INFRASTRUCTURE ANALYSIS FOR SEA LEVEL RISE IN MIAMI, FLORIDA

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DIGITAL TERRAIN ANALYSIS

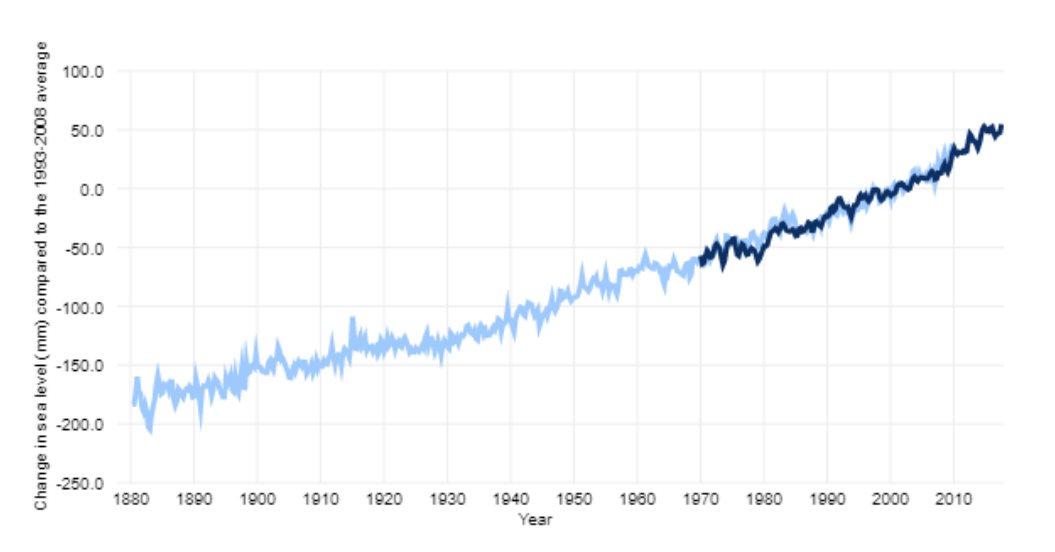
FALL 2017

http://www.bbc.com/future/story/20170403-miamis-fight-against-sea-level-rise

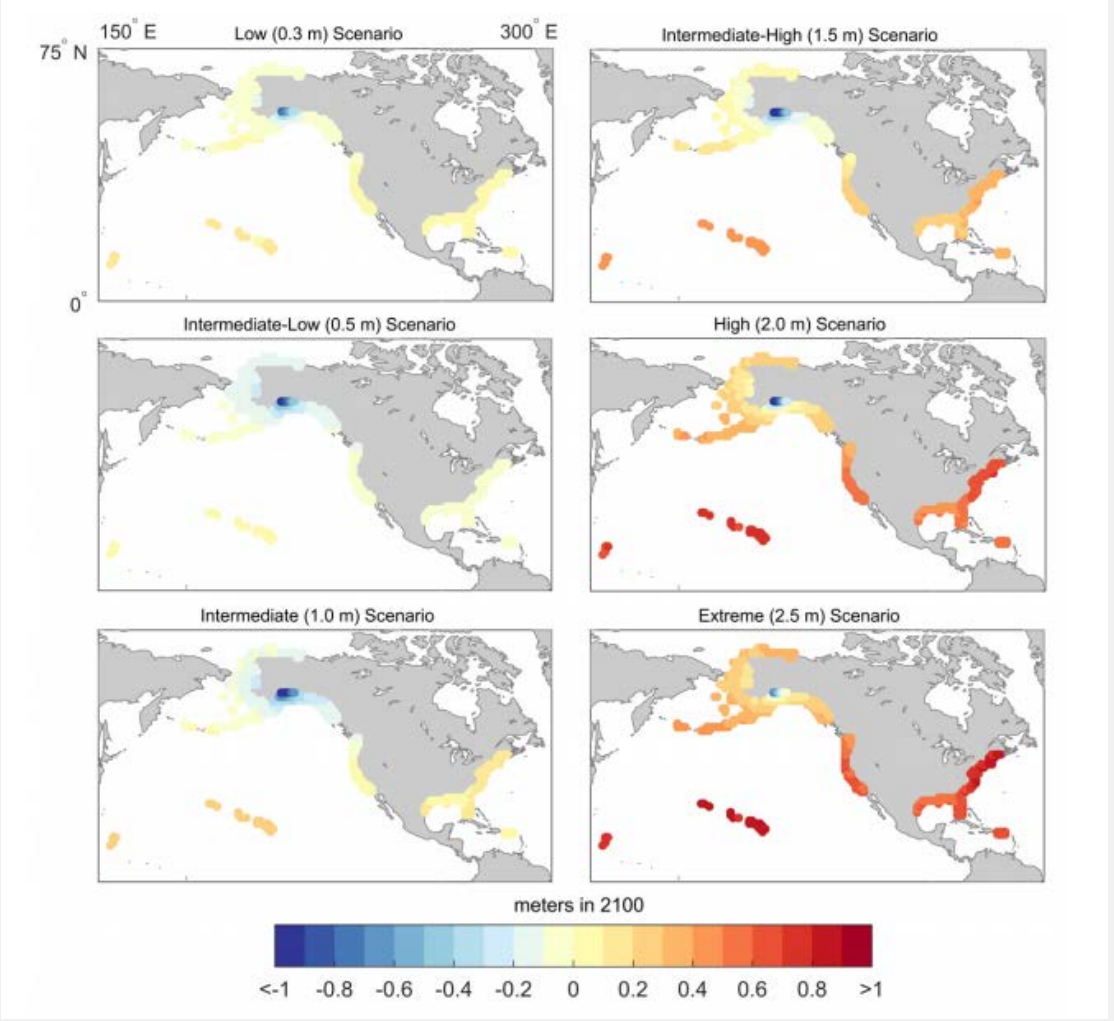
ABSTRACT

Sea level rises due to melting glaciers and ice sheets, the expansion of the ocean as water warms, and to a lesser degree, because groundwater pumping has shifted water storage from aquifers, lakes, and reservoirs to the ocean. There has been a consistent rise in sea level since the later 1800s, and we have, in recent years, seen a more dramatic increase. While global sea level is rising, it is rising at different rates in some locations. The study area I focused on, which is the coastline along Miami, Florida, is experiencing a rapid sea level rise, and is vulnerable to environmental hazards such as storm surges. The purpose of this study was to compare two different estimates for sea level rise in 2100, and how they affect the infrastructure of Miami. To calculate the area of Miami that would be submerged with a sea level rise of 1 or 2 meters, I obtained a 5m DEM of the area which I subtracted to symbolize the submerged area. I also utilized some features such as evacuation routes, hospitals, schools, and Superfund sites to assess how significant the damage would be at 1 or 2 meters of sea level rise. Based on my results, I concluded that there would be significant infrastructural damage in Miami with the predicted level of sea level rise by 2100. Furthermore, when using the higher of the two estimates, the level of damage increased exponentially. I concluded that planners must begin working now to target these sites that fall in the flood zone, particularly when considering other causes of floods such as hurricanes and storm surges that are becoming increasingly prevalent in the area. To improve this project in the future, I would like to include models for storm surges and hurricanes to more accurately predict the effects of flooding in Miami.

SEA LEVEL RISE: WHY IT IS OCCURRING AND WHO IS AFFECTED



Graph from NOAA, (https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level)

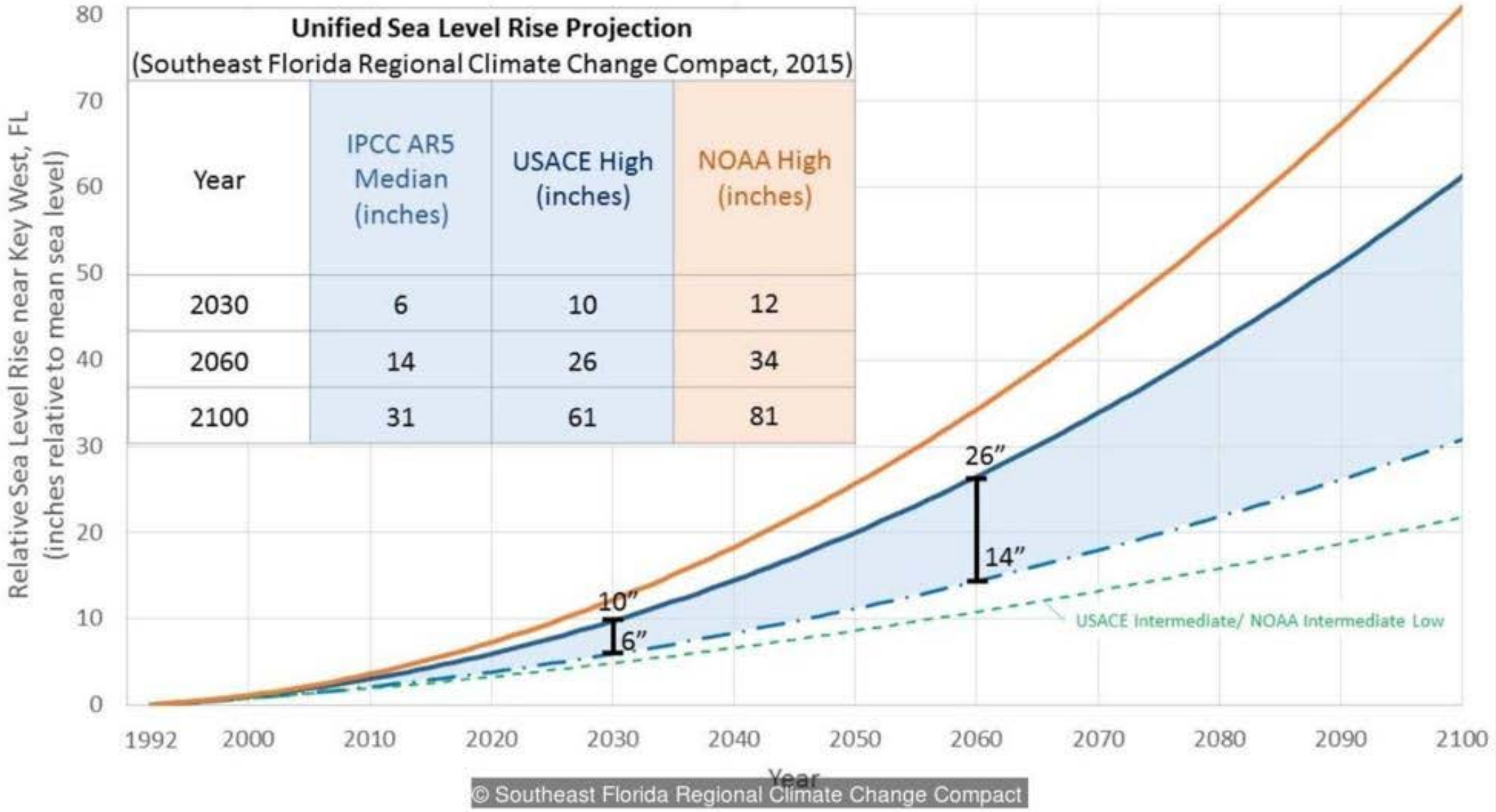


Why sea level rise occurs

1. Melting glaciers and ice sheets
2. Ocean expands as water warms
3. Groundwater pumping shifts water storage from aquifers, lakes, and reservoirs to the ocean

Unified Sea Level Rise Projection
(Southeast Florida Regional Climate Change Compact, 2015)

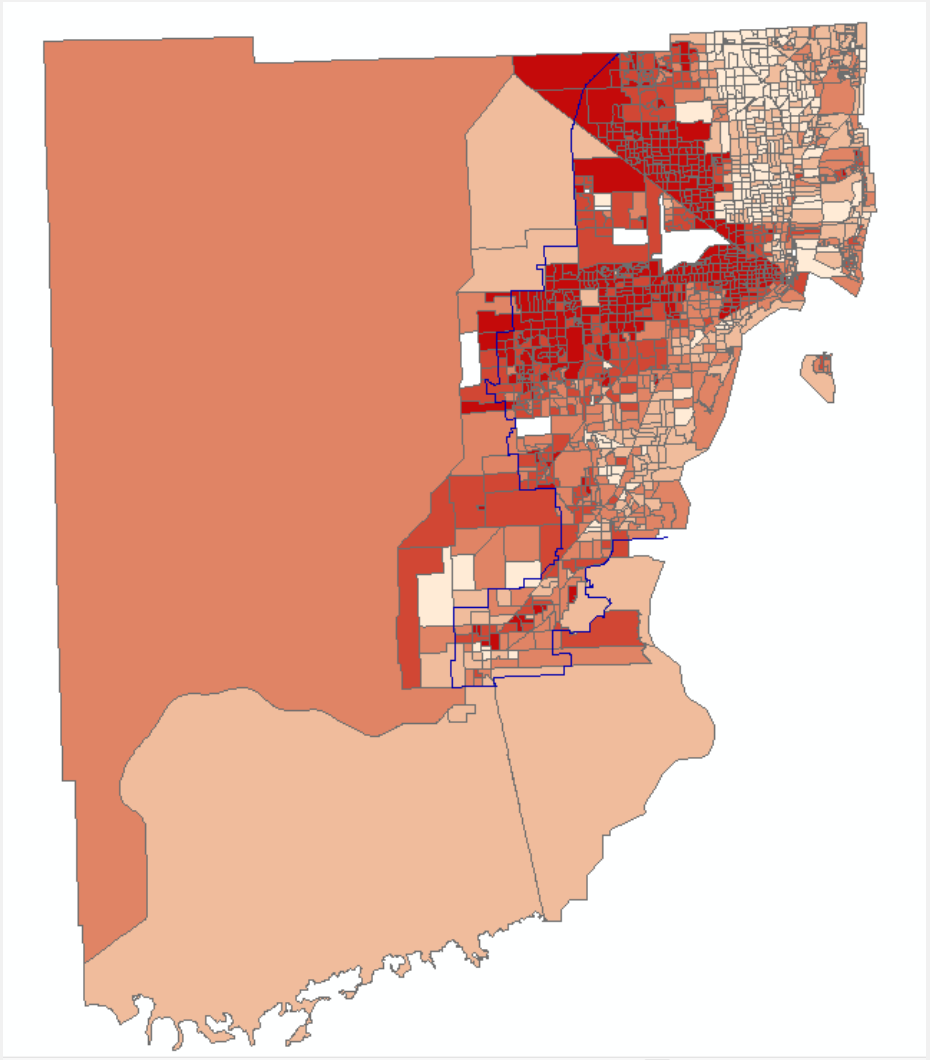
Year	IPCC AR5 Median (inches)	USACE High (inches)	NOAA High (inches)
2030	6	10	12
2060	14	26	34
2100	31	61	81

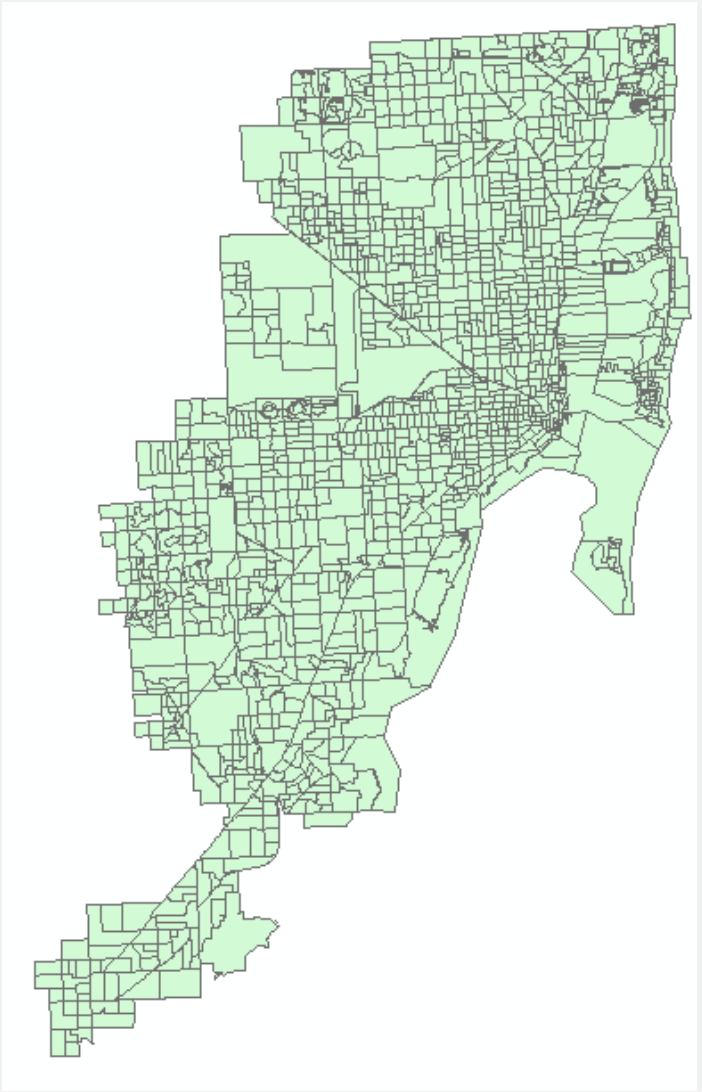


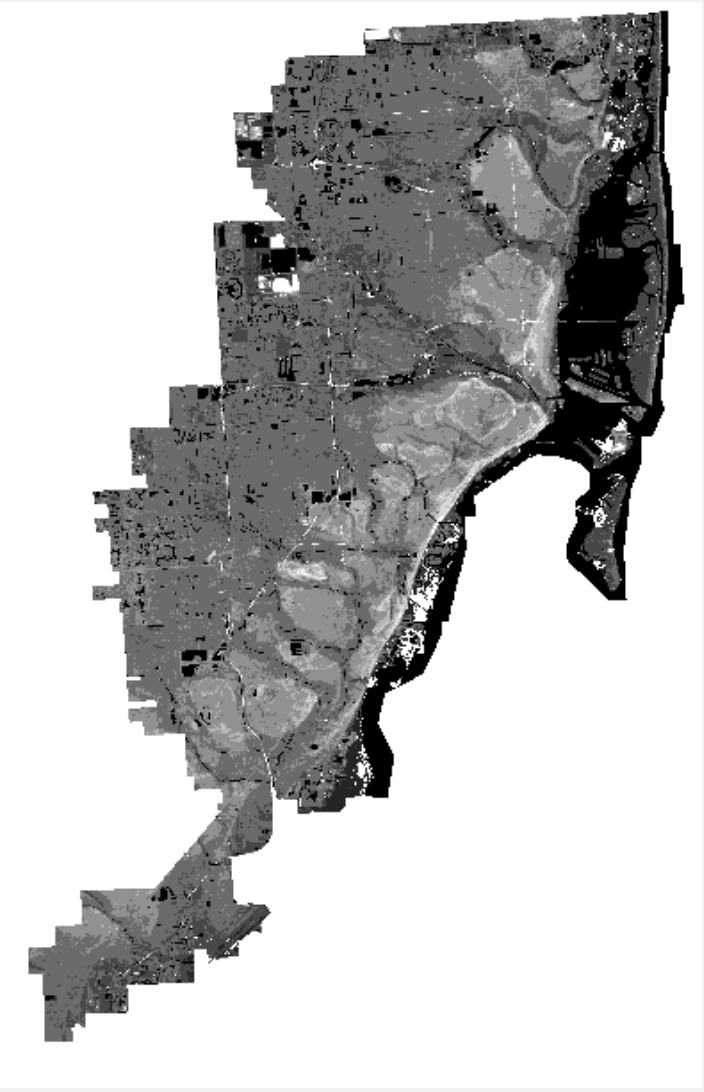
RESEARCH QUESTIONS

- How much land in Miami will be inundated by 2100 due sea level rise according to different predictions?
- How is infrastructure (such as roads and hospitals) affected by sea level rise based on different predictions?
- How much do the different predictions for SLR vary? What lessons can be learned for planners when considering different predictions?

CREATE STUDY AREA

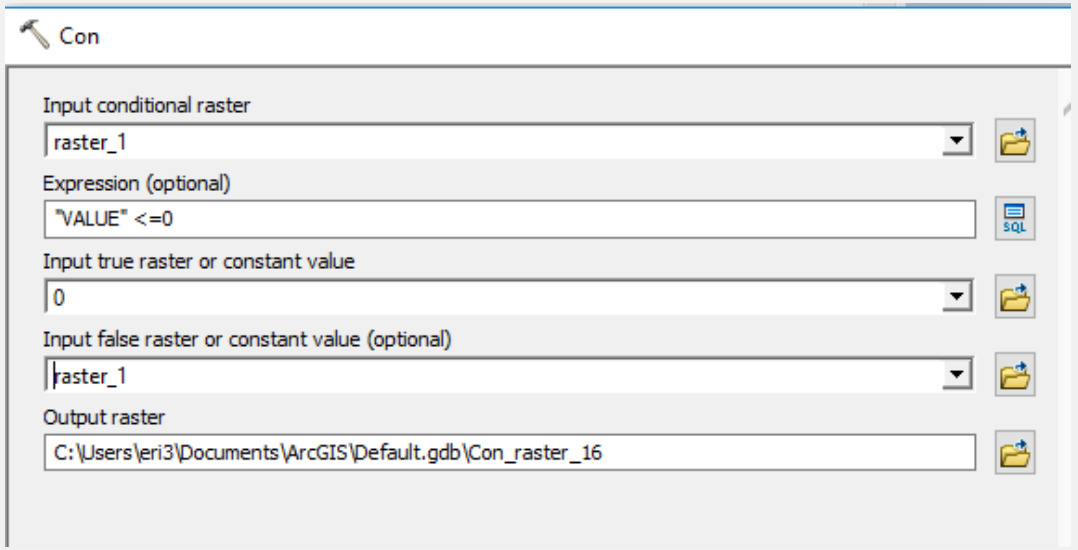






5m DEM from University of Florida

CURRENT AREA AT OR BELOW SEA LEVEL



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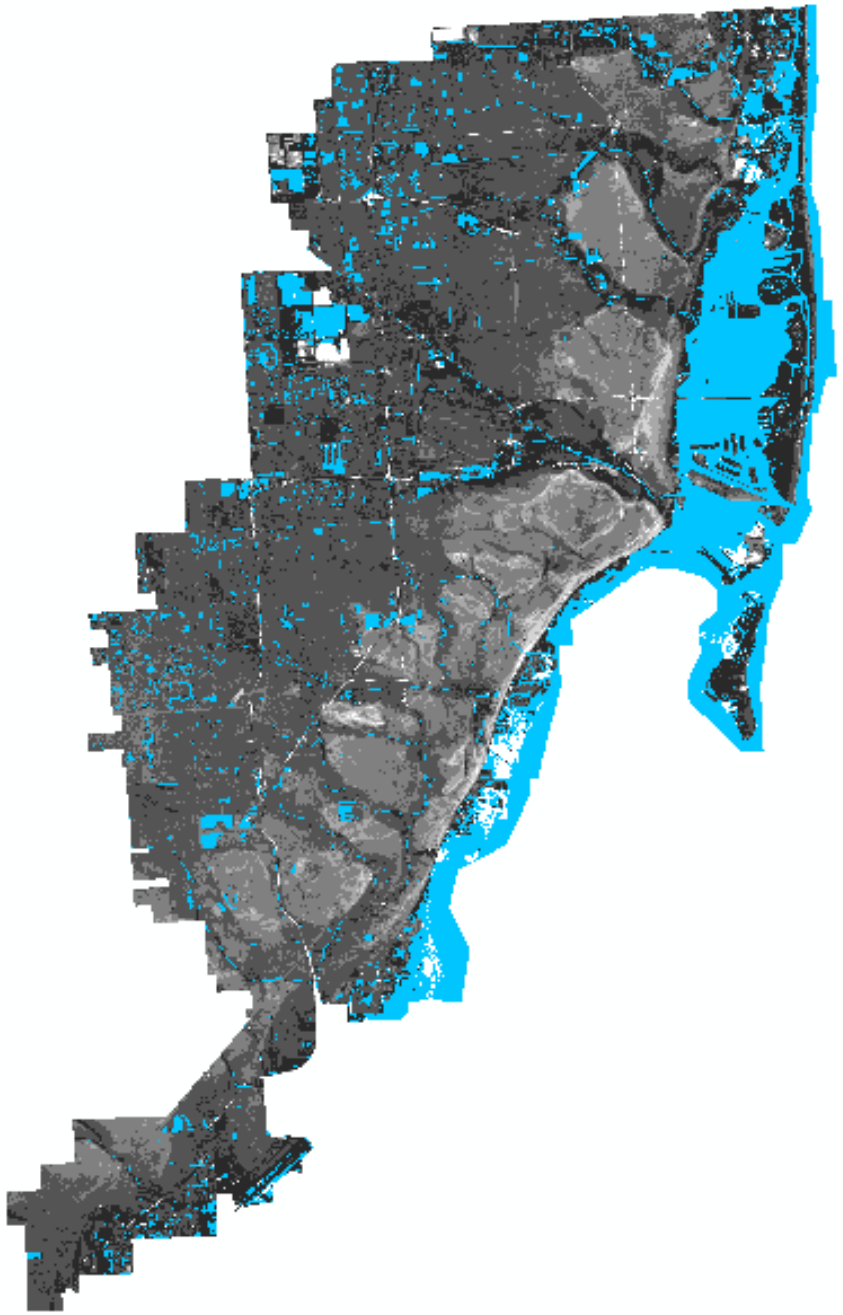


LOW ESTIMATE FLOOD: SEA LEVEL RISE OF 1 METER

Raster Calculator

Map Algebra expression

Layers and variables
- raster_1m
- con_raster_1
- raster_1
- raster_mask20
- raster_mask2
- dem

7 8 9 / == != &
4 5 6 * > >= |
1 2 3 - < <= ^
0 . + ( ) ~

Conditional
Con
Pick
SetNull

Math
Abs
Exp

"raster_mask20" - 1

Output raster
C:\Users\eri3\Documents\ArcGIS\Default.gdb\rastercalc15

Con

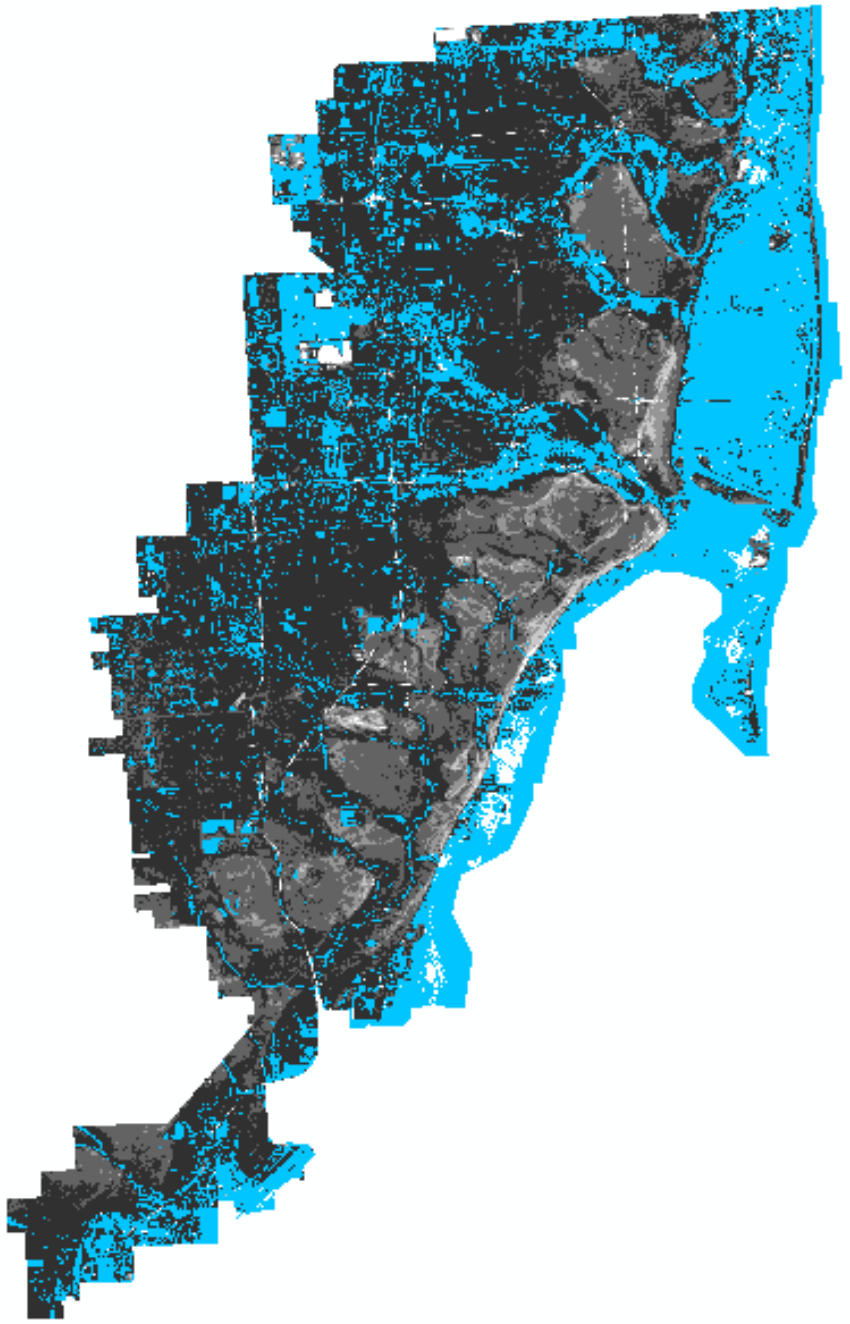
Input conditional raster
raster_1

Expression (optional)
"VALUE" <=0

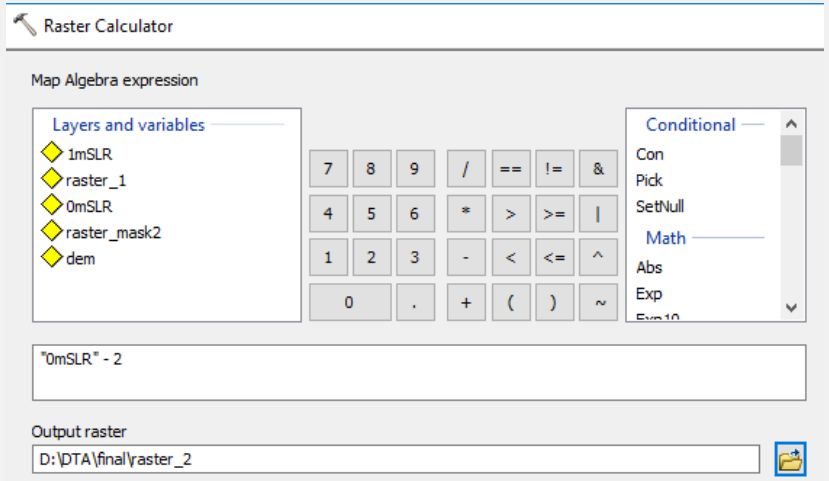
Input true raster or constant value
0

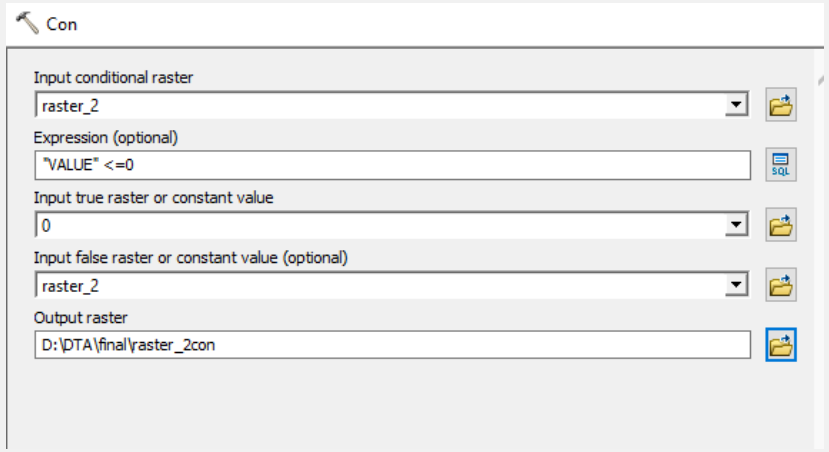
Input false raster or constant value (optional)
raster_1

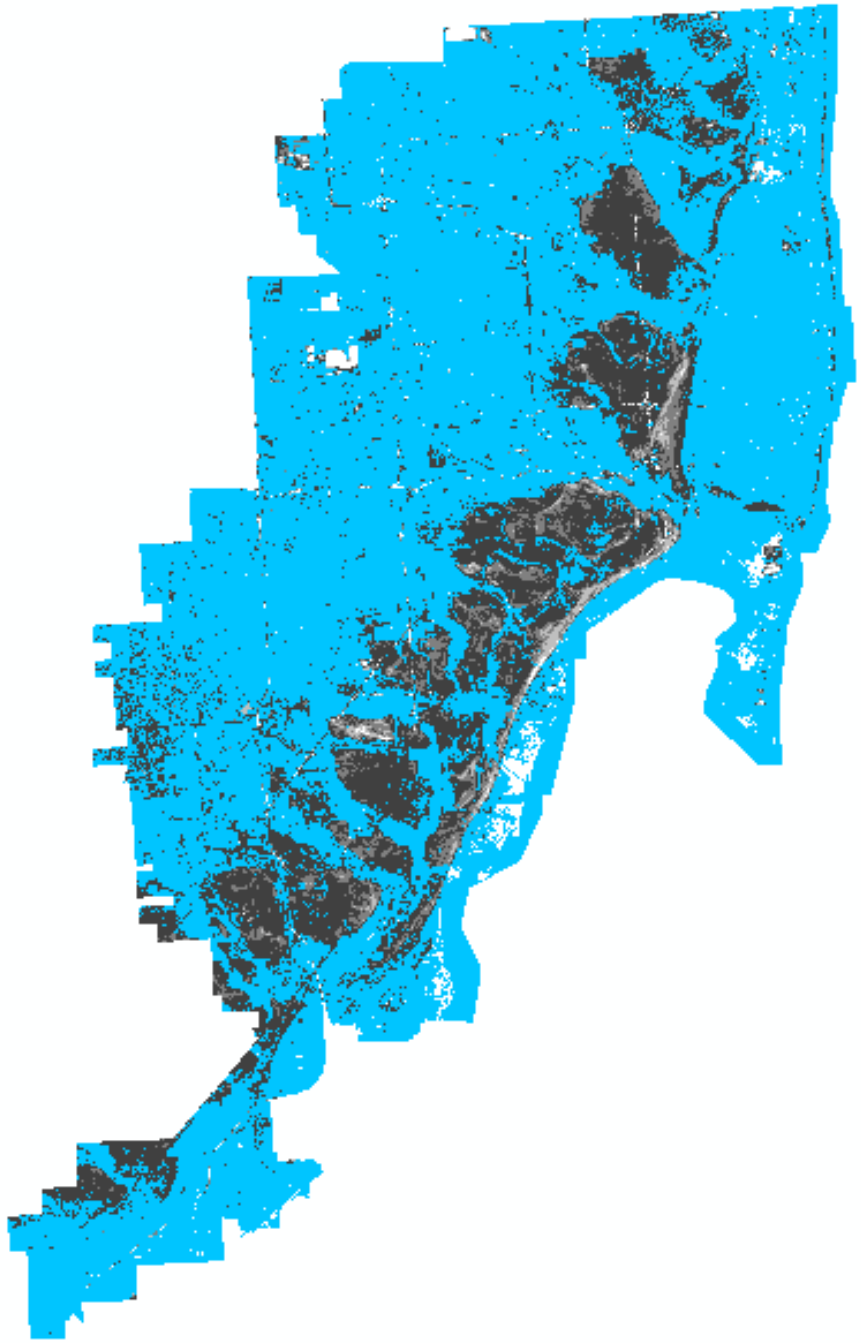
Output raster
C:\Users\eri3\Documents\ArcGIS\Default.gdb\Con_raster_16



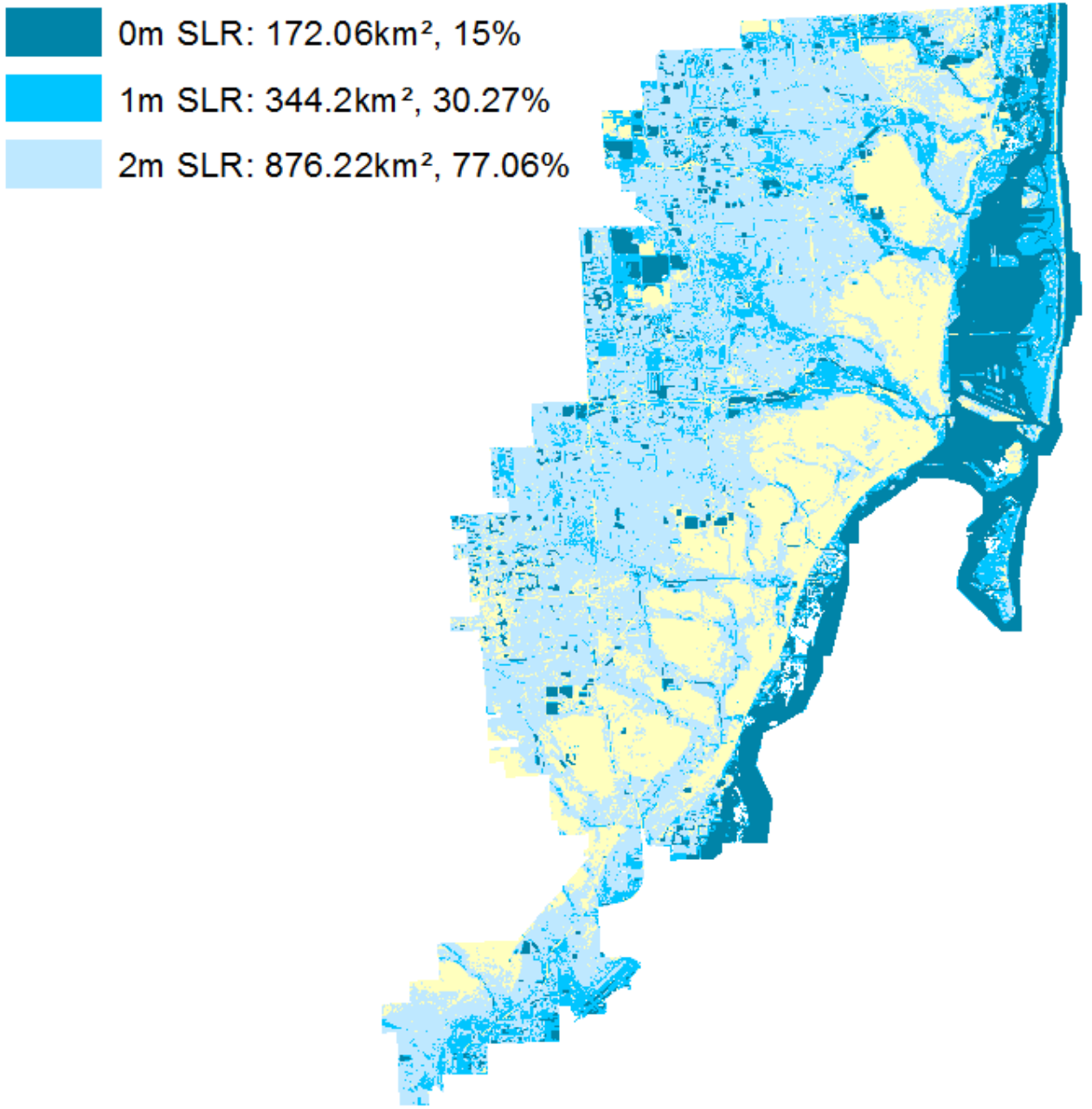
HIGH ESTIMATE FLOOD: SEA LEVEL RISE OF 2 METERS



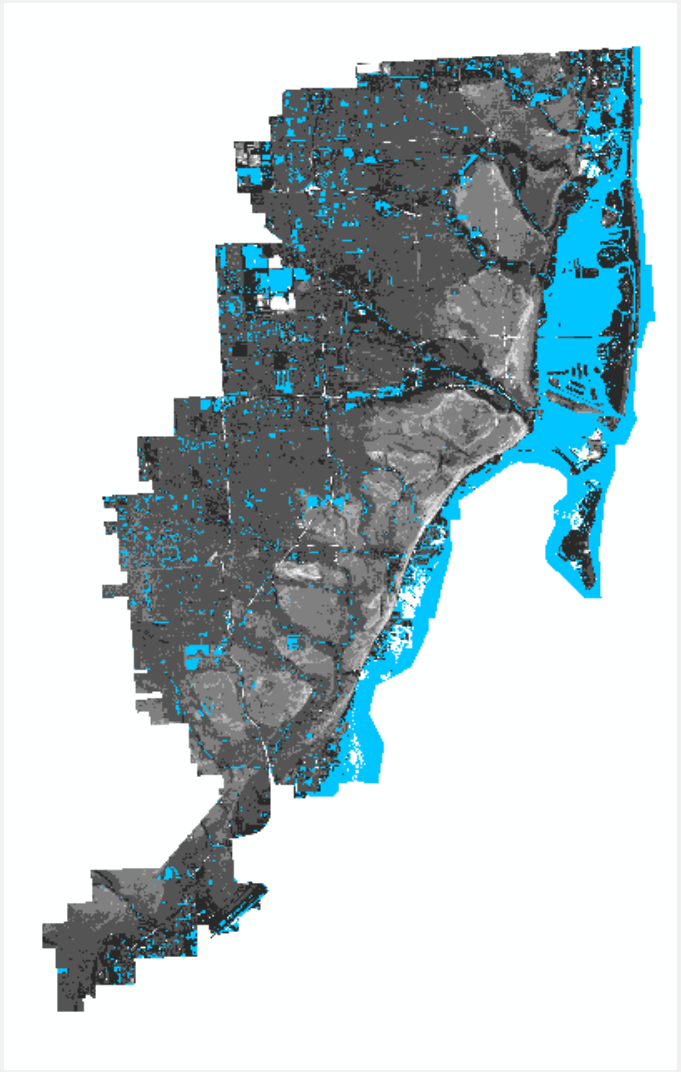




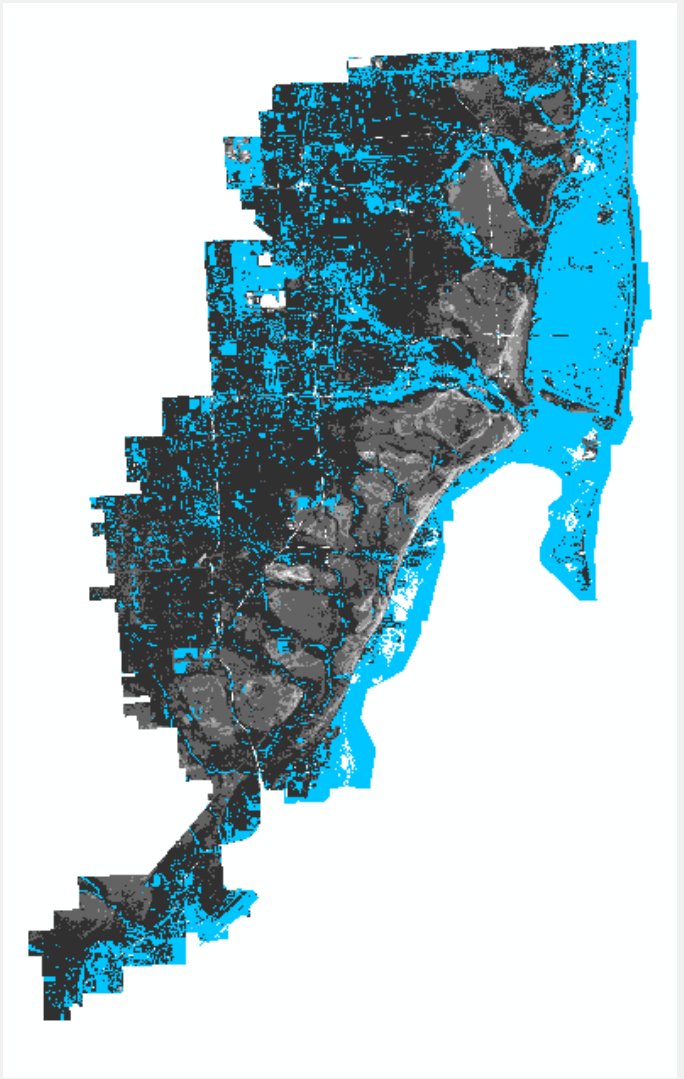
Amount underwater per sea level rise



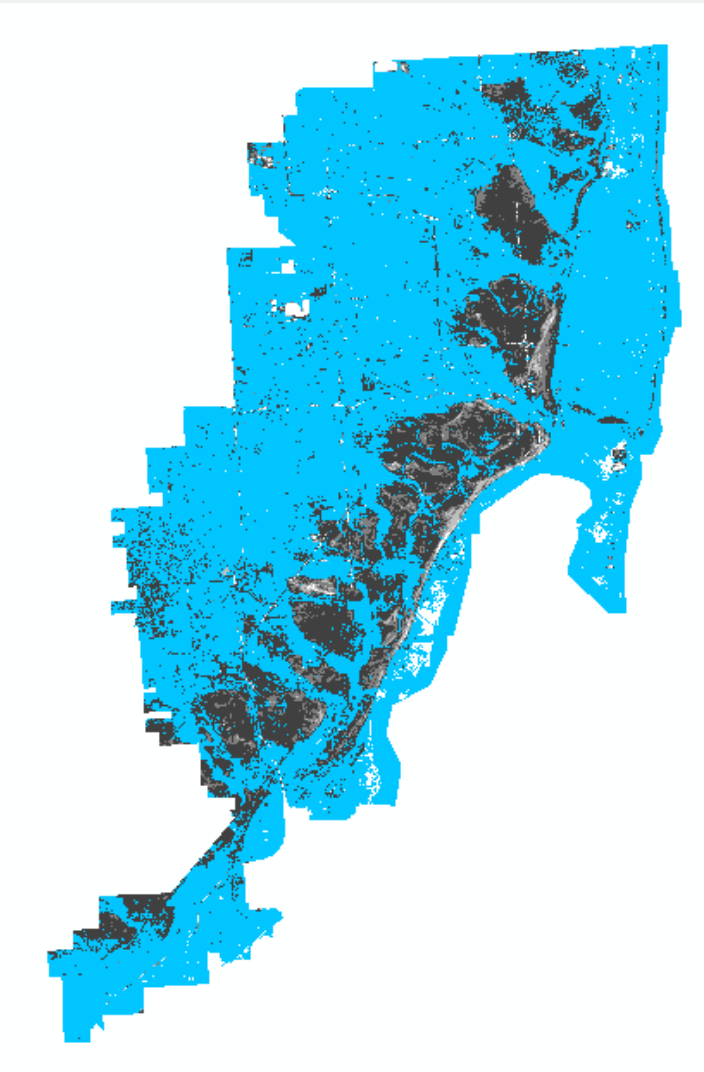
COMPARISON OF SEA LEVEL RISE



Original sea level: 15%



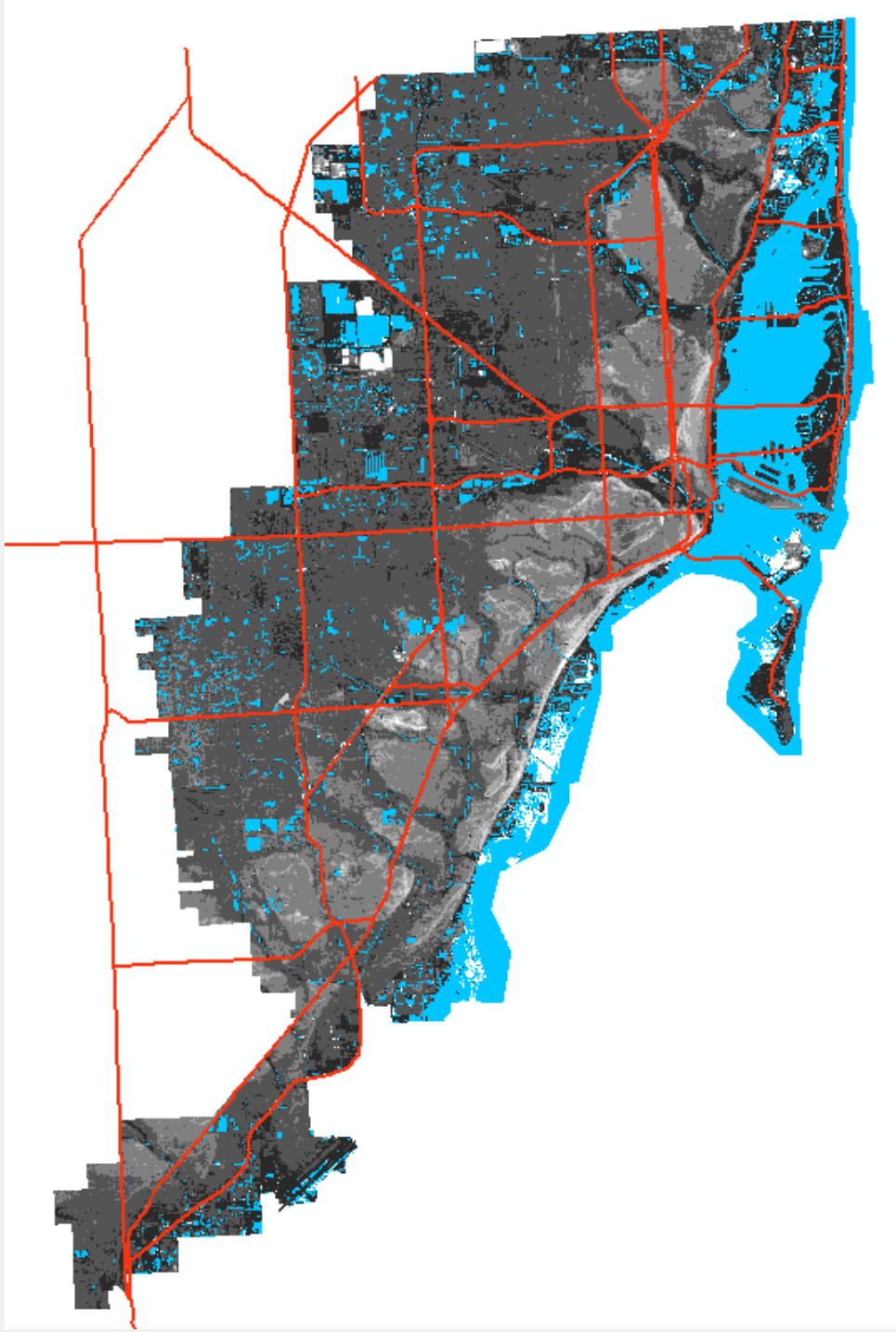
1m SLR: 30.27%,(15.27% increase)

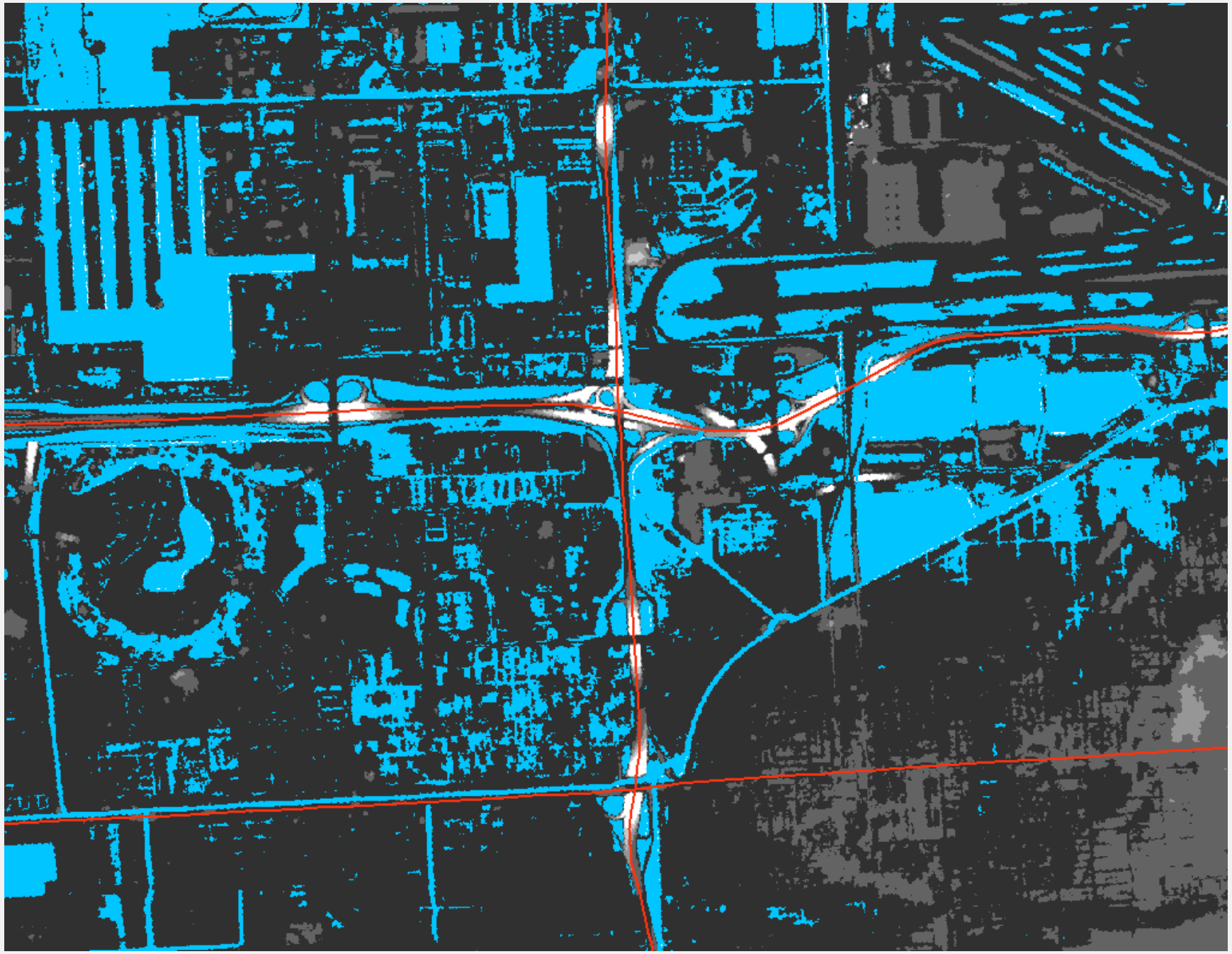


2 m SLR: 77.06% (62.06% increase)

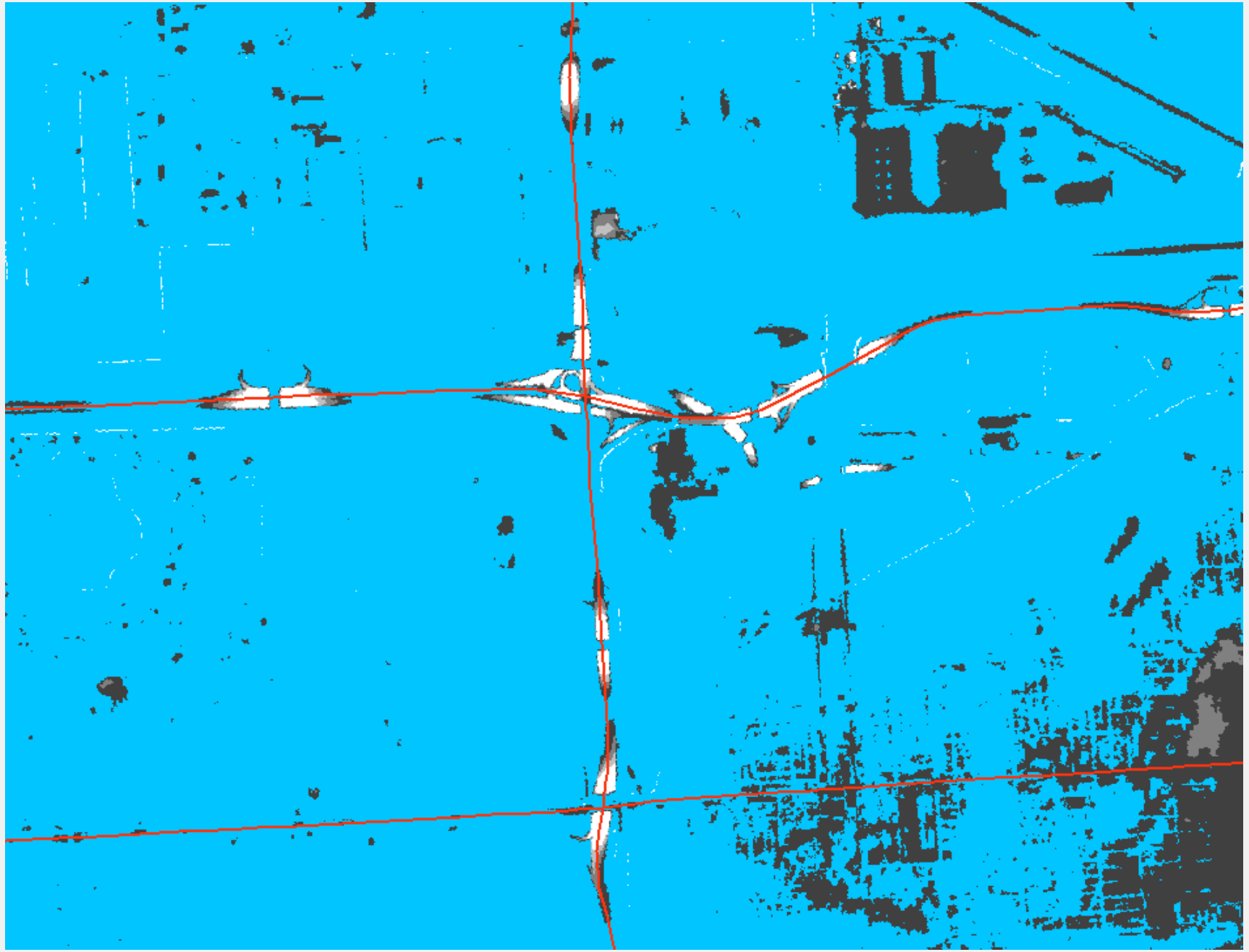
INFRASTRUCTURE ANALYSIS: PRIMARY EVACUATION ROUTES

http://www.bbc.com/future/story/20170403-miamis-fight-against-sea-level-rise



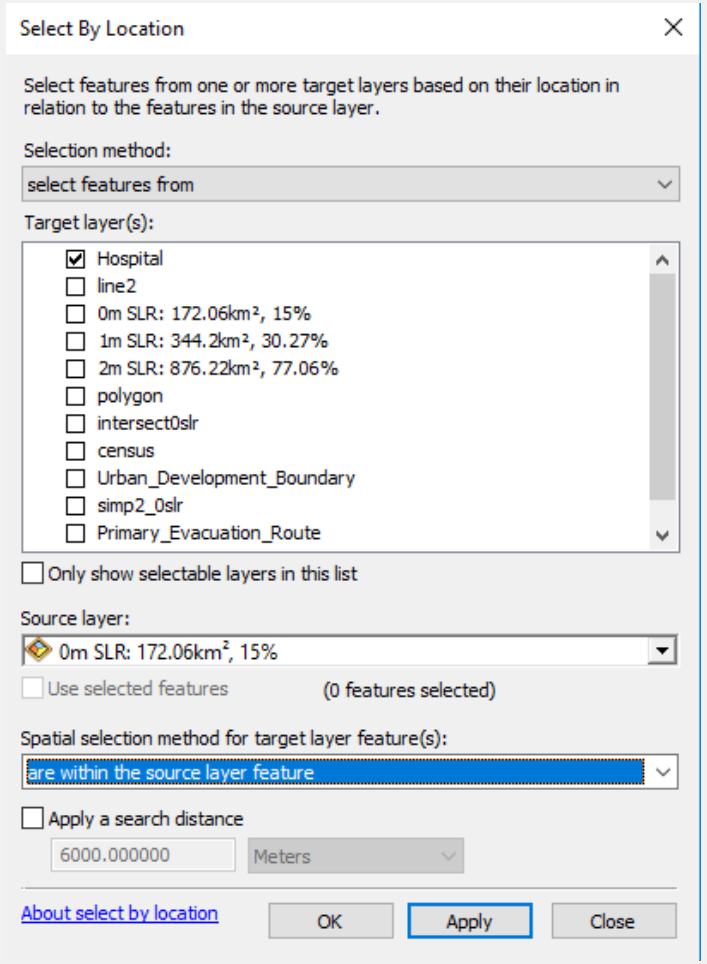


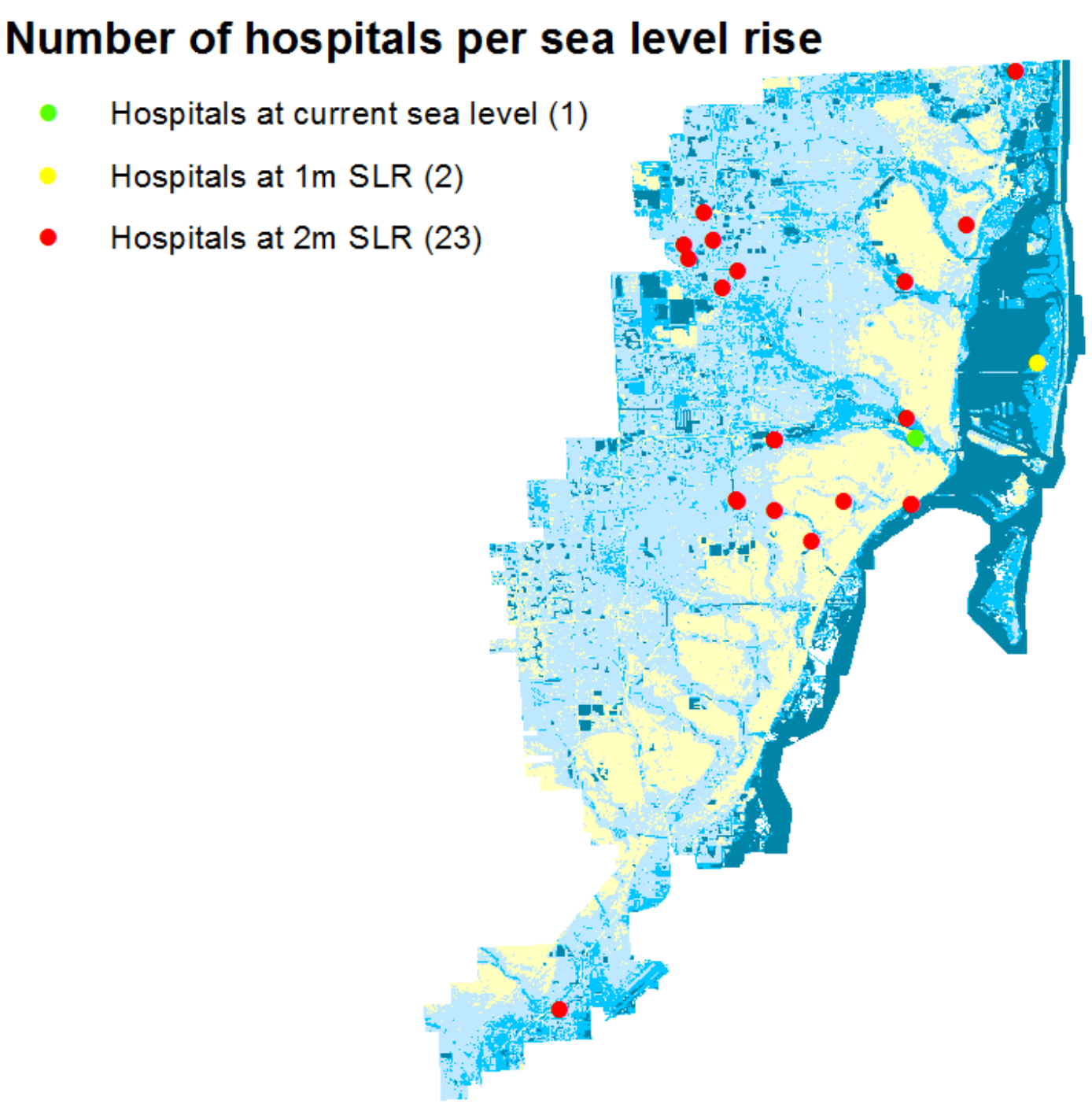
1 meter sea level rise



2 meter sea level rise

INFRASTRUCTURE ANALYSIS: HOSPITALS

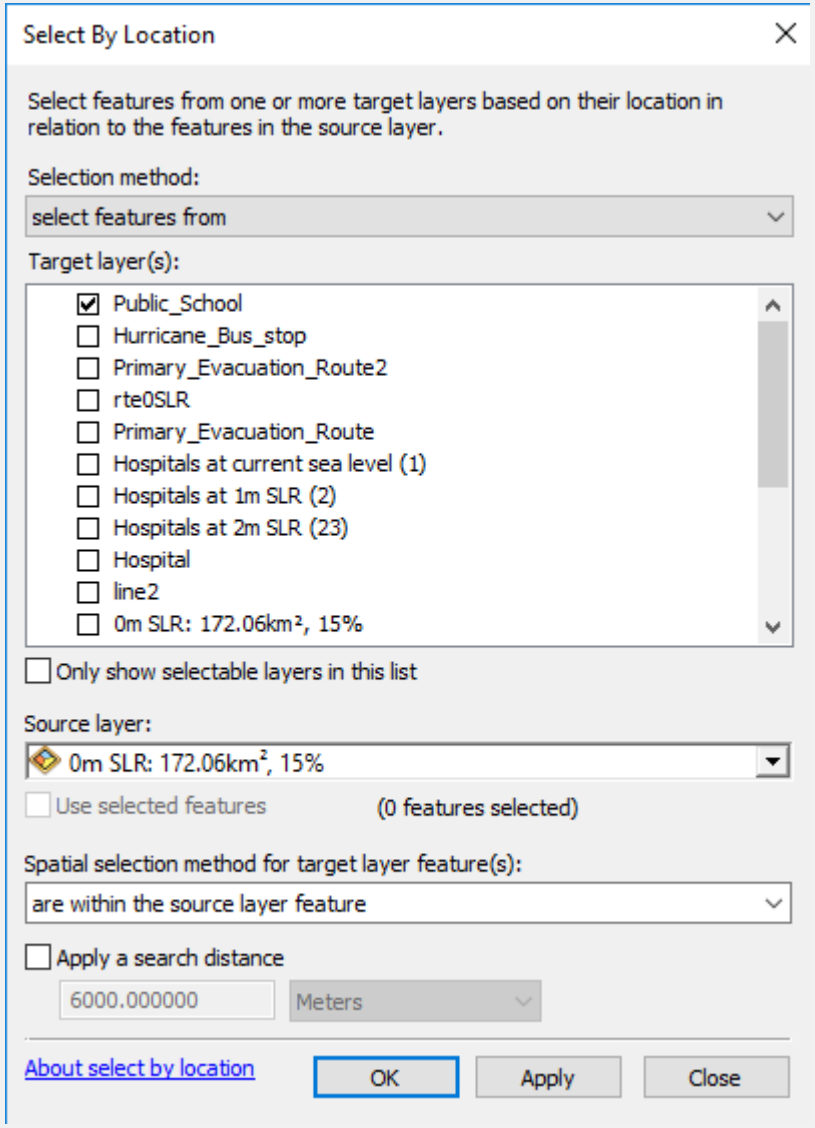




http://ak4.picdn.net/shutterstock/videos/5596124/thumb/1.jpg?i10c=img.resize(height:160)

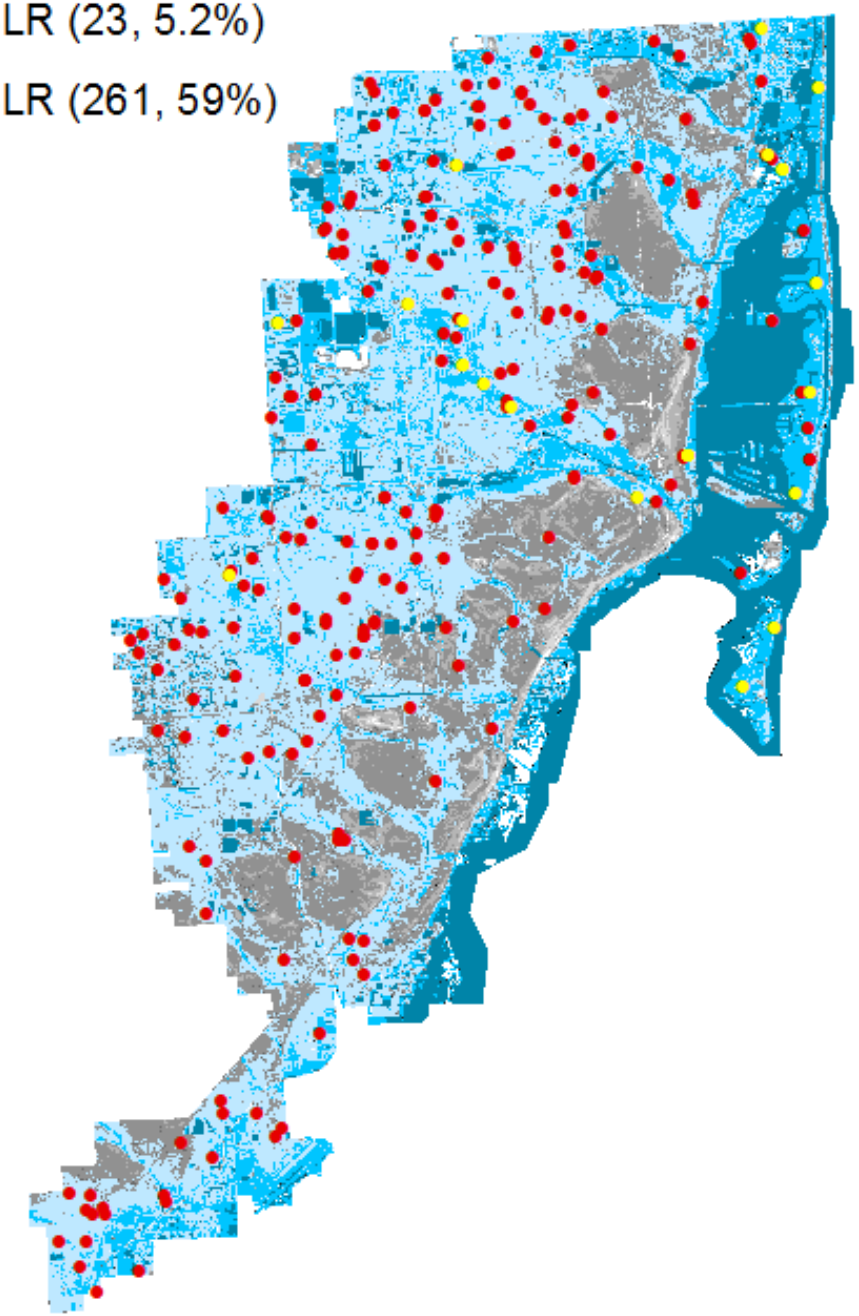
According to The Washington Post, Mt Sinai Hospital, Mercy Hospital, and Sister Immanuel Hospital were evacuated prior to Hurricane Irma. These are all in the 2m SLR flood zone, and Mt. Sinai is also in the 1m SLR flood zone.

INFRASTRUCTURE ANALYSIS: PUBLIC SCHOOLS



Public schools per sea level rise

- Public Schools at 1m SLR (23, 5.2%)
- Public Schools at 2m SLR (261, 59%)



INFRASTRUCTURE ANALYSIS: SUPERFUND SITES

Superfund sites are areas identified as containing hazardous toxic waste. They are targeted for remediation by the EPA.

After Hurricane Sandy, the Gowanus Canal overflowed into people's homes, resulting in massive contamination and cleanup. After Hurricane Katrina, increased chemical exposure in the groundwater and soil were traced back to the flooding of Superfund sites.

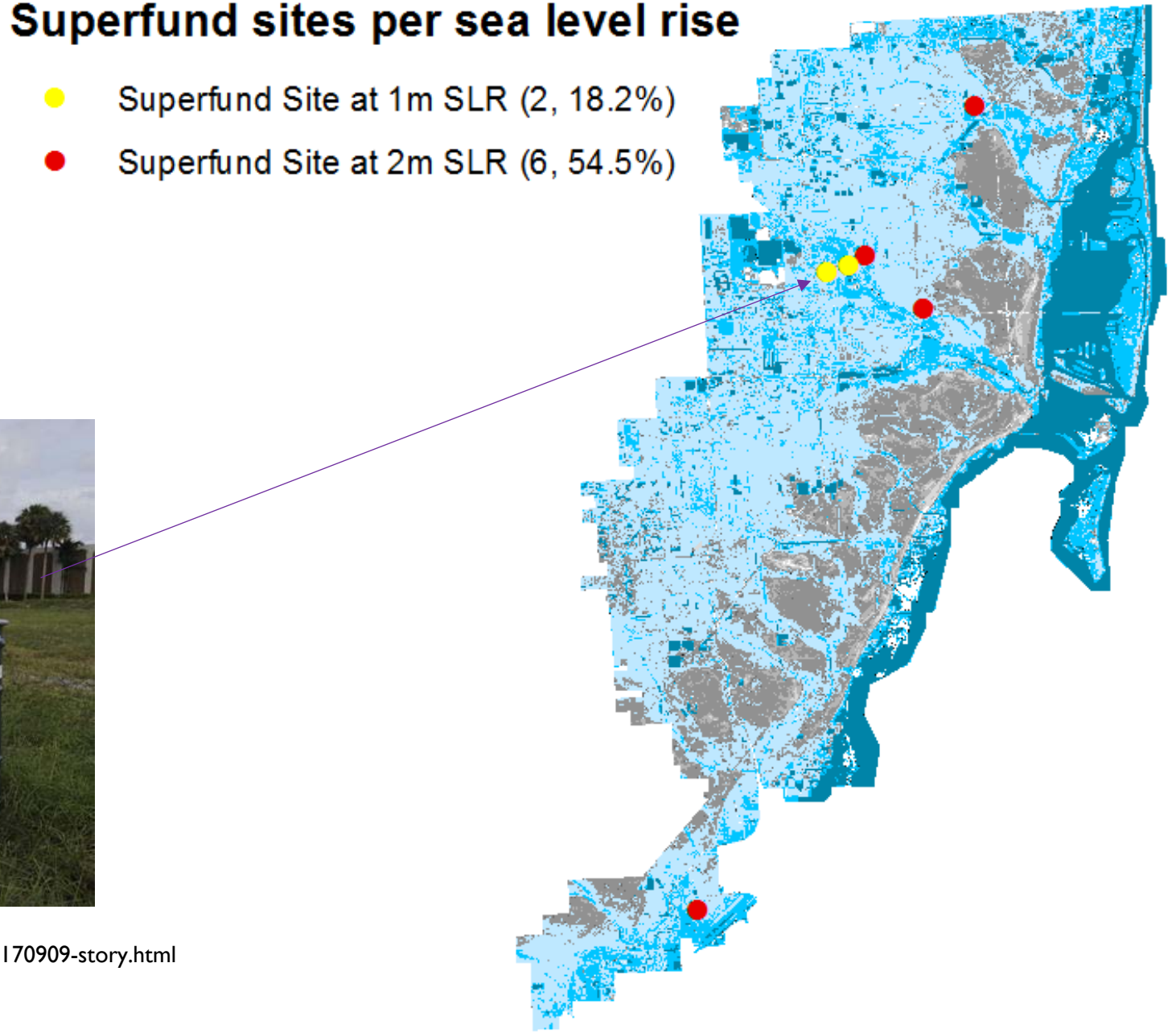
(Atkin, 2017)

Photo from a flooded Superfund site during Hurricane Harvey in Texas.

https://media.nbcdfw.com/images/1200*675/toxicwastewaterEPAharvey_1200x675.jpg

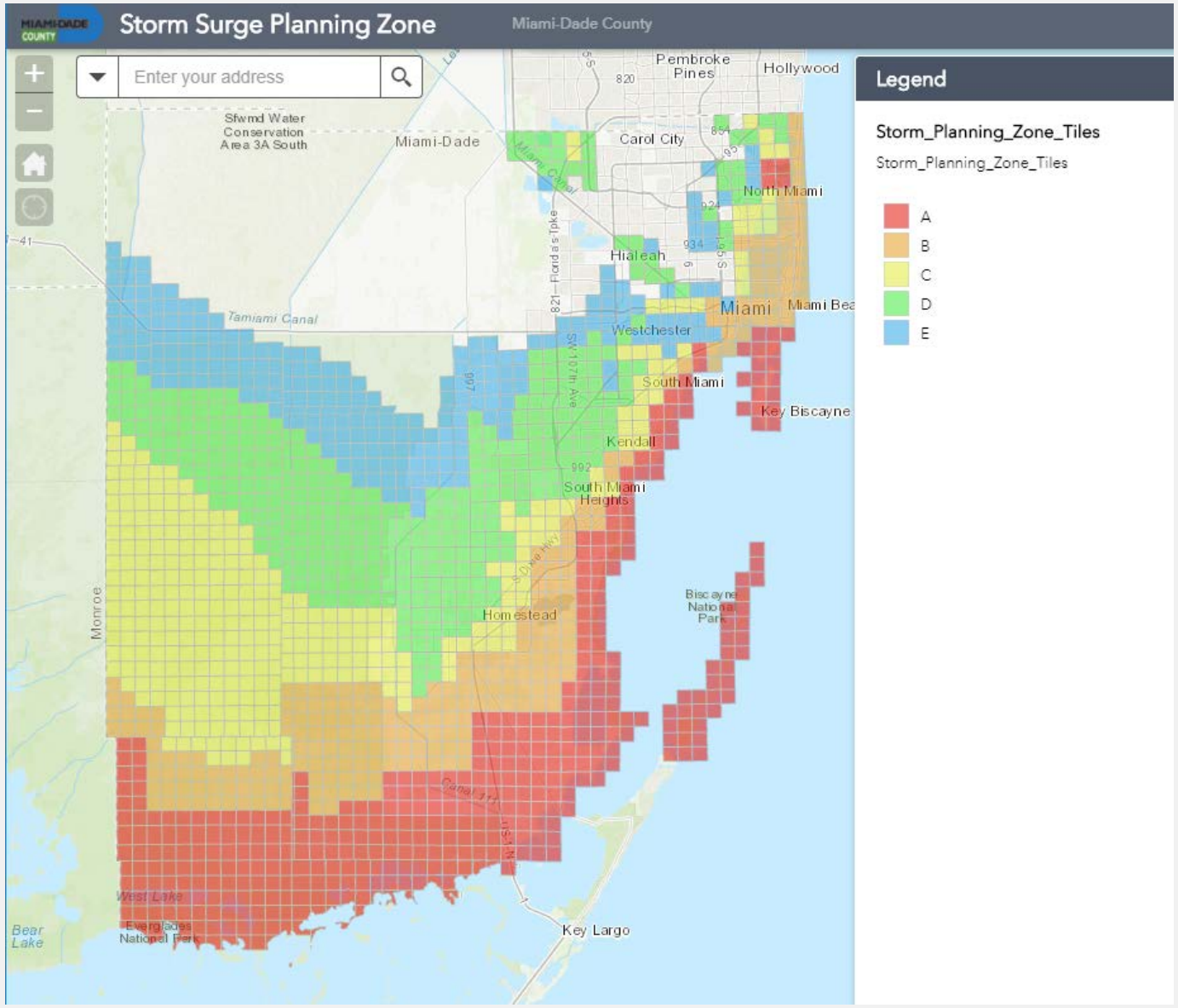
Barrels of IDW "Investigation Derived Waste" at Miami Drum Service, one of the Superfund Sites located at 1m SLR. This site is located over a drinking-water aquifer. (Kennedy, 2017)

http://www.chicagotribune.com/news/nationworld/ct-irma-toxic-waste-sites-20170909-story.html

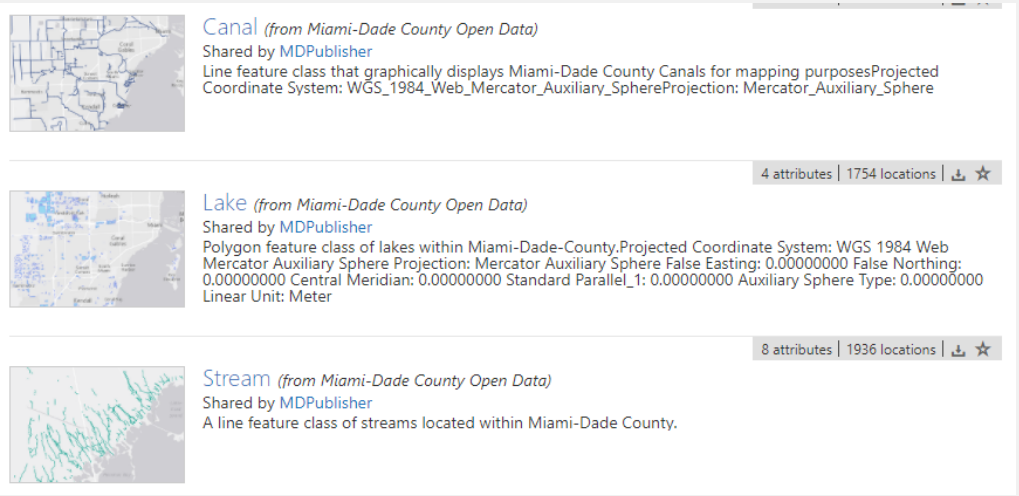


LIMITATIONS AND IMPROVEMENTS

- DEM resolution
- Storm surges
  - SLOSH Model (Sea, Lake, and Overland Surges from Hurricanes)
  - Accounts for physical factors like coastal area, bay, river shape, water depth, bridges, canals, etc.



http://mdc.maps.arcgis.com/apps/webappviewer/index.html?id=4919c85a439f40c68d7b3c81c3f44b58



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