Serial Report: Reports from USA (Part 1)

How is Florida Dealing with the Rising Sea Level?

Takefumi Takuma

Senior Advisor, Giken America Corp., 5770 Hoffner Avenue, Suite 101
Orlando, FL 32822, U.S.A., E-mail: ttakuma@gikenamerica.com

Note: This paper was originally prepared for the ASCE (American Society of Civil Engineers) Florida Section's 2015 Annual Conference and is reproduced herewith with its permission.

ABSTRACT: The rising sea level confronts many low-lying metropolitan areas of the world including the coastal regions of Florida. Hurricanes and tropical storms, which land there frequently, further heighten the sea level as they approach; exacerbating local flooding. This paper is to review the ways the sea level is being monitored and how some of Florida's densely populated coastal communities are dealing with the rising sea level.

INTRODUCTION

Florida has 8,426 miles of tidal shoreline with approximately 75% of its population residing in coastal counties.

Is the sea level really rising and, if so, why? According to the geological study, the world's sea level has been fluctuating over time primarily due to the changing amount of trapped ice on land. For example, during the last glacial period some 20,000 years ago, the sea level was as much as 100 to 120 meters lower than the current level with glaciers covering the continents. In contrast, other geological evidence suggests that the sea level was 4 to 6 meters higher than the current level during the last interglacial period 125,000 years ago. It is believed that we are currently in a warm interglacial period starting about 12,000 years ago.

If so, what is the estimated amount of sea level rise for the near future, if any, and at what rate? The estimate varies among researchers depending on the historical data they use and the methods of their analyses. For example, the U.S. Army Corps of Engineers (2009) has compiled tide gauge records taken at the U.S. tidal stations by NOAA (National Oceanic and Atmospheric Administration) to determine the mean sea level. Most of the record-taking locations showed the mean sea level rise of 0 to 2 feet per century except the stations in Alaska, where a falling trend was observed most likely due to the strong seismic and tectonic activities reported. With different parameters for future change predictions, the Corps of Engineers' report estimates the rise of the global sea level to be between 0.5 and 1.0 meter by the year 2100 (@1.7 mm per year). Speaking of the local sea level record in Florida, tidal data taken at Virginia Key, which is just south of Miami Beach and east of downtown Miami, is showing something more alarming. The tidal data collected there since 1996 indicates 0.27 inches (6.9 mm)/year of a high tide level increase over the last 15 years and 0.97 inches (24.6 mm)/year over the last 5 years. The sea level has been rising at an accelerating rate in south Florida recently.

IMPACT OF SEA LEVEL RISE TO FLORIDA

Florida is very vulnerable to the sea level rise due to the obvious reasons. The Miami metropolitan area is one of the most affected regions in the world by the sea level rise in terms of the exposed financial assets and the size of its population combined according to various analyses including the 2007 OECD report (Nicholls et al., 2007). Other populous coastal cities like Jacksonville and Tampa will also be greatly impacted.

What will happen if the sea level keeps rising? First obvious outcome would be coastal erosion and more frequent flooding, resulting in loss of coastal property, infrastructure, and habitats. The ground water quality will deteriorate due to saltwater intrusion. Agriculture and aquaculture will be negatively impacted. Tourism and recreational activities will be drastically reduced, resulting in huge monetary loss in places like south Florida.

(1) Tidal Flooding

As the mean sea level rises in conjunction with storm surge and/or seasonal high tide, such as king tide, the sea water not only blocks the storm water discharge from the land, but it also flows backward onto land and floods the low-lying areas. Unless sewer and storm water discharge systems are equipped with more robust pumps with backflow prevention and the elevation of the outfalls is reconfigured as necessary, the situation will get worse as the sea level rises. Porous limestone layers, which are very common in Florida, also allow sea water to seep through them to inundate low land areas.

(2) Saltwater Intrusion

Since freshwater is lighter than seawater, the former is normally "floating" on top of the latter in the ground while rain and nearby rivers constantly replenish groundwater. As the sea level rises, so does the interface between the freshwater and seawater in the ground, making the layer of freshwater thinner and thinner. Eventually, freshwater will no longer

exist along the coast line. When the well pumps draw freshwater from an aquifer, it lowers the water table and pulls the brackish water (mixture of freshwater and saltwater) and saltwater up higher and more inland (see Fig. 1). This is the case with the shallow Biscayne Aquifer; the primary fresh water source for the Keys, Miami, and the lower east coast of Florida. The aquifer is recharged primarily by the Everglades' freshwater. As the sea level rises, part of the Everglades will be contaminated by saltwater intrusion. (The Everglades is a huge "river of grass", an extensive area of continuous meadows with flowing fresh water from central to south Florida and one of National Parks)

(3) Coastal Erosion

Many beautiful coastal beaches in Florida are suffering from erosion due to hurricanes, tropical storms, wave actions, longshore currents, and, of course, the rising sea level. Human activities, such as building structures on or near the beach, may disrupt natural movement of sand, therefore, resulting in sand accumulation at some locations and deficiency at other locations. It is both environmentally and economically crucial for the state and its residents to keep the beaches from being eroded and washed away. Fig. 2 shows an eroded beach on Singer Island in 2006.

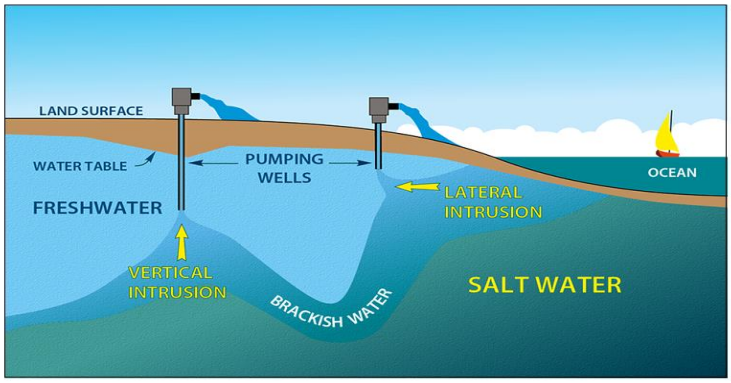

Fig. 1. Saltwater Intrusion (courtesy of www.floridaswater.com)

Fig. 2. Beach Erosion at Singer Island, Florida (2006)

How is Florida Fighting Back?

Coastal Florida is confronted by ever more frequent tidal flooding, increasing salinity in drinking water wells, and wide spread beach erosion. Will Florida be able to successfully fight back and adapt to the rising sea level and how? Let us look at some of the front line activities against the rising sea in Florida.

(1) Southeast Florida Regional Climate Compact

Four counties (Broward, Miami-Dade, Palm Beach, and Monroe) in southeast Florida have established a group called Southeast Regional Climate Compact (2009) to unify the efforts on assessing the amount of sea level rise and its impacts in addition to planning ways to deal with such impacts. The counties within the Compact are cooperatively working to have the Florida legislature recognize the "Adaptation Action Areas" where the sea level rise and storm surges pose a risk to local infrastructure. In October 2012, the "Southeast Florida Regional Climate Change Action Plan" was finalized with 110 action items with these counties adopting them in spring of 2014. Various workshops have been held to implement these action plans since then.

(2) Southwest Florida Regional Planning Council, Charlotte Harbor National Estuary Program, and City of Punta Gorda

The Southwest Florida Regional Planning Council (an inter-county organization made of 6 counties in southwest Florida) and Charlotte Harbor National Estuary Program (partnership of citizens, elected officials, resource managers, and commercial and recreational users working to improve the water quality and ecological integrity of the greater Charlotte Harbor watershed) prepared "The Comprehensive Southwest Florida/Charlotte Harbor Climate Change Vulnerability Assessment" in 2009. This report examined 5 different climate change scenarios through the year 2200 and identified 246 climate change management adaptations for the region.

Having been heavily hit by Hurricane Charley back in 2004, the City of Punta Gorda, as one of the southwest region cities, has been working towards a higher degree of preparedness. The aforementioned Southwest Florida Regional Planning Council and Charlotte Harbor National Estuary Program prepared the "City of Punta Gorda Adaptation Plan" in 2009 to identify the impact of sea level rise and to lay out the goals for the city and its residents to effectively deal with this issue. The report's Executive Summary states that the city has taken a variety of affirmation adaptation actions such as "elevation of structure and improvements of drainage systems, relocation of the public works facility to a location of lower hazard from natural disasters and coastal flooding, adoption of a transfer of development rights program to protect historical and natural resource areas, and a completed local mitigation strategy for natural disasters".

(3) Miami Beach and Key West's Fight Against Local Flooding

•The City of Miami Beach is installing 50 plus new pump stations in addition to 20 or so already-installed stations for storm discharge ($300 million project by 2020) along with more than 100 backflow preventers. It also plans to raise some of the city's lowest streets by 1.5 to 2 feet (45 to 60cm).

•The City of Key West is installing new pumps and improving the storm drain system in downtown. A new ordinance is requiring a new building to be built at least a foot and a half (45cm) higher than the flood plain.

(4) Restoration of the Everglades and Protection of Biscayne Aquifer

The state, Miami-Dade County, the South Florida Water Management District, and the U.S. Army Corps of Engineers are working together to reduce the negative impact of saltwater intrusions against the Biscayne Aquifer. The Army Corps' Jacksonville District is in charge of restoration projects in south Florida including the Comprehensive Everglades Restoration Plan, which is to increase the freshwater flow to the southern Everglades. The water agency has been monitoring the water table depth at certain locations to assess the saltwater intrusion to protect the aquifer.

(5) Protection Against Coastal Erosion

The sea level rise and hurricanes/storms in addition to natural migration of sand and construction/maintenance of navigational channels are causing beach erosion. Of Florida's 825 miles of sandy beaches, 495 miles of them (60%) are eroded (critically and non-critically combined). Beach nourishment is the most common way to replenish the "lost" sand on the beach by means of bringing in and reshaping the sand from offshore sources. This practice quickly restores the lost sand on beaches and habitats for shore birds and sea turtles. However, it is a perpetual process that has resulted in millions of dollars in expense each time since 1969 at Treasure Island, Florida which is known as the first federal beach nourishment project. For example, Miami Beach has spent approximately $140 million in today's dollars to bring in 12.3 million cubic yards of sand to its beaches over the years. The program is administered by the U.S. Army Corps of Engineers with 60% of federal funding along with 20% funding from the state and the remaining 20% from each involved county collectively. The state of Florida's annual budget for beach nourishment is approximately $30 million.

Critical erosion is defined by the state as "a level of erosion which threatens substantial development, recreational, cultural, or environmental interests". Once this occurs, the beach will need to be repaired promptly in order to protect "substantial development, recreational, cultural, or environmentally significant" assets. One way to mitigate this type of situation is to build a seawall in the most environmentally friendly manner. For example, the Town of Lantana suffered from severe beach erosion that threatened the structures on and near a beach in the fall of 2008. Fig. 3 shows an emergency seawall constructed to stop further erosion of the beach in 2009 by using steel sheet piles. They were driven by the press-in piling method, which was practically vibration free with very low noise. The construction did not disturb guests or residents at nearby condominiums, beach houses, and a high end hotel. This method has been utilized also on other beach restoration and sea wall projects in Florida in harmony with the local residents and animals.

Fig. 3. Lantana Emergency Seawall Construction with Pressed-in Sheet Piles

Conclusion

The sea level is rising and will most likely continue to rise. Identifying and prioritizing adaptation options and executing them effectively require political will. South Florida is more keenly aware of the risk of the sea level rise and is getting more prepared for its impact than the rest of the state. It is imperative that all of Florida's coastal regions integrate the adaptation options and effective tools against the rising sea level in their regional planning and start implementing them for the state's sustainable future.

References

Nicholls, R.J., et al, OECD (2007), Ranking of the World's Cities Most Exposed to Coastal Flooding Today and in the Future (Executive Summary)

Southwest Florida Regional Planning Council and Charlotte Harbor National Estuary Program (2009), "Comprehensive Southwest Florida/Charlotte Harbor Climate Change Vulnerability Assessment", Technical Report 09-3

Southwest Florida Regional Planning Council and Charlotte Harbor National Estuary Program (2009), "City of Punta Gorda Adaptation Plan", Technical Report 09-4

United States, Army Corps of Engineers (2009), "Water Resource Policies and Authorities Incorporating Sea-level Change Considerations in Civil Works Programs", CECW-CE, Circular No. 1165-2-211