Sophie Worrell
11/29/2016

The Loss of Urban Areas from Sea Level Rise in the Greater Houston-Galveston Area, TX

(1) Purpose:

Defined by flat coastal plains, the greater Houston-Galveston area is the most populated region in Texas. Therefore, as sea level continues to rise the greater Houston-Galveston area will be one of the first regions significantly affected. Global climate change is causing sea level to rise 7 mm/year in this area. This projects aims to project the loss of Houston-Galveston urban areas (in km^2) due to sea level rise; specifically, focused on sea level rises of 1 meter, 3 meters, 7 meters, 11 meters, 15 meters, and 20 meters.

(2) Data Collection:

- Texas Counties shape-file: From the United States 2016 Census data
  https://www.census.gov/cgibin/geo/shapefiles/index.php?year=2016&layergroup=Counties+%28and+equivalent%29
- Urban Density shape-file: From the United States 2016 Census data
  https://www.census.gov/cgibin/geo/shapefiles/index.php?year=2016&layergroup=Urban+Areas
- Digital Elevation Models: From the USGS National Map
  http://nationalmap.gov/3DEP/
- Cities Shape-file: From the Texas Parks and Wildlife
  https://tpwd.texas.gov/gis/data/baselayers/citypts-zip/view
- Houston-Galveston Base Map: From the Texas Natural Resources Information System
  https://tnris.org/data-catalog/entry/bathymetry-tx-coast-v0-1/
- Sea Level Rise Rate for the Galveston Area: From the Tides and Currents NOAA
  https://tidesandcurrents.noaa.gov/sltrends/sltrends.html

(3) Data Processing:

I downloaded all of the shape-files and Digital Elevation Models (DEMs) to my USB drive's Project folder. Then I extracted the files to make sure all the information was accessible.

(4) ArcGIS Processing:

a) I first changed the Layers coordinate system to GCS NAD 1983, so the data was projected with the least amount of distortion.

b) I added in all of my shape-files and DEMs to the blank ArcMap document. Then I used the project tool in Arctoolbox to project all of the shape-files to the same coordinate system as the Layers (GCS NAD 1983). To change the DEMs, I located each DEM in ArcCatalog and changed the coordinate system in the General Properties. Therefore, all the data was accurately used in the raster calculator and could be easily edited by outside users.

c) I wanted to create a state outline shape-file of Texas using the Counties shape-file, so I used the Union tool in the Editor toolbar (Fig. 1)

Figure 1:

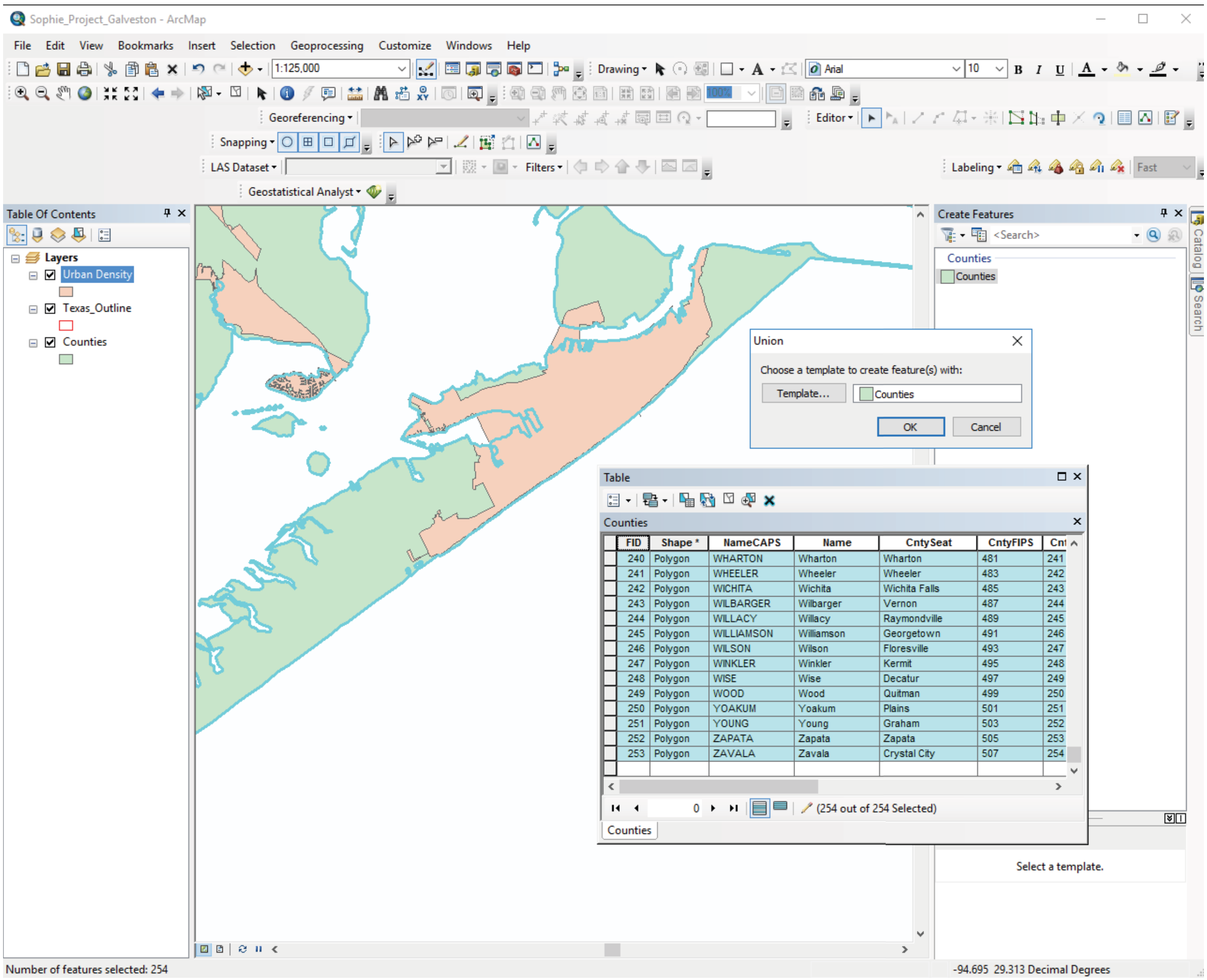

Figure 1 is displays my use of the union tool to create a shape-file outline of Texas. I clicked on the Editor toolbar and selected start editing. Then, I opened the Attribute Table of the counties shape-file and selected all of the counties. Next, I went to the Editor toolbar, and clicked on the Union tool and selected the counties.

d) Using the outlines of the counties, the Union tool created a new polygon of the Texas border. I used this new polygon to make a state outline shape-file (Fig. 2)

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Figure 2:

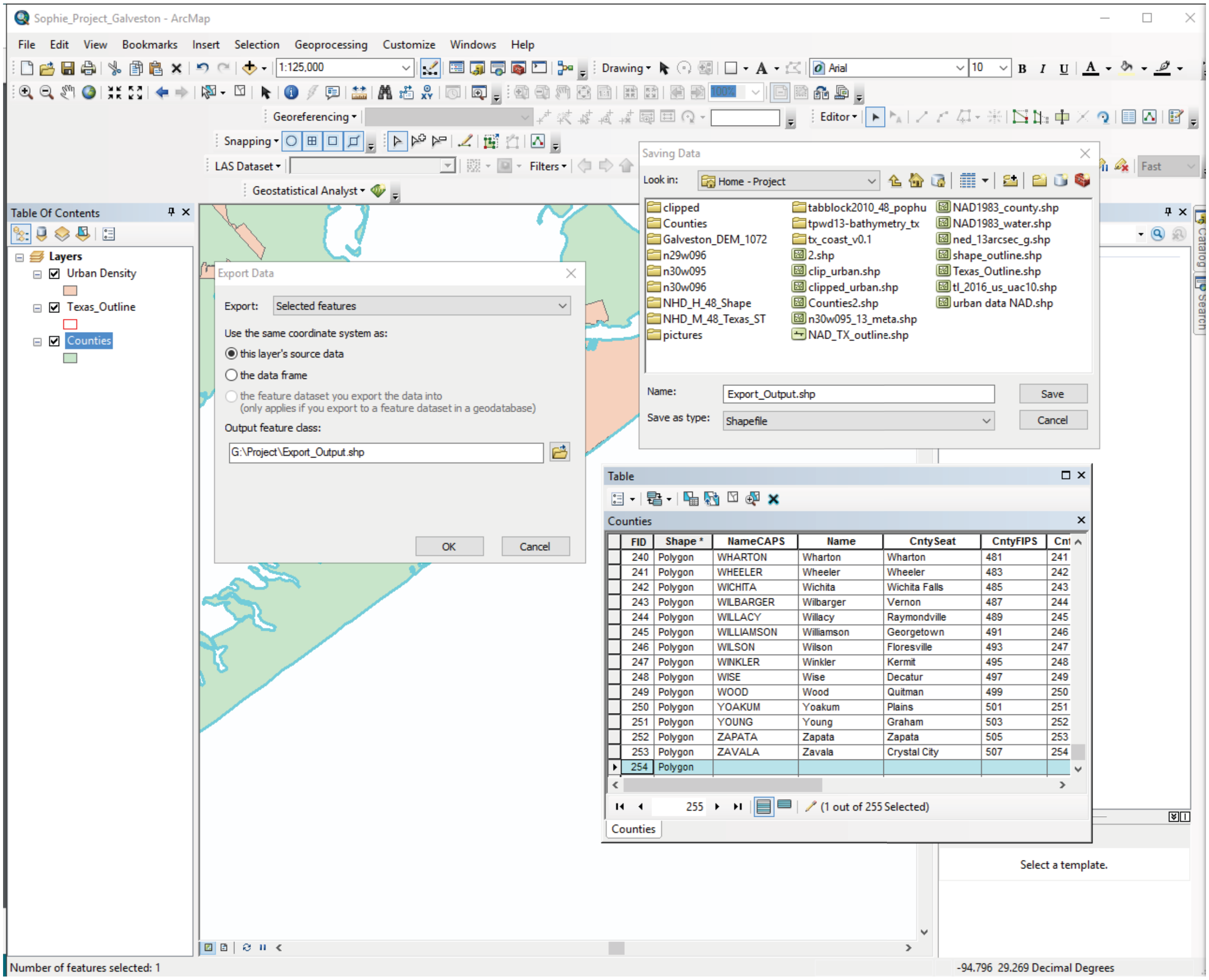

Figure 2 shows the highlighted Texas border polygon (254) and the process of exporting the data to create a new Texas outline shape-file.

- **e)** To only show the urban density centers in Texas, I used the Clip tool to clip the urban densities shape-file to the newly created Texas outline shape-file.
- **f)** I labeled only the greater Houston-Galveston area counties with the Labeling tool in the Drawing toolbar.
- **g)** To label large cities in the region I went to the cities Attribute Table and highlighted the cities I wanted to display. I right clicked on the cities shape-file and chose Extract Data. This created a new shape-file containing only the large cities in the region.
- **h)** Next, I created a mosaic raster out of the two DEMs of the area, so I could calculate values more efficiently in the Raster Calculator (Fig. 3)

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Figure 3:

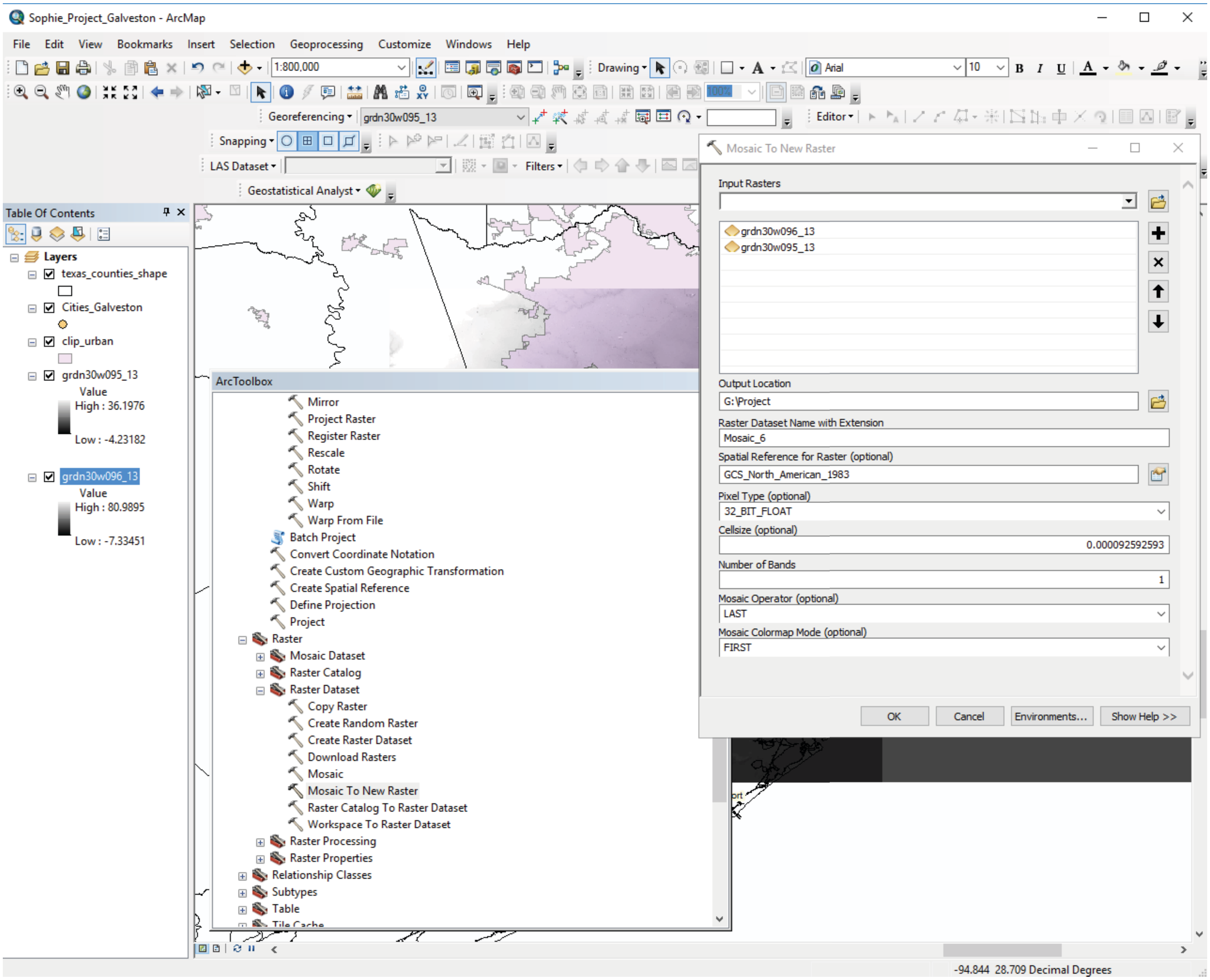


Figure 3 demonstrates how I created one mosaic raster out of two DEMs. Frist, I opened ArcToolbox and selected the Mosaic to New Raster tool. I inputted my two DEM rasters, put the GSC NAD 1983 coordinate system, the 32_BIT_FLOAT, the cellsize of 9.2592593e-005, and 1 as the number of bands. This created a new efficient mosaic raster.

i) I opened the Raster Calculator to create a new raster, from my mosaic raster, to represent 1 meter of sea level rise (Fig. 4). Using the same process, I made new rasters for sea level rise of 3 m, 7 m, 11 m, 15 m, and 20 m.

Figure 4:

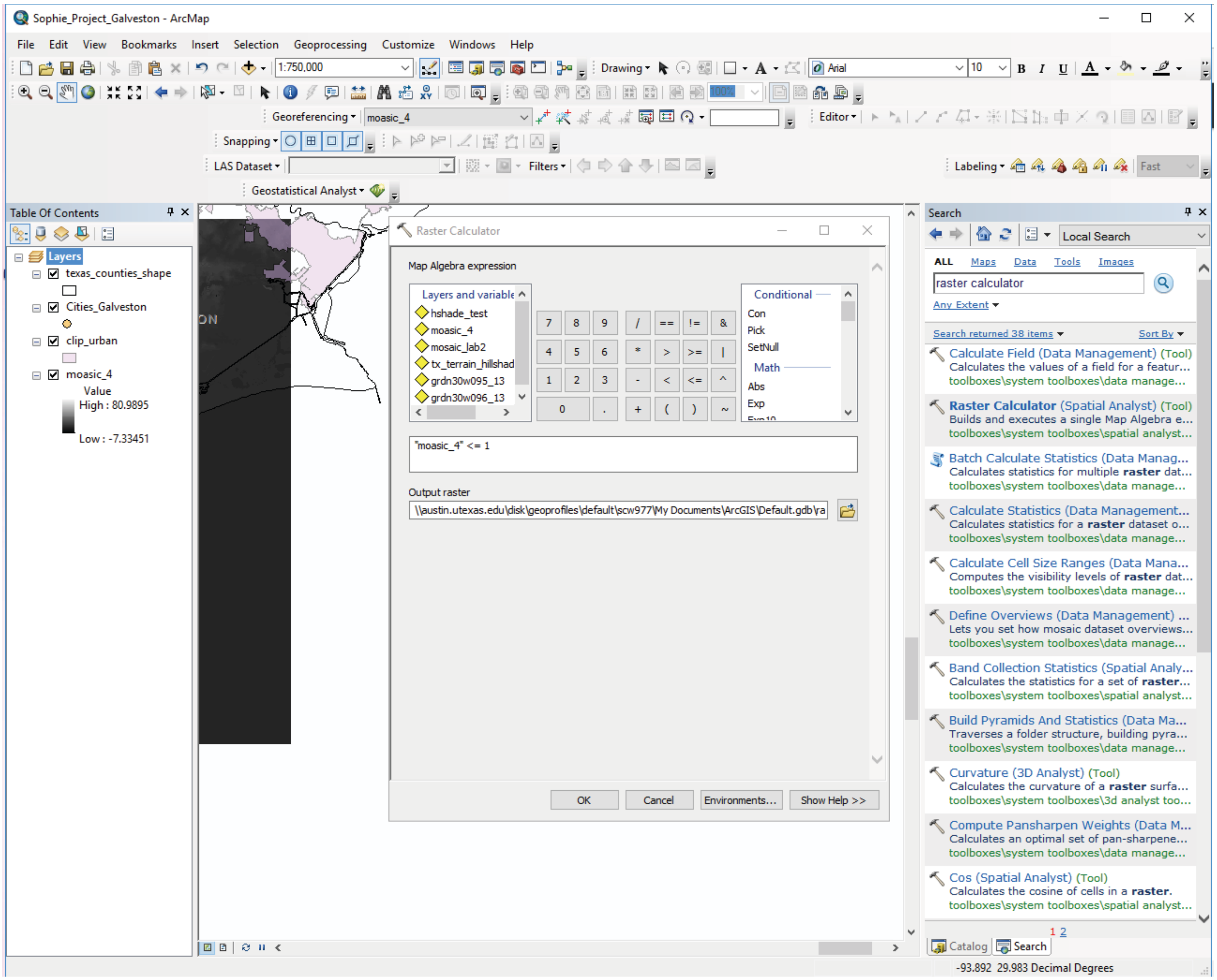


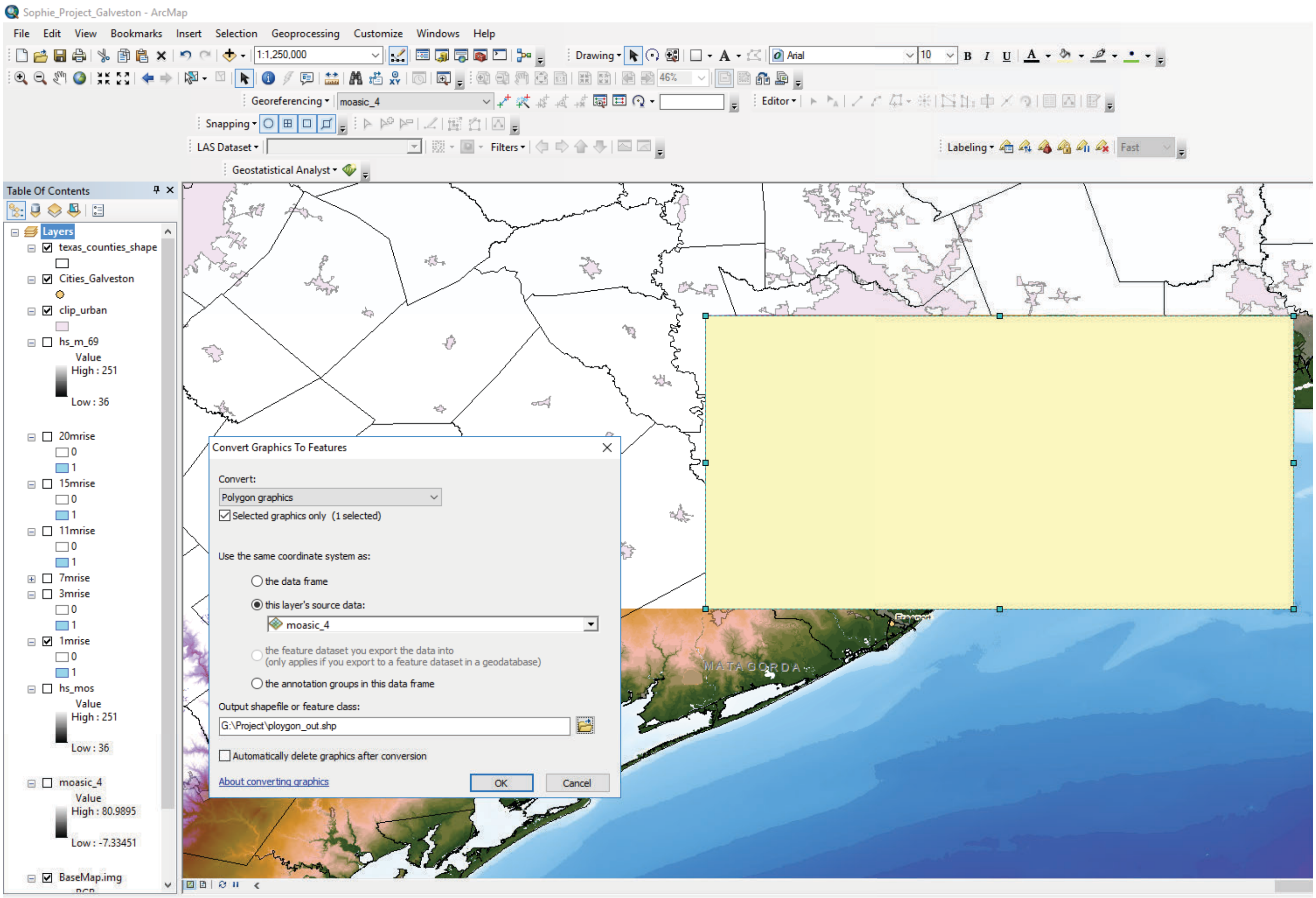
Figure 4 shows the creation of 1 meter sea level rise raster. I used the Raster Calculator tool in the Spatial Analysis toolbar, and entered my conditional statement. To show changes in sea level, I had to subtract the preferred meters of sea level rise I wanted to represent from the DEM elevation raster.

j) I symbolized the sea level rise as blue (for water) and the unaffected land as hollow.

k) I added a base map to give my map more definition.

l) I wanted to display the only the urban areas within the mosaic raster region. Thus, I used the Drawing tool to create a rectangle around the extent of the mosaic raster. I used this rectangle to clip the urban density shape-file to this region (Fig. 5)

Figure 5



In Figure 5 I converted the polygon to a shape-file using the Convert Graphics to Features tool under the Layers tab. Next, I used the Clip tool to clip the urban density to the polygon shape-file. This created a new shape-file that displayed urban areas within the mosaic raster region.

m) Next, I had to project the newly clipped urban shape-file, so I used the Project tool to project to NAD 1983 UTM Zone 14.

n) I calculated the area of the urbanized regions before sea level rise using the clipped urban shape-file (Fig. 6)

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Figure 6

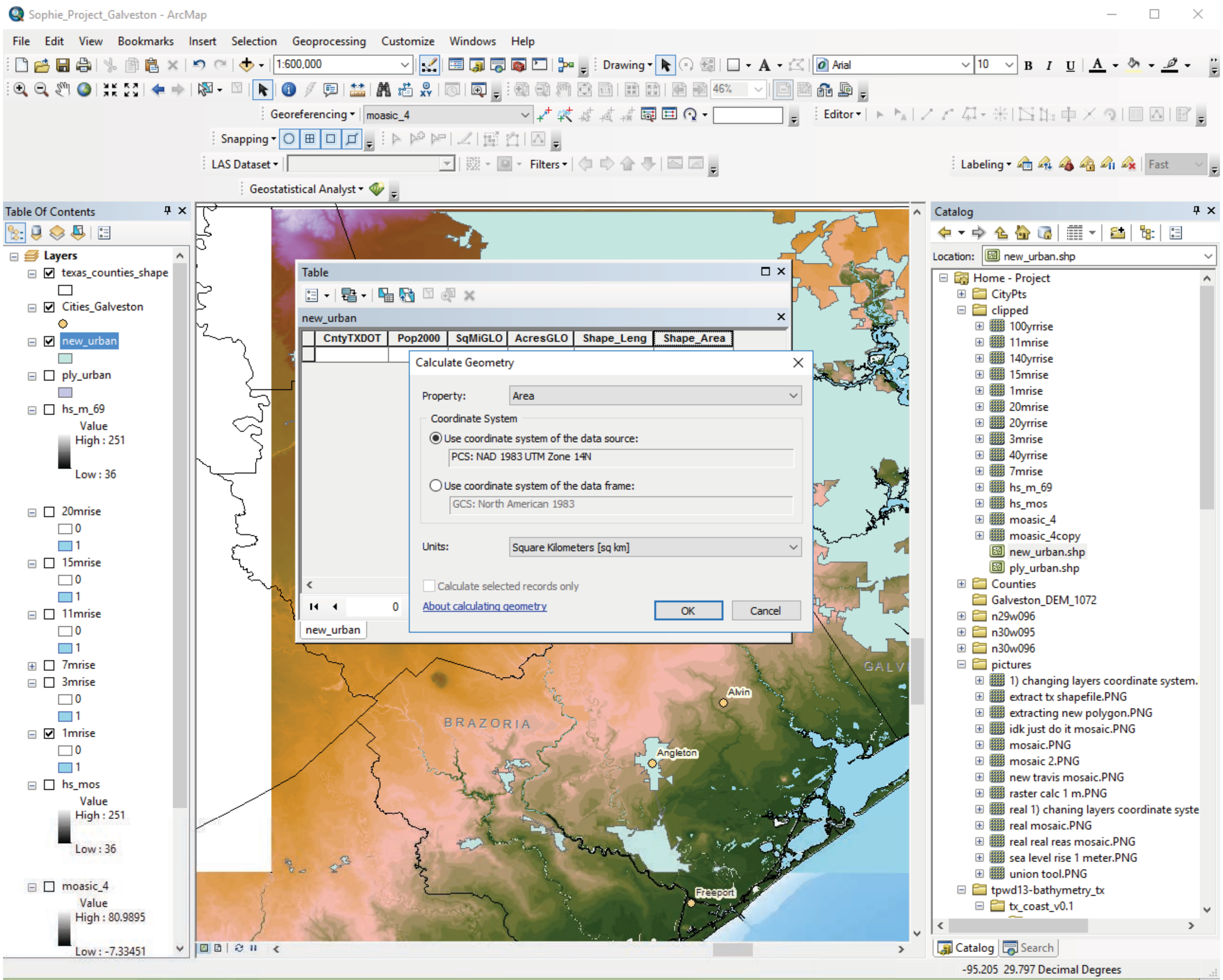

Figure 6 demonstrates how I calculated the area of the current urban extent in the Attribute Table using Calculate Geometry. I added a field to the Attribute Table and named it "Shape_Area" with the float preference. I right clicked on the field and clicked Calculate Geometry. I chose to calculate the area in km^2.

o) In order to calculate the loss of urban area after 1 m of sea level rise, I had to convert the 1 m sea level rise raster to a polygon (Fig. 7). This is because I want to be able to use the Erase tool later on, and it only uses shape-files.

Figure 7

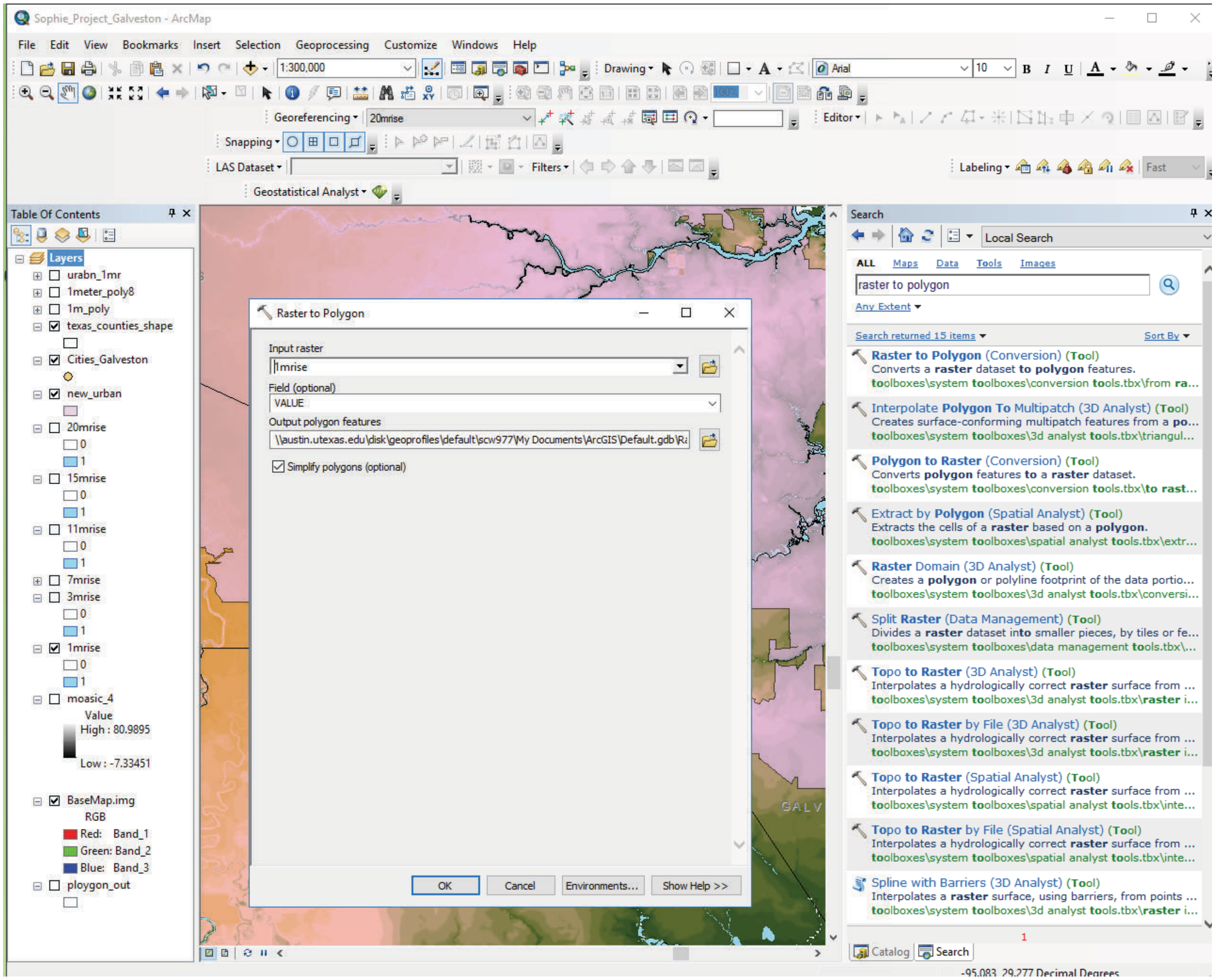

Figure 7 demonstrates how I converted the 1 m sea level rise raster to a polygon. I used the Raster to Polygon tool in the Spatial Analysis toolbar. This created a new polygon shape-file displaying the 1 m sea level rise.

p) Then, in the Attribute Table of the 1 m sea level rise shape-file I selected the 1 values to create a polygon only showing the new sea level (Fig. 8).

Figure 8

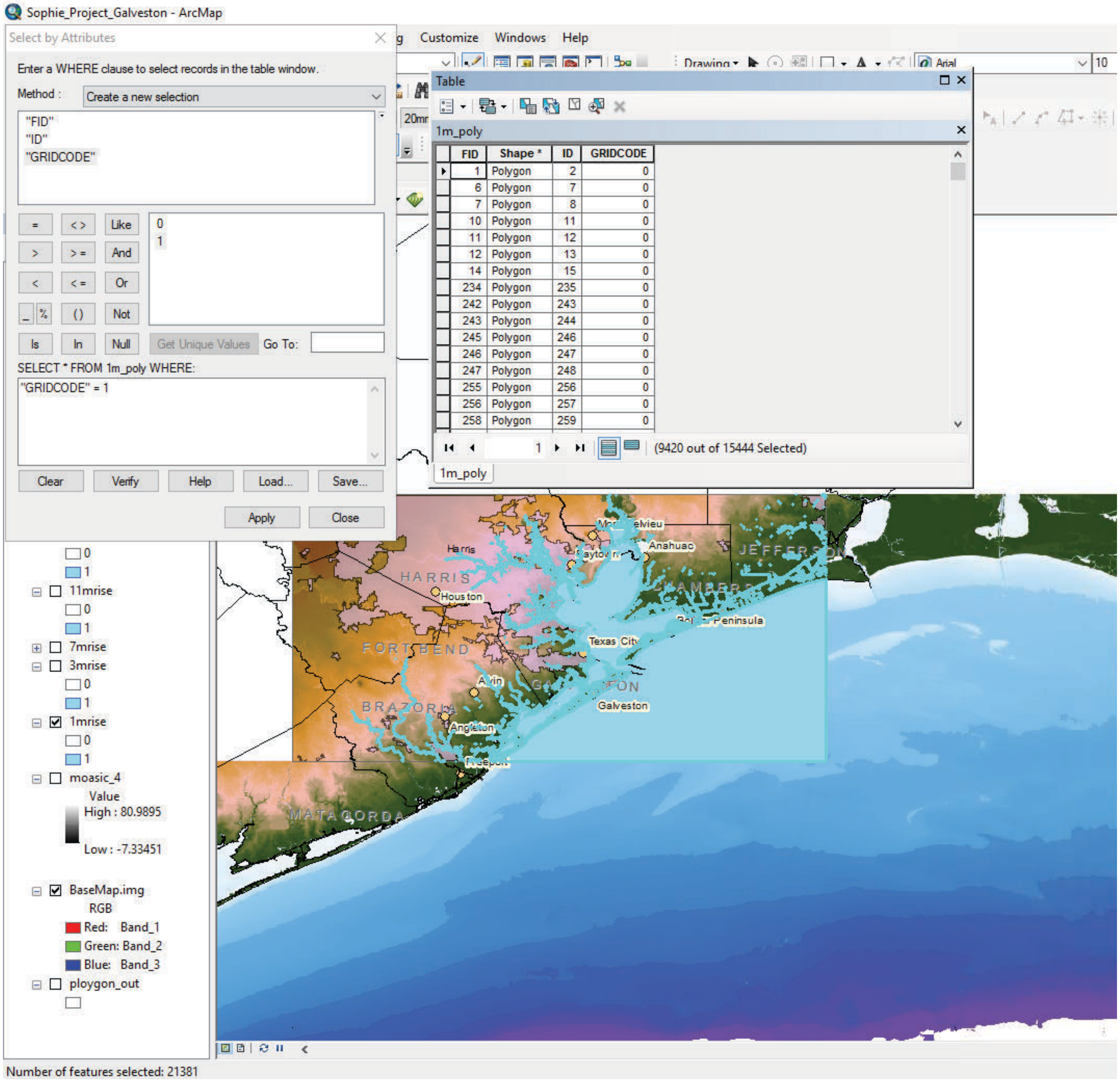

Figure 8 shows how I created a new polygon representing the new sea level after 1 m rise. I opened the Attribute Table of the 1 m sea level rise polygon and selected all of the 1 values. I selected these values using the Select by Attributes function. Next, I extracted the selected data to create the new polygon.

q) I used the Erase tool to remove the urban areas that were covered by the 1 m rise in sea level (Fig. 9).

Figure 9

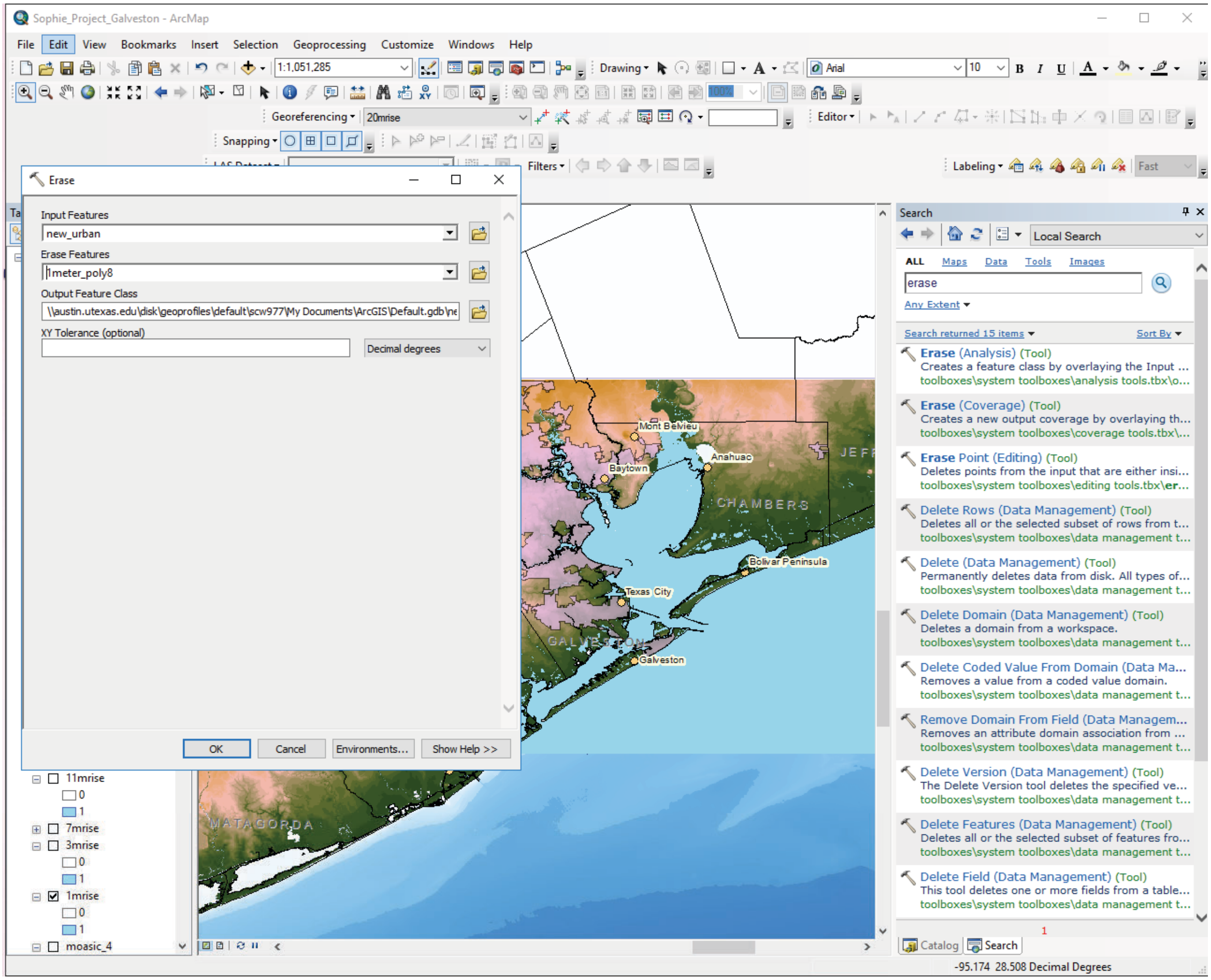

Figure 9 demonstrates how I used the Erase tool to remove the urban areas affected by the 1 m sea level rise. My input feature was the clipped urban shape-file and erase feature was the 1 m sea level rise polygon. The Erase tool produced a shape-file that represented the urban areas unaffected by the 1 m sea level rise.

r) I had to project the unaffected urban areas shape-file to NAD 1983 UTM Zone 14 using the Project tool.

s) After the shape-file was projected I added a new field in the Attribute Table, and calculated the area of unaffected urban expanse after 1 m of sea level rise using the Calculate Geometry tool.

t) I repeated steps **o)-s)** to calculate the area loss of urban extent from sea level rises of 3 m, 7 m, 11 m, 15 m, and 20 m.

(5) Conclusion:

The calculation of urban area loss demonstrates how significantly the rise in sea level from 1m – 20 m will affect the greater Houston-Galveston area. The pre-sea level rise urban extent was 4095 km^2. 1 m of sea level rise did not notably alter the urban area (Fig. 10). This is good news because at the rate of 7mm/yr., 1 m of sea level rise will occur in 143 years. Drastic changes in the urban extent will appear in 1000 years; the urban area will be reduced by 20% because of 7 m sea level rise. With 20 m of sea level rise, most of the greater Houston-Galveston urban area will be under water. Resulting in loss of more than half of the urban expanse by the year 4876 (Fig. 10). Thus, global warming induced sea level rise will greatly alter the urban expanse of the Houston-Galveston area.

Figure 9:

Current urban area	Urban area after 1m sea rise	Urban area after 3m sea rise	Urban area after 7m sea rise	Urban area after 11m sea rise	Urban area after 15 m sea rise	Urban Area after 20m sea rise
4095 km^2	4073 km^2	3940 km^2	3395 km^2	2729 km^2	2241 km^2	1675 km^2

Figure 9 displays all of my calculated areas of the urban expanse lost after different amounts of sea level rise.

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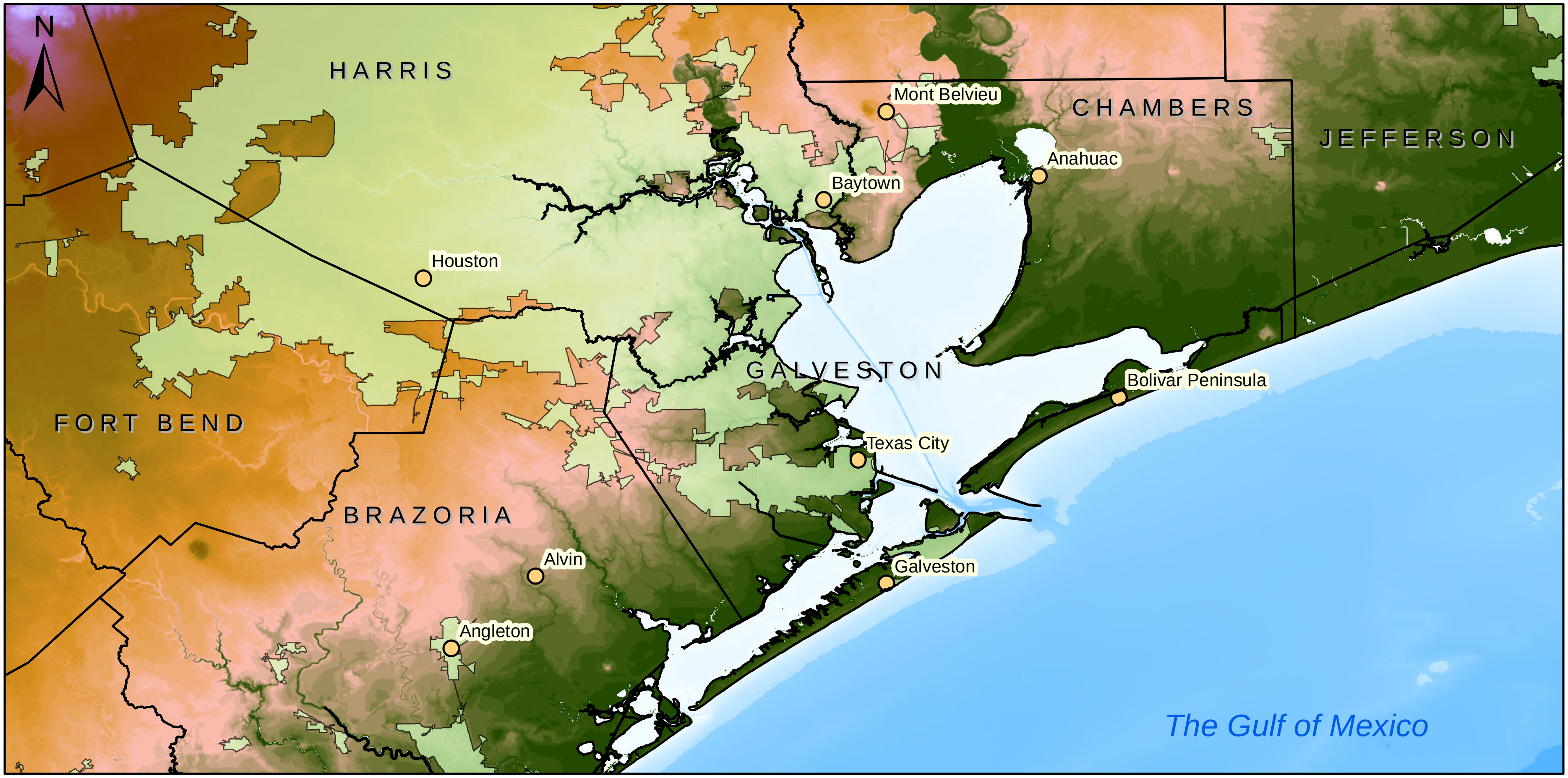
Present Day Sea Level



Legend

Counties

Urban Centers

Major Cities

Water Level

Shallow Water

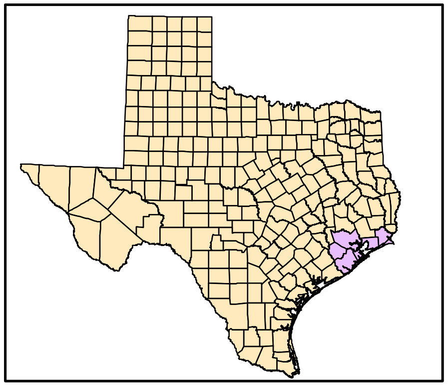
Moderatly Deep Water

Deep Water

0 10 20 40 Km

1:900,000

GCS North American 1983



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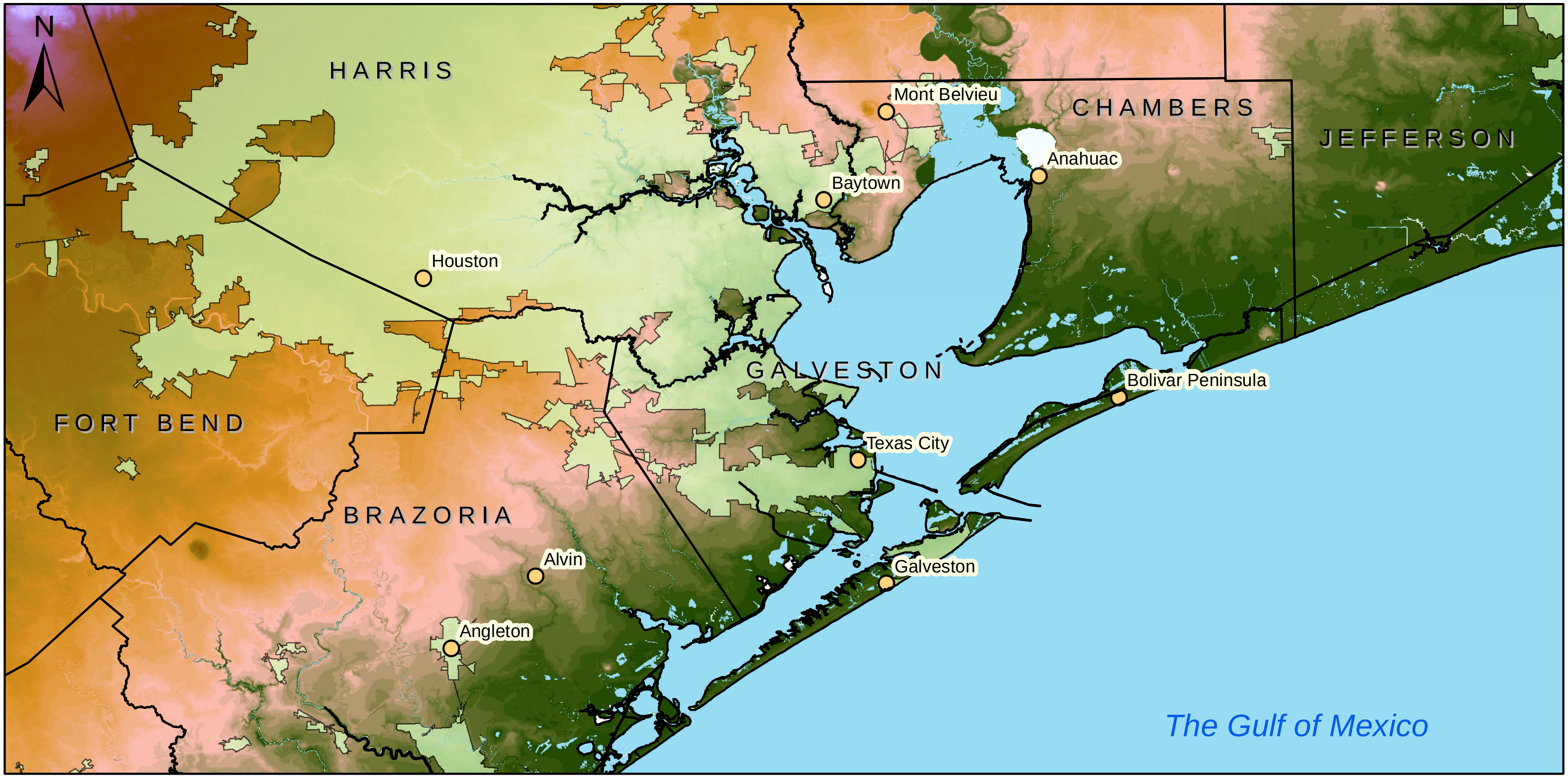
1 Meter Sea Level Rise



Legend

Counties

Urban Centers

Major Cities

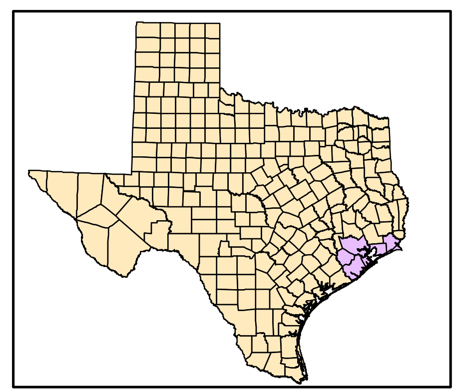
Water Level

Sea Level Rise

0 10 20 40 Km

1:900,000

GCS North American 1983



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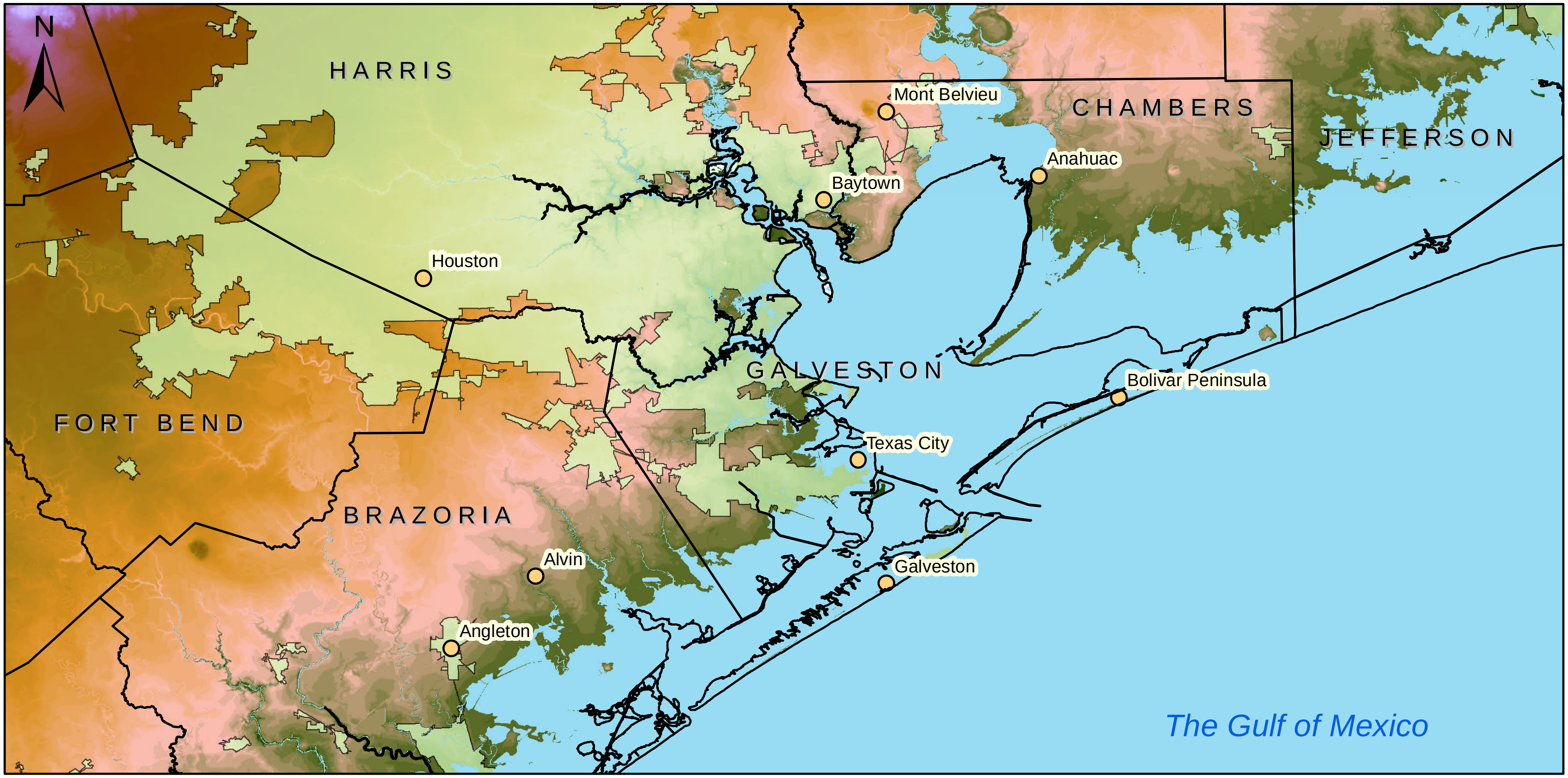
The Loss of Urban Area due to Sea Level Rise in the Greater Houston-Galveston Area, TX

3 Meter Sea Level Rise



Legend

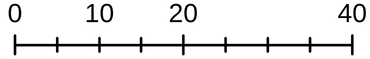
Counties

Urban Centers

Major Cities

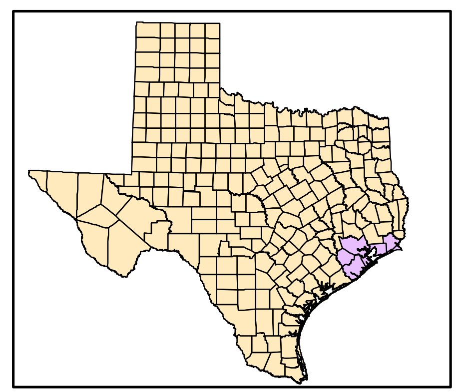
Water Level

Sea Level Rise



1:900,000

GCS North American 1983



The Loss of Urban Area due to Sea Level Rise in the Greater Houston-Galveston Area, TX

7 Meter Sea Level Rise

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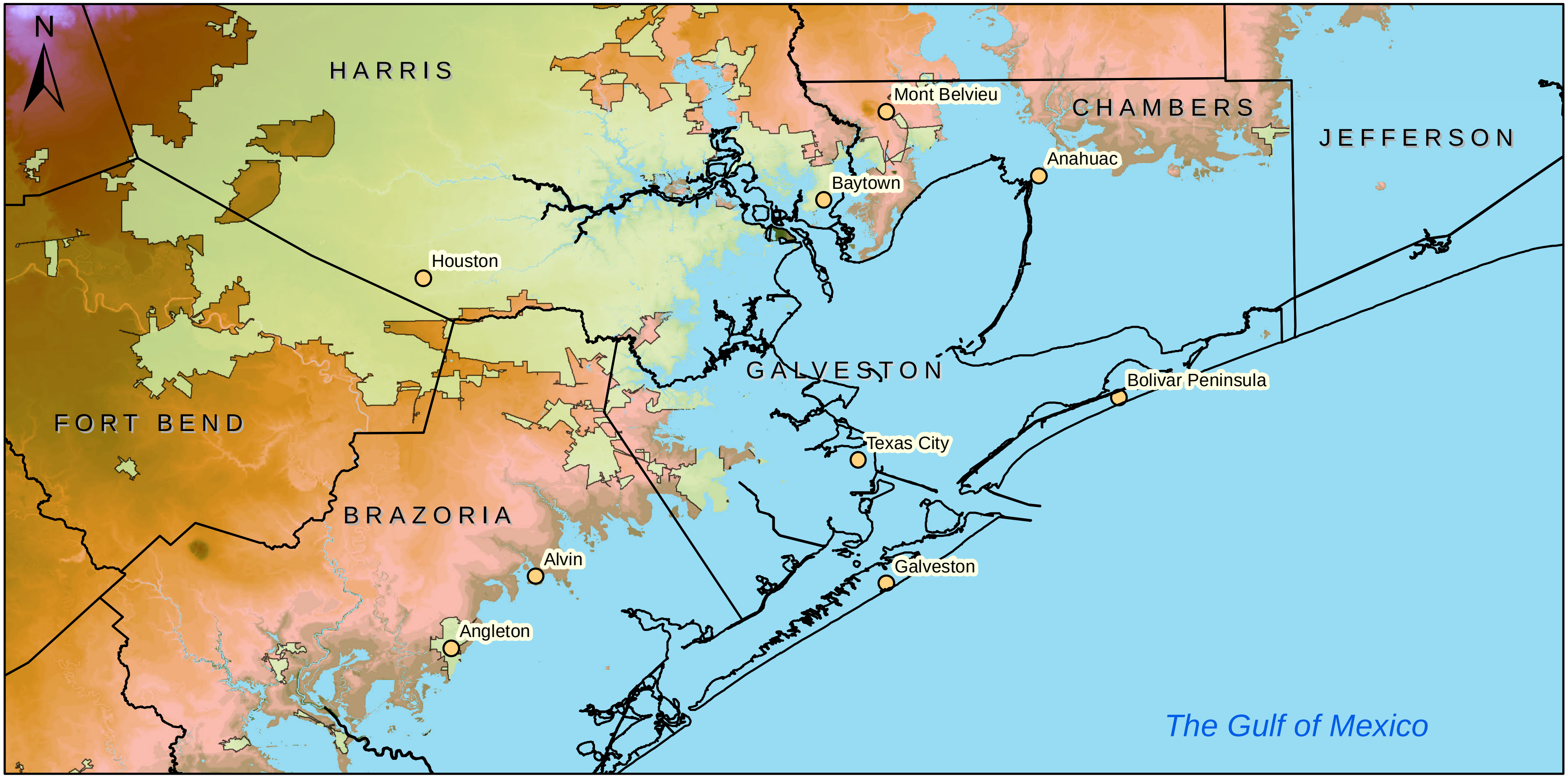


Legend

Counties

Urban Centers

Major Cities

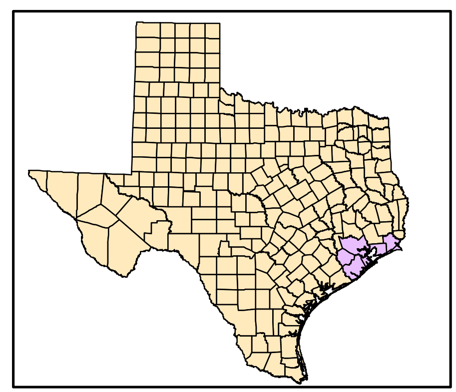
Water Level

Sea Level Rise

0 10 20 40 Km

1:900,000

GCS North American 1983



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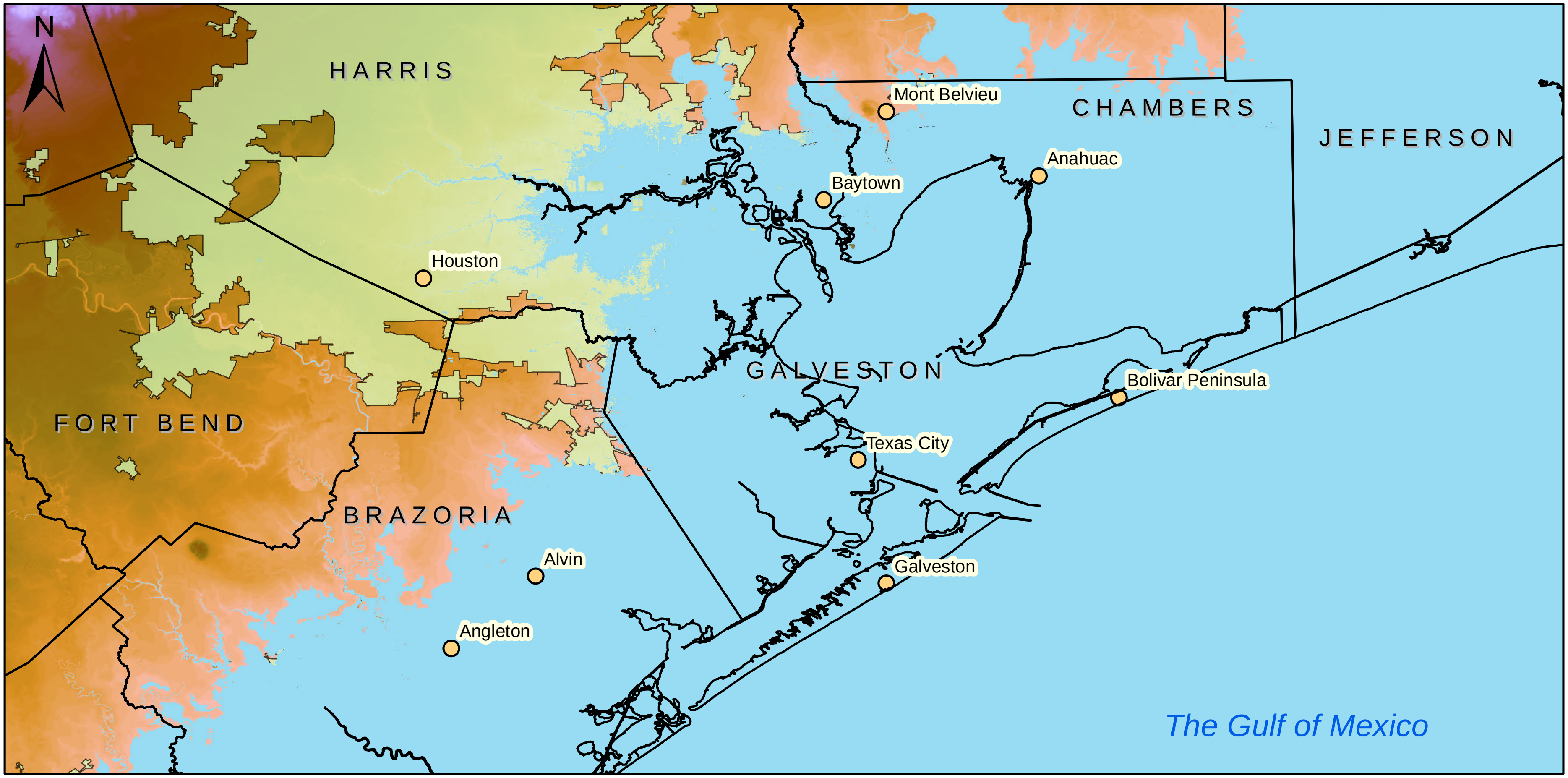
The Loss of Urban Area due to Sea Level Rise in the Greater Houston-Galveston Area, TX

11 Meter Sea Level Rise



Legend

- Counties
- Urban Centers
- Major Cities

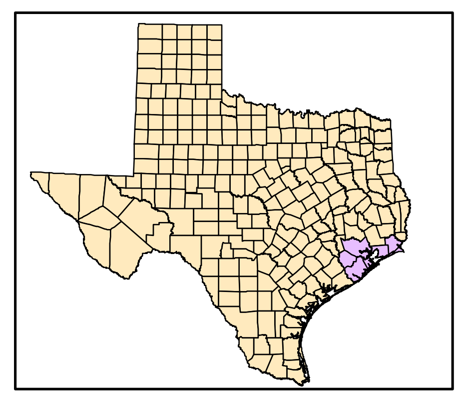
Water Level

- Sea Level Rise

0 10 20 40 Km

1:900,000

GCS North American 1983



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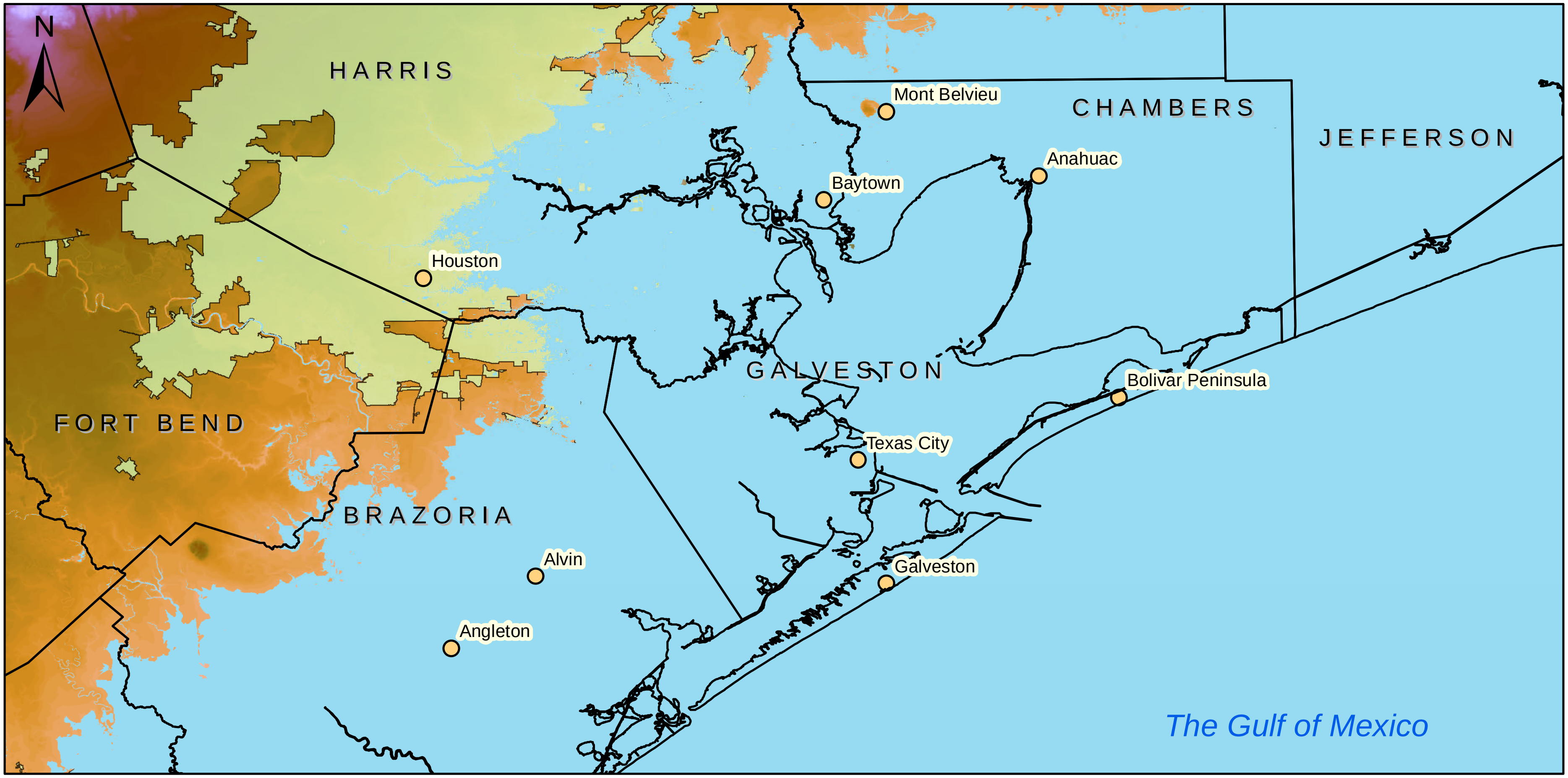
15 Meter Sea Level Rise



Legend

Counties

Urban Centers

Major Cities

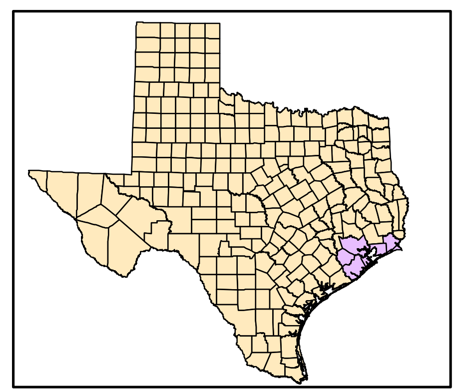
Water Level

Sea Level Rise

0 10 20 40 Km

1:900,000

GCS North American 1983



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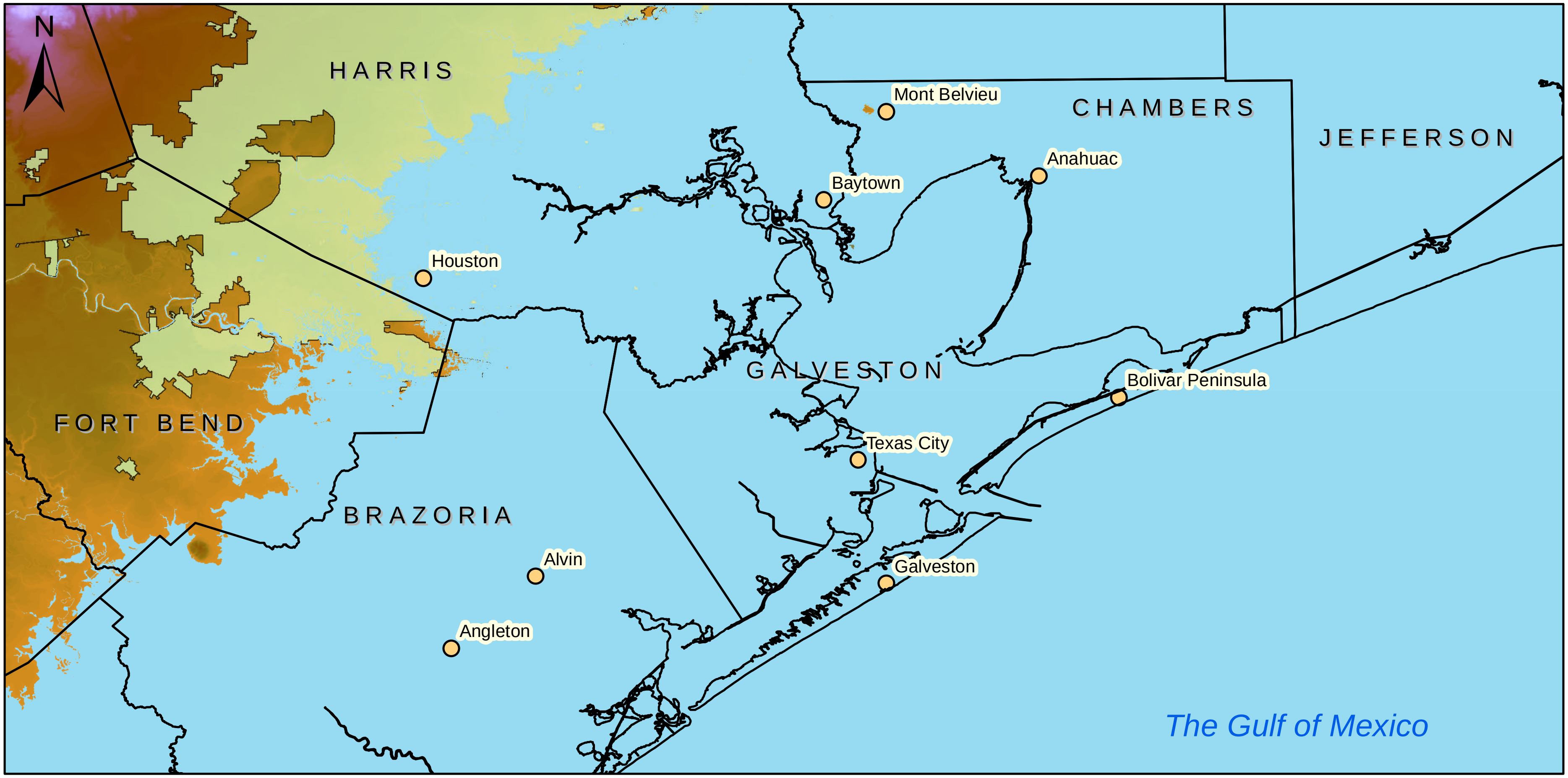
20 Meter Sea Level Rise



Legend

Counties

Urban Centers

Major Cities

Water Level

Sea Level Rise

0 10 20 40 Km

1:900,000

GCS North American 1983