RESILIENCY ROUNDTABLE

re·sil·ience
rəˈzilyəns/
noun

1. the ability of a substance or object to spring back into shape; elasticity.
2. the capacity to recover quickly from difficulties; toughness.

FEATURES

We approached six experts—a designer and urban planner at ***Perkins+Will***, ***Berkeley*** professor, resiliency director at ***ARUP***, ***San Francisco Foundation*** program director, ***AECOM*** senior VP, and the founder of ***The Resilient Design Institute***—and asked them an urgent question:

"What critical resilient designs must the built environment adopt now, and what are the best solutions for implementing those designs?"

The next 16 pages hold their warranted concerns, their savvy solutions, and their compelling insights—which could be the key to saving our buildings, our people, and our planet from the perils of natural disasters and climate change.

—*Amanda Koellner, managing editor*

KRISTEN HALL

"Instead of allowing ourselves to be overwhelmed, designers can help cities, stakeholders, and developers get creative about the benefits that a major investment in our water's edge can bring. As keepers of the vision of what cities can become, designers also have an opportunity to help move the public conversation away from doom and gloom, and refocus on the possibilities for positive change."

Kristen Hall is an urban designer and planner who specializes in complex urban infill projects. She has led the urban design of several high profile projects in San Francisco, including Mission Rock and Central Subway Chinatown Station. Through her experience both locally and internationally she has worked across many different scales and contexts to design masterplans, write guidelines, coordinate public outreach, and create implementation strategies. Kristen's core area of expertise is delivering projects that require innovation, interdisciplinary collaboration, and stakeholder engagement.

URBAN DESIGNER AND PLANNER
PERKINS+WILL

PHOTO: COURTESY OF PERKINS+WILL

The difficult first task of planning for resilience is to get your head around the challenges before you can begin to think about design solutions to address them. The most advanced cities are still working on understanding and interpreting what climate science is projecting for their region, mapping the impacts, and working out their vulnerabilities.

I live and work in San Francisco, where we face the ongoing and fairly well understood threat of earthquakes and the slow-moving threat of sea level rise. We are lucky that we don't have immediate and new challenges such as hurricanes and superstorms, but it does make it difficult to mobilize people to action when sea level rise seems like an abstract disaster that will happen far off in the future. However, if we want to protect our communities, we would be wise to begin to mobilize resources in the very near future to start building our way out of it.

Upon identifying and understanding your region's vulnerabilities, you are now faced with a dilemma of how to respond. When looking at a site-scale intervention, you must assess the state of preparedness at the city level and ask the question: do you wait for the city to come up with a solution, or do you solve the problem on your own site? There are strategies that can be pursued independently at the site-scale, such as physically elevating a site out of the rising floodplain. Many developers—now facing newly revised **FEMA** Floodplain maps—are looking to this approach, but it is a solution that comes with its own challenges. Because many cities are still working out how to address their own vulnerabilities, there is no clear plan for how to integrate an elevated site into a larger system of lower-lying streets and open spaces. Furthermore, you run the risk of investing in infrastructure that will become redundant or obsolete in the context of a broader, citywide approach to resilience.

Zooming out, we see the same challenges of coordination at the city scale. As a city, what if you plan to address your own vulnerabilities and your neighboring cities do not? Water knows no jurisdictional boundaries, and watersheds are often a multi-city affair, bringing even more stakeholders and more complexity to the table. Planning for resiliency is complicated by the fact that most cities struggle to provide adequate housing and maintain aging infrastructure, never mind provide solutions to an abstract, undefined challenge that is still 35 years down the road.

Designers can be instrumental in identifying the scale of the problem and working across agencies to come to an implementable solution. Thoughtful design is critical at a time when limited public funds are available. Cities can no longer afford large infrastructure projects with a single focus. A levee can no longer just stop the water; it must also create a public benefit by contributing a wonderful park and be financially linked to value generation of the adjacent land that benefits from this amenity. Instead of allowing ourselves to be overwhelmed, designers can help cities, stakeholders, and developers get creative about the benefits that a major investment in our water's edge can bring.

As keepers of the vision of what cities can become, designers also have an opportunity to help move the public conversation away from doom and gloom, and refocus on the possibilities for positive change. For example, the San Francisco Bay Area is a region that links its identity to the water—and yet, there are so few places to enjoy being by the bay, to go to the edge and actually touch the water. In the near future, the region will be spending a phenomenal amount of time, energy, and resources on adapting the water's edge, and we can use this opportunity to start a wonderful, exciting conversation about how this investment can not only adapt the waterfront for sea level rise, but also reinvigorate our community while enhancing our access and enjoyment of our Bay and waterways.

Hall's Resiliency Top 3:

1. **RDoC:**
   Developed by **Perkins+Will** in conjunction with **Degenkolb Engineers**, **Mazzetti Engineers**, **Public Architecture**, and **Alliance Health of San Francisco**, RDoC is a concept for a rapidly deployable health clinic that can be used as a replacement venue for critically ambulatory health services in the aftermath of a seismic or severe weather event.

2. **San Mateo Wastewater Treatment Plant (pictured on p. 59):**
   Perkins+Will developed a design competition submission to transform an unknown, inaccessible, undesirable municipal facility into a welcoming community asset. The goal of the design was to have the plant double as an educational Resource Recovery Center and use wastewater to generate clean energy while recovering nutrients and potable water from it—simultaneously collecting and reusing rainwater and recharging an adjacent creek with freshwater.

3. **Mission Rock (pictured on p. 58):**
   This 28-acre mixed-use district designed by Perkins+Will features 1,500 new rental homes, along with office, dining, and retail space to replace a parking lot near the **Giants**' stadium in San Francisco. It's instituting a "working waterfront" street to invite local manufacturers and makers to bring their production activities to the shore.

3 The Perkins+Will design for Mission Rock includes 8 acres of public open space including a 5-acre park with a shoreline walkway.

2 At the San Mateo Wastewater Treatment Plant, the design of the landscape provides storage for water at varying levels of flood conditions while maintaining pedestrian access through raised paths and bridges.

RENDERINGS COURTESY OF STEELBLUE/PERKINS+WILL, SAN FRANCISCO GIANTS; COURTESY OF PERKINS+WILL (TOP RIGHT)

DALE SANDS

SENIOR VP AND GLOBAL DIRECTOR, METRO REGIONS AND CLIMATE ADAPTATION SERVICES
AECOM

Dale Sands is global director, Metro Regions and Climate Adaptation Services for **AECOM**'s flagship environmental business. Sands, with experience in 65+ countries, completed service as vice chairman of the **United Nations' Private Sector Advisory Group** for the UNISDR (2013 to 2015), and was a board member from 2011 to 2015.

Resilience is increasingly important to incorporate into infrastructure design and construction. The United States had 212 disasters from natural events between 2005 and 2014, second only to China with 286 events. The capital losses from the US disasters were, by far, the highest in the world. The dollar losses approached $500B.

Making resilience a priority in the design of our infrastructure assets is gaining importance. While definitions of resilience vary, there is growing acceptance that human settlements must withstand, recover from, and continue to prosper in the context of increasing impacts from acute shocks and chronic stresses. Today, 50% of the population resides within cities, but it is projected to increase to 70% by 2050. This necessitates creating a more resilient infrastructure for society.

To achieve improved infrastructure resilience, it is important that building codes be reviewed and updated to reflect the conditions in which facilities are expected not only to survive but also to maintain their functions. In the aftermath of damaging events, the concept of "building back better" is extremely important because it sets a resilience pathway for the future.

Conditions have changed in the past 35 years with a significant increase in disasters of all types: geophysical (earthquakes, tsunamis, volcanic activity), hydrological (floods, landslides, subsidence), meteorological (blizzards, severe/tropical storms), and climate-related events such as extreme temperatures, wildfires, and droughts. These events are likely to continue to increase into the foreseeable future. In 2015, the reinsurance company **Munich Re** reported 1,060 natural disaster events compared to less than 400 events in 1980.

In this context, the importance of building codes for both new construction and repair/retrofit has never been more crucial. They can be an important part of the solution. And this is not just for economic viability; it is also critical for community safety. Given the increasing hazard events in the US and worldwide, our building codes must be visionary, robust, even cutting edge.

New building codes, with better standards as a minimum, must be developed and enforced. If infrastructure is going to be rebuilt in impacted locations, it must be built back better. Infrastructure projects must be constructed for resilience tomorrow, the next day, and for years out. Without robust building codes, every project plan should be evaluated for its resilience.

"The United States had 212 disasters from natural events between 2005 and 2014, second only to China with 286 events. The capital losses from the US disasters were, by far, the highest in the world. The dollar losses approached $500B."

Sands' Resiliency Top 3:

1. **San Francisco Public Utilities Commission (SFPUC):**
SFPUC is implementing a multi-billion-dollar investment in the city to upgrade its wastewater infrastructure in response to climate change, as well as to improve service. **AECOM** played a key role on the **Mayor's Sea Level Rise Committee**, developing storm surge inundation maps that are now the recommended standard for all sea level rise planning within the city and county.

2. **Australian Department of Defence (Defence):**
AECOM was commissioned by the **Australian Department of Defence** to define the potential risks to assets as a result of climate change. AECOM performed detailed modeling of coastal erosion and flooding from storm surge and extreme rainfall and also supported Defence's internal engagement by developing site-based visual summary sheets and animations for use in stakeholder workshops and internal branch briefings.

3. **Adapting to Climate Change Application (ACCA):**
This tool from AECOM helps to understand risk and increasing resilience and was created to identify potential future impacts of climate change on assets and operations and find ways of effectively responding and adapting to these impacts. **ACCA** has been used to carry out analysis on buildings, transportation, water, energy, and environmental projects. AECOM, in partnership with **IBM**, developed the **Disaster Risk Reduction Scorecard** in 2014 based upon the **UN**'s **Ten Essentials for Disaster Risk Reduction**. The Scorecard received the **ND GAIN 2015 Prize**. AECOM is working with **CDP** (formerly **Carbon Disclosure Project**) to develop a strategic approach for cities and companies regarding climate change. Further AECOM developed **Sustainable Systems Integration Model (SSIM)** to provide a holistic approach to measuring environmental, social and economic sustainability.

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.

PHOTOS: COURTESY OF AECOM (FACING PAGE); DAVID LLOYD

ALEX WILSON

"One of the most important priorities of resilient design is to provide for 'passive survivability,' which the Resilient Design Institute defines as ensuring that livable conditions will be maintained in a building that loses power."

PHOTO: COURTESY OF THE RESILIENT DESIGN INSTITUTE

FOUNDER
RESILIENT DESIGN INSTITUTE

Alex Wilson is president of the **Resilient Design Institute**. He is also founder of **BuildingGreen**, a 15-person, Brattleboro, Vermont company that has been publishing information and consulting on green building practices since 1985.

The priorities for resilient design are pretty clear. First, buildings should be sited and designed to achieve a reasonable level of protection from expected disturbances and interruptions, including those from climate change; and second, buildings should retain a reasonable level of functionality and keep occupants safe should they lose power for an extended period of time. In general, we know a lot about how to achieve the former, but we have barely begun to think about the latter.

Loss of power is a common secondary impact of many—if not most—natural disasters. Hurricanes, tornadoes, floods, wildfire, earthquakes, tsunamis, landslides, ice storms, heat waves, and drought can all result in power interruptions. Outages can also be expected with terrorist events, including cyber-terrorism, and can result from human error and equipment failures. One of the most important priorities of resilient design is to provide for "passive survivability," which the **Resilient Design Institute** defines as ensuring that livable conditions will be maintained in a building that loses power.

A big part of designing a building to achieve passive survivability has to do with the building envelope. A highly insulated building envelope will maintain livable conditions inside far better than a poorly insulated envelope. Overall building de-

PHOTO: ANTON GRASSL

Wilson's Resiliency Top 3:

1. **The Spaulding Rehabilitation Hospital (pictured here):** This was being planned when **Hurricane Katrina** hit New Orleans in 2005, and some hospital patients there were unable to be evacuated due to the flood. In some situations, hospital staff had to use furniture to break windows in patient rooms because temperatures had risen as high as 110°F without air conditioning. Perkins + Will, the designer of Boston's Spaulding Rehab, took that to heart and created what is probably the nation's first modern hospital with operable windows in all patient rooms. The hospital is filled with other resilience features, including elevated mechanical equipment, a fully floodable first floor, and two back-up generators, either of which could operate the building on stored fuel for weeks.

Wilson's Resiliency Top 3 (continued):

2. **The Brock Environmental Center of the Chesapeake Bay Foundation (pictured right):**
This is a remarkable building. Designed to withstand hurricane-force winds and storm surges that will become increasingly common at this site on the Chesapeake Bay, it is so well insulated that the solar and wind systems provide more than 100% of its energy needs. It also uses only water that is collected onsite; this rainwater harvesting and treatment system will keep operating even if the municipal water system fails. The building is one of a handful nationwide that is certified by the **Living Building Challenge**.

3. **Alain Hamel's home in Northern Quebec**
This homebuilder, who has been constructing **LEED**-certified homes in the Saguenay region for 7 years and was previously doing general construction in the Montreal region since 1985, may own the most resilient home in North America. It is only 100 feet from a lake but is 75 feet above the water level and boasts extraordinary insulation levels (R-80 walls and R-150 roof), solar-powered back-up electricity, a 3.3 kW gas generator, and a host of other resilience features.

sign, including orientation, passive solar design, inclusion of thermal mass, cooling-load-avoidance measures, and natural ventilation are also key aspects of such design.

Emergency power plays an important role in passive survivability. Back-up generators, solar-electric systems with battery storage (or specialized inverters that allow utilization of solar power even during outages), and microgrids that serve a group of buildings can all serve this need.

Access to potable water can also be a challenge during an extended power outage. In buildings that aren't served by municipal water, electric pumps are usually required to deliver water; in taller buildings served by municipal water systems, pumps are usually required to elevate that water to upper floors. Hand pumps and back-up power can serve these needs, respectively.

All of these aspects of resilient design are addressed in a new suite of LEED pilot credits on resilient design (credits 98, 99, and 100 in the LEED credit library). For projects going for LEED certification, this is a useful starting point.

The Brock Environmental Center of the Chesapeake Bay Foundation, pictured here and on our cover, produces 83% more energy than it uses. It is also the first commercial building in the continental U.S. permitted to capture and treat rainfall for use as drinking water.

PHOTOS: DAVE CHANCE PHOTOGRAPHY

KRISTINA HILL

"If cities wait, they'll be in triage mode and will have to abandon districts that can't afford to adapt using local funds."

Kristina Hill is an associate professor at the University of California, Berkeley, where she studies international strategies for adapting urban infrastructure and coastal districts to sea level rise. She has worked on urban water systems in the Pacific Northwest, New Orleans, the Mid-Atlantic and New England coasts. Her current focus is on the San Francisco Bay region, where unique opportunities exist to bring new housing strategies into a dynamic metropolitan landscape of wetlands, sand dunes, and beaches.

ASSOCIATE PROFESSOR OF LANDSCAPE ARCHITECTURE AND ENVIRONMENTAL PLANNING AND URBAN DESIGN
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Flooding is and will be our most significant urban adaptation challenge. Recent scientific estimates of future sea level rise predict 4-6 feet by 2100, rising rapidly after that. Some experts think a better estimate would be 6-9 feet by 2060. Groundwater levels will also rise, on top of sea levels, causing extensive freshwater flooding in coastal cities that may well double the area that floods by salt water. In addition, rainfall intensity has already increased and will continue to get worse. If cities wait, they'll be in triage mode and will have to abandon districts that can't afford to adapt using local funds. "Abandonment" is another word for economic and environmental disaster—when it happens in under-funded cities, it will leave behind underground infrastructure, building ruins, and soil contamination.

The most important new urban designs are those for floodable development, examples of which already exist in Europe. We could build a multi-functional version in North America, turning new housing investments into a hybrid infrastructure that protects existing neighborhoods and infrastructure systems. Low-rise or mid-rise housing can be built on pile foundations in areas that will be permanently flooded as a result of rising groundwater or salt/brackish water. The housing can be built in artificially excavated ponds surrounded by open water on three sides, with access on the fourth side to an earthen levee with a road on top and infrastructure hook-ups. These ponds would form a honeycomb pattern in a floodable area, functioning as a "micro-polder" that is able to absorb several feet of additional water from temporary flood events that otherwise would damage surrounding areas. These "micro-polders" could be protected from waves and debris by a perimeter system of larger storm-protection levees. By building this new kind of urban district with "wet feet," we can provide critical protection for existing urban districts.

Cities can implement this by creating a legal entity like a public development authority to prepare the ground. This authority would excavate the ground to build the levees, build roads on top, and supply the new floodable housing with electricity, water and other public services. Development fees from the new housing would be used to help pay for this infrastructure, and for other amenities such as artificial beaches and wetlands that add recreation and habitat value to the floodable district. Cities with flooding shores would be able to accommodate increased density while reinvesting in a resilient new system of stormwater infrastructure.

Hill's Resiliency Top 3:

1. **The Sand Engine (Zandmotor), near The Hague in The Netherlands:**
This is an example of an artificial landform, a sand spit made of dredge material, that was placed in a design-build operation to nourish the coast around it by utilizing the energy of waves to move the sand along the coastline and widen the surrounding beaches. It has produced recreational value, habitat value, and storm protection value, all in one project design that is less expensive than traditional beach nourishment.

2. **LEAP for San Francisco Bay (pictured right):**
A set of unbuilt landscape-based proposals that expand on the Sand Engine concept with other forms, this was illustrated and developed by a young designer based on ideas from my work and many experts he has spoken with around the Bay.

3. **European versions of floodable development: (A.) Nesselande housing, Rotterdam, The Netherlands; (B.) the site preparation for the HafenCity District, Hamburg, Germany; (C.) Backenhafen Water Houses (Studio Gang design), HafenCity District, Hamburg, Germany;:**
All three of these projects provide examples of floodable development—in (A.) it's housing on pile foundations in a high-water table environment; in (B.) it's a whole urban district built on mounded earth, with hardened or waterproofed first stories for the buildings; and in (C.) it's mid-rise buildings on pile foundations standing in the water of a canal.

PHOTOS: MARCUS HANSCHEN (TOP RIGHT); NATE KAUFFMAN (BOTTOM RIGHT)

FRANCESCA VIETOR

PHOTO: KATHI O'LEARY

PRESIDENT OF THE SAN FRANCISCO PUBLIC UTILITIES COMMISSION AND PROGRAM DIRECTOR FOR THE ENVIRONMENT, PUBLIC POLICY AND CIVIC ENGAGEMENT
THE SAN FRANCISCO FOUNDATION

Francesca Vietor, program director for Environment, Public Policy, and Civic Engagement at The San Francisco Foundation and president of the San Francisco Public Utilities Commission, is working to build climate resilience in the Bay Area's most vulnerable communities and to tackle the region's economic inequality and wealth disparity. Before this, she was executive director of the Chez Panisse Foundation, president of the Urban Forest Council, president of the Commission on the Environment, and the chair of Mayor Newsom's Environmental Transition Team. She has worked for several non-profits, including Rainforest Action Network and Greenpeace, and she serves on the boards of SPUR and Environmental Working Group.

Nowhere are the twin threats of affordability and climate change more pronounced than in San Francisco. One-bedroom apartments now rent for $3,500 a month or more, and residents are leaving the city in droves to find more affordable housing in the suburbs. Thousands of shoreline homes, businesses, and pieces of infrastructure are threatened by the rising tides of the Bay. When you add on the fact that California has more than a 99% chance of having a 6.7 or larger earthquake in the next 30 years, the drive to design for resilience becomes an imperative.

San Francisco's last major earthquake was in 1989. The "Loma Prieta" quake was a 6.9 in magnitude, and the shock was responsible for 63 deaths and 3,757 injuries. While the collapse of a section of the **Nimitz Freeway** in Oakland was responsible for the single largest number of casualties, the collapse of other man-made structures contributed to the economic and life loss as well. Another major earthquake in the Bay Area could cut off water supplies, disrupt energy, and cause untold damage to the 101 cities in the region.

Then there is climate change. We know from climate disasters like Hurricanes Sandy and Katrina that climate change acts as a threat multiplier for the poorest and most vulnerable communities. The nation wept as people in low-income neighborhoods in New Orleans and New York were flooded from their homes, cut off from fresh water supplies, left without power and abandoned by government. Many of these same communities even had raw sewage flowing in their streets—thanks to the legacy of waste treatment plants built in poor communities.

Lucky for us, San Francisco is the "city that knows how." We are winning the race against time in preparing our frontline communities for the impacts of climate change and earthquakes by building resilient energy, water, and wastewater systems. San Francisco's $4.8 billion **Water System Improvement Program** is nearing completion, and our $6.9 billion **Sewer System Improvement Program** is getting ready to launch. Pioneering programs like community choice power, green infrastructure, and wastewater reuse are coming online at rapid pace. The combination of these large scale infrastructure projects and innovative, performance-based technologies will create thousands of jobs, help protect our most vulnerable communities, and build resiliency system-wide.

PHOTOS: COURTESY OF SFPUC

Vietor's Resiliency Top 3:

1. **Community Choice Power:**
Community Choice energy is a way to reduce greenhouse gas emissions and address the impact of climate change by cutting energy consumption, increasing renewable energy, and building local clean electricity generation. By developing local clean energy resources, Community Choice programs can spur local economic development in the community, provide good local clean energy jobs, offer competitive electric utility bills and price stability, reduce pollution, and provide other community benefits. It can serve as a significant step towards a more resilient and sustainable economy. San Francisco's **CleanPowerSF** launched on May 1, 2016, and offers residents the opportunity to support a greener more resilient city.

2. **Green Infrastructure (pictured left):**
Green infrastructure enhances resilience in the built environment. Natural and constructed infrastructure, ranging from conserved riparian buffers to rain gardens and permeable pavers can help enhance stormwater management capabilities in ways that reduce vulnerabilities to flooding. In an urban environment, green spaces mitigate the urban heat island effect by providing shade. Natural features provide habitats for animals in urban and rural areas. Green infrastructure helps build climate resilience by managing stormwater that may otherwise flood communities. San Francisco has eight green infrastructure projects currently under construction with many more in the planning phases.

3. **Wastewater Reuse:**
The Living Machine at the San Francisco Public Utilities Commission headquarters not only treats the building's wastewater onsite but also seamlessly integrates into the building's lobby, front walkway, and city sidewalk. After collection and primary treatment, all wastewater flows into the Living Machine's tidal and vertical flow cells, where its fill-and-drain technology treats the water through periodic tidal cycling. The effluent is then double filtered and disinfected with both light and chlorine. The high-quality, clear water from the system will then be reused both inside the building for toilet flushing as well as exterior irrigation. The innovative model builds resilience by removing wastewater from the overall system and producing water for reuse. The SFPUC will save approximately 750,000 gallons of water per year and provide an additional 900,000 for non-potable uses off site.

LISA DICKSON

AMERICAS DIRECTOR OF RESILIENCE
ARUP

Lisa Dickson is an associate principal in **Arup**'s Boston office with expertise in translating the risk of climate change into resilient solutions within the built, social, public health and natural environments, including economic considerations. She was a contributor to the **World Resource Institute**'s **2010 Public Sector GHG Protocol** and aided in the development of the **Institute for Sustainable Infrastructure's (ISI)** project rating system. In 2010, she was invited to Shanghai to comment on China's 12th 5-Year Plan and present on the use of carbon markets to drive investment within the transportation sector.

It can sometimes be overwhelming to know where to start and how to translate the uncertainty of climate change into actual design criteria. At Arup, we approach this by breaking it into three steps: establishing the climate baseline, prioritizing risk, and then focusing on adaptation. Climate baselines are shifting, making the modeling process more challenging than it has ever been before. At Arup, we work closely with climate scientists to develop responses that are both robust and implementable.

Once we have determined what the climate is going to look like in 20 to 50 years in a geographical area, we work with the client to understand what the critical resources are and overlay the expected climate change impacts on these resources. The overall vulnerability is determined based on a combination of exposure, sensitivity, and adaptive capacity. Exposure is the extent of the climate impact (for example, depth of flooding, number of heat waves, etc.). Sensitivity is an assessment of how well the asset would function with this exposure. And adaptive capacity speaks to whether or not there is redundancy in the system.

Once we finish those evaluations, we subject the more vulnerable resources to the next step: the risk assessment. The risk assessment examines aspects of probability and consequence. What's the probability of failure; what's the consequence of failure? And that's what tells you the overall risk. In many cases, human health and safety and continuity of services are the primary things we consider when thinking about the consequences of failure for a particular resource or entity.

Consequence also lets us prioritize needs. For example, in comparing vulnerability, it might be that both a bike pathway and a substation are found to be equally vulnerable. However, in comparing overall criticality, it is more likely that there would be a higher consequence if the substation were to fail than the bike path? The substation then becomes more of a priority and area of focus than the bike path.

While we are highlighting the built environment here, we also analyze the natural and social environments, with a particular emphasis on vulnerable populations and public health. At the end of this assessment, we take the list of resources that have been identified as having the highest probability and consequence of failure and use that group as the focus for the last step: climate adaptation and preparation. **gb&d**

PHOTOS/RENDERINGS: FRANK MONKIEWICZ (FACING PAGE); COURTESY OF ARUP

Dickson's Resiliency Top 3:

1. **NY Rising Community Reconstruction Program (pictured above):** In this community-based, comprehensive planning process, Arup acted as the project manager and served as the technical liaison between the **Governor's Office of Storm Recovery** and affected community members over a nine-month process that resulted in five community reconstruction plans with recommendations in the areas of infrastructure, housing, economic development, natural and cultural resources, and community planning and capacity building. The resulting detailed list of projects is currently under proposal for federal funding.
2. **Partners HealthCare:** Arup is also conducting climate risk assessments across 30 of Partners' healthcare facilities, including hospitals, community health centers, clinics, and research-based laboratories—performing assessments that involve the development of climate scenarios for sea level rise, storm surge, precipitation, temperature, and wind. Vulnerability assessments will determine the most at-risk operations within each campus.
3. **NYC Office of Housing Recovery Operations:** Through extensive design analysis of 15 building typologies, Arup is helping assist flood-prone property owners rebuild better, stronger, and more resilient housing. Arup was hired to assist the **NYC Mayor's Office of Housing Recovery Operations (HRO)**—which assists property owners as they rebuild housing—to provide support and identify issues and challenges associated with rebuilding and retrofitting properties to withstand flood events.