



# MINI-GUIDE SUMMARY OF THE IMPACTS OF SEA LEVEL RISE

**How sea level rise affects our communities and infrastructure**

# IMPACTS OF SEA LEVEL RISE

As we have seen over the last ten years, places that used to flood just once or twice a year now flood ten or twelve times a year. As sea levels rise, the frequency, duration, and depth of flooding will creep up to twenty or thirty days a year unless adaptation measures are implemented. The map on the right (Figure 5-1) shows how many days of flooding we could expect each year after two feet of sea level rise. In some places, the flooding would just be a nuisance and something that happens a few times a year. However, other places would see tidal flooding every single day during high tide.

The County and our partners have been working for years to understand and prepare for these changes. We recognize that some of our communities and infrastructure systems are already being affected. This section provides an overview of current and potential impacts to our people, housing, transportation, critical facilities, wastewater systems, freshwater resources, drainage systems, beaches, and natural areas. This section describes potential solutions and provides links to existing studies, research, and programs focused on these issues.



PEOPLE



HOUSING



TRANSPORTATION



NATURAL AREAS



WASTEWATER SYSTEMS



FRESHWATER RESOURCES



BEACHES AND DUNES



CRITICAL FACILITIES



DRAINAGE SYSTEMS

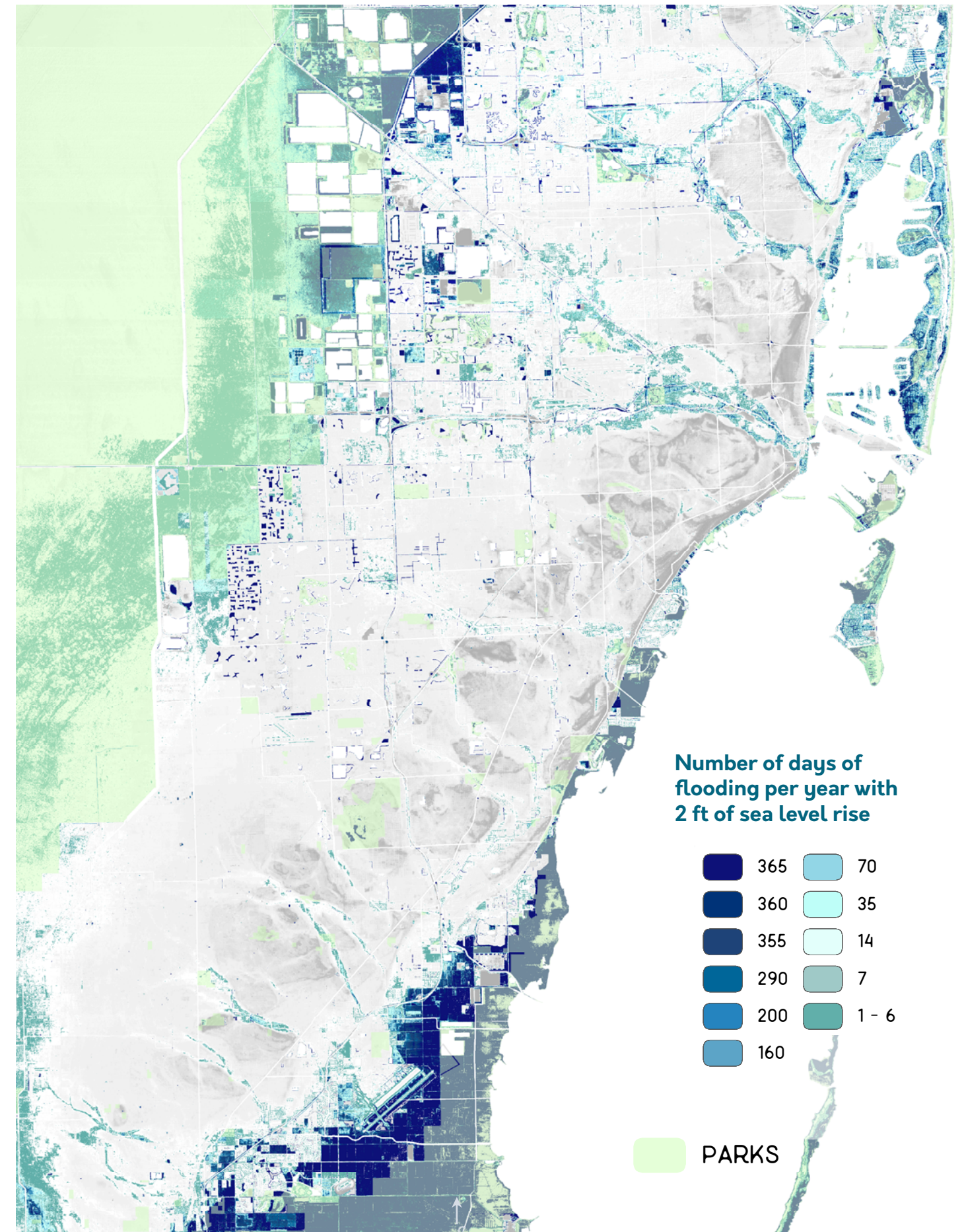


Figure 5-1. Map of days with flooding a year with 2 feet of sea level rise if no action is taken

# IMPACTS OF RISING SEA LEVEL

Tidal flooding is just one of the many changes we are already experiencing and can expect to increase in frequency over the coming decades as sea levels rise. Because we live just a few feet above sea level and a few feet above the groundwater, slow changes in sea levels ripple through our entire water system and amplify our existing flooding risks and hazards such as saltwater intrusion, shoreline erosion, and flooding from canals (Figure 1-6). Some of these changes are very visible, like when storm surge, stormwater flooding, waves, or tidal flooding impact areas they have not reached before. Other changes may be harder to notice, such as the impacts of groundwater flooding and rise on septic systems or the impacts on our regional drainage system and canals.

As we adapt to sea level rise, we must recognize that we have water on all sides. We need to choose adaptation strategies that make us safer by addressing our complex surface water and groundwater system in a comprehensive way. We cannot respond to sea level rise in a way that exacerbates other flooding risks or worsens water quality.

This combination of flood hazards made worse by sea level rise can affect people, the environment and the built infrastructure in many different ways. The County has been studying and monitoring closely, in some cases for decades, just how a future with more water may change residents' daily lives and the community's decisions about long-term planning.

## Sea level rise will increase the frequency and impact of other hazards

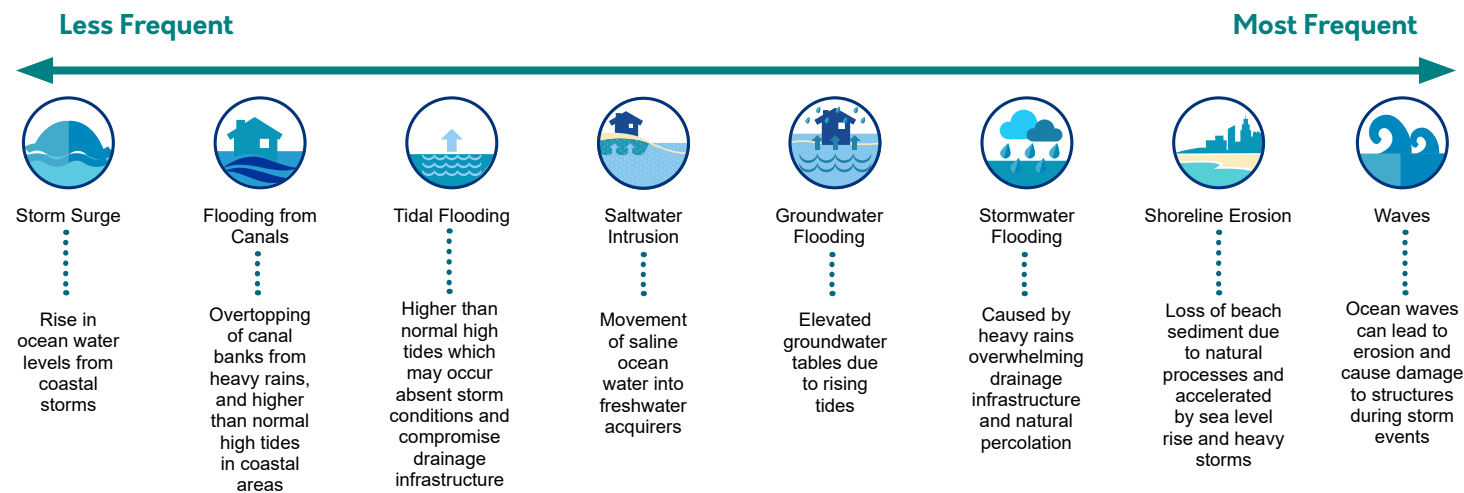
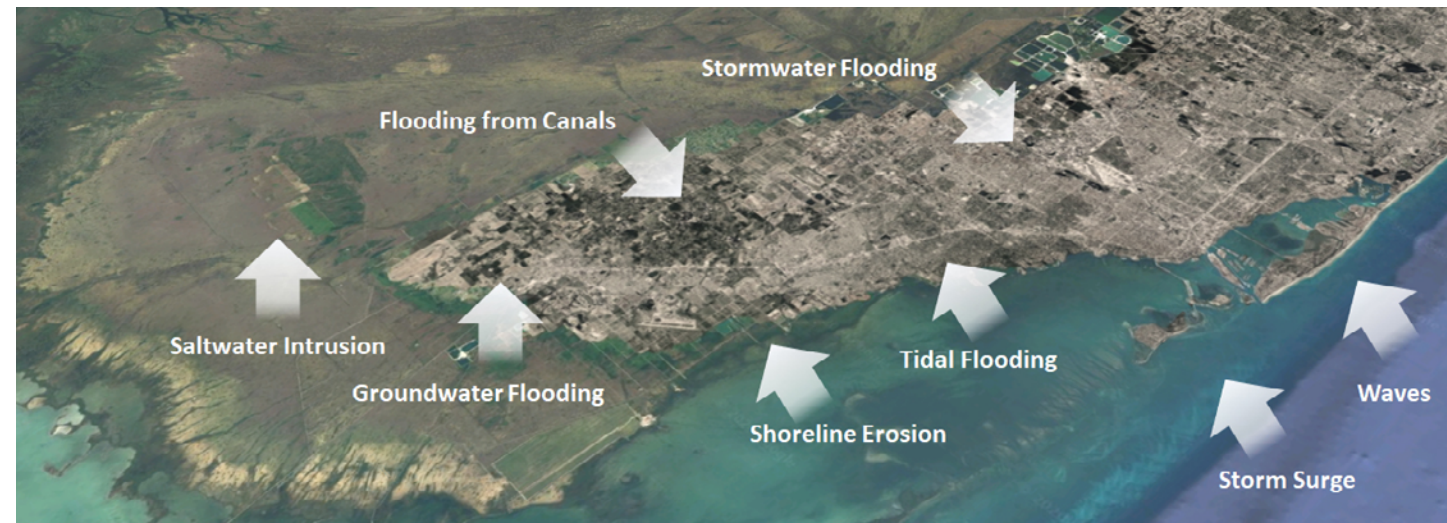


Figure 1-6. Forces of water

## Hazards



**Storm surge:** the abnormal rise in sea level during a hurricane caused primarily by winds pushing water onshore. Storm surge impacts vary and depend on the storm's direction, intensity, size, and speed as well as the depth and shape of the nearby ocean floor.



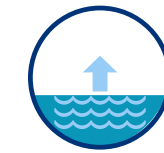
**Saltwater intrusion:** a term often used to describe the movement of saline, or brackish waters into freshwater aquifers. Because the County's geology is highly porous and transmissive (or permeable), the freshwater aquifer is not completely isolated from coastal waters. The interface between fresh and salty water is dynamic and can move both seasonally and over longer periods of time.



**Flooding from canals:** the rise of water levels in canals or rivers above a seawall, bulkhead or natural bank caused by extended rainfall upstream of an area. Our canal levels are partly controlled by a series of pumps, gates, and levees managed by the South Florida Water Management District, the County, and municipal governments.



**Stormwater flooding:** excess rain that cannot be absorbed into the soil or drain effectively through the stormwater management system. This water tends to pool in low-lying areas both near sea level and on higher ground. This is worsened when tidal flooding, storm surge, or groundwater flooding occur at the same time.



**Tidal flooding:** the higher than normal tides that flood low-lying areas. Tides are caused by the gravitational pull of the moon and sun and are affected by local weather conditions and seasonal changes in water levels. The highest tides are during the fall with our 'King Tides'. They are being amplified by sea level rise and can occur with or without a storm.



**Shoreline erosion:** the process by which sea level rise, waves, and coastal flooding wear down or carry away rocks, vegetation, soils, and sands along the coast or canals over short and long time periods. This can damage hard structures such as seawalls and soft shorelines resulting in beach erosion and habitat loss.



**Groundwater flooding:** the rise of underground water table level which is affected by surface water, rainfall, canal management, and, in some places, the tides. Higher groundwater can worsen stormwater flooding and water quality issues as it leads to reduced soil storage capacity and drainage infrastructure and septic systems often rely upon unsaturated soil to function.



**Waves:** the additional height and energy for water levels driven by wind speed, direction, shape of the seabed, and land cover near the shoreline. Waves can occur on top of higher sea levels, tides, and storm surges causing damage to buildings, infrastructure and the erosion of the shoreline.

# PEOPLE



## How could sea level rise impact people within our community?

People in Miami-Dade live in strong, creative communities and come from diverse backgrounds. Each person experiences impacts in different ways depending on who they are and where they live. Below are a few potential impacts that may be felt in disproportionate ways by certain groups. As decisions are made about how to reduce these risks, it is important to recognize that some communities often face inequities their neighbors do not including historic discrimination and disinvestment; unequal access to representation, information, and financing; and displacement. Like other cities and regions of the Country, this is particularly true for our Black, Indigenous, and other residents of color as well as undocumented people who must navigate systems that are designed to work for some, but not all people.

Even if your home or neighborhood is not directly impacted by tidal flooding, the entire community may be affected if sea level rise impacts property values. As a community much of our economy and our tax base is tied to property values so changes in the tax base affect a wide range of services and activities.

- **Young people** who will see rising impacts, costs, and risks as a result of sea level rise which could make buying and keeping a home challenging and reduce their ability to transfer that wealth to their children. They are also more susceptible to health issues resulting from pollution worsened by increased flooding.
- **Elderly and low-income** neighbors with limited or fixed incomes are less able to afford flood insurance, changing or elevating their home, or repairing storm damage. They may also be more vulnerable to floods because it is more difficult to evacuate due to more limited access to transportation and mobility.
- **Renters** who cannot afford rising rents, renters insurance or utility bills could be displaced to more vulnerable areas and potentially lose or experience weakened existing social connections.
- **Homeless populations** and other people who rely on social services (such as in-home care or meal delivery) could experience more disruptions or delays due to increased flooding.
- **Non- or limited-English** speaking residents may have more challenges accessing federal and state government programs and information.
- **Residents that have septic systems** or houses in very low-lying areas in vulnerable areas may need to make substantial investments in their properties as water levels rise.
- **Residents in low-lying areas** could be isolated when flooding blocks access to nearby roads or could experience flooding to their yards and homes.
- **Rural and Indigenous communities** close to the Everglades will experience increased frequency of flooding which may impact their access to services.

## What can we do to reduce the risks to people?

**Implement Resilient305 (R305)** in coordination with our many partners to address regional shocks and stresses to increase resilience for all people.

**Center the voices, values, and needs** of our most vulnerable populations in future planning processes, discussions of new development or redevelopment, and identification of possible approaches and tools.

**Expand and enhance education** that incorporates information in multiple languages about flood risk and sea level rise into housing assistance programs, public school curricula and programs, public libraries, and local business programs. (R305 actions #39 and #40)

**Invest in social cohesion and community-led projects** to enable residents to create adaptation plans within their neighborhoods.

**Develop and provide cost-share or rebate programs and small grants** for building and home hardening, flood-proofing, installation of green infrastructure, energy/water efficiency, or future voluntary home buyouts. (R305 action 37)

**Offer training on flood risk, sea level rise, and adaptation approaches and tools** for different stakeholder groups to inform decision-making and smart investment.

**Explore community benefit agreements** or community worker agreements (with local hiring requirements) for new development or redevelopment spurred by increasing flood risks.

**Increase flood insurance coverage** for those who can afford it as a first line of defense and increase the Federal Emergency Management's Community Rating System score to reduce flood insurance costs County-wide.

**Reduce air pollution and greenhouse gas emissions** to reduce the severity of climate change.



# HOUSING



## How could sea level rise impact housing?

For many of us, how sea level rise will affect our homes long-term is a top concern. Higher sea levels directly increase flooding risks for buildings near the coast. This can increase flood insurance rates for properties in high-risk areas, increase the likelihood of expensive storm damage, and decrease property values. These risks can be addressed when new structures are built with an elevated first floor or with better materials. However, building new or elevating properties is not always possible. Making these kinds of changes can be prohibitively expensive for many people. It may also be technically challenging for historic structures. Protecting housing from these risks also requires addressing the roads, wastewater systems, and other infrastructure that supports low-lying neighborhoods.

Even away from the coast, higher sea levels are affecting housing by making other forms of flooding worse. For example, higher sea levels might make the canals drain water less effectively. After a heavy rain or a hurricane, inland areas could see flooding for much longer than they do today.

Additionally, rising costs in one neighborhood can ripple throughout the entire housing market, affecting the affordability of housing. As housing becomes more expensive, it could push out some residents, particularly those who are renting and have low- or fixed incomes. Existing communities that are at higher natural elevations may see land values, development pressure, and housing costs increase because of the lower risk to certain types of flooding.

Homeowners who choose to sell their home in a low-risk area may not be able to afford an equal home in a similar area and could end up moving to a riskier location without knowledge of their increased risk to flooding hazards. With sea level rise it will be essential to ensure the availability of affordable housing in safer areas.

Long-term community resilience depends upon the availability of safe, affordable housing for all segments of our community. Adaptation approaches, tools, and projects must be considered in terms of how they will impact these two variables and how they will minimize disruptions to existing communities.

## What can we do to reduce the risks to housing?

**Elevate buildings** or elevate critical, sensitive, or expensive equipment. Many up-front costs pay for themselves over time by reducing damages during storms. When building a new home, a designer should include these elements. When purchasing an existing home, a buyer could consider the cost of these options in the price they offer for the home.

**Know your risk** by using free, online tools. These will help you better understand your flood risk and see how sea level rise might impact your broader community.

**Strengthen local and state building codes** to require all new buildings to be higher or protected from sea level rise. This will gradually reduce the risk to housing.

**Plan for affordable housing needs** in conjunction with sea level rise planning efforts. Currently, the least flood-prone areas away from the coast are also some of the most affordable areas. It is critical to consider how any changes in policy or housing preferences will affect the availability of safe, affordable housing for everyone.

**Expand greenways and blueways** in high-risk areas. In some areas, property owners might not want to make the substantial investment needed to flood-proof their property. In some instances, it may be possible to purchase, or offer voluntary buyouts, to repeatedly flooded property-owners who would like to sell their land and create new public spaces in these areas.

**Increase flood insurance coverage** for those who can afford it to reduce the financial risks of storms.

## Where can you learn more?

- To find out information on your flood risk visit the interactive map on Miami-Dade County's [website](#).



# TRANSPORTATION



## How could sea level rise impact transportation?

Sea level rise can make road flooding more common, making access to certain neighborhoods more difficult. In some neighborhoods, the roads are already so low that they are being inundated by high tides under today's conditions. With sea level rise, the frequency of this flooding will increase if no action is taken. Higher sea levels and groundwater levels also mean that it can take longer to drain roadways when it rains. This can cause incremental damage to the roads and associated bicycle and pedestrian infrastructure, which can lead to more potholes and increased maintenance costs. Flooded roadways can reduce access to properties, impact evacuation networks, and block access to a flooded area or force emergency vehicles to find alternative routes. Tidal flooding is also a concern because it damages vehicles that pass through saltwater. Some residents have lost their cars due to flood damage, which is not always covered by car insurance.

Other transportation assets, such as airport, bridges, railroads, and docks, are also affected by higher sea levels, particularly by the risk of higher storm surges. For example, in some cases, the elevated rail network is supported by electrical equipment that is at ground level and could be damaged by flooding.

These risks can be partially addressed by adapting our roads, but it might also create an opportunity to rethink the way we move around. There may be opportunities to use the water for our transportation with ferries across the bays or water taxis in the canals in the long-term. We can also redesign our roads using the Complete Streets model.

## What can we do to reduce the risks to transportation?

**Design and construct new roads, bridges and other new transportation assets to higher elevations.** This can be significantly more cost effective than repairing repetitively damaged infrastructure.

**Elevate critical equipment.** This will help reduce flood damage and speed up recovery after a storm. These protective measures also tend to be very cost-effective because relatively small changes can protect large systems.

**Raise existing roads and bridges.** It can be difficult to raise roads in some areas because most roads are designed to be lower than the surrounding buildings so the road can hold rainwater during a storm. If a road is raised above neighboring properties, it would not be able to store water in the same way. Thus, the risk of flooding in nearby buildings could increase. Therefore, a road's elevation is often limited by the elevation of the adjacent properties.

**Improve local stormwater management.** Drainage can be improved in many ways. Pumps can help with flooding in many places; however, they may be less effective in coastal areas where the groundwater is affected by the tides.

In these areas, pumps may circulate saltwater rather than drawing down water levels. Additionally, pumps require an uninterrupted power supply. They can have a negative environmental impact and contribute to greenhouse gas emissions. Pumps also cannot permanently draw down higher water levels due to sea level rise.

**Update evacuation planning** to ensure that designated evacuation routes are not vulnerable to King Tide flooding. Ensure that calculations of the amount of time needed to evacuate ahead of the storm account for the fact that some current evacuation routes flood during King Tides, which limits speeds and the number of available lanes.

## Where can you learn more?

- **Assessment of Available Tools to Create a More Resilient Transportation System**  
Miami-Dade County, 2016

This report describes how sea level rise has and could affect transportation infrastructure, specific studies that have analyzed vulnerability to sea level rise and storm events, and reviews the existing tools from the federal and state governments that can help assess the vulnerability of the transportation system moving forward.

- **Storm Surge, Sea Level Rise, and Transportation Network Disruption**  
Florida Department of Transportation and Southeast Florida Planning Partners, 2016

This study looked at the economic impact of driving delays due to interruptions from storm surge with sea level rise.

- **South Florida Climate Change Vulnerability Assessment and Adaptation Pilot Project**  
Federal Highway Administration, 2015

This study examined sea level rise, storm surge, and precipitation flooding, and identified vulnerable transportation assets and adaptation strategies. The study found causeways and regional facilities on barrier islands and in the Everglades are highly vulnerable due low elevations and lack of alternative routes.

- **Sea Level Scenario Sketch Planning Tool**  
University of Florida

This online mapping tool allows users to identify transportation infrastructure vulnerable to current flood risks as well as future sea level rise scenarios from USACE and NOAA.

# CRITICAL FACILITIES



## How could sea level rise impact critical facilities?

Many key public facilities such as police and fire stations, emergency shelters, hospitals, and other essential buildings are vulnerable to direct and indirect impacts of sea level rise.

While many critical facilities are built to a higher standard and are less at risk, a recent study of the County's critical facilities (the "Rapid Action Plan") found that about half could be impacted by sea level rise. Because these facilities provide emergency services or are essential to the regional economy, it is important to minimize disruptions and impacts. Critical facilities need to last for decades so it is important they are designed appropriately to account for the amount of sea level rise that is expected over the lifetime of that asset.

Critical facilities are scattered across the County and face a variety of hazards. The best way to protect critical facilities is similarly varied: measures could involve flood-proofing a specific building with waterproof doors to elevating or relocating. In addition to protecting the facility itself, there often needs to be adequate access to a critical facilities during flooding events. This may require elevating nearby roads or access points to maintain services at desired levels and ensure any potential issues at the facility can be addressed quickly.

It is important to note that many critical facilities benefit from protection from natural infrastructure such as mangroves and dunes, features that can be cost-effective to implement across the county.

Critical facilities provide essential services during and after a disaster. If our fire stations, emergency shelters, and water facilities are well protected, communities will be safer and bounce back more quickly after a storm.

## What can we do to reduce the risks to critical facilities?

**Flood-proof buildings** in vulnerable areas to help reduce the risk of damages or disruptions to public services. It is possible to flood-proof a building by installing flood panels or barriers to keep the water out. Alternatively you can "wet floodproof" lower levels which means they can safely flood. It is also possible to build with water-resistant materials; elevate the building above the floodplain; or in some cases, relocate the facility to a safer location.

**Flood-proof other assets** in place or by elevating them above the expected flood levels. It is most cost-effective to alter the elevation of a project early in the design process.

**Relocate facilities** out of vulnerable areas where feasible; however, many assets like fire stations or wastewater pump stations must be located near existing homes and businesses and cannot be moved so other adaptation measures must be considered.

**Create or protect living shorelines** which can help add an additional layer of protection for certain facilities.

**Create redundancy** in the system to minimize the risks of disruption. This can include having back up power on site or having replacement parts on hand to quickly replace any damaged equipment after a storm.

## Where can you learn more?

- [Sea Level Rise and Storm Surge Rapid Action Plan](#)

This report identified the impacts of sea level rise and storm surge on county owner facilities. The study looked at the vulnerability and criticality of existing assets to prioritize where to invest in flood protection.



# WASTEWATER SYSTEMS



## How could sea level rise impact wastewater systems?

Because sea level rise makes higher storm surges more likely, the sewer system faces an increased risk of flooding at facilities. Because the three wastewater treatment plants are located on the coast, the Miami-Dade County Water and Sewer Department built their treatment plants at an elevation above the minimum standard required. Additionally, the Water and Sewer Department is designing improvements to their wastewater treatment plants to anticipate the impact of rising sea levels on flooding frequency and higher storm surges and is applying new design standards for their assets.

Sea level rise (coupled with changes in rain patterns) also impacts the overall operation of the collection and treatment system. Increased groundwater levels and more precipitation can increase the volume of wastewater being treated. The flow added to the system from tidal flooding, rain storms, and high groundwater is referred to as “inflow and infiltration”. This can increase operation costs, reduce sewer and treatment capacity, increase the risk of overflows, and require oversized infrastructure. Inflow and infiltration is an issue that every utility must manage; however, it is exacerbated by the rise in sea and groundwater levels. Chronic flooding can also lead to an increase in inflow and infiltration when residents illegally remove manhole covers of the sewer system to alleviate the street flooding in their neighborhood.

Many properties are not connected to the sewer system and rely on septic systems to treat their wastewater. Higher groundwater levels compromise the effectiveness of septic systems, leading to public health and environmental risks. Some septic systems are already compromised under today’s conditions. A recent report showed that the impacts are expected to get worse with sea level rise if no action is taken.

From a public health perspective it is essential that all residents have access to functioning wastewater treatment systems. Providing this service in the future could increase costs and additional financial resources will likely be needed.

## What can we do to reduce the risks to wastewater systems?

**Elevate and protect critical buildings and equipment** to reduce the risks of damage or interruption during a storm. For the past several years, the Water and Sewer Department has developed an approach to ensure new projects will be designed to provide continuity of service throughout the lifetime of the assets.

**Reduce inflow and infiltration** by replacing pipes, repairing manholes, lining pipes and taking other measures to protect the system against climate change. These improvements pay for themselves by reducing treatment costs (and energy consumption) and reducing the need for additional capital projects to increase the capacity of the system.

**Address vulnerable septic systems.** Some properties can be connected to the centralized sewer system to reduce the risks of compromised septic systems leading to public or environmental health issues.

**Replace vulnerable septic systems** with newer, higher “mounded” systems in areas that cannot be connected to sewer to reduce the risk that they will be affected by rising groundwater levels.

**Improve maintenance and monitoring** of existing septic systems to identify problems early before they cause water pollution.

**Review existing policies** that allow variances and review the requirements around when properties must connect to the central sewer system.

## Where can you learn more?

- [Septic Systems Vulnerable to Sea Level Rise](#)

This report provides an overview of how septic systems may be impacted by current and future water levels. It identifies areas where those risks are most likely to be at risk today and that are expected to be impacted by 2030 and 2040.





# FRESHWATER RESOURCES



## How could sea level rise impact freshwater resources?

Miami-Dade County's drinking water comes from the Biscayne Aquifer, a shallow, surficial aquifer just under our feet. Because the County's underlying geology is highly porous, sea water "intrudes" (or pushes) into the freshwater Biscayne aquifer. When sea levels rise, saltwater can push further into the freshwater aquifer.

The interface between fresh and salty water is dynamic and moves seasonally and over longer periods of time. As conditions change, the interface can move landward or seaward. For example, during a drought, the salt front may move inland. During the rainy season, it may move closer to the coast in certain locations. The use (or withdrawal) of freshwater from wells can also affect the movement of the salt front. The way the South Florida Water Management District manages the regional water system is the most important variable for saltwater intrusion.

Rising sea levels increase the risk of saltwater intrusion into the region's freshwater aquifer. While the intrusion of saltwater cannot be completely prevented, it can be slowed by raising fresh groundwater elevations along the saltwater intrusion front. This can be done by redistributing withdrawals from the wellfields or increasing the flow of freshwater with Everglades restoration.

Miami-Dade County's primary wellfields are located inland so they are less vulnerable to saltwater intrusion expected through 2040. Saltier water can be treated to create drinking water, but these treatment methods require more energy and are more costly than current methods.

## What can we do to reduce the risks to freshwater resources?

**Continue to monitor saltwater intrusion** in real time to help the Water and Sewer Department shift withdrawals between wells to reduce the risk of saltwater intrusion. Long-term monitoring helps scientists plan for longer-term trends and plan for future changes.

**Shift water withdrawals to western wellfields** to help reduce the risk of saltwater intrusion. Fortunately, the County has many wellfields in the west which are not expected to be impacted in the mid-to long-term.

**Relocate vulnerable wellfields** away from affected areas or away from major flood zones to maintain the amount of water able to be withdrawn while still reducing the risk of saltwater intrusion.

**Slow the movement of saltwater** up the canals to reduce the risk of saltwater intrusion. Today, this is primarily achieved by a series of gates (known as "salinity control structures") along the canals which separate freshwater and saltwater bodies. In some places, this can also be achieved by strategically restoring wetlands along the canals. These projects allow the mangroves to regrow which slows the movement of saltwater, keeps the water behind the barrier fresher, and helps recharge the aquifer.

**Manage the water of canals, lakes and ponds, levees, and drainage systems** to control aquifer recharge, maintain water supply, preserve wetland systems, and reduce saltwater intrusion.

**Conserve water** to help slow saltwater intrusion by reducing the withdrawal of freshwater from the aquifer.

**Restore the Everglades** as protecting this ecosystem helps to protect freshwater supply.

**Preserve wetlands and open space** to protect the wellfield and allow water to recharge the aquifer, which helps reduce saltwater intrusion.

## Where can you learn more?

- [Miami-Dade County's website on saltwater intrusion](#)



# DRAINAGE SYSTEMS



## How could sea level rise impact drainage systems?

Drainage infrastructure helps us move rainwater off the land. Large scale infrastructure, such as our regional canal network, can also draw down the groundwater levels below natural levels in some inland areas away from the coast. Drainage infrastructure cannot be used to draw down sea levels or prevent coastal flooding from storm surges.

Much of the existing drainage in the county depends upon gravity to carry rainwater gradually downstream to the ocean or into our groundwater. However, as sea and groundwater levels rise, the water will not flow as quickly. This can mean that the canals do not drain as fast as they did in the past. Therefore, flooding can last longer or be more severe than it has been. Rising groundwater levels can also saturate drainage features, like French drains, which work best in unsaturated soils. Having higher groundwater levels and less unsaturated soil also means that when it rains, there is less soil to absorb rain water.

Rising sea levels require us to redesign our drainage systems to account for new conditions. It could also require relying less on passive drainage systems (that rely on gravity) or open drainage systems (that rely on unsaturated soils). However, moving to a new drainage system that relies heavily on pumping could have a number of direct and indirect costs. Pumps may be less effective in coastal areas where they may be pumping against the tide and recirculating saltwater rather than drawing down water levels.

## What can we do to reduce the risks to drainage systems?

**Improve the regional drainage system.** The system is controlled by the South Florida Water Management District and maintenance and redesign of the systems will reduce flooding risks for inland and western areas. The District is exploring potential adaptation measures such as reservoirs, operational changes, and additional forward pumps to help adapt the system to sea level rise. Forward pumps push water against the force of gravity and move water when the tides are too high to flow by gravity. The County should continue to advocate for the reassessment and redesign of the Central and South Florida Flood Control Project by the U.S. Army Corps of Engineers.

**Improve local stormwater management** to help alleviate flooding. These measures can be constructed by the County, municipalities, and property owners to improve drainage at a smaller scale. This can include cleaning drains, bigger culverts, or backflow preventors.

**Create blue and green neighborhoods** to reduce the amount of stormwater runoff and water pollution that leaves a property. Measures such as rain gardens, pervious pavers, trees, and swales can help reduce flooding and reduce water pollution to neighboring areas.

**Selectively use pumps to alleviate flooding;** however, this measure may be less effective in coastal areas where the groundwater is affected by the tides. In these areas, the pumps may end up circulating saltwater and may not be able to draw down groundwater levels. To be effective, pumps need to be part of a larger solution such as elevating structures and upgrading stormwater infrastructure. Pumps also require an uninterrupted power supply and have a cost and environmental impacts. Pumps also contribute greenhouse gas emissions and do not reduce the risks of flooding during a hurricane.

## Where can you learn more?

- **Miami-Dade County's Recommendations to Protect Water, Sewer, and Road Infrastructure from Sea Level Rise Impacts (forthcoming)**

This report provides an overview of past studies; discusses on-going efforts to reduce vulnerabilities; and provides recommendations for addressing flood risks.

- **Miami-Dade County's report on the Vulnerability of Sanitary Sewers and Stormwater Infrastructure to Sea Level Rise (forthcoming)**

This report provides an overview of how sanitary sewer and stormwater systems work; how both systems are impacted by current and future water levels; describes which areas will be impacted; and recommends steps to reduce these vulnerabilities.



# BEACHES AND DUNES



## How could sea level rise impact beaches and dunes?

Beaches and dunes serve as critical natural buffers between the ocean and our barrier island communities. During storms, they provide important protection against damaging surge and waves. However, they also suffer from erosion.

Erosion is a natural process that occurs at nearly all barrier beaches, but as sea levels rise erosion rates typically increase. It is necessary to add sand to the beaches to keep pace with the amplified erosion. This process, known as beach “renourishment”, helps maintain a beach’s shape and width to protect against storm surge.

Without this additional sand, the beach could become too narrow and expose the waterfront buildings to dangerous waves and surge. For these reasons, the federal and state governments are active partners in protecting our beaches. Additionally, beaches are a key part of our regional tourism economy.

Dunes are key component of the beach system. The plants that live on dunes trap sand that blows in the wind. They build up as a reservoir of sand to resupply the beach. As dunes trap more sand, they grow taller and become better barriers against wind, waves, and surge. The roots of the plants help hold the dune in place and act as another buffer against waves and erosion. Dunes also provide critical habitat benefits to a number of animals, such as sea turtles and shore birds.

## What can we do to reduce the risks to beaches and dunes?

**Enhance dunes and native dune plants** to help trap the sand that moves naturally with the wind. Over time, the plants help dunes grow vertically and protect areas behind them.

**Increase waterfront setbacks** to protect the beach and the dune system. Allow enough space for the systems to shift naturally with storms and seasons.

**Renourish beaches** to help slow changes to the beaches and dunes and provide important storm protection benefits.

## Where can you learn more?

- [Miami-Dade County Beach Erosion Control Master Plan](#)

In an effort to enhance and protect beaches from the effects of sea and wind erosion, a number of studies have been conducted to better identify problem areas, assess the causes of high erosion rates, and develop recommendations for these areas.

- [US Army Corps of Engineers’ plans for shore protection for Miami-Dade County](#)



# NATURAL AREAS



## How could sea level rise impact natural areas?

As sea level rise, natural shorelines, such as mangroves and other types of coastal wetlands, will need to adjust to the new conditions. However, in order to survive with higher water levels, mangrove forests and other coastal habitats need to migrate uphill. When development limits their ability to shift in the face of changing conditions it results in “coastal squeeze”. This means that the coastal ecosystems are squeezed between higher water levels and human development inland. As a result, ecosystems can diminish with time, which reduces their protective and ecological value.

In the Everglades, different ecosystems thrive in fresh and saltwater environments. As sea levels rise, the saltwater pushes further into the Everglades. Saltwater intrusion can lead to a loss of freshwater habitat. In some areas, it can cause the peat (or the soil structure that supports the wetland grasses) to collapse. When the peat collapses due to saltwater intrusion, it leads to a loss of wetland habitat as it is replaced by open water. These impacts will be less severe if there are adequate flows of freshwater in the Everglades.

In contrast to man-made flood defenses like seawalls, mangrove forests and living shorelines have a natural ability to adapt in place and keep pace with rising sea levels if the conditions are favorable. Therefore, they can continue to protect communities from storms and provide cleaner water and air even as seas rise. However, many factors may compromise their ability to acclimate. If the rate of sea level rise is too great, if there is a shortage of sediment, if water temperature or salinity is not right, or if development or environmental stressors impact the ecosystem, they may not be able to keep pace with rising water levels. As a result, they will die and the width and density of the forest will diminish. Protecting the health and integrity of these ecosystems contributes to the long-term safety of the communities protected by them. In Miami-Dade County, we are fortunate to have extensive natural areas and national parks surrounding our urban areas.

## What can we do to reduce the risks to natural areas?

**Preserve wetlands and existing natural areas** to give ecosystems the best opportunity to adapt to changing conditions.

**Continue resilience and land use planning** and policy implementation such as those in the Comprehensive Development Master Plan to help protect natural areas.

**Restore the Everglades and freshwater flows** to help wetlands adapt and minimize the intrusion of saltwater.

**Restore mangroves and marshes** to protect shorelines from erosion, provide critical habitat, and protect communities from waves.

**Increase living shorelines** to improve water quality and provide ecosystem benefits. Living shorelines can also protect against waves if they are designed appropriately.

**Increase individual stewardship** and work with large property owners to preserve or restore habitats on private property.

## Where can you learn more?

- [The EcoAdventures Program](#)

This program offers opportunities for you and your family to explore, kayak, snorkel, bike or hike through these scenic areas and learn more. You can also become a volunteer, join a team of nature enthusiasts, or participate in the students' seasonal Nature Camps.

- [Environmentally Endangered Lands Program](#)

The focus of the Environmentally Endangered Lands Program is the protection and conservation of endangered lands. These include pine rocklands, tropical hardwood hammock, and wetlands. The County has bought more than 20,700 acres of environmentally endangered lands since 1990.

