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# Florida Water Resources JOURNAL

September 2016



**Emerging Issues  
and Water Resources  
Management**

# Miami Beach Takes a Stand on the Edge of a Rising Sea



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Like many south Florida coastal communities, the City of Miami Beach is experiencing a rise in sea level at a greater intensity than the global average. The fight is already under way to keep streets, businesses, and residents dry on sunny days, let alone during storms. Higher tides, prolonged flooding after storms, and beach erosion are among the major effects being experienced by residents, property owners, and tourists. In addition, this low-lying area's porous limestone geology makes it exceptionally vulnerable to saltwater intrusion into infrastructure systems.

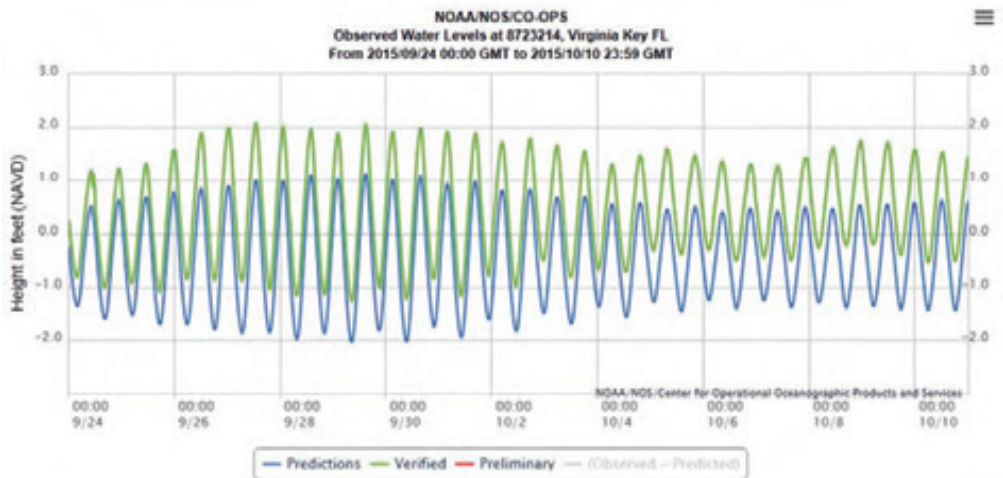
Miami Beach is a barrier island that consists of a coastal dune on the east that composes the famed beaches, and former mangrove swamps on the west that have been filled in for development. In addition, several man-made islands have been created in Biscayne Bay between Miami and Miami Beach. The island is highly impervious due to development, and is now built out, with the exception of three golf courses and some small parks.

Sea-level rise in Miami Beach has contributed to higher groundwater levels, higher tides, increased flooding, and decreased effectiveness of the gravity drainage system. In several areas of the city, the ground elevation is lower than the water level in the adjacent canal or bay during high tides, leaving gravity drainage systems ineffective. Because there is no confining layer in the porous limestone beneath the streets and buildings, solutions that have been effective in other coastal areas, including physical barriers, such as berms, dams, and dikes, may not be viable for the area. It is not unusual to see standing water on the streets of Miami Beach during seasonal high tides without any rainfall.

## Regional Coordination

As a member of the four-county Southeast Florida Regional Climate Change Compact, the city has teamed with other communities to develop a regional governance approach that coordinates mitigation and adaptation activities among Broward, Miami-Dade, Monroe, and Palm Beach counties. The compact has served to unite, organize, and assess the region through the lens of climate change in setting the stage for action. Specific accomplishments include the development of regionally consistent methodologies for mapping sea-level rise impacts, as-

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Tides predicted/observed in Miami Beach during 2015 King Tide.



Photos of Miami Beach flooding.

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sessing vulnerability, and understanding the sources of regional greenhouse gas emissions.

A regional climate action plan titled, “A Region Responds to a Changing Climate,” was published in October 2012 to provide the foundation for concerted action in reducing greenhouse gas emissions and adapting to regional and local impacts of climate change. Recommendations were developed through a collaborative process to accomplish these goals, while also serving to protect the assets of the region’s unique quality of life and economy, guiding future investments, and fostering livable, sustainable, and resilient communities. Recommendations were consolidated into seven categories: sustainable communities and transportation planning; water supply, management, and infrastructure; natural systems; agriculture; energy and fuel; risk reduction and emergency management; and outreach and public policy.

Miami-Dade County intensified efforts to respond to sea-level rise in July 2013 with formation of the Miami-Dade County Sea-Level Rise Task Force. The task force is charged with providing a realistic assessment of the likely im-

pacts of sea-level rise and storm surge over time and making recommendations relative to the comprehensive development master plan (CDMP), capital facilities planning, and other priorities. In July 2014, six recommendations were developed to lay the foundation for action and address the flooding risk, reinsurance industry, and potential economic implications. The overarching recommendation is to “accelerate the adaptation planning process by seeking and formally selecting the engineering and other relevant expertise needed.”

### Miami Beach Response

Miami Beach started implementing many plan recommendations in 2014 by modifying city design and construction standards that address sea-level rise. The city’s stormwater management master plan accounted for sea-level rise, but was inadequate to account for the level of rise that could be expected through the life span of the city’s infrastructure. To address road flooding in susceptible Miami Beach areas, the roads and sidewalks are being raised to reduce ponding, increase longevity of roadways, im-

prove stormwater quality, and enhance safety, particularly during storm events.

With the backing of Mayor Philip Levine, City Manager Jimmy Morales, and the city commission, city staff were encouraged to develop design standards that would account for the next 30 to 50 years of forecasted sea-level rise, which corresponds to the estimated life span of utility infrastructure. The mayor’s blue ribbon panel on flooding mitigation was established to advise the city in implementing a management plan to address sea-level rise. Critical to developing new design standards was agreement on a level of service that was realistic for the city to achieve. Keeping the roads completely dry at all times is likely not a realistic expectation for Miami Beach, but maintaining flood elevations below homes and buildings, and keeping roads passable for emergency traffic, was deemed a reasonable level of service.

Changes to the standards that have been adopted include:

- ◆ Design storm rainfall event increased from 6 to 7.5 in. in a 24-hour period.
- ◆ Design criteria for tailwater elevation increased from 0.67 to 2.7 ft North American Vertical Datum (NAVD). The maximum recorded tide level to date is 2.2 ft NAVD, measured on Sept. 29, 2015.

These modifications affect construction of seawalls and elevation of stormwater systems, roadways, and finished floor of buildings. Specific changes to city design and construction standards are summarized in the table at left.

Drainage improvements have been made by installing pump stations in areas of the city with the highest susceptibility to flooding. Initial projects have focused on flooding due to reverse flows in gravity stormwater outfalls with the implementation of a pumped drainage system. The city will be looking at addressing seawalls that are overtopped during high tides and adopting new building standards to prepare for the future.

The estimated cost to implement a comprehensive pumped drainage system has been projected at over \$400 million; the total cost to prepare the city for higher sea levels will far exceed this amount to build seawalls to more stringent criteria, raise streets and sidewalks in low areas to higher elevations, set new building standards to new finished-floor elevations, and continue to address rising groundwater levels that are directly related to sea-level rise.

### Sunset Harbour Neighborhood

Projects incorporating stormwater system improvements and roadway and sidewalk elevation increases are currently underway. Much of the work is being accomplished using design-

Civil Engineering Project Type	Design/Construction Standards Change
Seawalls	Minimum elevations raised from 3.2 to 5.7 ft NAVD88.
Stormwater Systems	Minimum inlet elevations set at 2.7 to 3 ft NAVD88, requiring all stormwater systems to be pumped.
Roadways	Minimum elevations of roadway crowns and edge of ROW established at 3.7 ft NAVD88.
Building Finished-Floor Elevations	Currently, per building code, may update to require finished floor to have freeboard above base flood elevation.



“Sunny day” flooding in Sunset Harbour prior to improvements.



Sunset Harbour roadway during elevated roadway construction.



Restaurant patio created by neighborhood flooding improvements.

build project delivery to complete the improvements as quickly as possible. In many areas, the roads will be raised to elevations that are higher than finished-floor elevations of adjacent buildings, which offer the unique challenge of harmonizing roadway and sidewalk elevations, such that driveways and building entrances remain accessible. Designs that include sloped, landscaped, drainage swales; short retaining walls; and bi-level sidewalks will be customized in each neighborhood. The first neighborhood to be completed with elevated roadways, sidewalks, and stormwater pumping improvements is Sunset Harbour, one of the lowest-lying areas of the city.

The city's active approach to implementing new standards and stormwater improvements has gained national and international attention. Actors Leonardo DiCaprio and Jack Black both interviewed Mayor Levine and toured the Sunset Harbour neighborhood as part of climate-change and sea-level-rise documentaries that they are producing. On separate occasions in 2015, the project was visited by the president of FEMA; one of President Obama's senior advisors, Al Gore; and Bill Nye, the Science Guy.

Miami Beach's response to rising sea levels focuses on implementing proven approaches, while continuing to look forward at how to best prepare for future flooding effects from climate change. Management of vertical flooding from rising groundwater remains one of the city's greatest challenges. The city is actively monitoring steps taken by other communities, as well as advancements in design technologies. A consultant has been commissioned to oversee the program to ensure consistency of new standards in the establishment of new city design and con-



struction criteria. A series of presentations will be held to inform the public on upcoming improvements, as well as to provide the opportunity to give feedback.

As the city's program continues to evolve, industry experts, firms, and the public are being encouraged to share their expertise and provide input on future infrastructure improvements. A

collaborative approach to adapt and mitigate the many challenges of a rising sea will benefit all of Miami Beach.

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