five pilots across the U.S., we tested the conceptual climate change risk assessment model developed by the Federal Highway Administration to assess climate change-related risks to transportation infrastructure. The lessons learned from this effort helped to inform the second wave of federally funded pilot studies. In addition, the first pilot garnered three prestigious climate change awards in 2012 from the American Planning Association, the Association of Environmental Professionals and Climate Change Business Journal.

The original pilot identified representative transportation assets at risk to sea level rise and storm surge. In the follow-on project, we conducted a more detailed vulnerability assessment for critical transportation assets in three focus areas in Alameda County, namely, the Bay Bridge Touchdown area, the Oakland Coliseum and the Hayward Shoreline areas. We developed inundation and overtopping maps for six sea level rise scenarios (ranging from 1-8 feet), which can also represent a range of sea level rise and extreme storm events. For example. a permanent one-foot sea level rise inundation already occurs temporarily on an annual basis during a king tide event. In addition, we looked at the combined impact of riverine flooding and coastal flooding around the Oakland Coliseum to really understand the worst case flooding that the area could expect. Based on the results

of the vulnerability assessment, we developed a suite of adaptation strategies addressing the physical, informational and governance-related vulnerabilities of the selected assets. Physical strategies include conceptual designs for living levees, which also provide valuable co-benefits of habitat and amenity and an offshore breakwater. Information strategies include guidelines for conducting a drainage study to address the joint issues of sea level rise and increased precipitation storm intensity for an area with complex drainage patterns and backwater flooding issues. Finally, the governance strategies include guidance on mainstreaming climate change considerations into transportation agency planning and processes.

The methodologies and framework are also being used to support a similar project for Caltrans in northern San Francisco Bay for Highway 37—the most low-lying and vulnerable state transportation route in the larger Bay Area, for the City of San Francisco shoreline and for the *Silicon Valley 2.0* regional adaptation project in Santa Clara County.



#### San Francisco Bay Area

7.7 million people today. GDP equivalent to Sweden.

### <u>The beating heart</u> <u>of the Internet</u>

AECON

The San Francisco Bay Area's 7.7 million people are spread across 100 cities and towns within nine counties, but they share one coastline. Many of the assets across the Bay Area city region are global; for example, the headquarters of many of the world's leading technology companies are clustered here, on low-lying land in close proximity to that single coastline. With this in mind, AECOM had developed *Silicon Valley 2.0*, a regional vulnerability assessment with an on-line decision support tool and regional climate adaptation guidebook to inform the area going forward.

### N

Datong 1.4 million people today. Urban since the 2<sup>nd</sup> century BCE.

# Once ranked the world's most polluted city

### Changing Perceptions and Framing a New Future with the Datong People's Government

Reviving and protecting ecological resilience at Wenying Lake, Datong, China, is helping to bring back to life its waters and natural habitats and restoring this place to its former beauty. During the past half century, the rapid processes of urbanization and industrialization of Datong, one the largest industrial cities in northern China, has depleted and degraded the local water resources and landscape. In some international surveys, the coal-belt city was rated among the most polluted in the world. Today, with progressively minded leaders at the helm, Datong is cleaning up its act.

To restore the ecosystem through meticulous planning and design, the three main challenges addressed were improving the quality of the water, landscape design and protection of the restored ecological system. Our work included transforming areas into various sized detention basins, rain gardens, retention ponds and wetlands, which are essential to stormwater management, flood control and stabilizing the overall ecological system. We also created sculpture gardens and a bird island serving as protected habitat.

Since opening, the Wenying Lake Park has become one of the important assets and public facilities in a city that has long been suffering from environmental problems. During construction, the bird sanctuary became a habitat for thousands of waterfowl, including hundreds of swans. Such ecological richness has not been seen for generations in this region. The work here has a strategically important solution that emphasizes ecological restoration and the embedding of green infrastructure before urban development; in the process, this burgeoning city has secured its reservoir, and gained an extremely valuable public space. For the city, the positive impacts are helping to change perceptions of the place and framing a future that is healthier, more sustainable and resilient.

Urban green space is infrastructure that expands a city's carboncarrying capacity, increases property values and lowers obesity levels. equit.

#### Pictured Facilitating a

resiliency workshop with stakeholders in Quito, the capital of Ecuador.

Client

VCT4 (15 MT

Municipio del Distrito Metropolitano de Quito

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CDMX 190años

#### Quito

2.7 million people today. Urban since the early 16<sup>th</sup> century.

#### Mexico City

9 million people today. Urban since the 13<sup>th</sup> century.

Till and

Notes on leadership and strategy from the Mexico City Perceptions Workshop.

Pictured

<sup>Client</sup> Gobierno de la Ciudad de México

# Liderazgo y Estrategia



### In Partnership Making Cities Fit for the 21st Century

Partnerships are fundamental to successful resiliency outcomes, whether within cities or between cities. AECOM is a natural partner with organizations that empower cities. One such initiative with the Rockfeller Foundation is taking off, reports <u>Claire</u> <u>Bonham-Carter, Director of Sustainable</u> <u>Development.</u> To help cities around the world confront the challenges of growing urban populations and to celebrate its centennial, the Rockefeller Foundation launched the 100 Resilient Cities (100RC) program in 2013. Sponsored by the Rockefeller Philanthropy Advisors, 100RC provides grant funding for the assignment of one chief resilience officer per city, and the assistance of a strategy partner to support the position in the development of a city resilience strategy. We are working as the strategy partner with 14 of the first 67 cities to be selected for the program.



Christchurch to Quito, San Francisco to Oakland, building resilient futures.

We are working as the strategy partner with 14 of the first 67 cities to be selected for the program. These include San Francisco, Berkeley, and Oakland in the U.S., together with Melbourne, Christchurch, Bangkok, Rome, Quito and Mexico City. We are working with teams of participants drawn from government, industry, non-government and community groups, and academic institutions. Our workshops are designed to build stakeholder engagement around resiliency, identify focus areas for the chief resilience officers, and acknowledge existing resilience work and achievements of the cities.

We have also worked with 100RC to develop an Excel-based tool to help the cities develop a high-level asset inventory, and to identify and quantify the shocks and stresses that a city may face. This tool is part of a suite of tools being offered to the cities within the 100RC network for use during the first phase of their strategy development process.



Above Workshop with Roma Capitale.

Right Right Conclusion of 100RC workshop with Bangkok Metropolitan Administration.

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9 million people today. Urban since 15th century.



Pictured 100RC Perceptions Workshop with the City and County of San Francisco.

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Pictured The new 11th Street Bridge connecting the cities of Washington, DC and Alexandria, which AECOM oversaw as a design-build contract

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<sup>Client</sup> District of Columbia Department of Transportation Washington, D.C.

660,000 people today. Urban since the late 18<sup>th</sup> century.

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### Resilient Infrastructure Assessing the Challenges

As we become a more urban planet, the impacts of disasters and climate change will be felt even more acutely on our infrastructure. It means the time for resilient infrastructure is now, says <u>Vahid Ownjazayeri, Global Chief</u> <u>Executive, Civil Infrastructure</u>. Travelling regularly through many of the world's major cities, it's easy to see that many urban infrastructure systems are operating at sub-standard and, at times, unacceptable or unsafe levels of service. Local and federal governments are hard pressed to commit required funding, estimated at several trillions of U.S. dollars currently, thereby ensuring that further degradation will occur.

This essential under-investment dilemma is being exacerbated significantly by two interrelated demographic considerations and trends between now and 2050: more people in bigger cities.

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Pictured New York's Second Avenue Subway will relieve congestion on existing lines by creating a new 8.5-mile train line with 16 stations serving culturally diverse neighborhoods with historic business, institutional and major tourist attractions.

<sup>client</sup> Metropolitan Transportation Authority, New York City Transit

New York

8.5 million people today. Urban since the early 16<sup>th</sup> century.

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Consider some of the numbers: the forecast of global population growth from 7.5 billion to almost 9.5 billion people, and the urbanization trend where people living in urban centers will grow from 51% now to nearly 65% of the world's population—an increase of 60 million people a year in the world's cities.

### What today's disasters mean

Over the past few years we have all witnessed the catastrophic impacts of natural disasters on numerous countries and cities in the developed as well as the developing parts of the world: Superstorm Sandy in New York City, floods in Europe, China, and the Midwest region of the United States, earthquakes in Latin America and Asia and other such events that have resulted in the loss of life, loss of homes and hundreds of billions of U.S. dollars of reconstruction and repair. Various scientific reports and predictions show that the impact of climate change, rising sea levels and other factors will create more significant occurrences of natural disasters globally thereby impacting current and future build scenarios. The United Nations Secretary General, Ban Ki-moon stated recently, "Climate change is affecting the weather everywhere. It makes it more extreme and disturbs patterns. That means more disasters; more uncertainty."

We have seen how adverse impacts to the infrastructure systems of our cities and countries can have direct impacts on the quality of life of our citizens as well as economic growth and viability of all of our countries and cities. All of these factors clearly indicate that action must be taken to harden infrastructure systems, develop plans and strategies for readiness in anticipation of the recurrence of such events, and invest in solutions to improve and make our transportation, water/wastewater, telecom and energy networks and systems resilient in order to handle the needs of the future and be ready for the unknown events that may occur.

## 60 million people a year are becoming urbanized.

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#### Pictured

40 million people a year pass through Stratford, in East London, which was once one of Western Europe's most deprived areas. A reinvigorated Stratford High Street and the Queen Elizabeth Olympic Park are making this a vibrant commercial anchor in London's longterm development.

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client London Borough of Newham, Thames Gateway Development Corporation

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8.5 million people today. Urban since the 1st century. H H H H

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### The Long View Best of Both Worlds

While there is wisdom in investing in the future, we all like to enjoy an improving quality of life now; and it is possible to have the best of both worlds, says Jason Prior, Global Chief Executive, Buildings + Places. It's useful always to remember that what is good for communities is good for towns and cities too. There are times when we become so focused on our technical prowess and success at solving today's multitude of daily challenges from the effects of climate change to cyber or terrorist attack, that for a moment, it may slip our minds about who this effort serves.

Communities are at the heart of the case for making cities resilient. To thrive and prosper, people need to feel that they are safe and secure, that they can put down roots, invest their time, effort and skills and build a future. Pictured Weishan Wetland Park restores ecosystems that had been impacted by China's South-North Water Diversion Project. Today, residents from nearby cities share this rebalanced piece of the Chinese hinterland, with nature. <sup>Client</sup> Weishan Wetland Investment Company

<u>Weishan</u>

630,000 people today. Urban since the 10<sup>th</sup> century BCE. 120.00.00

At the same time, cities need to encourage inward investment from business and other entities that want to join the dynamic networks of commerce and exchange that cities offer. Shock and upheaval are the enemies of a city's well-being and long-term prosperity.

### Looking to the future and living better now

Safe and robust cities, those that can anticipate and avoid or deal with risk, will continue to have a strong attraction and energy. Of course, every urban area will be facing its own particular set of challenges for the future, but as we weigh and balance the various possibilities of what may happen, it's crucial also to think about how we want to live now. How do we want our working lives to improve, our transportation systems, our water, energy, waste systems? And then there's public space, healthcare. education and more.

Each one of us can see the potential for making things better and we are hungry for improvements all the time. So the approach to making cities resilient needs to be woven into every project, and into the very fabric of the place whether it is a repair, a replacement, a retrofit, a renovation, redevelopment or new build. The opportunities are always there, but it requires a fresh cast of mind to see and seize them.

### Invest to save

Because risk is present and its timing uncertain, our view is that investment in resilience should look to the future and deliver tangible benefits now. While work is underway on longterm durability and security, we need some early rewards. New developments and renovated neighborhoods can incorporate green infrastructure to help manage flood while also creating

# Resilience in every project and every place.

a new park, and improvements to energy systems can build in the potential for reducing vulnerability to widespread outages while also improving service and reducing costs to consumers. We know that spending to build in resilience is a great deal more cost effective than repairing the damage of unprotected places.

There will be tough choices for urban authorities and utility providers in where and when and how much to spend. Again, communities can play a role in helping to decide, and if they can see early benefits, engagement and support will be powerful.

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10-11: Kam Yuen Weng and Stefano Pampanin. "General Building Performance in the Christchurch CBD: a Contextual Report," prepared for the New Zealand Department of Building and Housing (DBH). Christchurch: University of Canterbury, November 2011; and Anderson, Charles. "Christchurch: After the Earthquake, a City Rebuilt in Whose Image?" *The Guardian*, January 27, 2014.

12-13: Firat Kayakiran, Onur Antand and Ercan Ersoy, "Turkey's 10-Hour Blackout Shows Threat to World Power Grids." *BloombergBusiness*, April 2, 2015.

14-15: U.S. Patent and Trademark Office, Patent Technology Monitoring Team. "Patenting in technology classes, breakout by origin: U.S. Metropolitan and micropolitan areas." Average of 2000-2013 of utility patent grants as distributed by calendar year of grant with patent counts based on the primary patent classification. Combination of San Jose-Sunnyvale-Santa Clara (California) Metropolitan Statistical Area and San Francisco-Oakland-Fremont (California) Metropolitan Statistical Area; and fDI Intelligence and *The Financial Times*, "American Cities of the Future 2013-14" report.

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