Infrastructure

MIAMI BEACH HAS MADE A COURAGEOUS START to combat sunny-day flooding and stormwater through its existing stormwater management program. The city should be commended for its timely action, investment in physical infrastructure, identification of self-funding sources for physical infrastructure to address flooding, decision to include sea-level rise and increased precipitation in planning, and close collaboration with the Southeast Florida Regional Climate Compact and the regional participants in the 100 Resilient Cities initiative.

However, Miami Beach is significantly at risk, so more infrastructural advancement and investment are necessary. The city is vulnerable to three distinct sources of flooding:

- Coastal flooding including king tides;
- Flooding caused by rainfall; and
- Flooding from groundwater.

KATHARINE BURGESS/ULI

Miami Beach's investment in stormwater infrastructure can be seen throughout the city in its new, elevated pumps.

WIKIPEDIA

Sunny-day flooding is a common problem; here, Brickell Bay Drive, in nearby Miami, flooded during a normal high tide in 2016.

Current flood management practice is rightly focused on alleviating flooding as a whole and clearing the surface water as efficiently as possible. However, future holistic flood risk management should differentiate contributions from the three discrete sources, understand how each source influences the others, and strategize accordingly. Any strategy should include increased collaboration with the local community and education about the mechanics of flooding and how the city's infrastructure investments are addressing existing and future risk. In addition, all investments should seek to serve multiple purposes to achieve the highest possible benefit/cost ratios and maximize ownership and support from the citizens, companies, and organizations in the city.

To build a more holistic strategy and increase the city's preparedness for the increasingly severe impacts of climate change, the city should strive to incorporate the following recommendations:

- Improve the flexibility and robustness of the current system.
- Enable more informed decision making and risk management through enhanced modeling.
- Implement blue and green infrastructure to advance a more integrated and holistic approach to living with water.
- Ensure appropriate modeling, study, and funding availability for green and blue infrastructure projects.
- Implement living-with-water pilot projects.
- Create tools and highlight opportunities for living-with-water projects at the building level.
- Consider a level-of-service (LOS) concept to guide future decision making.

- Address water quality concerns.
- Improve communications about and education on engineering and infrastructural solutions.

More information about all of these recommendations follows, starting with recommendations related to the two primary elements of the city's current approach—floodwater pumps and elevated roads—and moving to new options informed by a robust optimization model.

Improve Flexibility and Robustness of Current System

The city's current plan for stormwater infrastructure, including pumps and elevated streets, is well tested and thoroughly designed but lacks flexibility—the system is not designed to adapt. This lack of flexibility is the Achilles's heel of the current system. Indeed, the system is costly to install, operate, and maintain and is—at this stage—not

Green and Blue Infrastructure

Green and blue infrastructure are approaches to water management that incorporate natural processes to manage and treat water. Rather than speeding water underground or away from a site or road, green and blue infrastructure slow water down and integrate it into natural systems, often conveying it and treating it through landscape amenities.

These terms can refer to a wide variety of different processes and approaches at the site or regional scales that can function in many different climates and habitats.

- *Green infrastructure* manages water through natural processes, slowing water to be absorbed and filtered through a combination of vegetation and soils. Approaches include living shorelines, mangrove plantings, rain gardens, bioswales, cisterns, and many other technologies that can be implemented independently or together in a "rain chain," funneling water from one source to another.

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A rain garden acts as a sponge, helping water permeate the ground naturally while also nurturing the landscaped plants.

DAVE PAPER | FLICKR

Planting of mangrove trees is a green infrastructure strategy that can provide protection from storm surge while enhancing the biodiversity of the ecosystem.

- *Blue infrastructure* works with the natural hydraulics of the aquifer and can refer to new canals, wetlands, and retention on urban plazas and other public facilities managing water during extreme rain events.

At the scale of a real estate project, green infrastructure may refer to design features that will capture and slow the release of water after routine and peak rain events. Green infrastructure may also refer to public works projects implementing landscape systems in parks, rights-of-way, and elsewhere to create a community-wide or citywide network for water conveyance.

Green and blue types of technologies have many benefits compared to traditional gray infrastructure such as pumps and pipes: the former are more affordable, offer opportunities for enhanced green space, can be implemented incrementally, and have public health benefits. Cited benefits of green and blue infrastructure have included improved water quality, reduced water use, flood risk mitigation, improved wildlife habitat, enhanced real estate value, enhanced recreational spaces, cost savings, and opportunities for green jobs.

completely guaranteed to function during all peak events because of reliance on a generator-backed power system. Not all pumps are backed by standby generators, and even these will not necessarily provide sufficient robustness. Nor does the system provide ample collateral benefits to the local community.

Furthermore, how long the system will continue to function well is unclear, taking into account development in climate change projections, maintenance of systems, and so on.

Going forward, the city should identify a broader range of strategies, including blue infrastructure, green infrastructure, and seawall improvements, together with its committed pumping systems and elevated streets, to both introduce more flexibility in managing water and offer more visible collateral benefits to the local community.

Trends in Hydraulic Design

The hydraulic design of drainage systems is linked with many uncertainties, especially considering the life span of the structures. These uncertainties should be addressed in a structured way split topic by topic. Opportunities to improve include integrating the following:

- Factors to accommodate for increase in extreme precipitation caused by climate change during the lifetime of the pipes: these factors should be derived using the most updated data and provide recommendations for a factor for design criteria and for stress test (this would often be a factor 1.2–1.4 for design criteria rainfalls and as much as 1.8 for the extreme rainfalls—corresponding to an expected increase in rain intensity of 20 to 80 percent, depending on return period);
- Factors to accommodate for building out and densification on private and public property 1.0–1.2, which is directly related to the ongoing trend to pave and build and to connect more impervious areas to the drainage system; and
- Factors to accommodate for general uncertainties in model and rain statistics 1.2–1.3 (uncertainties on dimensions, levels, state of repair).

First and foremost, the current stand-alone pump and pipe solutions are not particularly flexible to changes in boundary conditions, power outages, and exceeding of design criteria. Opportunities to improve include the following:

- Implement storage volume upstream to retain runoff and reduce peaks at pumping stations; for example, use storage in public parks, porous sub-base of roads, private cisterns, swales, and tree strips, many of which can be implemented with green and blue infrastructure.
- Improve design and increase capacity of gravitational overflows from pump stations by installing flap weirs designed to extreme events.
- Implement a monitoring system for tracking infiltration to pipe systems (and for calibration of hydraulic models).

The city should consider implementing electrical and infrastructure enhancements to mitigate extreme weather, to supplement a generator-backed pump system that presents issues with power backup supplies. The system also needs to be "safe to fail," allowing controlled flooding in the case of some extreme events.

Street elevation is another key component of the city's current strategy. Raised land has been a tested successful solution to alleviate tidal flooding in new development and, to a lesser extent, in retrofit solutions. Where street elevations are determined to be the best flood mitigation solution, the city could improve and further optimize this strategy to local areas with more information on geology and groundwater, which is explored further in an upcoming section on modeling. Opportunities to improve include the following:

- Revisit the criteria and time span for the solution (through community and risk modeling, explored in a subsequent section).
- Better understand the context with groundwater and the aquifer.
- Explore solutions related to porous geology.

KATHARINE BURGESS/ULI

Barceloneta, a restaurant in Sunset Harbour, is surrounded by elevated streets and now has patio seating at the original street elevation.

- Test the impacts on lower-lying property through detailed hydraulic models.
- Analyze alternative uses for low-lying property.
- Revisit options such as channeling road drainage to the pumped system.
- Consider the cost/benefit, including elevated streets and pumps, as well as the ongoing operations and maintenance costs for the pumps.
- Ensure best-in-class stormwater treatment before discharge to the bay.

Use Enhanced Modeling for Better-Informed Decision Making

The situation regarding flooding in Miami Beach is extremely complex, and quantifying the likely effects of events and suggested solutions, including pumps as well as green and blue infrastructure, is currently difficult. The city must take more actionable steps to ensure that its efforts are driven by hard data that is consistently being updated to reflect current conditions, including the complex interplay between the three different sources of flooding extant in the city. To address this, the city should create an integrated, hydrodynamic computer model that simulates the physics of flooding caused by the three sources:

- Coastal flooding, including king tides;
- Precipitation; and
- Groundwater.

This model would provide a physics-based tool to quantify the relative contribution of coastal flooding, precipitation, and groundwater to the flooding mechanics at all locations across the island. Changing climate conditions and other boundary conditions such as new infrastructure and buildings could be simulated with this tool, showing how flood risk evolves in the future, based on estimates of future conditions. Importantly, this risk relates not just to protection of physical property from damage but likely costs of damages and repairs.

Such a model would be state of the art, and the tool is not yet commonly used by cities. By adopting such a tool, Miami Beach would continue to be a leader in climate adaptation and offer a model for many other cities to rep-

Who Makes Hydrological Models?

Federal government: The most widely used models come from publicly available sources that are free to use. Federal agencies such as the U.S. Army Corps of Engineers have been making such software for decades. The software is divided by usage, with coastal areas using different programs. Governments and researchers use all of the publicly available programs often.

Researchers: Research institutes, universities, and even private researchers are the source of many models. The larger institutes have more widely used models, but universities and local researchers sometimes develop models for use within their region. These are often not publicly available, except from larger institutes, which usually require subscriptions or licenses.

Private sector: Private sector firms specializing in modeling software often offer the most developed models, including software that integrates different types of systems (tides, groundwater, etc.). The software requires paid licenses.

licate. However, the city will need to develop staff capacity to make the best and most efficient use of such a tool and will require external expertise to procure technology.

Any flood mitigation could be input into this tool, including pumps as well as green and blue infrastructure, the results simulated, and the benefits of this action would be clearly quantified. These quantified benefits could then be compared with the costs to implement and thus enable informed economic choices about the city's future. Importantly, this tool would allow the city to clearly quantify and communicate the outcomes of any chosen mitigation action.

In addition to the flood risk calculation tool, the city can calculate the value of the co-benefits and build the business case on a complete cost/benefit analysis. A clear cost/benefit analysis is an important tool for decision making, and this integrated water model is the best possible way to simulate current and future conditions, and directly quantify the benefits expected from any given mitigation action.

Digital Elevation Models

A digital elevation model (DEM) is a digital three-dimensional elevation model that shows the terrain's surface. These can sometimes be referred to as digital terrain models or digital surface models. Digital surface models, however, usually include the objects on the land, such as buildings or trees. They are most often created using satellites, radar, remote sensing, or other aerial techniques instead of by direct physical survey. A DEM is the foundation of most hydrological models for flooding and drainage, and accurate modeling depends on its quality.

The quality of a DEM is ultimately determined by the scale and type of survey technique. A model that is more detailed, and uses newer technology, will be considered more useful and accurate. However, such models are more expensive to survey, and the file sizes are more difficult to manage.

The city currently has a pipe-network model that allows it to simulate the hydraulic load in the drainage systems and on the pumps during heavy rainfalls. In addition, the city is logging water levels and groundwater tables in boreholes. These assumptions and others relevant to the feasibility of a model include the following:

- The city's pipe network is currently about 90 percent modeled and can be exported.
- Geology can be modeled as an equivalent porous medium, and an additional geophysical survey will take place at project level.
- Digital elevation is mapped in a detailed DEM (in grid cells about four feet by four feet).
- Logging of groundwater and water level in the bay is continuing.
- Five to eight rain gauges will be installed close to existing SCADA (Supervisory Control and Data Acquisition) points for calibration.
- Eight clamp-on meters or channel-flow meters will be rented and installed for a six- to eight-month period.

As a next step, the city should couple the pipe-network model with a digital elevation and groundwater model to make more informed decisions regarding flood risks. This digital model would function as a comprehensive simulation incorporating physics related to groundwater and stormwater levels, which would allow the city to quantify and compare risk when making decisions related to resilience. An integrated model of digital elevation of this nature would require a geophysical survey of parts of the island, but its implementation is relatively cost-effective, fairly easy to execute, and can be carried out and implemented in the model over time, for example, when detailed information is required in relation to detailed design on project level.

Established computer programs could independently model these scenarios. To begin work implementing a model, the city would likely require both the purchase of modeling software (which would represent both a fixed upfront cost and an ongoing license and maintenance fee) and a separate engagement of consulting expertise to build, calibrate, and verify the model.

Engagement of a third party to provide quality control review of the model is also recommended. The city might consider engaging a consultant to serve as an owner's representative during the procurement process for identifying both the model and the associated consulting services. This engagement would be similar to the common practice of hiring someone in this role to oversee large construction projects on behalf of a government owner.

This owner's representative should have technical knowledge of complex, integrated hydraulic modeling and provide the city with the expertise to parse and compare the proposed products and consultants' proposals. This owner's representative may possibly be able to provide the third-party quality review but is not required to have this capacity.

Over the medium to long term, the city should consider adding a member of staff, such as a "flood risk model manager" position, to monitor the city's use of the tool. The flood risk model manager would track use of the model, ensure that the information is up to date, and become the city's in-house "guru" on the tool. Many members of staff should be literate and comfortable with the tool and be able to input scenarios for modeling and subsequent decision making.

The end goal is a model that accurately represents the interplay among the coastal, precipitation, and groundwater flooding sources, as well as the ground elevations, pipe networks, pump facilities, and land use throughout the entire city. It will be an accurate digital model of the city, which can be used to simulate any flood mitigation proposal under consideration.

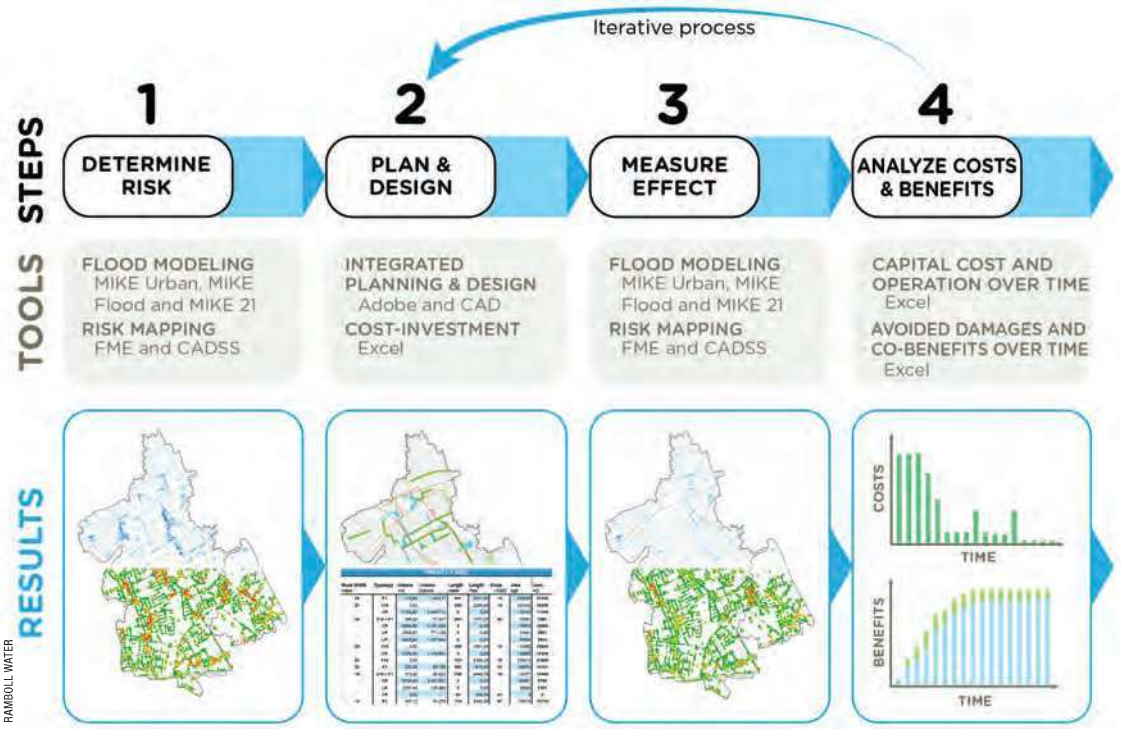
After procuring and implementing this digital model, the city of Miami Beach could then make informed decisions (risk/benefit-based management) regarding flood protection strategies. A more comprehensive model would do the following:

- Calculate risk for various impacts, such as different types of storm conditions or volumes of rainfall or levels of king tides;
- Enable the city to be more informed before investing in specific civil works actions, such as raising a seawall, implementing more pumps, or building more blue/green infrastructure;
- Help formulate optimal socioeconomic protection levels and define collateral benefits;
- Work in "safe-to-fail" limits to infrastructure, allowing for effects of extreme events;
- Create safer guidelines for densification, climate change, system data, and rain statistics; and
- Allow flexibility for climate change, system data, and rain statistics.

As an example, if the city could create large-scale retention in park areas, thereby reducing the flood risk further downstream, the model would be able to predict the benefit/cost ratio of such an investment, including the following elements:

- Capital and operational expenditures;
- Reduced damages;
- Reduced investments in underground infrastructure; and
- Co-benefits in terms of health effects, increased property value, and so on.

Another scenario would be to model reduced saltwater flooding. Under a given management scenario, it would be possible to eliminate sunny-day flooding caused by upwelling of groundwater during high tides. But what would the



RAMBOLL WATER

The modeling process requires a layered approach in terms of both programs and iterative steps.

optimum mix of street elevation and pump capacity be now and in the future? With this tool and updated climate scenarios, the city could accurately simulate all three sources of flooding in the city, answering these vital questions.

Building and using the model is likely to take a year or so. The city's ongoing use and upkeep of the model would include keeping the model calibrated by monitoring flow rates and levels in pump stations and selected manholes.

CITY OF MIAMI BEACH

Planting mangroves is a natural way to protect the shoreline.

Implement Blue and Green Infrastructure

With the knowledge of an enhanced hydraulic model, the city can better explore a more diverse array of options for flood mitigation from all three flooding sources. Green and blue infrastructure will be key options to explore and integrate into the current strategy, particularly given the opportunities for co-benefits.

Broadening Miami Beach's strategy beyond pumps and street elevation to integrate green and blue infrastructure and other innovations in resilience could lead Miami Beach to become a worldwide model of living with water. With this approach, resilient infrastructure should not only clear water away during tidal flooding and peak rain events but also identify opportunities to improve quality of life through vibrant public spaces, water features, and water recycling. Blue and green infrastructure should be key components of this strategy and offer many opportunities for co-benefits related to public space, aesthetics, water quality, and recreation.

The city should consider the following strategies:

- Living shorelines;
- Mangrove plantings;
- Rain gardens and bioswales;
- Porous pavement;
- Cisterns;
- Tree strips and cells;
- Multifunctional use of parks and plazas; and
- Changes in land use to allow more of the preceding options.

A more integrated living-with-water approach will not only include the incorporation of more types of flood mitigation infrastructure, but will also require more structured collaboration and potential cofunding of infrastructural investments across city departments. Strategies to introduce this type of interagency planning could include the following:

- Ensure fluency with the outputs of the hydraulic model and the opportunities for better understanding the impact of different flood mitigation mechanisms and

Living with Water: New Technologies, Attitudes, and Design Aesthetics

Miami Beach has the opportunity to be a world leader in the concept of living with water. This theme could be a core component of the stormwater management and resilience strategies, as well as the city's economic development, tourism, and placemaking strategies. The approach entails not only the use of different technologies to manage water, but also different attitudes about convenience, mobility, health, and aesthetics. Notably, living with water would entail embracing green and blue infrastructure that can manage water using natural systems.

The visual effects of blue and green infrastructure are very different from pumps or pipes that send influxes of water out of sight and out of mind. Adopting a living-with-water approach would therefore require that Miami Beach residents, businesses, and stakeholders change some of their comfort levels about ponding, minor flooding, and visibility of water in the public realm. Notably, water is likely to be more visible after storm events and take longer to subside. Aesthetics are also different: instead of monotone manicured lawns, a green infrastructure palette typically includes more wild-looking native plants that can, although will not necessarily always, look unkempt when they are at peak ecological function. These plantings can be part of beautifully textured compositions that would contribute to Miami Beach's sense of place, but they would not necessarily chime with aesthetic norms of mowed lawns and English-style gardens.

If implemented successfully, living with water could be more than an infrastructural approach and become part of Miami Beach's tourism and economic development branding. For instance, tourists could come to Miami ready to ride amphibious vehicles or tour newly implemented natural coastlines and mangroves; small businesses interested in climate adaptation would relocate here to find peers and clustered work environments for climate technology and green infrastructure. However, to ensure that the city maintains this resilience leadership, prioritizing the minimization of greenhouse gas emissions from fossil fuels in the stormwater and flood resilience solutions implemented will also be key to maintaining a reputation as a climate leader.

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A bioswale helps filter the runoff at ECO Modern Flats in Fayetteville, Arkansas.

infrastructural cost/benefit analysis across different agencies.

- Prepare two or three integrated/interagency master plans per district, developed through charrettes with communities and agencies.
- Integrate stormwater master plans at the highest level of city planning to ensure harvesting of budget synergies with other investment plans and projects and the least possible nuisance for the citizens.
- Build the clear business case based on the cost of doing nothing, the traditional solution, and the living-with-water approach, generating co-benefits that in many cases exceed the reduced damages and other tangible outcomes.
- Invest in high-quality pilot projects to generate enthusiasm and ownership of the living-with-water concept.
- Examine the land use ordinance to plan for future flood mitigation needs and potential changes to built environments.

Ensure Appropriate Resources for Green and Blue Infrastructure

The city is currently advancing some blue and green infrastructure projects that align with the living-with-water vision, including living shorelines and green infrastructure in park design. However, the funding sources are independent of those currently being used for the stormwater management program, and some are grant based or otherwise not as reliable as those in use for the stormwater program. These green infrastructure investments are also not necessarily being modeled and considered in conjunction with the stormwater management program underway. A more holistic approach should not only offer funding for innovative green and blue infrastructure strategies but also ensure that their contributions are effectively measured and studied in the context of overall flood mitigation efforts.

Implement Living-with-Water Pilot Projects

Miami Beach should create iconic pilot projects that involve the community to determine the best future approaches for resilience and to test and explore the living-with-water concepts. These pilot projects should represent exciting opportunities to both enhance resilience and introduce co-benefits related to green infrastructure, public space, and quality of life. Pilot projects are excellent opportunities for community engagement and for broadening public understanding of the goals of the stormwater management program.

Communities in Miami Beach that experienced the first phases of stormwater investment were complimentary about how the program has improved sunny-day flooding and eliminated the many related inconveniences they once experienced on a regular basis. However, these same citizens showed clear concern about how the pump program had been implemented, citing concerns about reduced quality of public spaces or low-quality streetscapes—and even questionable public safety near pumps that block vision and views. These responses represent a clear missed opportunity: communities that experienced early phases of investment are the best candidates to become ambassadors for the program and to inspire and excite neighborhoods that will receive investment later. Launching pilot projects that represent innovative approaches and respond to community interests will better serve the city and help generate community buy-in for the program.

Iconic pilot projects could include the following:

- Green and blue infrastructure designed into iconic public parks, or even pocket parks;
- Raised streets, including coordination with other desired infrastructure investments, such as bike lines or bike-share stations;
- Centralized stormwater retention;
- Retention on private property (e.g., the development of a “climate neighborhood”);

Ecological Design for Bishan Park, Singapore

One of the largest parks in central Singapore has undergone an ecological renovation. Originally constructed in 1988, the 62-acre park was built around a portion of the Kallang River, which had been channeled through a constructed canal. The canal, however, was at maximum 75 feet wide, making for limited drainage, and its concrete construction created a physical division within the park. Because water is a critical resource for the island of Singapore, the large park was seen as an opportunity for collection. In 2009, Ramboll Water partnered with the Public Utilities Board (PUB) and the National Parks Board to restructure the park, hoping to make it more dynamic and ultimately more efficient for stormwater. The project became a case for PUB's Active, Beautiful, Clean Waters program, which seeks to transform existing areas into ones that serve both form and function—beauty, recreation, and stormwater collection.[6]

The project centered on restructuring the Kallang River, taking it out of its concrete casing and making it a more natural river system. It took nearly a dozen experimental trials to come to a decision about the right bio-engineering standards both to create the system and to prevent soil erosion.[7] Hydraulic models also helped the teams plan. The new river follows a floodplain concept and allows for widening up to 330 feet into the park, permitting 40 percent more conveyance capacity. It also connects to the city's greater drainage system.[8]

The park was planned to provide multiple benefits. Landscaping was carefully considered to maintain and encourage rich biodiversity, and bridges and stepping stones help integrate recreation and learning. In addition, new playgrounds seek to engage families, including the water playground, an active, partially inundated play area that won the Singapore Design Award.[9] Outdoors, the park encourages active learning, providing materials for self-guided trails. Many local schools visit it for this purpose and have even created their own trails throughout. To create a truly varied recreational experience, users can also book particular areas or visit a number of on-site businesses and restaurants. Importantly, much of the park was built with accessibility in mind, including the playground areas.[10]

Implementing the new river system actually cost Singapore 15 percent less than constructing the concrete canal, showing that sometimes a slew of benefits can actually come at lower cost.[11] And today, more than 3 million people visit the area annually.[12] Bishan Park is an exceptional example of how an area can fulfill PUB's Active, Beautiful, Clean Waters program, integrating design elements with critical function.

RAMBOLL WATER

The cleansing biotope helps filter the water before it is returned to the drainage system in the park.

RAMBOLL WATER

The Kallang River was removed from its concrete encasing and now can widen up to 330 feet in flood conditions, increasing conveyance by 40 percent.

- Retention in the sub-base of streets;
- Cleansing biotopes, which are assemblages of plants in a filter medium, for example wetland cells, that can cleanse water, absorb nutrients, and provide filtration;
- Private landowner adoption of indoor and outdoor adaptation strategies; and
- City action on private seawalls and other barriers.

Create Tools for Building-Level Living-with-Water Projects

Building owners are an important part of the solution to living with water and have a responsibility to design their projects for flood waters. They should be encouraged to follow the city's leadership by implementing flood water management strategies on and in their properties. The city can also provide them with further resources and toolkits on climate adaptation segmented for different property types; this possibility is explored in more detail in the "Communications" section of this report.

Consider Level of Service in Future Decision Making

The city of Miami Beach requested the panel's thoughts about the current phasing and sequencing of the storm-water management work. To date, the strategies for pumping and roadway elevations have largely been based on the amount of surface water that is expressed and the roadways relevant to a specific design elevation. Moving forward, the city might consider instead pivoting to a level-of-service model that considers flooding disruption in terms of likely flood frequency, depth, and duration.

To decide on the socioeconomic optimum level for flood management, different options should be calculated in terms of the following:

- Reduced damages;
- Capital expenses;
- Operating expenses;
- Savings on other capital expenses such as upgrades of sewers and wastewater treatment plants; and
- Co-benefits.

The optimum LOS concept would consider how flooding disruptions inconvenience the community at a district scale. This approach then integrates community preference on level of mitigation into the decision-making process, working across agencies and integrating public engagement into the process.

This LOS strategy may mean conducting direct cost analysis, or cost/benefit analysis, to compare and find the optimum net present value of a plan. For example, if local stakeholders are interested in protection beyond the 100-year storm, this strategy could factor in the likely costs and determine whether there is appetite to fund the intervention.

Address Water Quality Concerns

Water quality frequently presents an issue within storm-water infrastructure, and the city has thus far done a very good job at implementing solutions to uphold the area's water quality. However, the city should take this work to the next level, including state-of-the-art systems such as green infrastructure and cleansing biotopes.

Pumped systems including a traditional grid, sand trap, and vortex have a tendency to underperform and fail during extreme events. Moreover, the citizens and stakeholders of Miami Beach are clearly concerned about water quality and the potential water quality implications of the pump system.

Going forward, the city should implement state-of-the-art treatment systems through green infrastructure that will absorb pollutants while increasing flexibility. Upstream green infrastructure should be a key aspect of the living-with-water plan but also include outlets with cleansing biotopes for treatment and polishing of water quality by filtering, sorption, and sedimentation.

Level-of-Service Approach to Flood Protection

Climate projections are showing a strong trend toward more extreme weather. Most scientists and experts generally agree on the magnitude of the sea-level rise, whereas the extreme rainfalls are harder to predict, especially because of their often very local character—both statistically and in short-term forecasts. The threats are imminent, but in many cases the traditional planning approach is insufficient or not fit for the purpose.

Thus, many cities are moving toward a flood protection planning approach based on a cost/benefit analysis, which combines the calculated risk of doing nothing with the benefits and costs related to adapting. The cost/benefit analysis also allows monetization of the co-benefits from investing in green infrastructure. The concept can be framed as the level-of-service (LOS) approach. The LOS approach refers to the planning method, in which cities clearly define the maximum level or frequency of floods acceptable during a given time period. It has the potential to reduce damages and nuisance, environmental, and health-related issues.

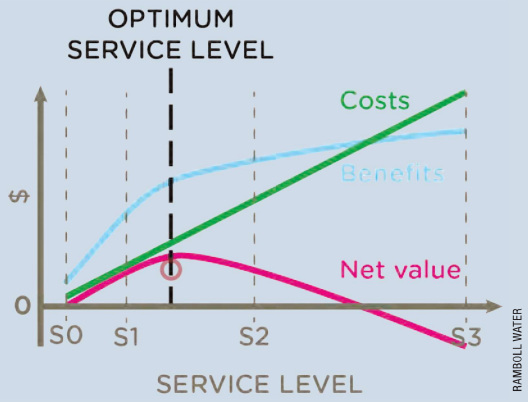
In Copenhagen, for instance, the city guarantees that no flooding will occur during a ten-year storm, while four inches of flooding is allowed during a 100-year storm. (Both measures factor in the expected impact of climate change.) The city provides flood control on public right-of-way and drainage from private property up to a ten-year storm. Beyond this, or if the private landowner wants a higher level of protection than four inches, it is up to the individual landowner. Furthermore, the city guarantees that the plans will improve—or have no negative impact on—the quality of the receiving waters.

This level of service is based on socioeconomic calculations of the capital investments, operation, and maintenance of a suggested plan over time, compared to the benefits of reduced damages and downtime of businesses, improved connectivity, and co-benefits from green solutions.

The LOS concept has some clear advantages when compared to traditional planning and design approaches:

- Strong business case to support investments in flood protection;
- Clear definition of responsibility between the city and its citizens and companies; and
- LOS based on actual flood events regardless of the reason—rainfall, storm surge, groundwater, or malfunction of system.

In order to calculate and implement the optimum level of service for the city of Miami Beach, an integrated and dynamic hydraulic model including runoff from rainfall, groundwater and infiltration, sea level, and overland flow needs to be built. This should be combined with a spatial model of assets, land use, and socioeconomic information to calculate the risks and benefits. To ensure the best business case, all relevant strategies and visions for the city should be incorporated into the adaptation design and subsequent business case.



The approach requires finding the optimal service level of flood protection where benefits and costs are maximized.

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Pollutants from upstream can contaminate the water around Miami Beach.

CITY OF MIAMI BEACH

The city removes pollutants from its waterways three times a week.

Beyond implementing further infrastructural investments to protect water quality, the city should prioritize transparently communicating the outcomes to local constituencies. For example, the city currently has 80 sampling locations: making the data publicly available would be one opportunity that could facilitate innovation with the potential interest and involvement of local activists and citizen scientists.

Improve Communications about Engineering and Infrastructural Solutions

How are local stakeholders currently connecting and digesting the best information available? Flood vulnerability in Miami Beach is a complex issue, and evolving weather patterns and available data mean that new information is often available, changing the context behind decision making.

Local stakeholders clearly articulated that the outreach process that led to the current stormwater management system was not sufficient. Stakeholders particularly noted the minimal opportunities for community input and a tone that did not welcome input. The outreach process also did not provide enough time or interagency coordination opportunities to streamline the stormwater management investments with other desired infrastructural upgrades.

More information on the overall communication strategy for the future resilience and stormwater management strategies is available later in this report. On the infrastructure and engineering side, the panel recommends the following:

- Consider adding a "climate science translator" role to city staff to map best state of science into basis of design criteria, inform all city design decisions, and help communicate vulnerabilities, risk, and mitigation opportunities to the public, including what will happen in a do-nothing scenario.
- Continually monitor different areas for changing conditions and strategize about how to communicate new information to residents and businesses as new information becomes available.
- Ensure that communications are clear regarding the anticipated time frame for implemented infrastructure and the overall cost/benefit analysis and rationale behind implementing different types of technology and infrastructure.

Were Miami Beach to not stay on the vanguard of infrastructure planning and implementation related to stormwater management and climate adaptation, the prospects for a continued high quality of life are unlikely. Thus, continuing to evolve and mature the city's infrastructure strategy is imperative.

Physical Design and Typology

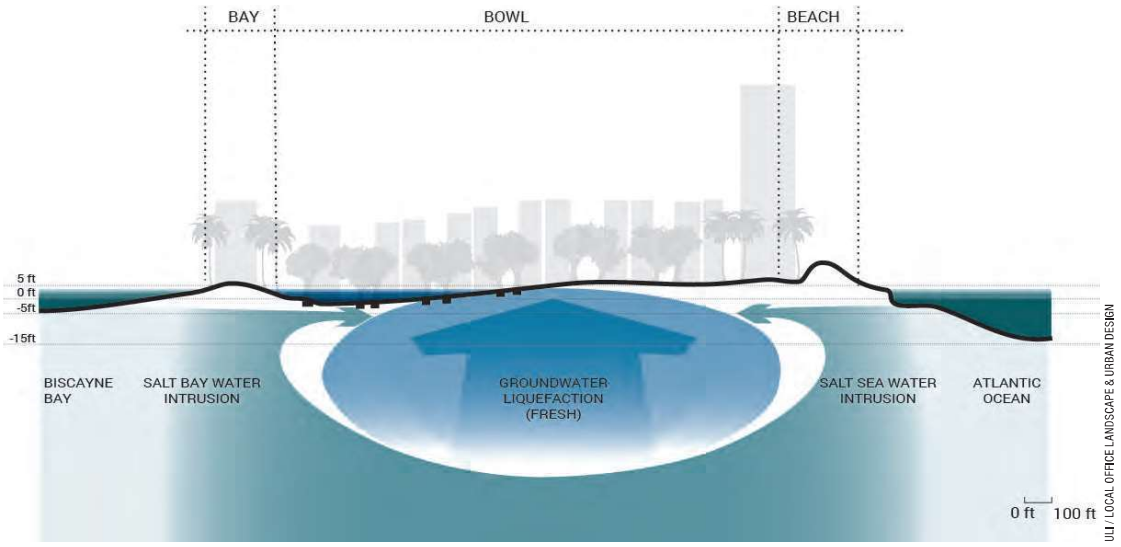
MIAMI BEACH'S PHYSICAL TYPOLOGY presents a unique opportunity to craft a more innovative and cost-effective solution than the present stormwater management system. This more holistic strategy could better respond to natural topography and land and water conditions, incorporating green infrastructure, parks, open spaces, and opportunities for the incorporation of renewable energy that will increase preparedness for peak events and power failure.

The following recommendations, as well as ideas and examples of how to achieve this goal, are discussed in more detail below:

- Select design and infrastructure interventions that respond to the city's beach/bowl/bay typology.
- Look to golf courses as underused green spaces for water management.
- Consider modifying road specifications for permeability.
- Pursue opportunities with solar and renewables.
- Consider long-term options for neighborhood design and green space.

Select Interventions Responding to the City's Beach/Bowl/Bay Typology

The island of Miami Beach follows a beach/bowl/bay typology. The beach dunes are at a higher elevation than the center of the city, which is its lowest base elevation area. However, design analyses completed during the panel noted that the bay side of the island is also slightly elevated, which creates a bowl in the center of the island that is currently a major challenge for the city. Moreover, an analysis of the water levels within this bowl reveals a freshwater bubble, mostly rainwater, that is interfacing with rising tides. This fact explains why flooding is especially prevalent within this area: the freshwater runoff from leaky pipes is creating optimal conditions for flooding.



An illustration of the beach/bowl/bay typology that results in a freshwater "bowl" in the center of the island.

Currently, about 20 percent of the island is within this urban bowl condition, according to topographical analyses conducted during the panel's visit. This percentage will grow as new bayfront towers create an architectural levee of elevated floors, gardens, and seawalls. Notably, the majority of Miami Beach's historic districts are located within this bowl.

Miami Beach's future resilience plan should respond to the natural conditions at each portion of this typology when implementing strategies for water management. In the beach upland zone ("beach zone"), for example, water can be buffered, stored, reused, and released; this is the part of the island with the most "room" to store water in the landscape and architecture.

- Development should incentivize or require on-site water storage and could incorporate blue roofs and walls and cisterns.
- Green infrastructure and green streets should be designed with capacity to retain, purify, and release water.
- FEMA is currently in the midst of a floodplain mapping update, to be completed in 2019. After mapping is updated, the city should consider whether dunes should be modified to comply with the FEMA 540 rule, which could improve the city's rating in the NFIP Community Rating System.

In the "bowl zone," the focus is managing the interface between freshwater, saltwater, and groundwater. The key goal is storing and conveying water through the rainwater/groundwater interface, including within parks and green spaces.

- Groundwater monitoring and management should be a top priority.
- Green streets could store water uphill.
- Blue streets should be designed for conveyance and filtration, conveying and percolating water, and ultimately conducting it toward the bay treated and without the use of pipes.

Golf courses are the largest source of open space in Miami Beach, making them a critically underused land area for stormwater management potential.

In the "bay zone," a living shoreline meets and manages the freshwater/saltwater interface. Architecture, open space, and the seawall can work together to manage potential inundation. Note that this typology is likely to "lift" in the future, creating more of a bowl condition, as property owners harmonize with the seawall. Accordingly, future finished floor elevations may be higher than those seen today.

Look to Golf Courses as Underused Green Spaces

Currently, Miami Beach has about 17 percent green space as a percentage of overall land area, including the beachfront, active open spaces, and golf courses. Future approaches to water management and resilience should use these open spaces, including green infrastructure designed to manage both groundwater and stormwater. In comparison, leading U.S. cities for public open space include Washington, D.C., with 21.9 percent, New York with 21.3 percent, and San Francisco with 19.6 percent.[13]

According to calculations completed during the panel, of Miami Beach's open space

- Roughly 5 percent is the beachfront;
- Roughly 5 percent is active open spaces like fields; and
- Roughly 7 percent is golf course.

At the moment, the golf courses represent the largest single type of open space on the island, and they are currently incredibly underused as water management resources. These golf courses represent great opportunities for water storage for the following reasons:

- They include artificially elevated land.
- They are connected to the groundwater.

Future water management efforts, supported by the outputs of the city's hydraulic model, should explore opportunities for taking advantage of the green absorption potential of golf courses.

Modify Road Specifications to Enhance Permeability

The roads of Miami Beach offer another opportunity to better live with water and be prepared for flooding events, and they are currently a major part of ongoing public works through the stormwater management program. However, existing road specifications can fail prematurely under rising groundwater, including in the following ways:

- Creating hydrostatic pressure under impervious roads that scour the sand foundation;

Adapting Parks for Water Management: Emerald Isle, North Carolina

Emerald Isle is one of several communities that have begun to use local parks for the purpose of stormwater detention. The small island notably lacks public land and thus has had to work with the resources that it can access to address stormwater concerns. Nine different stationary pumps are set in different neighborhoods that use an automatic float system to flow through underground pipes.[14] They lead to a specific area of Emerald Isle Woods Park designated for hiking and passive stormwater accumulation; other parts of the park include a nine-hole golf course. The stormwater area is planned so that the natural environment treats the water, since state policies prohibit depositing it into the Atlantic Ocean or Bogue Sound.[15]

The island began to focus on its stormwater concerns in 2004, when an update to the Land Use Plan required drainage systems and development regulations for on-site stormwater retention. The North Carolina Department of Environmental Quality's Universal Stormwater Management Program authorizes the town to enforce not just its local ordinances, but also related state policies, thus allowing it to have stronger regulating power. The stormwater program helps support the overarching Pamlico Sound Regional Hazard Mitigation Plan, a five-county plan required by both state and federal policies and approved by FEMA, to help alleviate drainage, water quality, and storm surge concerns from yearly hurricanes.[16]

The stormwater system has been a top funding priority for the town of Emerald Isle, and funds to support it are allotted by a capital project ordinance. A recent pump cost the town around $150,000, which included consulting with engineers and a negotiated construction cost with local builders.[17] Although the current system has helped alleviate many concerns, the town continues to prioritize ways to improve and expand upon the program.

A Permeable Plaza: Giralda Avenue in Coral Gables

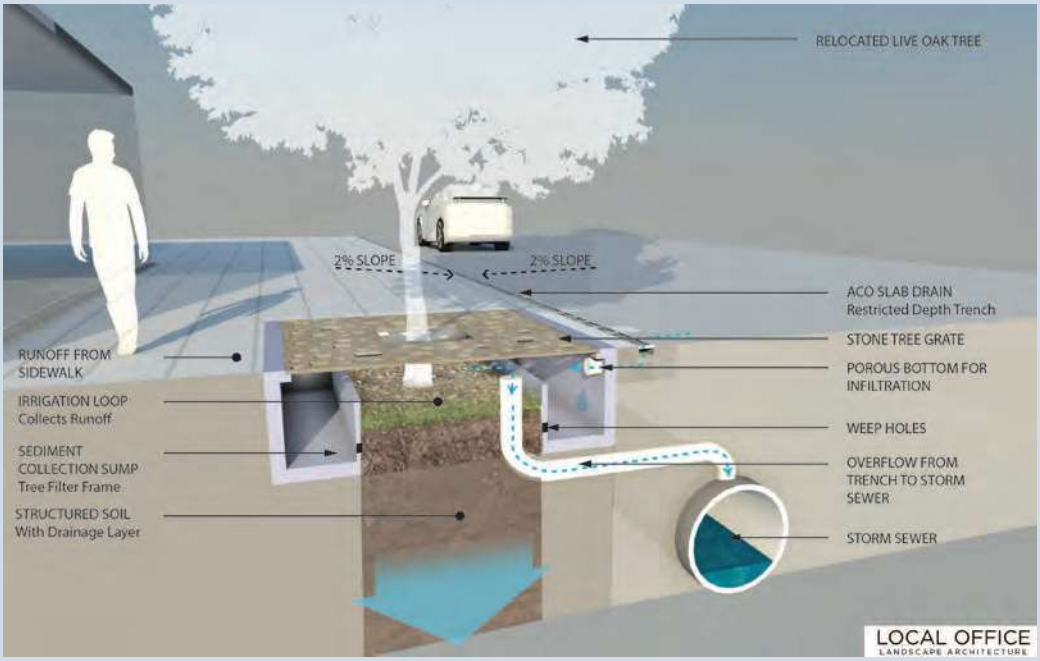
In Coral Gables, Florida, Giralda Avenue was recently completed as part of the city's Miracle Mile project, which spans a total of four blocks. Giralda Avenue, physically divided from the Mile itself, was designed to become a curbless pedestrian plaza. The entire project, designed in collaboration with Local Office Landscape and Cooper Robertson, works to integrate both resilience and art, creating paving patterns that imitate tropical raindrops.[18]

The stormwater system was designed to withstand rains of 7.5 inches per hour, which far surpasses the code. This system used porous paving, which blends permeable products such as rubber to absorb more water. The project also used hurricane-wind-resistant planting techniques, which plant trees deeper into the ground so as a network they can collectively mitigate groundwater. A testament to structural soil and decentralized line drains, Giralda Avenue recently withstood Hurricane Irma while neighboring streets experienced intense flooding. To further synthesize these elements with the streetscape, the project plans to cover stormwater utility boxes in artwork.[19]

LOCAL OFFICE LANDSCAPE & URBAN DESIGN

Giralda Avenue, part of the Coral Gables Miracle Mile district, is a pedestrian plaza designed with resilience in mind.

The $20 million project took years to complete. The city commission, whose membership was evenly split between the city and property owners, initially approved funding in 2014. Property owners in the Business Improvement District paid a special assessment tax dependent on location: 35 percent if directly on the Mile or plaza, and 15 percent if adjacent to it. To help diminish these costs, the city agreed to pay interest for two years and raised parking meter fees to ease parking costs for businesses.[20] The project is a laudable example of integrating several solutions into one, merging economic improvements, artistic elements, and resilience initiatives.



LOCAL OFFICE LANDSCAPE & URBAN DESIGN

The integrated stormwater system is designed to withstand rains of 7.5 inches per hour, surpassing local code requirements.

- Removing fines from the lime rock base; and
- Creating large cavities and potholes.

Coastal resilience specifications for porous paving can have as much as twice the life of existing road standards and overcome the shortcomings of older versions of porous paving, with lower maintenance requirements. In addition, these systems offer significant water quality benefits. The city should look into using these road specifications and moving toward a porous road model.

Pursue Opportunities with Solar and Renewables

Moving forward, the city should embed solar and renewables into the resilience strategy and the stormwater management strategy. Strategies could include the following elements:

- Incentivizing the incorporation of renewables, energy resilience, and water reuse systems into new development, as discussed in the "Regulations" section of this report. Note that precedent exists for these types of regulations and incentives, such as Miami Beach's current green building ordinance.
- Partnering with utilities or infrastructure providers, such as Miami-Dade Water and Sewer Department and Florida Power & Light, to establish frameworks for more widespread adoption.

Consider Long-Term Options for Neighborhood Design

Miami Beach's neighborhood typologies are as iconic as the city's natural landscape typologies. Culture, architecture, and the arts are critical aspects of the city's identity and draw, and the corresponding policies are explored in the "Creative Placemaking" and "Governance" sections of this report.

While analyzing the stormwater management program, the panel discussed and explored how building and neighborhood types could evolve with climate adaptation. One long-term typology that may become more prominent because of the increasing effects of climate change and increased flood risk is the neighborhood in which not every property decides to adapt, owing to the cost of home elevation and other measures.

If neighborhoods evolve as renovation of every property becomes cost prohibitive, Miami Beach may follow precedents in other U.S. cities to create floodable public green spaces in neighborhoods where residents are interested in relocation. The public green spaces could serve a flood function and become valued amenities and centers for neighborhood character, following the historic precedents of cities such as Savannah, Georgia, whose squares provide valuable public gathering spaces and form a crucial part of the city's character.

Creative Placemaking

ARTS, CULTURE, AND DESIGN are core elements of Miami Beach's identity and key draws for this international tourism destination. The city recognizes that its cultural capital is a major economic driver and an important attraction for the approximately 12 million people who visit Miami Beach proper each year.[21] From the allure of its natural environment to its historic communities and art-centric culture, the city should implement creative placemaking techniques as an important factor in its stormwater management and resilience strategies. Creative placemaking intentionally leverages the power of the arts, culture, and creativity to serve a community's interests while driving a broader agenda for change, growth, and transformation.

Miami Beach has been a cultural icon for nearly a century. The art deco architectural style that the city is known for began as far back as 1923 and spanned a 20-year period.[22] Its prominence was recognized as early as 1979, when it became the first 20th-century neighborhood to be recognized by the National Register of Historic Places.[23] Even today, this national district, made up of four local districts, is the nation's largest collection of art deco, with more than 800 buildings constructed in the style.[24] The city has continued to hone in on the arts in recent years, by first hosting the annual art fair Art Basel in 2002. Today the event hosts 250 international galleries and more than 82,000 guests in a matter of days. Economists have estimated that south Florida benefits from $400 million to $500 million in annual economic impact from this art week.[25]

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Color and texture are integral to the Miami Beach art deco style.

The art deco architectural style of Ocean Avenue is part of Miami Beach's cultural identity.

© LAURA WEINSTEIN-BERMAN

The residents of Miami Beach have stressed the importance of maintaining the cultural identity of the city and its neighborhoods as it proceeds with implementation of its stormwater management and resilience plans. Placemaking is a strategy that can address this concern. Placemaking refers to the act of creating a sense of place or identity. *Creative placemaking* leverages art and culture interventions in the process. According to a 2010 study by the National Endowment for the Arts, creative placemaking "animates public and private spaces, rejuvenates structures and streetscapes, improves local business viability and public safety, and brings diverse people together to celebrate, inspire, and be inspired."[26]

Incorporating creative placemaking into the resilience and stormwater management plans would enhance the overall

value of the stormwater management mitigation efforts and offers a number of benefits, including the following:

- Improving the aesthetics of visible components of the city's stormwater management program, including the raised streets, pumps, and generators;
- Presenting physical components in ways that are culturally relevant to the neighborhood or place;
- Enhancing awareness and understanding of the city's resilience program through solutions that are informational in nature;
- Building buy-in and support for the Miami Beach resilience program through early engagement of artists and residents; and
- Branding Miami Beach as the Resilient Art City.

When properly executed, creative placemaking is wholly synergistic, benefitting both private and public stakeholders by cementing the city's cultural aesthetic and driving more economic investment into the region. The city, in turn, benefits from increased spending and tax revenue to drive its resilience plan forward.

Strategies such as these to incorporate creative placemaking into the stormwater management and resilience strategy are described in the following sections:

- Ensure that partnerships with local arts and culture stakeholders are embedded in the placemaking strategy.
- Incorporate public art in the stormwater management strategy.
- Involve and engage artists in the design process.
- Create open spaces that respond to resilience needs while engaging local artists and designers.
- Incorporate creative placemaking strategies into the overall resilience communications plan.

WILL GRAHAM/ULI

Wynwood Walls, a graffiti and street-art open gallery, hosts special exhibitions for Art Basel in Miami.

Partner with Local Arts and Culture Stakeholders

All of the city's placemaking efforts will be most effective when developed in partnership with stakeholders already engaged in the dynamic arts and culture scene in Miami Beach. The city should work in partnership with key organizations, such as the following:

- Miami Design Preservation League;
- ArtCenter South Florida, one of Miami Beach's largest and longest-standing artists' studios;
- Universities, including those that have considered the visual arts and design in their approach to this topic, including
  - University of Miami, which is incorporating sea-level rise in its curriculum across numerous disciplines, including the School of Marine and Atmospheric Science, School of Architecture, College of Engineering, and College of Arts and Sciences, among others;[27] and
  - Florida International University, which includes the Lincoln Road–based Miami Beach Urban Studios, and its Sea Level Solutions Center, which is incorporating design technology such as 3D printing into its work, and has hosted events such as a symposium on sea-level rise and the public realm;[28] and

Evacuteer: Placemaking and Preparedness

In New Orleans, Evacuteer merges hurricane awareness programming with a creative use of placemaking. Sculptures around the city help direct residents to locations at which they can meet during mandatory evacuations, which are called EvacuSpots. These locations serve to register people, pets, and luggage and transport them to safe locations if they lack their own resources. Seventeen EvacuSpots dot the city, including four specifically near senior centers. Although official signage was in place, originally concerns existed over its visibility to users.[29] As a result, in 2013, Evacuteer partnered with the Arts Council of New Orleans to hold a design contest to create sculptures at the various locations. The winning design, by artist Douglas Kornfield, resulted in a $200,000 public art project throughout the city.[30]

The design was selected for its clarity and interpretation. The hailing-a-cab gesture is universal, making it easily understood and avoiding anxiety-inducing interpretations. The gesture also fits New Orleans well—although unintended, it is serendipitously the same one used to collect beads during Mardi Gras. However, the focus is in functionality. Each sculpture has a plaque on its leg indicating registration rules and instructions. In addition, they are built to last: at 14 feet tall and 800 pounds, the stainless-steel structures were designed for up to 200 years of wear and tear.[31] In 2015, Evacuteer began a fundraising program to light them, to ensure that the figures are visible at all times. For help in locating them, citizens can go to the city's NOLA Ready website, managed by the New Orleans Office of Homeland Security and Emergency Preparedness, or can dial 311—which also hosts Evacuteer volunteers.[32]

WIKIPEDIA

Each EvacuSpot sculpture has a plaque that indicates pick-up instructions.

© JAMES SHAW

An illuminated EvacuSpot sits outside the Arthur Monday Center in New Orleans.

The program has been in place since just after Hurricane Katrina, when New Orleans sought to find ways to better protect its citizens from risk. As a result, in 2005, the city developed the City-Assisted Evacuation (CAE) program to help an estimated 35,000 to 40,000 of its residents who lack safe evacuation transportation. CAE provides transportation to safe shelter and a ride back when the city is opened. During Hurricane Gustav, Evacuteer was formed as a temporary volunteer program to help with the first CAE evacuation, but was authorized by the city to permanently operate when the city found opportunities in the system. Today, more than 500 volunteers a year are trained by Evacuteer to help not just with evacuations, but also with community outreach, education, and risk awareness.[33]

By initiating a sculptural element to the EvacuSpots, the program makes it easy for the community to locate evacuation areas. As important, the art serves as a persistent reminder of prevailing risk and emergency awareness without negative connotations. Evacuteer shows how creative visibility in the public realm can amplify programming that lacks existing infrastructure.

- Art Basel, which presents an incredible opportunity to engage both the international artists' community and the international community of art enthusiasts and buyers.

Incorporate Public Art in the Stormwater Management Strategy

Miami Beach's current stormwater management program features significant gray infrastructure components. In particular, the pumps and generators are large and often unwieldy structures, which look out of place in a right-of-way or park. Numerous residents participating in the panel's interview process complained about the aesthetics of the pumps, describing them as an eyesore in an otherwise vibrant and architecturally exciting city. Some also noted public safety concerns when the pumps had a lack of visibility from the street or well-lit areas.

Incorporating public art into this stormwater management infrastructure has exciting potential to address such concerns and otherwise build Miami Beach's brand as a resilient arts city. Accordingly, the city should actively include art in current and future stormwater management investments. For example, public art could be installed at pump stations that are currently deemed to be disruptive or unsightly, or artists could be involved in developing cladding or accompanying sculptural pieces. When used to showcase art, the pumps offer an opportunity to celebrate unique aspects of Miami Beach and the different characters of various neighborhoods. Instead of looking like invaders, the pumps could become local landmarks and signifiers of neighborhood identity or interests.

The public and other stakeholders should have a key role in selection and procurement of these public art works. The city could take the following actions:

- Partner with the Art in Public Places (AiPP) Committee to create a strategy for creating a new iteration of AiPP art works in conversation with stormwater management plans.
- Identify artists through a request for proposals procurement process, highlighting strategies to include and draw local artists.
- Engage artists for both site-specific installation opportunities and opportunities that could be prototyped for use at more than one pump or generator station.

KATHARINE BURGESS/ULI

Collins Park now hosts Miami Mountain, *a 41-foot sculpture by Ugo Rondinone that was recently acquired by the Bass Museum of Art.*

Placemaking and Water Management

The city of Miami Beach can look to several national examples of best practices in resilience and creative placemaking, particularly in the design of public spaces that effectively manage water.

Vine Street, Seattle, Washington

The Vine Street installations in the Belltown neighborhood of Seattle take innovative approaches to showcasing the management of water in an urban context. Located in the downtown waterfront area, Belltown is one of the most densely populated neighborhoods in the city and dominated by impervious surfaces.

In the mid-1990s, a group of residents organized the Growing Vine Street initiative to implement artistically designed green infrastructure along an eight-block strip of the street, ultimately connecting the community to the waterfront. The residents' group partnered with Seattle Public Utilities (SPU), the Seattle Office of Arts and Culture, and other city departments to pool resources and community input, while raising awareness of SPU's water conservation efforts.[34]

The driving priority of Growing Vine Street is to capture and naturally filter rain and stormwater runoff before channeling it into Elliott Bay. A few projects along Vine Street demonstrate the potential impact of integrating art into stormwater capture-and-release infrastructure.

- The *Beckoning Cistern*, a ten-foot-high, six-foot-diameter cylinder collects roof runoff that is first filtered through a candelabra-form vegetated downspout, then distributes the water into a series of cascading planters.
- The *Cistern Steps* installation is a tiered series of biofiltration basins that directs water through a dramatic zig-zagging channel of planters that taper down from a plaza, flowing into a pool at the bottom of the hill.[35]

SARAH BURGESS/ULI

The ten-foot-high Beckoning Cistern *distributes water down the hill in a series of cascading planters when it becomes full.*

SARAH BURGESS/ULI

Environmental sculptor Buster Simpson designed several pieces for Vine Street, including this feature on a building facade, which helps filter rain and stormwater runoff.

Most of the green infrastructure projects along Vine Street are designed to amuse pedestrians while processing runoff through an ecological approach.

Confluence Park, San Antonio, Texas

Confluence Park is part of a more than $400 million river restoration project to upgrade San Antonio's water storage systems. The Mission Reach Ecosystem Restoration and Recreation Project spans over eight miles, and Confluence Park serves as a five-acre gateway to its trails and conservation systems. The park is centered on its signature landmark, the BHP Pavilion, which serves not only as an event and meeting place but also as a way to collect and store rainwater.[36] The pavilion was designed by Andrew Kudless of Matsys Design, who worked in close collaboration with the architect and designer at the start of the project. Its "petals" lead to underground storage and an embayment, which together collect over 200,000 gallons of rainwater for irrigation and plumbing.[37] The park's use of regional ecosystem plantings also allows for less landscaping and water usage, and the educational facility, Estela Avery Classroom, features a green roof and solar panels to work toward energy neutrality.[38]

STUART ALLEN AND CADE BRADSHAW FOR THE SAN ANTONIO RIVER FOUNDATION

Confluence Park's landscape is largely composed of native species that are irrigated by rainwater captured in on-site storage containers.

STUART ALLEN AND CADE BRADSHAW FOR THE SAN ANTONIO RIVER FOUNDATION

Weekly yoga sessions are a part of the events and programming schedule that keep the park engaged with its community. Here a yoga class gathers under the central pavilion, which serves as a water management feature.

The Estela Avery Classroom supports the pavilion and grounds the park's education-focused mission. The classroom provides a free educational facility, supported by an education endowment, and even free transportation for participating schools. The pavilion and classroom are both frequently used for educational programming, including free tours and field trips, while the pavilion itself is highlighted by regular yoga sessions, as well as special events put on by the city, such as its Get Out and Play initiative.[39]

Funding for the park came from both public and private sources, but the majority was covered by private donations to the managing San Antonio River Foundation.[40] The private funding included a $750,000 gift by Estela Avery, the foundation's former director, to build the Estela Avery Classroom.[41] The city has already seen an economic benefit returning on the $13.5 million investment, with many new housing projects sited nearby. One of the projects hopes to bring in over $1.5 billion in impact through 2,100 housing units and nearly 1,500 employees.[42] Confluence Park's diverse benefits demonstrate how creative placemaking can dramatically enhance a city's resilience strategy.

Tanner Springs Park, Portland, Oregon

Tanner Springs Park is located in the Pearl District of Portland on land that was previously a wetland and lake. As the city's population grew, the water system was rerouted via an underground pipe system and filled to allow creation of warehouses and rail yards, which have since been replaced by the current vibrant neighborhood with shops, open spaces, and residences.[43]

Local residents advocated reclamation of two blocks of the former wetlands to create Tanner Springs Park. Emphasis on the area's native wetlands and industrial history is a key theme seen throughout the design of Tanner Springs Park. The design intentionally connected the urban park with Tanner Creek, which previously flowed through the area. The park also includes an Artwall, which runs along the edge of the park and is made up of recycled railroad track with fused glass images of hand-painted dragonflies, spiders, amphibians, and insects. Children are encouraged to explore local species of plants and insects in the splash pond and floating decks.[44] The park is a product of an intense community engagement process led by a local stakeholder steering group to ensure that the park represents the community's vision.

RAMBOLL WATER

With the help of local stakeholders, two blocks of former wetlands were reclaimed to create a dynamic outdoor space.

- Include citizens, key stakeholders, and arts partners in the selection and award process.
- Consider opportunities for synergy with national events in Miami Beach, such as Art Basel.

Involve and Engage Artists in the Design Process

Elaborating on the preceding ideas, artists could go beyond proposing accompanying visual or sculptural art pieces for stormwater management infrastructure and become involved in the actual infrastructural design process. For example, artists could contribute to the design of pumps as follows:

- Establishing design points or requirements, such as solutions that are culturally relevant, educate and inspire, and use historical facts, data, and metrics.
- Establishing partnerships with the city arts department, local nonprofits, and businesses to consult in the creative placemaking process. Note that many leading local universities and groups are already engaging in the intersection of the arts and sea-level rise.
- Awarding artists formal roles in the design and implementation processes to engage with the engineers or design team.

Create Open Spaces Responsive to Resilience Needs While Engaging Local Artists

Parks and green spaces should be a key strategy of the city's overall resilience and stormwater management plans, an idea that is explored at length in other parts of this report. Creative placemaking can then be a core component of the design and planning for these public spaces. Many nationally recognized parks have used the arts as part of stormwater management plans, both beautifying stormwater infrastructure and providing important opportunities for outreach through descriptive signage and accompanying educational materials. Artful cisterns, water recycling systems, rain gardens, and more can add texture and personality to water management schemes and anchor memorable public spaces.

Incorporate Creative Placemaking Strategies in the Resilience Communications Plan

Creative placemaking is a dynamic topic that can be more likely to engage stakeholders than discussions of stormwater management. Content on creative placemaking should be integrated into the overall communications materials for Miami Beach Rising Above and used as a tool to engage more residents and broaden the reach of the plan.

Governance

THE CITY OF MIAMI BEACH has taken a bold first step in addressing its stormwater management challenges, which have been exacerbated by changes in the climate. However, to continue to develop and expand such an ambitious, costly, and dynamic program will require a greater focus on governance.

A key driver of the ability of any community to effectively deliver, monitor, operate, and maintain interventions for stormwater management and climate adaptation is the governance of the system. Implementing a multifaceted plan, including gray and green infrastructure and many vehicles for funding and community involvement, will involve more complex governance structures than are currently in place. Enhanced governance will ultimately deliver a more data-driven resilience program that is rooted in efficiency, transparency, and accountability and that is more likely to garner community support.

The panel's recommendations for governance of the future resilience and stormwater management plans include the following:

- Establish a Miami Beach Rising Above program delivery office or realign existing departments.
- Create a scientific advisory panel through the program delivery office.
- Establish an agency for public investment and development in resilience.
- Establish a community adaptation fund.
- Establish a robust risk transfer department.
- Consider new strategies to better align historic preservation and climate adaptation work.

CITY OF MIAMI BEACH

Miami Beach City Hall is the central civic and government building in Miami Beach.

Establish a Rising Above Program Delivery Office

Miami Beach currently has dedicated resilience staff located in the City Manager's Office and supported through the Rockefeller Foundation's 100 Resilient Cities initiative. This team is currently leading the development of the city's resilience plan in partnership with counterparts in the Offices of Resilience in Miami-Dade County and the city of Miami, managing a full assistant city manager portfolio, including the Building, Planning, Code, Environment and Sustainability Departments, and managing other special initiatives such as the city's participation in the Bloomberg Mayor's Challenge. The team has leveraged and grown the Miami Beach Rising Above branding and communications collateral and integrated new climate adaptation content along with the information provided on the investments in stormwater management. The City Commission has a Sustainability and Resiliency Committee, established in 2015, that provides a forum for policy development and review.

Separate from the staff team responsible for resilience strategy, the city of Miami Beach should open a Rising Above delivery office to monitor and communicate the effectiveness of its Rising Above program, or realign existing departments to create such a team. This office can commission new tools for project performance, community outreach, and codesign of stormwater management systems. A delivery office like this is likely to make the Rising Above program more sustainable over time and would be a platform to help local stakeholders and the public better understand the program's performance and opportunities for improvement. The current lack of public understanding of aspects of the existing program, and the likely time frame for the investments in stormwater management, indicates a need for both better communications and a dedicated vehicle.

This separate project delivery office could serve the following roles:

- Develop tools that promote greater transparency on project selection, development, funding, and expenditures;
- Monitor and communicate project performance;
- Manage strategic communications, community outreach, and community codesign, and facilitate creative placemaking and artist engagement in projects; and
- Embark upon the establishment of a scientific advisory services panel to review and advise the city on the latest climate science data and relevant tools (more below).

Given the excellent regional collaboration already underway in the Greater Miami area through the Southeast Florida Climate Compact and the resilience strategies supported by the 100RC initiative, some scope exists for a program delivery office to be a regional vehicle. Although this would certainly add complexity to the task, it opens up the opportunity for regional comparison and the exploration of goals district by district.

Create a Scientific Advisory Panel

A key component of the program delivery office should be the establishment of a scientific advisory panel to provide data-driven recommendations on how the city can continue to advance its resilience work. This panel should be focused on generating recommendations relevant to the city over the long term, considering the current program's 30-year horizon and the strategies and investment that could be required for 40-, 50-, 60-, and 70-year horizons. The panel could also introduce new strategies for benchmarking to acknowledge increased future risk and the changing climate. Such a panel should be coordinated with the efforts of and data from the Southeast Florida Climate Compact.

Establish an Agency for Public Investment and Development in Resilience

The future viability of Miami Beach is rooted in the financial ability of the city and property owners to continue investments in adaptation and stormwater management projects. Additional sources of revenue will be needed as the city aims to meet 30-year and future-year benchmarks. Furthermore, more flexible sources of revenue are needed: the current stormwater management program exclusively funds gray stormwater investments, such as pumps and enhanced street elevations, and does not include funding eligible for investment in green infrastructure and nature-based solutions such as mangroves. The current program also has not focused on fostering investment at the property owner scale, instead focusing on investment in critical public infrastructure.

The establishment of an agency for public investment and development that can capture additional value from real estate and direct it toward a suite of resilience projects and investments is needed and would streamline the financing of the many facets of such a complex program. Such an agency has the potential to set the national standard for investment in risk reduction projects.

This agency would be tasked with creating strategies to capture increased real estate values and leverage them for public investment in resilient infrastructure, including blue and green infrastructure and a community adaptation fund. The agency may also establish opportunities to encourage development that would contribute to the tax base through incentives, streamlined permitting programs, or tools such as special assessment districts. The last could be a key tool for the city, but they need to be approved by the county in each instance. The enhanced real estate value generated could then contribute to the construction, operation, and maintenance of resilient infrastructure projects.

This agency could be responsible for the following:

- Establishing opportunities for incremental value capture from real estate that could be directed toward resilience projects;
- Directing investment and development of resilience projects (including green and blue projects involving nature-based defenses, as well as gray infrastructure projects);
- Managing operations and maintenance of green and blue resilience projects;
- Exploring opportunities for special assessment districts and embarking on the partnerships and coalition-building needed to accomplish these with the county and others;

DUCKY JOHNSON HOME ELEVATION LLC

A community adaptation fund would assist residents with making the necessary improvements to their homes to protect them, as with this elevated home in the Northeast.

- Exploring potential for additional revenue as a result of group reduction in insurance (through a special assessment district or other instrument); and
- Administering a community adaptation fund.

Establish a Community Adaptation Fund

A key opportunity for this agency will be establishing a community adaptation fund, which could assist homeowners, businesses, institutions, and other property owners with retrofits and investments. Designed to leverage public investment and encourage more widespread adoption of resilient design, the fund could provide low-cost loans and grants for projects in line with the city's overall adaptation goals, such as the following:

- Home elevations;
- First-floor retrofits;
- Private seawall enhancements; and
- Investment in on-site water management mechanisms, such as cisterns, green infrastructure, and permeable surfaces.

This fund would contribute to individual mitigation projects by homeowners and businesses and respond to community concerns about the ability to fund individual projects such as seawall contributions. A fund like this would be a valuable resource for the resident and business community and would ultimately fortify the city by creating a stronger network of solutions across the island.

Establish a Robust Risk Transfer Department

Currently, the city's human resources department manages risk transfer and insurance. The city should instead create a risk transfer department that would be tasked with developing and administering innovative solutions for insurance, including opportunities for insurance savings through investment in resilience and mitigation projects.

The art deco style in Miami Beach historic districts is world renowned. The Breakwater Hotel (far right) was built in a streamlined modern style in 1939.

This department is likely to require new staff, including experts in finance.

The degree of capital investment and exposure to risk in Miami Beach requires a creative approach to managing that risk. By implementing new insurance solutions and programs such as a special assessment district for both driving public investment and transferring risk, Miami Beach has an opportunity to set the national standard for risk reduction in the wake of sea-level rise.

Align Historic Preservation and Climate Adaptation Strategies

Miami Beach's art deco architecture is a vital component of the city's identity, a key contributor to the architectural heritage of the country as a whole, and a very important economic development and tourism generator. Visitors from across the country and world flock to Miami Beach for this historic architecture as well as the natural assets such as the ocean and beaches, which first drew settlers from the northeast United States to Miami. Preserving the city's culture and architecture is an inherent aspect of supporting the city's economy.

The city's existing heritage regulations and governance have done a formidable job of preserving the integrity of the city's historic architecture. However, given the extent of the risk that the city faces and the vulnerability of many historic buildings, all stakeholders must begin to reconsider what preservation means and strategize accordingly. If Miami Beach successfully engages in this conversation locally, the city and heritage community will have the opportunity to lead a national conversation regarding how to respect and care for cherished historic assets in the face of environmental vulnerability.

The city is already moving in this direction. For example, in 2017 the city released a request for qualifications (RFQ) for a consultant to provide input into historic district resilience and adaptation guidelines. These guidelines will address the renovation, elevation, and repurposing of historic structures in vulnerable parts of the city, considering both increasing tidal flooding and sea-level rise. The RFQ requested a multidisciplinary team, with expertise in engineering, architecture, planning, historic preservation, hydrology, geotechnics, and cost consulting.

A recent edition of the National Trust for Historic Preservation's *Forum Journal* noted that "climate change and rising sea level mandate a new kind of assessment of the vulnerability of historic resources, requiring stakeholders to look at adaptation options and to decide what will be saved for future generations."[45] Miami Beach is well positioned to develop tools and frameworks that vulnerable cities across the country can use to both safeguard heritage and support the related decision-making process.

First, the extent of the risk faced by the city mandates a more extensive survey of the vulnerability of historic assets. The city should use the new modeling technology (discussed in the "Infrastructure" section of this report) to better understand the vulnerability of historic districts over the upcoming decades and share this information with all relevant stakeholders. All the relevant stakeholders can

then use this information to better understand context, consider adaptation options, and strategize about which historic assets should be prioritized to be saved for future generations.

Unfortunately, no one-size-fits-all solution or easy answer for how to achieve the continued preservation of Miami Beach's historic districts exists. Quite possibly, the entire spectrum or ensemble of historic architecture in Miami Beach may not be able to be saved, given both the intensity of the threat and the cost of adaptation measures such as elevating buildings. If this is the case, the city and all associated stakeholders will need to strategize about how to protect the most important "historic jewels."

Local stakeholders should be prepared for this eventuality and begin to strategize about how to fund climate adaptation measures for historic buildings and how to prioritize these investments if entire building ensembles cannot be safeguarded. These discussions may ultimately include revisiting historic district regulations and modifying approaches to heritage regulation, such as revising policies for contributing and noncontributing buildings within neighborhood ensembles, or introducing opportunities to enable climate adaptation investments for historic buildings.

Throughout this process and before major decisions on individual policies, buildings, or ensembles move forward, the city should better equip heritage professionals and others to be informed about these issues. For example, the "Regulations" section of this report explores how to embed knowledge of climate adaptation, water management, and resilience into local decision-making groups, such as review boards. City officials and local boards should also continue to contribute to and build from conversations that are already underway locally, such as through the Miami Design Preservation League's annual Resiliency Workshop, and engage with international conversations on historic preservation and sea-level rise, such as the "Keeping History above Water" conference series. Requiring review boards to adhere to performance-based goals on managing stormwater in historic districts will also lead to discussion about opportunities and tradeoffs, as explored in the "Regulations" section of this report.

This map shows historic districts, indicated in blocks of pastel colors, and road elevations, indicated in a spectrum of blue to red. The lack of red and orange roads on the map shows the vulnerability of the historic areas.

In short, while moving forward with preservation aspects of its governance strategy, the city should take the following steps:

- Continue to recognize the inherent value of the city's historic architecture.
- Undertake new assessments of the city's historic resources, given the extent of vulnerability to climate change, using the modeling technology previously explored in this report.

Miami Design Preservation League Annual Resiliency Workshop

Miami Design Preservation League, the city's preeminent local preservation organization, held its Annual Resiliency Workshop on April 7–8, 2018. The event began with a lecture series, followed with a day of site assessments in the Flamingo Park neighborhood. The workshop focuses on "solution-based ideas" for resilience and preservation and uses a multidisciplinary approach. Attendees and speakers included keynote speaker from FEMA Nicholas A. Shufro, lawyers, engineers, academics, and designers, as well as city and local government representatives such as the city's planning director, city commissioner, and a Historic Preservation Board member.

The workshop focused on five key lessons learned: change beginning at the local level, interdisciplinary efforts, effective government communication and early stakeholder involvement, economic incentives for preservation adaptations, and how to continue to lead in resilience efforts as a city. With over 30 percent of the building stock designated as historic on the local level, preservation is and will be a critical element of plans for the resilience of Miami Beach.

- Establish performance-based goals for managing stormwater in historic districts, and work with key stakeholders to establish innovative ways to achieve these goals (more information in the "Regulations" section of this report).
- Implement changes in local review boards to improve knowledge of resilience in everyday decision making (see the "Regulations" section of this report).
- Begin to establish strategies to fund necessary adaptation work, consider how adaptation fits into existing preservation policies, and strategize about phasing of investments, prioritizing the city's "historic jewels."
- Be ready to lead this conversation internationally, building from dialogues already underway locally and nationally.

Over the long term, the city should be ready to critically examine what comprises historic preservation and consider definitions focused on both strict preservationist approaches and approaches focused more broadly on urbanism, walkability, and district character that may support more adaptation investments being made.

Other cities across the world are likely to look to Miami Beach for leadership on this topic and learn from the city's process and decisions.

Keeping History above Water

"Keeping History above Water" is an annual preservation conference addressing the challenges of sea-level rise and historic preservation and exploring precedents and potential solutions. The conference recently began in 2016 with the Newport Restoration Foundation (NRF) and was hosted by Annapolis, Maryland, in 2017, including participation by ULI's Urban Resilience program.

The conference strives to create an interdisciplinary environment for people involved in preservation—from elected officials to designers to engineers—to discuss protecting historic structures, emphasizing real-world applications.[46] After the initial year, the NRF partnered with the U.S. chapter of the International Council on Monuments and Sites to create a Knowledge Exchange on Climate Change and Heritage.[47] Through this exchange, diverse historic communities, including critically endangered ones such as Annapolis and New Orleans, have had the opportunity to engage in an international dialogue on historic coastal resilience.

LEAH SHEPPARD/ULI

A packed room shows the popularity of the "Keeping History Above Water: Annapolis" conference of 2017. Professionals and officials meet annually to discuss strategies to adapt and protect historic structures from sea-level rise.

Financing

FINANCE IS CRITICAL for an effective stormwater management and climate adaptation strategy and will be front of mind as the city of Miami Beach determines how to implement the many strategies needed to better live with water.

Sources of finance include public and private capital as well as contingent capital, such as insurance. A close relationship exists between insurance and capital flows. Insurance can lower the cost of capital as it reduces the risk of default. Lenders typically require insurance for loans, both commercial and residential.

The city should take a holistic view of finance that recognizes the role stormwater management and climate adaptation play in the pricing of insurance premiums. This ensures a stable tax base and good credit rating so the city is able to deliver the stormwater management infrastructure Miami Beach needs to adapt to climate change. By retaining a robust tax base and growing economy, the city will have a range of revenue streams to consider.

Building on the recently commissioned stormwater business case analysis, the city needs to continue to progress on a more comprehensive approach in evaluating existing costs and benefits of stormwater and adaptation financing decisions:

- The core of an effective risk financing strategy should be a total cost of risk (TCOR) approach. TCOR is a finance strategy that looks at underlying exposure and expected losses and then examines the cost of risk engineering, insurance, and risk retention. It allows the most efficient use of capital for a given risk appetite.
- Operations and maintenance costs need to be taken into consideration when evaluating solutions.

Once costs and benefits are assessed, the city needs to carefully consider the most effective revenue streams that link to the benefits businesses and residents receive from investments that improve stormwater management and climate adaptation. The following revenue streams could be considered for contribution:

- Assessment districts, such as a business improvement district, where a special levy can be introduced, although they will require approval of the County Commission;
- Incremental finance or land value capture districts where increases in value tied to stormwater management and climate adaptation can be used to finance solutions;
- Incentive programs or fines stemming from building owner lack of action;
- Increases in stormwater fees and other rates; and
- State and federal grants that may be available—the city should decide when these sources may be appropriate, without relying on these funds because they may not be available in perpetuity.

The need for adapting private properties to the risks of sea-level rise is a significant burden for many businesses and residents. A community adaptation fund could be a unique solution.

- The establishment of a community adaptation fund would provide low-interest loans to help residents and businesses finance the large upfront costs of retrofitting properties. This could be tied to the property tax so the loan gets transferred to a new owner, similar to a property-assessed resilience method tied to a mortgage.

- The fund could adopt a blended finance approach, using an initial source of public capital backed by private sector capital that could be tied to reduced insurance premiums, enhanced property values, workforce housing, and the like.

To secure the public balance sheet, the city should consider insurance as a form of risk transfer that can play an appropriate role in reducing the burden on taxpayers by offloading the balance sheet risk of implementing large resilience projects.

- Take a TCOR approach in deciding where engineering solutions should be used, where insurance should be used, and when the risk should be retained by the city and its residents.
- Consider insuring key infrastructure critical to maintaining the resilience of Miami Beach to lower the burden additional repair costs place on the city's ability to service the debt of building resilient infrastructure.
- Because 84 percent of properties in Miami Beach are covered by NFIP, outline an insurance pool for the city should NFIP undergo significant negative changes in the future. Insurance pools have been successfully implemented in the Caribbean, New Zealand, the United Kingdom, and other parts of the world to ensure access to affordable insurance.
- Discuss the role parametric insurance, which pays a preagreed amount when a particular condition is met, could play in dealing with some of the chronic risks sunny-day flooding and noncatastrophic storms present to the stormwater system.
- Advocate for living with water to insurers diversifying their portfolio and otherwise potentially moving policies away from coastal Florida.

Finally, finance must be integrated into the city's communication and engagement strategy. Finding a credible and clear way of communicating how investments in resilience benefit credit ratings, lenders, investors, taxpayers, and visitors includes the following:

- Regular engagement with credit rating agencies to ensure a stable credit rating, keeping the cost of borrowing and associated taxes affordable, and emphasizing that the city is reducing the vulnerability component of risk;
- Regular engagement with the insurance industry for feedback on how the city's investments in stormwater management and climate adaptation can be reflected in insurance premiums, thereby benefiting businesses and residents;
- A clear communication strategy aimed at investors to demonstrate that Miami Beach has a healthy and prosperous future; and
- Engagement with residents and businesses on the changing landscape of climate risk disclosure from international regulators and financial institutions, to enable more open conversations about how improvements the city is making have a positive impact on asset values.

By bringing together new revenue streams that are equitable, risk based, and tied to the total cost of risk, the city has the opportunity to explore new risk transfer solutions and communicate its strategy with financial stakeholders in a way that improves confidence.

In summary, the panel recommends that the city do the following:

- Continue to comprehensively evaluate existing resilience costs and benefits.
- Find effective revenue streams to link to stormwater and resilience benefits.
- Establish a community adaptation fund.
- Use insurance as a form of risk transfer to reduce taxpayer burden.
- Integrate financing into the communications strategy.

Regulations

MIAMI BEACH'S CURRENT STORMWATER management strategy focuses largely on investments in public infrastructure. However, the regulation of private development offers an important opportunity that is not thoroughly integrated into the current water management strategy. Sea-level rise and sunny-day flooding present grave threats to the community. Addressing these issues should be a high priority for any new development and should be considered alongside long-time priorities such as historic preservation and environmental impact.

Using regulatory tools to influence the development and redevelopment of property will allow Miami Beach to take advantage of the natural building cycle to spread the cost of enhancing resilience over time and leverage private financing and expertise. Miami Beach is in a privileged position given the high value of land and the desirability of the community: the city should leverage this private financing and expertise to help achieve the goals of a more ambitious resilience plan.

Precedent already exists for these types of regulatory changes in the recent ordinances offering increased height and density for taller first floors to accommodate climate adaptation measures. Increased regulations specifically addressing stormwater will allow the city of Miami Beach to regulate private development to accommodate green infrastructure and manage water at the parcel and building levels, as well as continue to invest in neighborhood and citywide infrastructure. The city can also use its existing regulatory infrastructure to incentivize increased stormwater management at the parcel level.

Implementing new regulations is likely to require an investment in additional city staff, which is critical to manage a potential uptick in development approvals or a more complex process. If development is backlogged or delayed, the incentives will not generate the additional tax money required to invest in resilient infrastructure.

KATHARINE BURGESS/ULI

This Publix supermarket was initially built at a higher elevation, so when local roads were raised, it actually became more accessible.

Miami Beach should consider the following regulatory opportunities:

- Embed water management goals in development regulations and/or incentivize resilient design.
- Leverage and reform regulatory boards.
- Adjust stormwater fees.
- Create an islandwide sea barrier, including enacting regulations to allow centralized efforts.
- Continue to support elevation for new construction.

Embed Water Management Goals in Development Regulations

To implement the integrated water management strategy necessary to protect Miami Beach, the city will have to manage water at the parcel and building levels as well as continue to invest in neighborhood and citywide infrastructure. Parcel and building level water management can make a huge contribution. For example, Philadelphia's *Green City, Clean Waters* plan, kept 1.5 billion gallons of

polluted water out of the rivers annually in its first five years, using 1,100 individual stormwater tools implemented by both private developers and Philadelphia Water.[48]

Embedding water management in private development regulation can be accomplished through a mix of requirements and incentives such as rebates, density bonuses, and expedited permitting. In Miami Beach, almost all new development and most rehabilitation and redevelopment require the approval of multiple regulatory bodies, and further certainty in the approvals process can be a key motivator for the incorporation of sustainable or resilient design approaches.

Beyond the recent ordinances addressing building height, Miami Beach already has other incentives in place to encourage sustainable design, but it does not currently have incentives for stormwater management specifically. For example, developments larger than 7,000 square feet are required to comply with LEED Gold or more stringent parameters.[49] On the water conservation side, Miami-Dade Water and Sewer Department has irrigation restrictions and offers rebate programs related to water efficiencies for landscapes, showerheads, toilets, and faucets.[50] Incentives are also in place for other types of development, such as density bonuses for the incorporation of affordable housing.

The city also should look into models for incorporating resilient design into regulations, whether through incentives or requirements. Norfolk, Virginia, provides one example.

KATHARINE BURGESS/ULI

The Miami Beach Property Management Facility, constructed in 2009, was required to be certified LEED Gold.

There, new development projects must adhere to a points-based resilience quotient, a matrix featuring building-scale interventions related to risk reduction, stormwater management, and energy resilience, all of which are awarded different numbers of points.

Moving forward, the city should take the following actions:

- Continue to allow greater height and density, given the future loss of usable space (i.e., floors designed to accommodate future raised entryways) as groundwater rises and tidal and stormwater flooding increase. Although increased height may not always be politically popular, additional elevation can offset the loss of ground-level floors for productive use.
- Develop additional design standards and specifications to help mitigate the impact of increased height. These resources will not only be critical for Miami Beach but will also be important resources for many other cities grappling with sea-level rise.
- Explore opportunities for incentives for multifamily and commercial properties that specifically incorporate stormwater management, green infrastructure, cisterns, and other opportunities for water capture and reuse. Incentives could include the following:
  - Streamlined development approval process;
  - Greater density, addressing setbacks, height, or floor/area ratio;
  - Flexibility on historic preservation requirements; and
  - Public financing in the form of grants, loans, or guarantees for single-family housing.

Examples of Stormwater Management Policies

Cities across the United States have taken a range of approaches to stormwater management policies. The following policies, which do not reflect all policies in each market, represent a cross section of types and approaches that may be relevant to Miami Beach.[51]

City	Policy type	Example project	Further information	Administrator	For more information
Boca Raton, FL	Fee	A nonresidential property must pay a fee calculated on its impervious area, its number of equivalent residential units (ERUs), and $3.35, the current value of one ERU.	The program relies on ERUs to calculate fees. The ERU increases yearly based on the Consumer Price Index. An ERU in Boca Raton is determined as 2,837 square feet, the average amount of impervious surface on a local residence.	Stormwater Services, under the Department of Municipal Services	https://www.myboca.us/693/Stormwater-Management
Charlotte, NC	Buyout and acquisition	The city purchased 19 buildings of apartments in a floodplain and relocated the residents.	Charlotte has operated a buyout program since 1999. Originally using FEMA funding, it now relies on stormwater fees to help fund the program.	Charlotte-Mecklenburg Storm Water Services	http://charlottenc.gov/StormWater/Flooding/Pages/FloodplainBuyoutProgram.aspx
Houston, TX	Regulation	A new development must be built two feet above a 500-year floodplain.	On a mandate from the mayor, the city overhauled the Floodplains section (Chapter 19) of its Code of Ordinances in early 2018, amending all 42 pages. Development must now reference a 500-year floodplain instead of a 100-year floodplain.	Houston Public Works/Houston City Council	https://library.municode.com/tx/houston/codes/code_of_ordinances?nodeId=COOR_CH19FL#fn_81
Philadelphia, PA	Regulation	New development, redevelopment, and retrofits trigger stormwater management requirements.	Stormwater regulations are one aspect of Philadelphia's *Green City, Clean Waters* plan, which addresses stormwater quantity and quality through strategies for public and private investment, using both development regulations and stormwater billing.	Philadelphia Water Department	https://www.pwdplanreview.org/manual/chapter-1
Pittsburgh, PA	Regulation	A new home being built in the Stormwater Overlay must go through a Stormwater Plan Review.	The Stormwater Overlay area requires that any development or land disturbance that meets its requirements (even 10,000 square feet of disturbance, less than one-quarter of an acre) must submit a Stormwater Plan. The plan requires existing conditions, a stormwater analysis, premits, and maintenance programs.	Department of City Planning	https://library.municode.com/pa/pittsburgh/codes/code_of_ordinances?nodeId=PIZOCO_TITNINEZOCO_ARTIIIOVZODI_CH906ENOVDI_906.07STMAOVDI
Portland, OR	Voluntary program	The city encourages private stormwater management through the Disconnected Downspouts Program.	The program seeks to prevent downspout water from causing sewer system backups. From 1983 to 2011, 56,000 downspouts were removed in Portland, and today the program helps prevent 1 billion gallons of water from entering the system annually.	Portland Environmental Services	https://www.portlandoregon.gov/bes/54651
Washington, DC	Stormwater Retention Credit Trading System	D.C.'s Department of Energy and Environment has created the first stormwater credit market in the United States.	The market for Stormwater Retention Credits enables developers to purchase credits toward compliance with current stormwater regulations. The market also creates an opportunity for landowners to receive an income stream from functioning green infrastructure.	D.C. Department of Energy and Environment	https://doee.dc.gov/src

Leverage and Reform Regulatory Boards

Miami Beach has a very robust regulatory infrastructure system, including four regulatory boards governing new development:

- Historic Preservation Board;
- Design Review Board;
- Planning Board; and
- Zoning Board of Adjustment.

Miami Beach should leverage these regulatory boards and revisit their charters and missions to ensure that water management is prioritized at the building and parcel levels. Although the city and its boards are taking steps in that direction, the missions and charters of existing boards should be expanded to give equal priority to water management. Water management is an existential issue for Miami Beach, and it must be given an equal footing with other public priorities, including design, historic preservation, and economic development.

The Natural Building Cycle

The natural building cycle is the pace at which buildings are reinvested and updated or replaced. Working within the context of this cycle can minimize potential disruptions and excess costs, as well as prevent risks from adapting aging buildings. When constructing new buildings, flood adaptation measures can be integrated more seamlessly. Established structures could receive resilience adaptations when being maintained, for instance by adding energy-efficient windows instead of making a like-for-like replacement. Less invasive interventions could be used for older buildings, such as operational changes, including moving storage that is at risk for flooding. By leveraging the building cycle, owners can make building adaptations more efficient and accessible.[52]

Strategies for ensuring that water management is addressed could include the following:

- Add members to the Historic Preservation Board and the Design Review Board, either in the existing seats or by creating additional seats, who have expertise and background on water management and climate adaptation. To effectively consider and advance water management goals, members with appropriate technical backgrounds are needed. Given that Miami Beach is a leader in resilience, locating individuals with the appropriate water management and resilience expertise to sit on these boards should not be difficult. Having this perspective and knowledge base consistently represented and part of board deliberations and decisions will ensure that the topic remains a priority. In addition, existing board members should receive training on these topics to give them clear guidance on the strategies they should be using and applying. There is precedent elsewhere in the United States for requiring training on this topic. In 2017, Rhode Island approved legislation that required all members of local planning commissions or boards to receive training on floodplain development and sea-level rise, including modules on climate change, flooding, mapping tools, and stormwater.
- Allow real estate professionals to participate on these boards, because real estate expertise is needed to understand how to effectively finance potential future retrofits or investment in resilient infrastructure. Currently, restrictions limiting participation from developers include rules against members contracting with the city and against using Community Development Block Grants.
- Provide training and technical support to both boards on water management issues (as referenced above). This should include training and context on current challenges, projected future conditions, tools available to manage water, and the city's stormwater management and resilience strategies.

- Provide specific measurable water management goals that the boards are responsible for helping achieve for the respective watersheds and districts. Providing the boards with measurable goals at the district and watershed levels will give them greater flexibility in how they balance historic preservation, design, and economic development goals on a property-by-property basis and will enable them to put site-specific decisions and tradeoffs into context. For example, a district could be required to achieve 100,000 gallons of water storage, which would need to be allocated within both new development and public spaces and rights-of-way.
- Ensure that the planning department has the staff and outside support to review and approve proposed development and redevelopment projects. Additional staff with technical knowledge will be needed to support the boards in their decision making. Without this staff, the approval process will bottleneck, and the pace at which water management is improved will grind to a halt.

Adjust Stormwater Fees

A mix of incentives and requirements will nudge more property owners in Miami Beach to capture, contain, and treat water on their own properties, which will greatly benefit the city as a whole. Central to this strategy is the stormwater fee.[53] The city should be applauded for recently introducing a fee and using it to fund the stormwater management improvements underway—and for passing this fee without major opposition. The city's entrepreneurial approach of using this fee, given the opportunity for its introduction without involvement from the county, should also be lauded. However, the current flat rate does not encourage retention of water on private property.

As a next step, the city should adjust the current stormwater fee structure from a uniform fee across the board to one that assigns a fee according to each property's runoff levels. This structure would look at both the size of a lot and the percentage or area of connected green and permeable surfaces, thereby encouraging investment in permeable driveways, green roofs, and green spaces to lower fees. This updated structure will reward property owners that effectively manage water on their property and decrease the burden on pumps.

©KOREY DAMS

Stormwater fees have helped fund stormwater infrastructure and hazard mitigation.

At this point, the stormwater fee has been a very effective tool for raising funds as well as awareness of stormwater investment. A next step will be modifying the fee to encourage on-site water management at the parcel level. This modification will also offer an educational opportunity to share tools for on-site water management (such as cisterns, permable pavers, and so on) with homeowners within the city's broader Miami Beach Rising Above communication efforts. Implementation of on-site water management can even lead to zero fees for homeowners generating zero runoff.

Models for the city to consider include the following:

- Rates based on square feet of connected impervious area;
- Other, more complex rate formulas, such as
  - Fees based on impervious areas as a percentage of gross area;
  - Fees based on an average of impervious area per single-family residence; and
  - Fees based on the likely runoff factor on site, considering impervious area, slope, and soil type; and

Stormwater Fee Structures

Stormwater fees can take a range of forms, many of which encourage homeowners, businesses, and developers to implement on-site stormwater management and decrease impervious surfaces. This explanation of different types of fees has been sourced and subsequently modified from a report produced by the Bureau of Governmental Research in New Orleans. For more information, see the source notes.

Type	Details	Formula
Development intensity	Charged by gross property area as compared to the percentage of impervious area, charging more for sprawling structures.	Fee: Gross area × Rate applicable to percentage of impervious area
Dual fee	Charged by classifying parcels into categories for residential or nonresidential and levying a flat fee.	Fee: Rate per type of parcel
Equivalient hydraulic area (EHA)	Based on the impervious area compared to total gross area, as a combined effect.	Fee: (Impervious area rate × Impervious area) + (Pervious area rate × Pervious area)
Equivalent residential unit (ERU)*	Based on the average impervious surface area of a local single-family residence. The ERU value is used for single residences, but fees for other types are calculated based on their individual surfaces.	Residential fee: 1 ERU (base rate); Nonresidential fee: Total impervious area/1 ERU × ERU base rate
Flat-parcel fee	A standard fee per parcel.	Fee: Rate per parcel
Gross area	Based on total gross area of a property multiplied by a base rate.	Fee: Gross area × Rate per square foot
Runoff	Fee based on the runoff of a property, including volume and rate, based on different environmental factors.	Calculations vary
Total impervious area	Charged by measuring the total impervious area and multiplying by a base rate.	Fee: Total impervious area × Rate per square foot

Sources: Bureau of Governmental Research, Beneath the Surface: A Primer on Stormwater Fees in New Orleans *(New Orleans, February 2017), www.bgr.org/files/reports/BGR_StormwaterFees2017_Report.pdf; Amanda M. Dritschel, "The Impact of Different Stormwater Fee Types: A Case Study of Two Municipalities in Virginia" (MS thesis, Virginia Polytechnic Institute and State University, 2016), https://vtechworks.lib.vt.edu/bitstream/handle/10919/71379/Dritschel_AM_T_2016.pdf?sequence=1&isAllowed=y.*

*1 ERU is the average impervious area for single-family residences within the relevant jurisdiction.

- A trading system for retention volume, such as Washington, D.C.'s Stormwater Retention Credit system. This type of system offers developers the opportunity to purchase stormwater retention credits implemented off site, but within the watershed, of a development project.

These systems can lead to more widespread adoption of green infrastructure across a greater metropolitan area, including underserved areas as well as areas experiencing redevelopment. The implementation of green infrastructure on underserved sites can also offer opportunities for cottage industries related to green infrastructure maintenance and workforce training.

Create an Islandwide Sea Barrier

The city currently instructs property owners to manage seawalls on a parcel-by-parcel basis. This approach does not encourage consistency in terms of height and quality and therefore does not provide the level of protection required.

As part of a more holistic resilience strategy, the city should enact new regulation for a centralized approach creating an islandwide sea barrier that could incorporate both walls and barrier protection. Investing in a seawall

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In Miami Beach, seawalls generally have been managed on a parcel-by-parcel basis, which prevents cohesive protection.

Stormwater Retention Credit Systems

Mount Olivet Cemetery, built in 1858, recently just finished the first phase of a green infrastructure program that was designed to pay for itself. The unlikely candidate was approached by the Nature Conservancy (TNC) to participate in a local Washington, D.C., program in which stormwater retention credits (SRCs) can be bought and sold. The cemetery has converted 18,000 of its 437,000 square feet to date, creating bioretention cells and rain gardens as well as other projects the staff could easily maintain, and hopes the credits it earns from such projects ultimately will pay the $1.7 million tab fronted by District Stormwater LLC.[54]

Washington, D.C.'s SRC program began in 2013, when the local Department of Energy and Environment created more stringent stormwater retention rules. To help cope with the changes, it introduced SRCs, which can be bought and sold on an SRC Market, the first of its kind in the United States. Developers whose projects cannot meet the stormwater requirements are allowed to purchase credits from entities that produce more than what is required. The plan envisioned the creation of opportunities for landowners such as churches, community organizations, and cemeteries, including those in underserved parts of the city, where excess land could be converted into green infrastructure with income-producing potential.

TNC approached the Archdiocese of Washington, D.C., which manages the site, and proposed a stormwater program that would not just satisfy requirements, but could generate enough revenue to pay for itself through such excess credits. The program was especially appealing to the cemetery, which was facing almost $140,000 in annual fees for its impervious surfaces, stemming from a charge of $25.18 for every 1,000 square feet.[55] The rate is a drastic increase from 2009, when it was $1.24 for the same area. DC Water, which charges the fee, is steadily increasing its regulation as a part of a 20-year, $2.4 billion project to reduce the more than 3 billion gallons of runoff and sewage that enters the Anacostia and Potomac rivers each year.[56]

The upfront costs for the cemetery's program came from outside sources. The funding came from District Stormwater LLC, a new investment fund created by NatureVest, the TNC's investment sector, and Encourage Capital, a firm specializing in social and environmental issues. Prudential offered the $1.7 million necessary, and the program plans for repayment through SRCs exclusively, relieving the Archdiocese of financial responsibility. Such projects have become increasingly popular in the District, with only 15 credits sold in its first year, increasing to 105,000 in 2017.[57]

TNC's urban conservation director, Kahlil Kettering, has lauded the efforts of the program, saying that the SRC market "is great because it provides an opportunity to bring in new sources of funding to do conservation projects and also show that you can use private equity [to finance] conservation outcomes."[58] As an additional perk, the Archdiocese's connections to the greater Catholic Church create an information network that can spread stormwater knowledge. DC Water's SRC program is a success story that has the potential to creative positive outcomes not just for the ecosystem, but for both buyers and sellers in a development market.

could have benefits beyond greater protection, such as the potential for an improved NFIP Community Rating System rating.

To undertake this approach, the city could create the following plan elements:

- Special assessment districts for affected properties, which could include waterfront properties, properties on and in the vicinity of the waterfront, or all of Miami Beach—given that the entire city will be protected by an enhanced seawall, this final option may be the most appropriate;
- A user fee; and
- Other public funding mechanisms.

Approval by the Miami-Dade County Commission is required for implementation of a special assessment district. Recognizing that many funding partnerships and other partnership arrangements are in place throughout the county and in Miami Beach, the city should pursue this strategy, given the urgency of enhancing the seawall.

Seawall investment and enhancement along private property could be addressed through the proposed community adaptation fund.

Continue to Support Elevation for New Construction

Elevation is a very political topic in the community, given the importance of Miami Beach's historic fabric and the architectural precedents on the island. Many local stakeholders and community members articulated concern about building elevation during the panel's visit, alluding to cost, compromised aesthetics, and reduced privacy.

KATHARINE BURGESS/ULI

Ramps help with access to elevated buildings.

Although the issues mentioned are valid concerns, the city should continue to encourage the elevation of buildings because of the dire need for protection from sea-level rise and potential peak storm events. As waters rise and flooding becomes more regular, elevated buildings—or buildings with "floodable" first floors—will be the most prepared to endure and will shoulder fewer costs for damages. Allowing additional building height will offset the loss of the ground-level floors for productive use.

As buildings are torn down or retrofitted in natural building cycles, requiring elevation or flood-ready design on the ground floor is appropriate. It is the most reasonable way to pace these investments, given the astronomical cost of raising many of the existing structures at one time.

Moving forward, the city should continue to strategize about how to most sensitively promote building elevation and minimize potential impact on neighbors, including through the development of design frameworks and use constraints.

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New construction in Miami Beach is designed with living space well above ground, allowing the ground floor to flood.

Communications

MIAMI BEACH'S STORMWATER MANAGEMENT plan initially did not have a robust communications plan, and many residents interviewed during the panel process complained about an early lack of information or opportunity to engage meaningfully in discussions about local infrastructural investments. However, the city has since made great strides in communicating its resilience challenges and efforts to the local community, including through the Miami Beach Rising Above website. The city should be recognized for the following robust and proactive communications efforts:

- Diverse methods of communication and community outreach, which have included the following:
  - Strong engagement on social media channels;
  - Publications in magazines for residents; and
  - Hosting neighborhood meetings and educational programs;
- Tools and resources for residents, including workshops, reference guides, and personal impact calculators;
- Development of the Rising Above website to serve as an all-inclusive resource and guide on the city's challenges, plan, and efforts;
- High-quality communication materials;
- Commitment to including and engaging all of the city's stakeholders;
- Development of crucial channels of communication within the community through engagement with neighborhood leaders, homeowners associations, and community groups;
- Collection and analysis of data regarding outreach efforts to date, and subsequent adaptation of strategies; and

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A packed house attending the ULI panel presentation in April 2018 shows the engagement of local stakeholders.

- Miami Beach Rising Above branding, which embraces the city's living-with-water dynamic and enables it to control the narrative and take ownership of its future.

The issues facing the city are complex, far reaching, and divisive, however, and will continue to challenge the city for the rest of its foreseeable future. Addressing them will require unceasing commitment, aggressive short- and long-term planning, innovative solutions, difficult decisions, and continual assessment and adaptation.

Projections of weather patterns, impacts, and intervention results vary considerably, and the city's response will change significantly over the course of its adaptation process. One thing that is certain is that Miami Beach's future will involve living with higher levels of water more often. The city needs to recognize that communicating this future to its residents and weaving it into the city's identity are necessary to garner long-term support for adaptation measures.

Moving forward, the city should maintain its focus on communications as a key tool to the success of its long-term survival. In addition to continuing to pursue current strategies, the city should strive to incorporate the following recommendations:

- Build on comprehensive efforts and focus on promoting the Miami Beach Rising Above website as the primary resource for residents and business owners.
- Be bolder in its communications, engagement, and marketing strategies.
- Build public trust through constancy, clarity, and improved transparency.
- Create a broad communications plan focused on resilience and stormwater management, including information developed specifically for different audiences.
- Improve the diversity and robustness of communications.
- Leverage others to spread the city's messaging, grow networks, and gather support.
- Create opportunities to celebrate successes.

More information on each of these recommendations follows.

Promote the Rising Above Website as the Primary Resource

Since the early days of the stormwater management program, the city of Miami Beach has made significant strides in communicating resilience challenges and opportunities.

The Miami Beach Rising Above website is one critical resource with strong branding and a positive outlook, which embraces the city's living-with-water dynamic and enables it to manage the narrative. The website is an all-inclusive resource and guide to the city's resilience challenge and includes materials that are clear, concise, and accessible to community members without technical knowledge of engineering and climate change.

The city has also complemented this website with diverse methods of communication and outreach, including social media engagement, neighborhood meetings and educational programs, articles in magazines for residents, and other engagement with neighborhood leaders, homeowners associations, and community groups.

The city cannot hope to achieve the necessary work to adapt to climate change without a base of widespread and dedicated community support and engagement. Miami Beach should actively and aggressively build this base within its community and must leverage its community to spread its message and contribute to its solutions. Throughout these efforts, the city should focus on promoting the Miami Beach Rising Above website as the primary, comprehensive resource for the city's residents and business owners and enabling community members and leaders to share and promote the city's message and goals within their own networks.

The Miami Beach Rising Above website offers an excellent guide to local resilience planning.

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Be Bolder in Communications Strategy

Although the existing communications portfolio, particularly the Miami Beach Rising Above website, offers excellent resources, the city can do more to communicate climate challenges and hone the messaging for both local and global audiences.

The city of Miami Beach is on the front lines of resilience challenges worldwide, and its process and strategies are being watched and analyzed by municipalities around the world. The current headlines and narrative are often dire and paint the city as one of the first global victims of climate change.

The city should not shy away from this narrative and avoid discussing the difficult questions and topics it raises. Instead, the city should strive to embrace its challenges as part of its current identity and shape the narrative. Miami Beach should aggressively promote itself as the leader in climate resilience, serving as a testing ground and case study to communities worldwide.

The city has the potential to capitalize on its testing-ground status and should actively promote Miami Beach as the resilient city at both local and global levels by communicating the city's adaptation measures and successes to key industries and power players around the world, including those key to the city's financial success, such as investors, credit rating analysts, politicians, and trade partners. The communications strategy should also strive to combat misleading information and negative media narratives: Miami Beach must be able to respond quickly and boldly to misinformation and negative press.

Build Public Trust through Clarity and Transparency

Miami Beach's flood vulnerability is a complex and ever-changing issue. As weather patterns change, new adaptation methods are designed and studied, and lessons are learned, the city's approach and stance on many issues

Northern Virginia: "Only Rain Down the Storm Drain"

The Northern Virginia Clean Water Partners have worked to create a regional stormwater campaign, helping mitigate a polluted runoff problem in the region. "Only Rain Down the Storm Drain" branding was introduced in 2011, including a website and regional radio spots.

Each year, efforts have expanded into a larger campaign, where televised public service announcements and internet ads increasingly inundate the market. To augment the marketing efforts, storm drains in cities such as Alexandria are labeled with the logo—featuring a shad, a local fish—and tell the location of the drainage output for awareness.[59]

More recently, in 2018 the program began a "Write as Rain" subcampaign, using messages written on the sidewalk in resin polymer. An example features a shad with "Your river starts here" written above it, combining the recognizable image with pleas for awareness. The writing appears only when exposed to water, reminding citizens to be aware when it rains, and lasts for two to three months.[60]

The combination of efforts over the years has largely been successful: in 2017, a regional survey showed that 62 percent of residents recognized the campaign logo, and 24 percent reported seeing the advertisements.[61]

Currently, 19 partners make up Clean Water Partners, including governments, school systems, a university, independent water and sewer authorities, private businesses, and the Virginia Coastal Zone Management Program. The program operates under the jurisdiction of the Northern Virginia Regional Commission, a political subdivision of Virginia made up of a group of local commissioners.[62] The structure of Clean Water Partners allows the group to pool resources to reach a broader audience for marketing and awareness efforts. The regional collaboration is an important example for municipalities to consider, especially when working with watersheds that transcend legal boundaries.

CATALYST MIAMI

Residents of Miami-Dade County meet at a local engagement session led by Catalyst Miami. Inclusive, transparent outreach efforts will be critical in repairing a feeling of distrust felt by many local people during the initial stormwater planning process.

and methods will continue to change and develop. This constant evolution poses difficulty for the city in building a sense of trust with the community, which often relies on clarity and continuity of messaging to grow public trust.

Constancy, transparency, and robust public engagement and involvement are crucial aspects of any communication strategy because of their importance in growing the public's trust. These goals will be particularly crucial in Miami Beach as the city strives to address immense and complex challenges and implement monumental changes in a landscape of public fear, hopelessness, uncertainty, and mistrust.

Key local leaders and communicators—mayors, commissioners, and trusted community and business leaders—should be identified, trained, and kept up to date on resilience measures, progress, and successes, and they should be provided with talking points relevant to their sectors. These messages will resonate with a broader range of residents and other stakeholders and reach further than messaging from experts on resilience or stormwater management. The city must work to maintain constancy and continuity of its communication, messaging, and message-bearers by taking the following steps:

- Naming dedicated community leaders as spokespersons to share the city's resilience messaging with the public across platforms to clarify messaging and put trusted faces before the public;
- Establishing a call-in resource center to answer the community's questions on resilience and resilience measures, serve as dedicated help resources to residents and business owners, and field questions from the greater public; and
- Maintaining consistency among the communication channels and methods used over time.

Few things will remain constant in the city's adaptation strategy as it moves forward. Crucially, the city needs to emphasize communication on the adaptation process and long-range plan over specific challenges and measures, while still taking the time to recognize benchmarks and achievements. It should also strive for increasing transparency by taking the following steps:

- Own rather than avoid the city's resilience identity and living-with-water future.
- Acknowledge uncertainties, mistakes, and the unknown.
- Ensure that communications are clear regarding anticipated timelines for adaptation projects and the rationale and the cost analyses behind the city's decision processes.
- Regularly bring in outside experts on climate topics.
- Be willing to discuss and tackle tough topics and answer difficult questions.
- Proactively address specific community concerns that arise, such as water quality.
- Share live or near-live data publicly on the following:
  - Flood levels;
  - Water quality;
  - Service status;
  - City service response times; and
  - Resilience spending and budget.

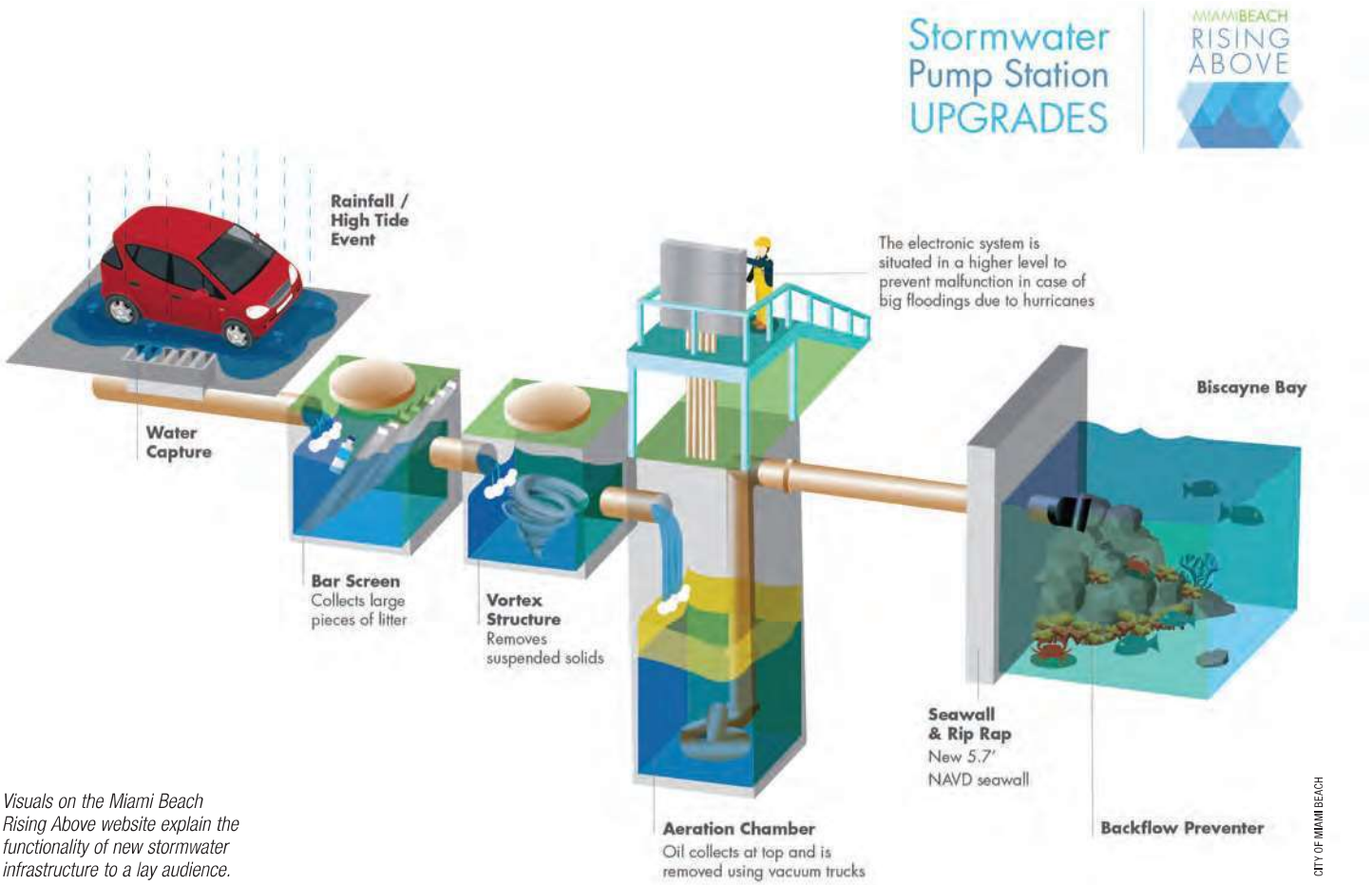
Time will test the city's adaptation approaches and measures and will provide clarity on successes, mistakes, and failings. To maintain the highest possible level of public trust throughout the adaptation process, the city should strive to refrain from "saving face" regarding mistakes rather than risk jeopardizing transparency and losing the public's trust.

The city should be clear and open about the fact that it is on the cutting edge of flood adaptation and is forging its own path, which will require continual learning as well as adjustment and refinement of methods and approaches. The city should also acknowledge where mistakes have been made in the past and highlight opportunities for public engagement to galvanize support and rebuild the community's sense of trust.

Create a Broad Communications Plan

To increase community support, address issues of mistrust, and ensure that a range of audiences is reached, the city should create a comprehensive and diverse communications plan related to stormwater management and resilience. Much of this work is already underway but may not necessarily be coordinated into a comprehensive communications plan about climate adaptation, clarifying how different audiences are reached.

The plan should outline the stormwater management and resilience strategy and leverage neighborhood-level organizations and their leaders to communicate the city's challenges and strategies to the rest of the community. As described earlier, a key part of this plan is educating



Visuals on the Miami Beach Rising Above website explain the functionality of new stormwater infrastructure to a lay audience.

private citizens and providing them with tools and information they need to share the city's resilience messaging effectively within their own networks. This plan could also incorporate the communications strands for separate but relevant communications initiatives, such as communications plans related to the Community Rating System or pilot projects featuring community engagement, such as the Bloomberg City Challenge.

Part of the communications plan may also be providing technical knowledge and toolkits specifically for different groups able to advance climate adaptation at the property scale, such as the following:

- Homeowners of historic single-family homes;
- Homeowners of recently constructed single-family homes;
- Homeowners in small, multifamily co-op units;
- Homeowners in larger multifamily units;
- Renters in both single-family homes and multifamily units;
- Small businesses;
- Hotels and other hospitality companies; and
- Civic and institutional buildings.

Residents participating in the interview process for the panel expressed interest in having more information on personal adaptation measures that could be taken alongside the city's infrastructural investment strategy and particularly requested information tailored to different scenarios, that is, to single-family homeowners with complete control of their property or a condominium owner making decisions collectively with a condominiium board.

Increase Diversity and Robustness of Communications

The city should expand the robustness and diversity of its communication strategy to include pilot projects, educational programs and events, and creative placemaking strategies.

For example, Miami Beach should use living-with-water pilot sites and neighborhoods to provide the community with tangible examples of its proposed adaptation methods. Pilot projects and case studies are excellent methods for broadening public understanding and acceptance for new or complex interventions. These pilot projects should be used to explore and test the city's living-with-water adaptation concepts and represent the city's vision for its future aesthetic, public space, and quality of life. These pilot sites should be constantly promoted and referenced to raise awareness of intervention methods, serve as measures of success, and educate and dispel misleading information and negative press.

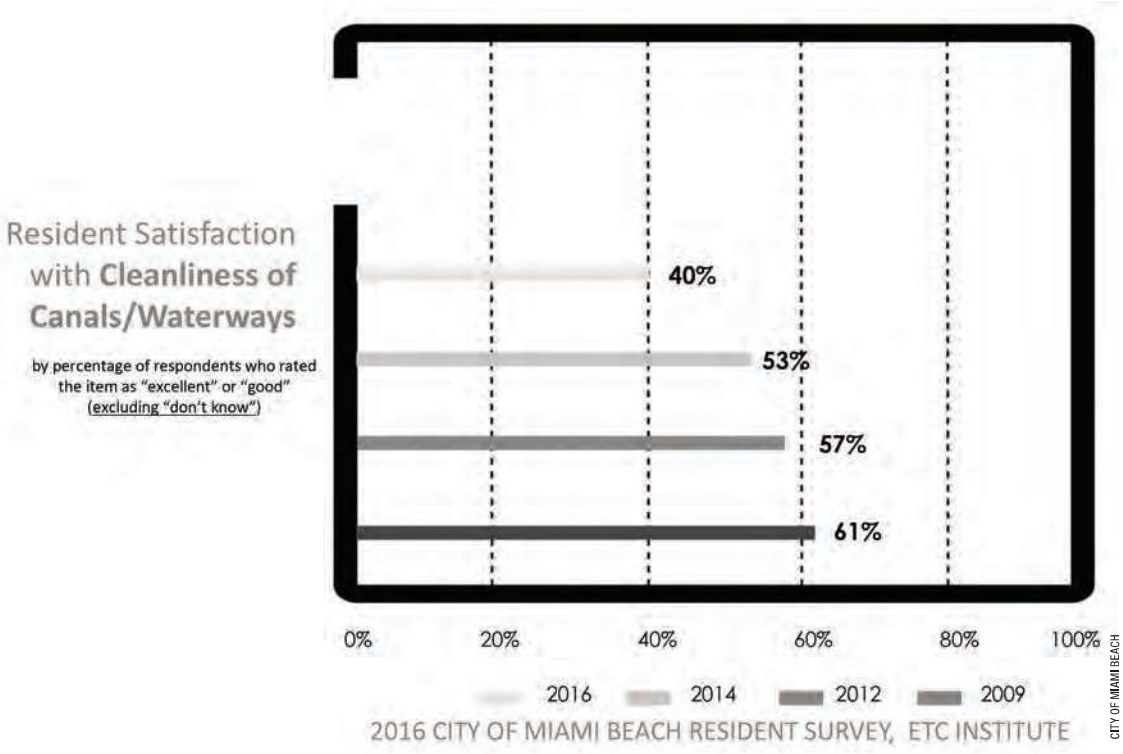
The city should continue to develop and implement educational programs, tours, and events to communicate its resilience to a broader base of individuals and should use creative placemaking and public educational elements to augment the city's messaging and provide tangible

Training Stakeholders in Resilience

The Building Resilience Network, based in Los Angeles, has become a leading example of stakeholder training for resilience efforts, with a focus on training about how to embed resilience into operations. The organization offers training and workshops on resilience strategies with businesses, organizations, and communities.

One of the premier clients is LA Metro, the public transportation network for Los Angeles County, which has open training sessions for all employees and partners. Its training program reviews resilience topics, then moves into identifying risks, preventive efforts, strategies and planning, and working with stakeholders.

Ninety-minute sessions are held once a week, and half-day workshops once a quarter, with employees being able to opt in as desired. Members of the public are welcome to attend workshops. Additional specialized workshops are available to focus on efforts for specific teams or projects within LA Metro. Other clients are welcome to customize training for their own needs.



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The city should be proactive in responding to community concerns, such as the perception of water quality.

examples to the public. Some of this is already underway through the Rising Above website, including the development of app-based and mobile tours of climate adaptation investments at Sunset Harbour and South Pointe Park.

Other communications projects underway, such as the flood communications technology being piloted through the Bloomberg City Challenge, represent exciting opportunities that should be embedded in the overall communications plan.

Solicit Community Input and Leverage Other Resources

The city faces a particularly difficult issue of lack of community trust. Because of mistakes made in the past, many stakeholders now distrust the city's information, measures, and spokespeople. Rebuilding this trust will be a long process, which the city cannot afford to wait for to move forward. To address this issue and leverage existing resources, Miami Beach should actively strive to grow a network of community-led outreach partners to spread the city's message and lead discussions and adaptation solution processes within their own networks. This should be done through a multifaceted approach including the following:

- Aggressive engagement in community-led planning and consensus-building processes;
- Growing a network of community outreach ambassadors and partners to reach a much larger audience including low-income and underserved communities that historically have been excluded from planning and engagement processes;
- Partnering with local organizations and community groups; and
- Leveraging the community's top communicators and business and community leaders to spread information within their respective circles.

The city should inform and educate community and business leaders and champions on the challenges, plan, and process, and provide them with the information and talking points they need to communicate the resilience plan within their respective communities.

Neighborhoods in Miami Beach that have already experienced the first round of stormwater interventions generally responded positively regarding their effectiveness, even if they were not complimentary of the process. However, many residents outside these neighborhoods still seem confused about the interventions and unaware of their successes, a clear missed opportunity for the city to use existing pilot projects and community support.

The communities and areas that have already seen positive impact from the stormwater interventions should be leveraged as pilot projects and community ambassadors, educating other neighborhoods and community groups on the program and interventions, generating community buy-in, assisting other neighborhoods throughout their stormwater improvement processes, and inspiring them to contribute to the process and develop and champion solutions. Success of a program like this relies on residents feeling engaged, valued, and informed throughout the process, as opposed to simply happy with the ultimate results.

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The improvements in Sunset Harbour are an example of one of Miami Beach's many stormwater successes.

Miami Beach should also consider encouraging citizen scientists to collect and contribute data, soliciting community-based observation and reporting, particularly on hot-topic issues such as flood levels, water quality, and power outages. This increases transparency, community sense of contribution and ownership, and provides more varied opportunities for resident engagement and education.

Recognize Achievements and Successes

The city of Miami Beach's resilience challenges will not have an end point, and its adaptation process will be continuous and ongoing. To maintain community morale and sustain its commitment over the long term, the city needs to build workable goals and benchmark points into its plan that will allow the city to measure its progress, celebrate its achievements, and rally engagement and support for next phases in the process.

Conclusion

THE CITY OF MIAMI BEACH has made a proactive start to addressing sunny-day flooding, beginning execution of a projected $600 million stormwater management program. The city has shown a clear commitment to addressing this challenge, identifying local funding sources and making swift progress in the most affected neighborhoods.

Moving forward, Miami Beach needs to broaden its approach to more holistically and effectively address the extent of flood risk faced by the city and enhance overall resilience to the impacts of climate change, including sea-level rise. Strategies for flood mitigation need to address the three distinct sources of flooding vulnerability: coastal flooding, including king tides; flooding caused by rainfall; and flooding from groundwater. An enhanced strategy should both approach these types of flood risk in an integrated way and address other social, economic development, and environmental issues. Living with water is likely to be a key theme, and this proactive approach will also present opportunities related to the city's branding and cultural identity, particularly in comparison with its coastal competitors.

Resilience planning should not only entail investment in gray infrastructure, as does the current plan, but also adopt blue and green infrastructure tools and maximize impact through design, placemaking, governance, finance, and regulation strategies. Furthermore, the plan needs to prioritize clear outreach to and opportunities for input from local stakeholders, residents, and the business community, many of whom did not feel sufficiently engaged in past efforts.

The challenges the city is facing do not have a finish line; they are ongoing. The impacts of climate change can already be seen, and the community will experience increased environmental volatility in the future. Accordingly, efforts to address flooding will require an incremental approach, including regular opportunities for evaluation and recalibration. The city also should regularly step back to ensure that climate adaptation efforts are benefitting the entire community, including low-income households, and preserving the city's vibrancy and historic character.

The city asked this panel to evaluate the stormwater management program and provide feedback, to help develop a more holistic vision for resilience in Miami Beach. However, the bigger—and unspoken—question was what the long-term opportunities are for the city, given the extent of risk faced. Although the future is uncertain, the panel concluded that the answer is in the city's hands. To make progress and address menacing environmental challenges, all stakeholders need to show a willingness to work together, as well as have some level of comfort with the likely costs and inconveniences that will arise. Stronger collaboration and greater interconnectedness among stakeholders and between the city and stakeholders will be crucial.

Miami Beach is already a national and international leader in its proactive approach to climate adaptation and is in a good financial and cultural position to hone a living-with-water approach. To move toward a more resilient future, the community, the city, and its stakeholders should continue to build on the work already underway, crafting a more integrated overall strategy and striving to preserve and enhance the value, sense of place, and identity that is unique to Miami Beach.

Appendix: Summary of Recommendations

Topic	Recommendation	Page
Infrastructure	■ Improve flexibility and robustness of current stormwater system	31
	■ Create an integrated, hydrodynamic computer model to better inform decision making on flooding issues and risk management	33
	• Engage an owner's representative to consult on product selection	
	• Purchase integrated modeling software	
	• Add "flood risk model manager" position to ensure most productive use of model	
	■ Implement blue and green infrastructure to advance a more holistic living-with-water approach	36
	■ Ensure appropriate modeling, study, and funding availability for green and blue infrastructure for living-with-water projects	38
	■ Implement living-with-water pilot projects	38
	■ Create tools for living-with-water projects at the building level	40
	■ Consider a level-of-service concept to guide future decision making	40
	■ Address water quality concerns	40
	■ Improve communications about engineering and infrastructural solutions	42
Physical design and typology	■ Select design and infrastructure interventions that respond to the city's beach/bowl/bay typology	43
	• Within the beach zone, incentivize or require on-site water storage at the building scale	
	• Within the beach zone, design green infrastructure and streets with capacity to filter water	
	• Within the beach zone, explore opportunities for dunes to comply with FEMA 540 rule	
	• Within the bowl zone, prioritize groundwater management	
	• Within the bowl zone, implement green and blue streets to convey water	
	■ Look to golf courses as underused green spaces for water management	45
	■ Consider modifying road specifications for permeability	45
	■ Pursue opportunities with solar and renewables	47
	■ Consider long-term options for neighborhood design and green space	47
Creative placemaking	■ Partner with local arts and culture stakeholders	49
	■ Incorporate public art in the stormwater management strategy	51
	• Identify artists through an RFP process	
	• Include citizens, key stakeholders, and arts partners in selection and award process	
	• Identify opportunities for synergy with national events such as Art Basel	
	■ Involve and engage artists in the design process	54
	■ Create open spaces that respond to resilience needs while engaging local artists	54
	■ Incorporate creative placemaking strategies in the communications plan	54
Governance	■ Establish a Miami Beach Rising Above program delivery office	55
	■ Create a scientific advisory panel through the program delivery office	56
	■ Establish an agency for public investment and development in resilience; that agency would do the following:	56
	• Establish opportunities for incremental value capture from real estate for use in resilience projects	
	• Direct investment and development of resilience projects	
	• Manage operations and maintenance of green and blue resilience projects	
	• Explore opportunities for special assessment districts	
	■ Establish a community adaptation fund	57
	■ Establish a risk transfer department	57
	■ Consider new strategies to align historic preservation and climate adaptation	58

Topic	Recommendation	Page
Financing	■ Continue to comprehensively evaluate existing resilience costs and benefits	61
	■ Find effective revenue streams to link to stormwater and resilience benefits	61
	■ Establish a community adaptation fund	61
	■ Use insurance as a form of risk transfer to reduce taxpayer burden	62
	• Outline an insurance pool for the city as a backup to NFIP	
	• Consider parametric insurance	
	• Advocate for living with water to insurers	
	■ Integrate financing into the communication strategy	62
	• Engage with credit rating agencies to ensure stable credit	
	• Engage with insurance industry regularly for feedback on resilience results	
	• Create a communication strategy for investors	
	• Engage with residents on climate risk disclosure	
Regulations	■ Embed water management goals into development regulations and/or incentivize resilient design	63
	• Continue to allow increased heights and denisities to accommodate future raised entryways and floods	
	• Use design standards to mitigate impact of height increases	
	• Explore resilience incentives for multifamily and commercial properties	
	■ Leverage and reform regulatory boards	66
	• Ensure that charters address water management at building and parcel levels	
	• Add climate or water management experts to Historic Review and Design Review Boards	
	• Train existing board members on resilience	
	• Ease restrictions on development and real estate professionals	
	• Provide boards with measurable water management goals	
	• Hire additional staff to support and review development projects	
	■ Adjust stormwater fees	67
	• Adjust from flat fee to one that accounts for property runoff	
	• Allow fee to incentivize or encourage on-site water management	
	■ Create islandwide sea barrier, include enacting regulations to allow centralized efforts	69
	■ Continue to support elevation for new construction	70
Communications	■ Promote Miami Beach Rising Above as the primary comprehensive resource	72
	■ Be bolder in engagement, communication, and marketing strategy	73
	■ Build public trust through constancy, clarity, and improved transparency	73
	• Provide city leaders with training and talking points to spread resilience message	
	• Name local leaders as resilience spokespersons	
	• Establish call-in resource center for resilience questions	
	• Maintain consistency among communication channels	
	• Share live data publicly on response times, spending, service, and water systems	
	■ Create a broad communiciations plan focused on resilience and stormwater management	75
	■ Increase the diversity and robustness of communications	76
	■ Solicit community input and leverage community members and leaders	77
	• Create a network of community outreach ambassadors	
	• Partner with local organizations and community groups	
	• Consider encouraging citizen scientists to help with data collection	
	■ Recognize achievements and successes	78

Notes

1 "City Strategies," 100 Resilient Cities, updated 2018, https://www.100resilientcities.org/strategies/.

2 The current road elevation strategy is based on a king tide elevation of 1.7 North American Vertical Datum (NAVD) in 2014, requiring an additional one foot of elevation to account for projected sea-level rise elevation and another additional foot to elevate a road out of water for a 3.7 NAVD crown-of-road elevation.

3 *Burden* is defined as paying more than 35 percent of one's income for housing. In addition, the median income of $49,444 obscures the inequality shown by the mean income, which jumps to $95,728 because it accounts for the highest income values. ("American Factfinder," U.S. Census Bureau, updated 2018, https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml.)

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7 "Kallang River @ Bishan-Ang Mo Kio Park," Singapore Public Utilities Board, 2018, https://www.pub.gov.sg/abcwaters/explore/bishanangmokiopark.

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About the Panel

Joyce Coffee

Panel Chair
Chicago, Illinois

Coffee is the founder and president of Climate Resilience Consulting and an accomplished organizational strategist and visionary leader with over 20 years of domestic and international experience in the corporate, government, and nonprofit sectors, implementing resilience and sustainability strategies, management systems, performance measurement, partnerships, benchmarking and reporting. She is a senior sustainability fellow at the Global Institute of Sustainability, where she advises various high-level resilience groups, including the Global Adaptation and Resilience Investment work group and the National Science Foundation's Urban Resilience to Extremes Sustainability Research Network.

She received a BS in biology, environmental studies, and Asian studies from Tufts University and a master's in city planning from the Massachusetts Institute of Technology. Coffee holds the LEED AP professional credential from the U.S. Green Building Council.

Juanita Hardy

Washington, D.C.

Hardy is the ULI Senior Visiting Fellow for Creative Placemaking, where she supports the Institute's Building Healthy Places Initiative. As the senior visiting fellow, Hardy has done extensive writing and research on creative placemaking and has worked with ULI District Councils on programming and capacity-building activities. Hardy has over 43 years of business experience, including 31 years with IBM, and over 35 years in the arts as a nonprofit leader, trustee, collector, and patron of the arts. After retiring from IBM in 2005, she founded Tiger Management Consulting Group, a global training and business consulting firm.

She is the former executive director of CulturalDC, where she worked closely with developers to integrate arts and culture into development projects across the Washington, D.C., area. She currently serves as an executive coach with Right Management and on many nonprofit art boards in the region.

Jeff Hebert

Baton Rouge, Louisiana

Hebert serves as the Water Institute of the Gulf's first vice president for adaptation and resilience, where he leads the interdisciplinary work being done to help communities better adapt to changing environments. In addition, Hebert is an adjunct faculty member in the graduate sustainable development program at the Tulane School of Architecture.

Before joining the Water Institute, he served as deputy mayor and chief administrative officer of the city of New Orleans and as the city's first chief resilience officer, where he developed the city's first climate action strategy. Before joining the city of New Orleans, Hebert served as the director of community planning for the Louisiana Recovery Authority following the devastation from hurricanes Katrina and Rita.

He holds a bachelor's degree from New York University, earned a master's degree in city planning from the Massachusetts Institute of Technology, and is a graduate of the Achieving Excellence in Community Development program at Harvard University's Kennedy School of Government, where he was a Ford Foundation Fellow.

Phillip Kash

Washington, D.C.

Kash is a principal at HR&A Advisors specializing in climate adaptation and housing affordability for cities. He has led the evaluation of climate risks for cities, developed adaptation strategies, and supported the implementation of adaption projects. Most notably, Kash developed the climate change adaptation plan for the city of Boston, is supporting the implementation of a resilience district in the Gentilly neighborhood of New Orleans, and advised on the development of 100 Resilient Cities.

He also leads HR&A's housing affordability work to help cities create neighborhood, city, and regional housing plans; develop new affordable housing programs and policies; and redevelop public housing. Before joining HR&A, Kash was a director at Enterprise Community Partners and led multiple technical assistance engagements focused on disaster recovery, resilience, and affordable housing.

Greg Lowe

London, United Kingdom

Lowe is global head of resilience and sustainability at Aon plc, the leading provider of risk management, insurance and reinsurance brokerage, and human resources solutions and outsourcing services. He is focused on leveraging Aon's leading proprietary analytics platforms to meet the needs of clients looking to address disaster risk, climate finance, and the global protection gap. Heading Aon's strategy on sustainability and systemic risk, Lowe leads dialogues with clients, investors, and regulators on global environmental issues. He has collaborated with organizations as varied as the United Nations, the OECD, and the Urban Land Institute. Before working at Aon, Lowe was an executive director at Willis Towers Watson, having begun his career in investment banking at UBS.

He holds an MSc in environment and development from the London School of Economics and a BA in political economy from the University of Maryland.

Walter Meyer

New York, New York

Meyer is an adjunct professor at Parsons the New School for Design and founding principal of Local Office Landscape Architecture. Operating between infrastructure, urbanism, and territory, the firm has won awards from across the disciplines of architecture, landscape architecture, public policy, science, and art. Before founding the firm in 2006, Meyer worked in urban and landscape design at Cooper Robertson and Wallace Roberts & Todd.

He received his bachelor's degree in landscape architecture from the University of Florida and his master's degree from the Harvard University Graduate School of Design.

Christian Nyerup Nielsen

Copenhagen, Denmark

Nielsen is the senior director for the global division for Climate Adaptation, Landscape and Flood Risk Management at Ramboll Water. He has more than 20 years' experience in stormwater management and engineering and extensive experience with project management of large-scale projects within infrastructure planning, urban development, and resilience planning, including flood risk management for cities, regions, and infrastructure owners.

Nielsen's international expertise in the field of climate adaptation and flood risk management has been developed and implemented on numerous projects on a global scale, including the screening of megacities in Asia for the Asian Development Bank, Cloudburst Pilot for the New York City Department of Environmental Protection, storm surge protection planning for Washington, D.C., low-impact developments in Copenhagen, and the detailed flood protection plans for Copenhagen and Gothenburg, Sweden.

Mark Osler

Alexandria, Virginia

Osler serves as an associate vice president of Michael Baker International and leads the firm's coastal science and engineering practice, where he focuses on the analysis of coastal hydrodynamics, impacts of sea-level rise, and resilient coastal design. He has provided management and technical leadership for a range of coastal resilience projects, from rural community settings to urban, state, and nationwide studies, encompassing considerations of riverine and coastal flood risk, changing precipitation patterns, and tsunami risk. Following Superstorm Sandy, Osler led the flood risk vulnerability study and resultant flood mitigation design at the World Trade Center, as well as analyses of climate change impacts to JFK, LaGuardia, and Newark airports.

He serves on the National Institute of Building Sciences Scientific Resolution Panel, an independent group that reviews the accuracy of FEMA's flood analysis and mapping. Osler holds a bachelor's degree from Lehigh University and a master's degree from the University of Delaware's Center for Applied Coastal Research.

Greg West

Miami, Florida

The president and chief executive officer of ZOM Holding Inc., West is responsible for all of the company's real estate activities. Since joining ZOM in 1997, he has been involved with all aspects of the development process, including identifying new opportunities and compiling due diligence and underwriting parameters. He has been directly responsible for over $3.5 billion of development. Before joining ZOM, he worked in a development capacity for Paragon Group, where he implemented new multifamily developments and repositioned existing projects in the Midwest and Florida.

West received a BA in accounting from Southern Methodist University and has received two MS degrees from Texas A&M University in land development and construction management. He serves on the board of directors of the National Multifamily Housing Council and sits on the Advisory Board and Management Committee of ULI Southeast Florida.

A ULI Advisory Services Panel Report

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