Counteracting the Effects of Sea Level Rise on Southeast Florida’s Water

Fred Bloetscher1 & Barry N. Heimlich2

1. Department of Civil, Environmental & Geomatics Engineering
2. Florida Center for Environmental Studies
Florida Atlantic University


Contact Info: Barry Heimlich, 954-963-3564, barryCES@bellsouth.net

This project was funded by National Commission on Energy Policy
www.energycommission.org
Sea level rise accelerated at 0.013 mm/yr\(^2\) since 1880 and currently exceeds IPCC 2007 projection.

Sea level rise accelerating during the 20\(^{th}\) Century at 0.013 mm/yr\(^2\)
(Church and White, 2006)

Sea level rising faster than IPCC-2007 projection
(IARU-Synthesis Report, June 2009)
Glacial Melt Accelerating in Greenland and Antarctica

GRACE satellite gravity mission

- Greenland Ice Sheet mass loss from 2002–2009 is accelerating.
- Acceleration of ice mass loss is 30 km³/yr².
- Ice mass loss from Antarctic Ice Sheet also accelerating.
- Combined equivalent to sea level rise acceleration of 14 ft/yr².
- Portends sea level rise of ~4 ft by 2100.

(Velocogna, 2009)
Sea level rise in 21st Century
2 to 5 feet projected by 2100

Projected Sea Level Rise, in feet, Quadratic Acceleration Model

\[ \Delta S = v_0(\Delta t) + \frac{a(\Delta t)^2}{2} \]

Current Trend 3.1 mm/yr

2100 Projections
Historic sea level rise in South Florida 2.1 mm/yr; similar to global average

3.1 mm/yr
Perils of a Rising Ocean

- Beach erosion
- Encroachment by seawater
  - Waterfront and low lying property
- Inundation by seawater
  - Coastal wetlands
  - Lower Everglades
- Saltwater intrusion threatening water supply
- Increased inland flooding during heavy rains
- Hurricane storm surge and wave action increased
Figure 1 - Broward County Elevation Map. This is LiDAR elevation data from 2008. Elevations less than 5 feet above sea level are shown in purple.
Saltwater intrusion
With controlled water table

\[ \Delta z = 41 \text{ SLR} \]

\[ \frac{z}{h} = \frac{\rho_f}{(\rho_s - \rho_f)} \approx 40 \]

Ghyben–Herzberg Relation
Saltwater intrusion zone
Defined by coastal flood/salinity structures
Coastal structures lose capacity as sea level rises

According to Bernoulli’s Law

\[ Q = AC\sqrt{2g(H - h)} \]

(Obeysekera, SFWMD, 2009)
Coastal structures lose capacity as sea level rises

S-13 Pumping Station

- Capacity = 540 cfs = 14.5 million gal/hr

Based on data from Obeysekera, SFWMD, 2009)
Flood control system can backup

(Obeysekera, SFWMD, 2009)
Increased Ponding – Annual Cycle

- At Current Sea Level
- With 1.5’ Sea Level Rise

(Provided by: Obeysekera, SFWMD)
The Current Situation

~55% rainfall drained as stormwater to ocean

~20% of rainfall to municipal use, winds up as treated wastewater
An Alternative to Consider

Should pumping treated stormwater and/or treated wastewater back to the Everglades be considered?

Challenge: How to economically treat so much stormwater and wastewater sufficiently?
Is this an idea worth considering?

- Stormwater Treatment Plants
- BIG CYPRESS (10')
- WATER CONSERVATION AREA
  - HIGH WATER +8'
  - LOW WATER +5'
- 0' NGVD
- CANAL STRUCTURE
- OCEAN
- COASTAL RANG
Migration and possible reduction of mangrove forests

Migration of wading birds northward

Potential peat collapse, coastal erosion, and redistribution of sediments

Salinity intrusion into freshwater marshes:
  ◦ Emission of greenhouse gases and toxic hydrogen sulfide
  ◦ Coastal fish kills
  ◦ Habitat loss
  ◦ Threat to Biscayne Aquifer water supply

Obeysekera, SFWMD, 2009
An Everglades Concern –

- Sea Level Rise will cause saltwater to migrate northward in lower Everglades
- More freshwater flow needed to “keep sea at bay.”
- Water levels throughout the Everglades basin may increase.
  - “Water flows downhill.”
- Sawgrass prairies may flood.
- Sea level rise of 2–5’ is likely to cause major ecological changes.
Transection of Shark Valley

1 meter = 3.25 ft. rise
Current – High tide at 2 ft above MSL
Future with 1’ SLR – High tide at 3 ft above MSL
Future with 3–5’ SLR – High tide at 5–7’ above MSL
Seawater flows past Tamiami Trail
Much of lower Everglades is saline 24/7
Conclusions

- Sea level could rise by 2’–5’ or more by 2100; 1–1.5’ by mid-century
  - Everglades National Park, the Keys, barrier islands, and coastal lowlands could be inundated.

- Municipal water supply would be threatened
  - Saltwater intrusion
  - Reduced groundwater flow

- Increased risk of flooding during heavy rain events
  - May require additional pumping stations along coast and
  - Other engineering modifications of storm drainage system

- Effects on water supply and flooding
  - Will continuously worsen as sea level rise progresses

- New solutions may be needed
  - Reengineer stormwater drainage systems
  - Rethink wastewater reuse.
  - To protect Everglades from salinization.
  - Model current plans and new ideas in consideration of sea level rise.

- The Best Solution: An Ounce of Prevention
  - Global reduction of greenhouse gas emissions to minimize effects of global warming

The Best Solution: An Ounce of Prevention

FAU
Reference:
Heimlich, B.N.; Bloetscher, F.; Meeroff, D., Murley, J.,
Southeast Florida’s Resilient Water Resources: Adaptation to Sea Level Rise and Other Impacts of Climate Change, FAU, 2009

Questions?

http://www.ces.fau.edu/climate_change/
Contact Info: Barry Heimlich, 954-963-3564,
barryCES@bellsouth.net