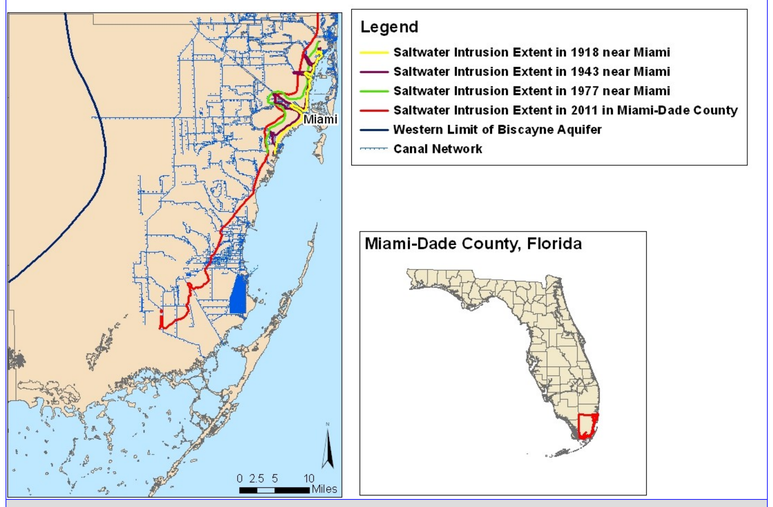
# The Effect of a One-Foot Sea Level Rise on Saltwater Intrusion in the Biscayne Aquifer in Miami-Dade County, Florida

By Kelsey Sanborn

## Introduction

Southeast Florida is one of the world's most vulnerable areas to climate change, given its low elevation and densely populated coastal area. With the Intergovernmental Panel on Climate Change predicting a 7-23 inch sea level rise by the year 2100, this area will soon be forced to contend with serious climate-related threats. (IPCC) One factor that will pose a problem to Florida's coastal population is saltwater intrusion into the area's limited groundwater source, stored in the underlying Biscayne Aquifer. Mitigating saltwater intrusion is an ongoing problem for Miami-Dade County in southeast Florida. The inland movement of the saltwater interface into the Biscayne Aquifer is due to a combination of factors, including intensive municipal withdrawals from the freshwater supply, the lateral movement of ocean water from the Atlantic Ocean into the aquifer, and the seepage of seawater into the aquifer through canals and recharge areas. The combined effects of natural and human factors are resulting in a diminishing freshwater supply and threatening the habitability of this region.

**Changes in Saltwater Intrusion Extent near Miami over the Last 100 Years**




*This map combines data on historical saltwater intrusion around the Miami Canal, obtained from the USGS, with current data on the saltwater interface through the Biscayne Aquifer. A base map of Miami-Dade County was used and the western limit of the Biscayne Aquifer in the county is shown.*

Over the past 100 years, the saltwater interface in the Biscayne Aquifer has gradually moved further inland. A major cause of this movement is the increasing population of Miami, which has more than doubled in the past 50 years. (US Census) Despite expensive measures implemented to lessen saltwater encroachment, such as building salinity control structures and increasing seaward canal flow, there is a strong disequilibrium in the system causing saltwater to flow inland. (Miami-Dade Water and Sewer Department)

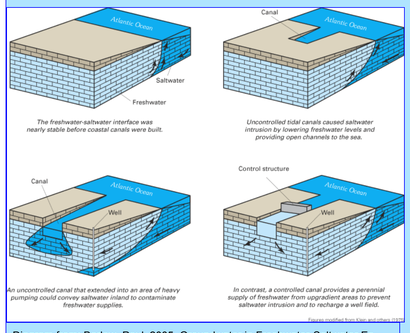
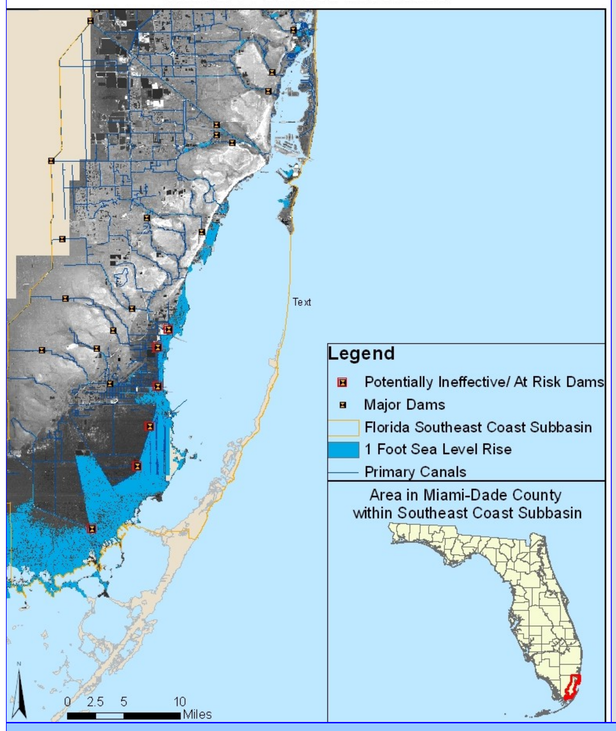



Diagram from: Barlow, Paul, 2005, Groundwater in Freshwater-Saltwater Environments of the Atlantic Coast: US Geological Survey Circular 1262.

Saltwater intrusion can occur at canal pathways when the water table in the canal is higher than that of the aquifer. Water will naturally move from the aquifer into the canal when the aquifer has a higher water level, but when the aquifer is depleted from inadequate recharge and excessive withdrawals, water will flow from the canal into the aquifer. This can lead to the intrusion of saltwater from canals into the aquifer. Constructing control structures in canals is necessary to create a barrier between freshwater and saltwater.

**Miami-Dade Dams at Risk in Southeast Coast Subbasin With a 1 Foot Sea Level Rise**




*This map uses high resolution elevation data (10-ft DEM) from the South Florida Water Management District to determine the coastal area that would be flooded given a one-foot sea level rise. Dams located along the elevated coast line were identified as at risk, as they would be submerged or rendered ineffective from canals overflowing around the dam. Ineffective dams would cause ocean water to flow into canals and potentially seep into the Biscayne Aquifer.*

## Results

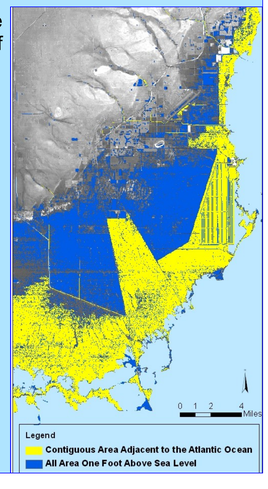
- 6 dams at serious risk of flooding or being rendered ineffective
- All connecting canals at risk of increasing saltwater intrusion

## Methodology

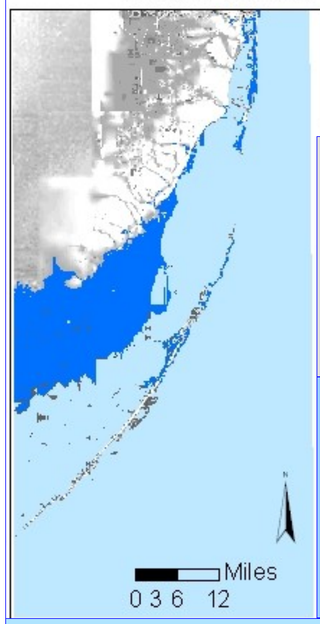
First, using 10-ft DEM data for Miami-Dade County coastal area, a raster was created of all of the land that lies one foot or less above sea level. However, this does not show all of the area that would be flooded if sea level were to rise by one foot, as natural and artificial barriers would protect some low-lying inland areas from flooding. Only the area adjacent to the Atlantic Ocean and not protected by elevated land or control structures would be inundated. Using the "Regroup" tool, connecting areas of one-foot elevation were selected from the initial one-foot elevation area (seen in blue). Based on this, contiguous unprotected areas of low elevation areas next to the coast were identified, and made into a single raster using the "Reclassify" tool (seen in yellow).

## Analysis

Though using high resolution elevation data and data analysis tools increase the accuracy of this flooding model, it is still limited. Local factors near each dam site will determine if the dam would still be effective given a one-foot sea level rise, as it is uncertain the paths that the incoming water will take. It is also likely that along with rising sea levels, climate change will cause storms to intensify and waves to strengthen, leading to increased land erosion and higher storm surge, which would also effect flooding patterns.




**Possible Area Flooded in Miami-Dade County Given a One Foot Sea Level Rise**




*This map shows another possible model of the area that would be flooded given a one-foot sea level rise based on 1-arc-second (approximately 30 meter) resolution for all of Miami-Dade County, using the same methodology described. The area of the raster was calculated by extracting the raster, converting it to a polygon, and calculating the area. This displays a larger possible extent than the previous map due to lower resolution data.*

## Results

- Area covered by raster = **351.98 square miles**
- Total area of Miami–Dade County= **1,946 square miles**
- Percent of Miami–Dade County at risk of flooding given a one-foot sea level rise = **18%**

## Conclusion

The resulting maps show two possible models of land inundation caused by a sea level rise of one foot, with different implications for saltwater intrusion in Miami-Dade County. The higher resolution 10-foot DEM data identified the minimum area of land flooding and the bordering dams that would be at immediate risk, which would cause saltwater flow into canals and into the underlying aquifer. The lower resolution 1-arc-second data shows a larger low-lying coastal area that could be flooded, which would cause saltwater seepage into the Biscayne Aquifer by flooding freshwater recharge areas and wells with ocean water.

Although the elevation data was analyzed and manipulated to improve accuracy, the resulting models are very approximate. Many other factors will affect what areas of land will be inundated besides elevation, and it is difficult to determine the path that the incoming seawater will take. However, there is strong evidence indicating that an increase in sea level of one foot will result in a significant increase of saltwater intrusion into the Biscayne Aquifer by flooding recharge areas, wells, and increasing subsurface intrusion in canals, particularly if control structures are damaged. Saltwater intrusion will be a serious consequence of sea level rise in Miami-Dade County, and one of many threats posed by climate change.

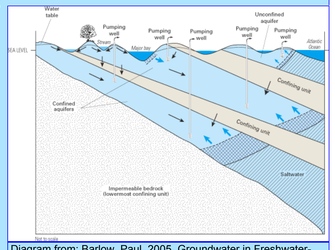



Diagram from: Barlow, Paul, 2005, Groundwater in Freshwater-Saltwater Environments of the Atlantic Coast: US Geological Survey Circular 1262.

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