

# **The Effect of Rising Sea Levels on the Greater Houston Area, Texas**

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Geo 327G

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**Problem:**

The city of Houston and the surrounding suburbs and metropolitan area is home to approximately 6 million inhabitants and serves a major hub for communication, petroleum refining, and business for the United States Gulf Coast Region. Recent global temperature fluctuations and subsequent melting of polar and other continental ice sheets have resulted in a rise in sea levels, threatening populations and urban centers situated near shorelines at relatively low elevations. Sitting at an elevation of just 13 meters above present day sea level, the Houston metropolitan region may be affected by the predicted rises in sea level, over the next century, which may reach a maximum height of up to 6 meters above present day levels.

**Goal:**

Produce a map of the Texas coast highlighting the Houston metro region using GIS techniques and spatial analysis to assess how various sea level rises may affect the city. Using raster data to create elevation models, satellite imagery, and state population data an accurate hazard map can be produced.

**Data Sources:**

- <http://www.gis.ttu.edu/center/DataCatalog/CntyDownload.php> - acquired shape-files for population extent and statistics for the Houston metro area.
- <http://nationalmap.gov> – source of background imagery and DEM grids
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## Methods:

1) Adding the downloaded data to a blank map in ArcMap 10, and establishing a folder workspace for all of my data. Data loaded:

- Rasters: grdn31w097\_1, grdn31w096\_1, grdn30w096\_1, grdn31w095\_1, grdn30w097\_1, grdn30w095\_1, grdn29w097\_1, grdn29w096\_1
- Compressed SID multiband image: N-15-25\_30\_loc.sid

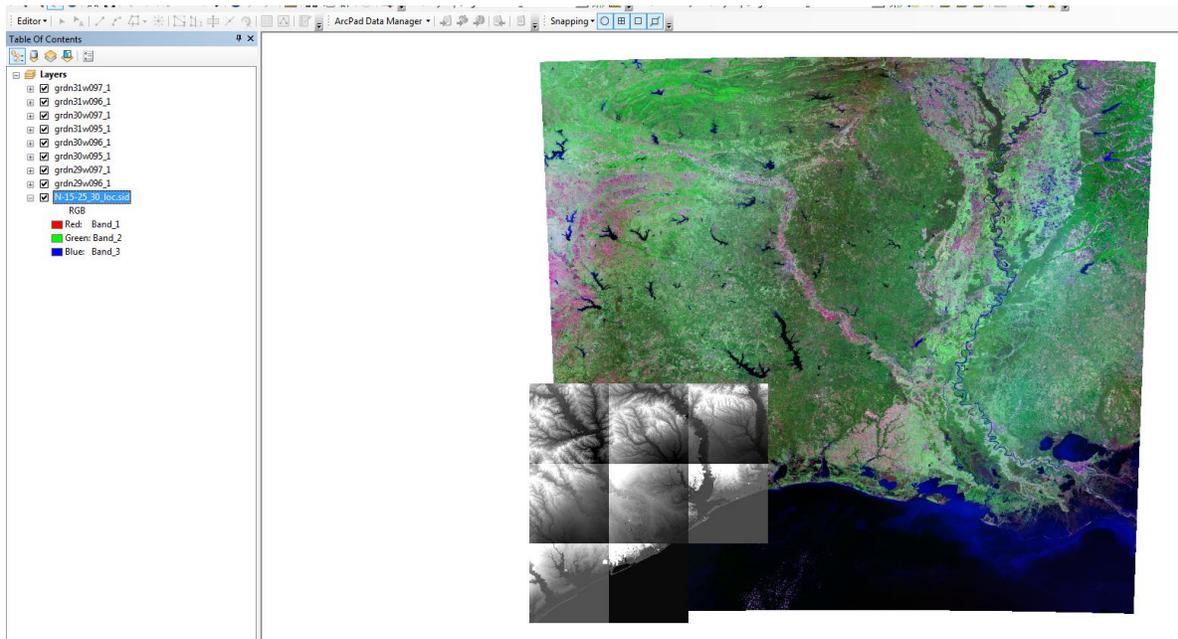


Figure 1. The added satellite imagery and DEM rasters. The DEMs must be stitched together using the mosaic tool to make any sense of them.

- 2) Stitching the rasters together and inputting the correct parameters so it comes out with the same cellsize and bit type as the original rasters.

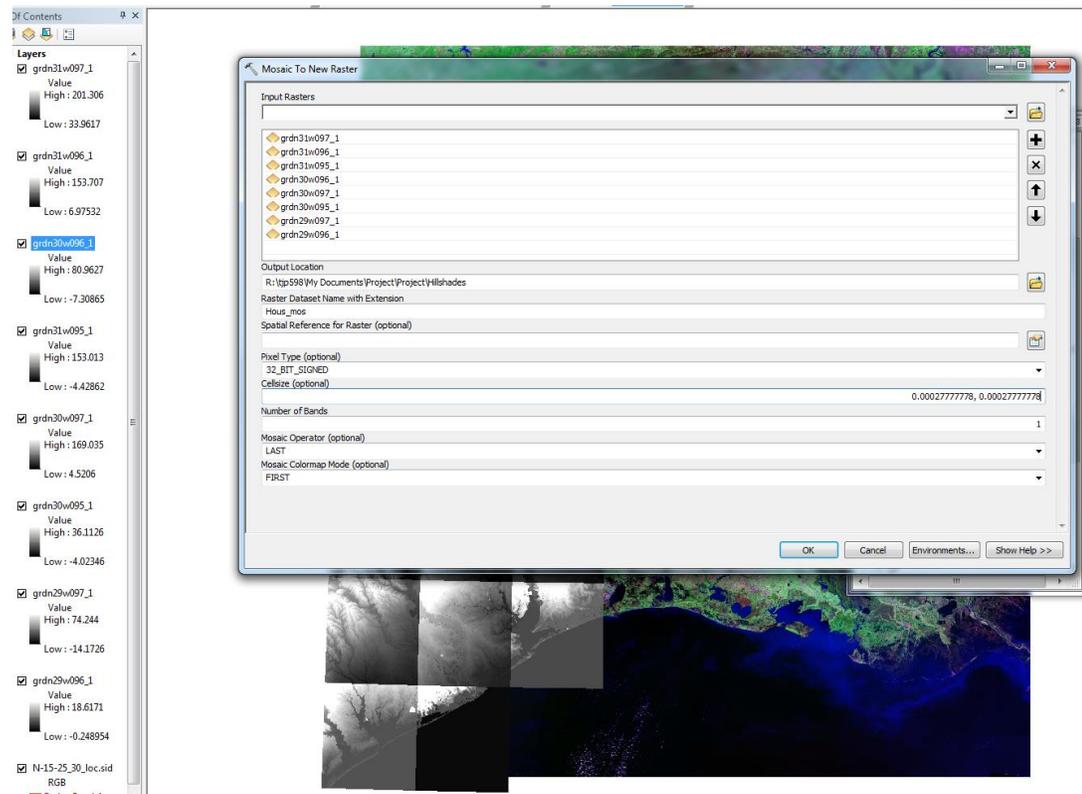


Figure 2. (ArcToolbox > Data Management > Raster > Raster Dataset > Mosaic to New Raster)  
This tool stitches together the different DEM rasters into one raster.

- 3) I then moved this DEM behind the imagery photo by moving it below that file in the TOC and set the transparency of the imagery to 50%. This allows me to visualize the DEM under the actual imagery of the region.

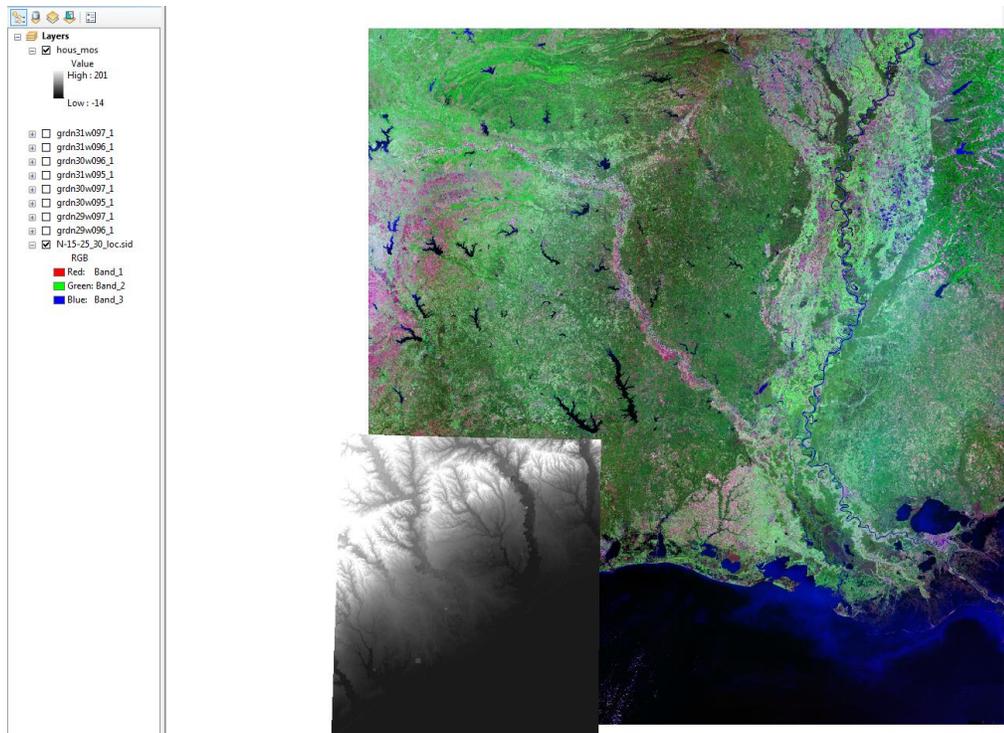


Figure 3. The finished mosaic of the raster data sets.

- 4) Setting the coordinate system spatial reference of the mosaicked DEM and imagery to the same reference of WGS 1984 UTM Zone 15N.prj and the datum to D\_WGS\_1984. This will also change the units of the DEM to meters, which is the unit I would prefer to work with. I accomplished this using the Project Raster tool, setting a new cell size to 30 m, and using the geographic transformation: NAD\_1983\_To\_WGS\_1984\_1. I also used a bilinear resampling technique, rather than nearest neighbor, because I was not working with a categorical raster, but with continuous data.

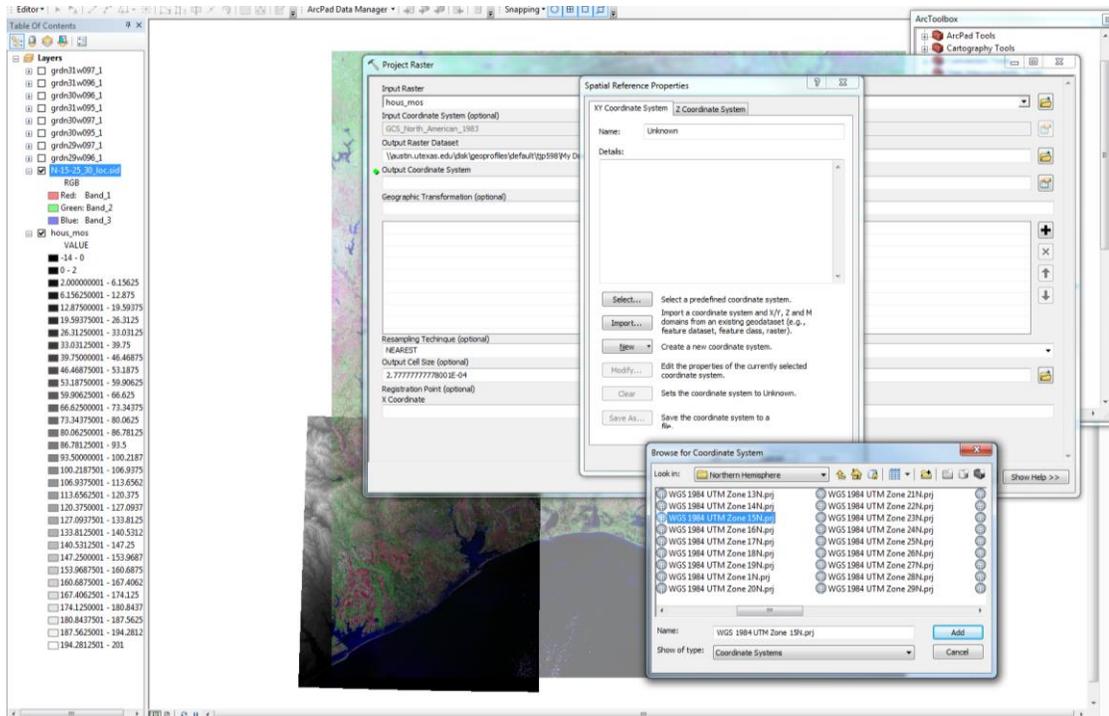


Figure 4. (ArcToolbox > Data Management > Projections and Transformations > Raster > Project Raster) This shows the required input parameters to project my DEM raster to the same coordinate system as my imagery.

- 5) Changing the symbology of the mosaic to an equal interval classification to display the data in a more manageable way and so elevation contours are grouped together. During this step I was also able to calculate a mean height for my DEM, which was 32 meters.

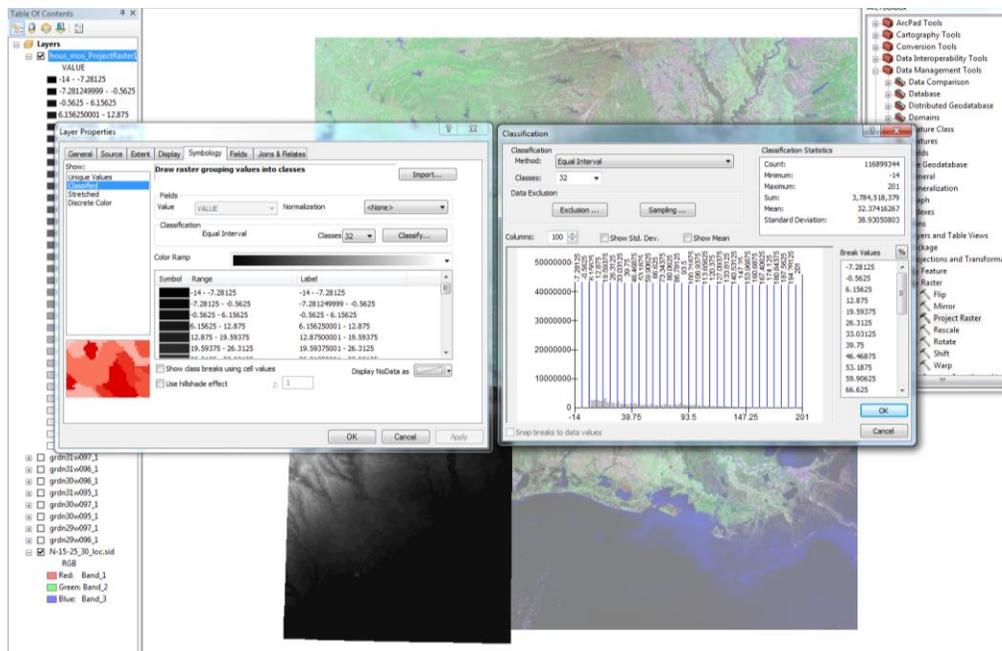


Figure 5. Changing the symbology.

- 6) After moving things around in my TOC some more it was time to clip the DEM to the size of the satellite image to remove the edges that went beyond the bounds of the image, then do the same thing for the image by clipping to the bounds of the DEM. This will establish my study area in a box. However, because the imagery photo did not lend itself to any type of clipping tools in the ArcToolbox I was forced to circumvent any traditional approach and create a "clipping rectangle" in the editor to create the bounds of my study area.
- 7) I created a new Personal GeoDatabase and feature class, in ArcCatalog, for the rectangle in the same coordinate system as the rest of my data and drew it around the bounds of my study area.

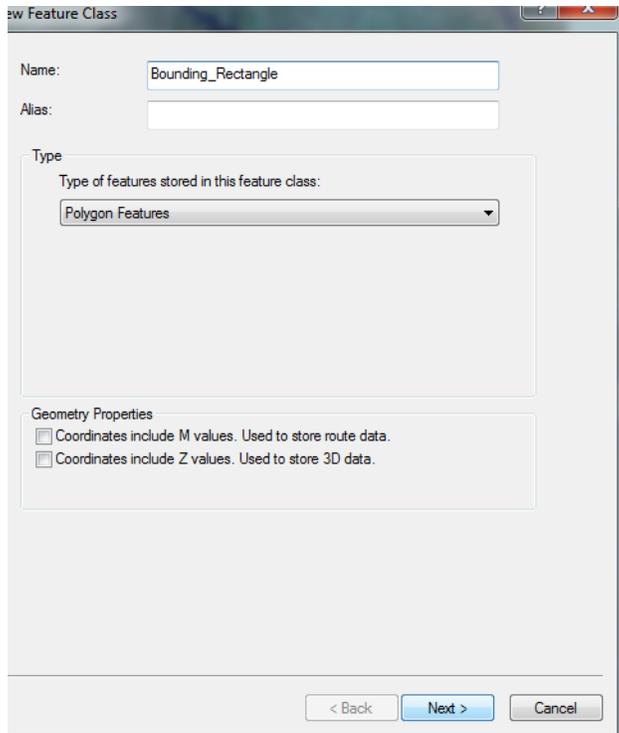


Figure 6. Creating the PGD and feature class.

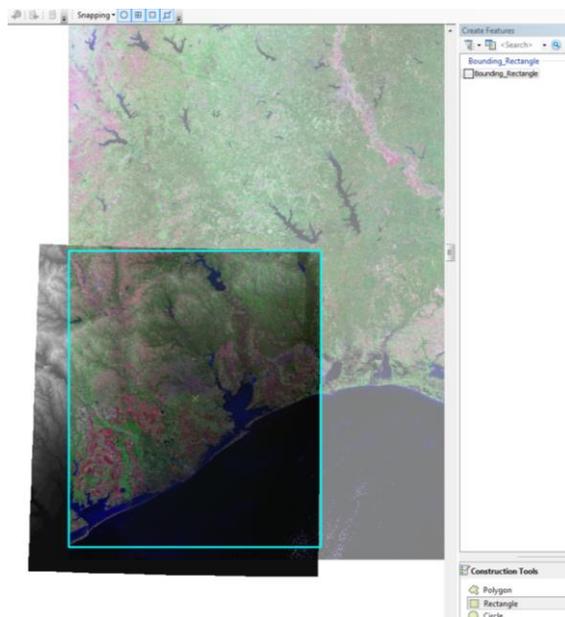


Figure 7. Drawing the bounding rectangle that I will use to clip the DEM and imagery to.

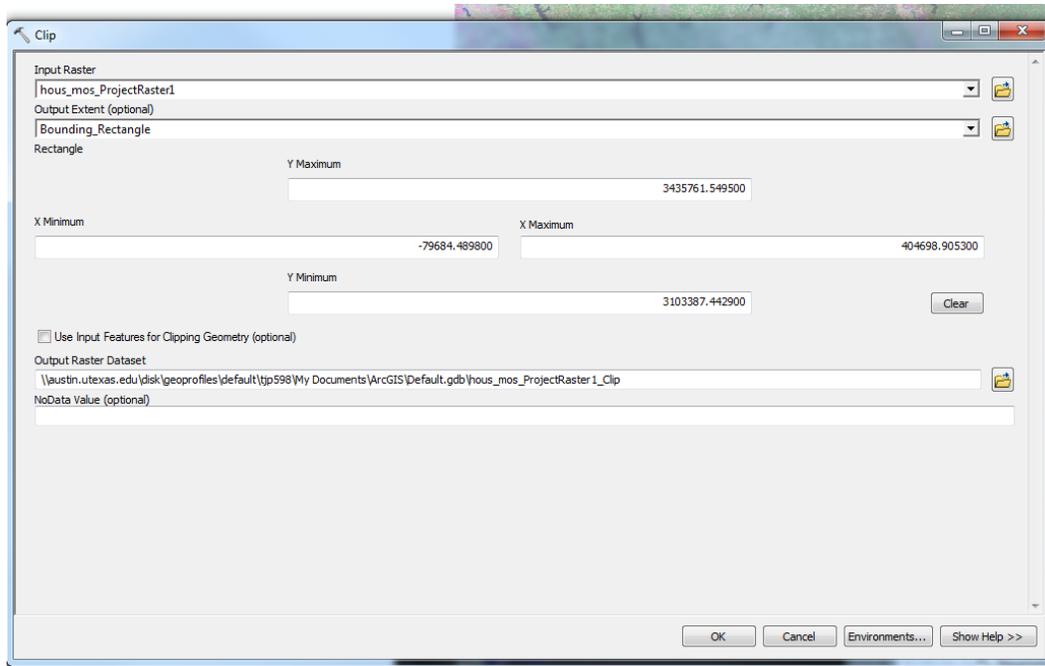


Figure 8. (ArcToolbox > Data Management > Raster > Raster Processing > Clip) Using the clip tool to bound the DEM, the same procedure was utilized for the satellite image, though for the image it clipped each band of the multi-band image at a time.

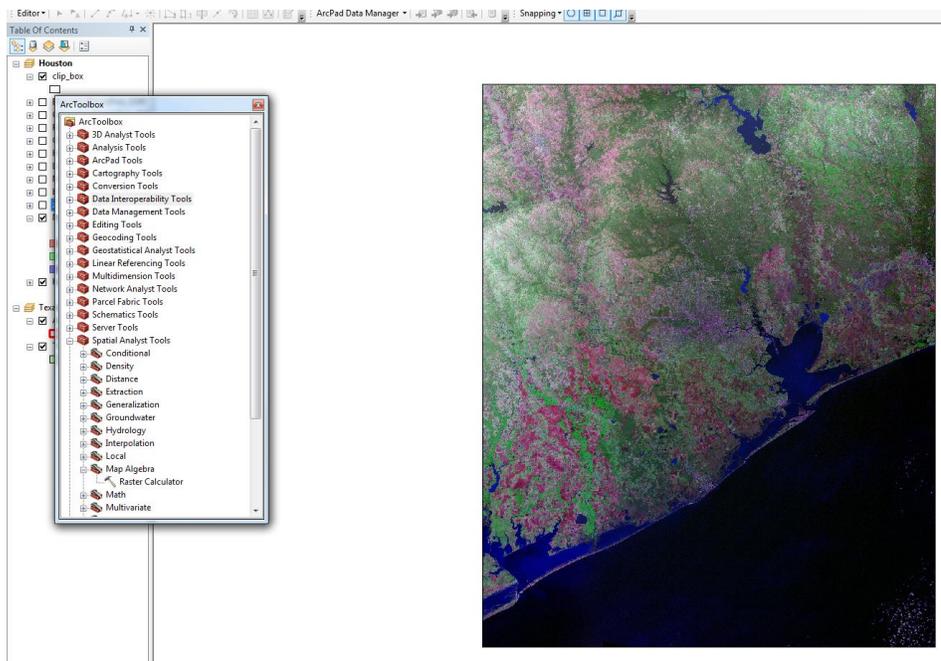


Figure 9. The product of clipping.

8) Next I added the shapefiles I downloaded containing the population data for the Houston Metro Area so when I create the DEM of the predicted rises in sea level we can visualize what regions will be affected. These shapefiles are projected on the fly by ArcGIS.

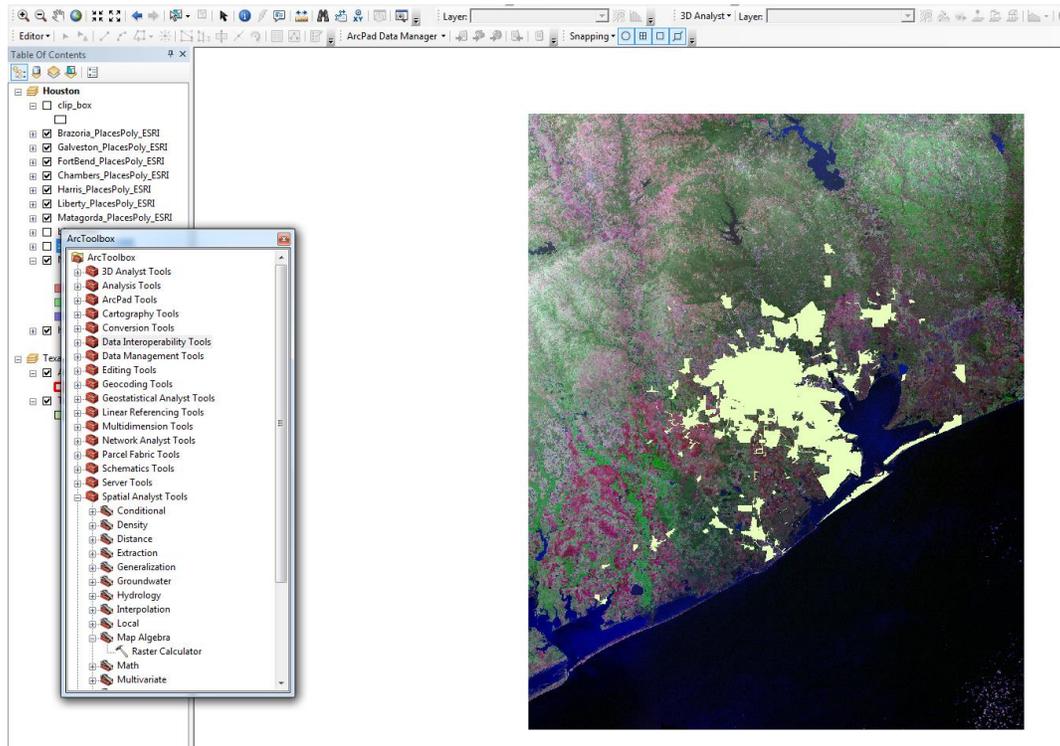


Figure 10. The product of clipping. The Houston metro region shown in green. The TOC indicates the name of the shapefile by region (ex. Brazoria poly, or Galveston poly).

9) I then created a zero elevation contour to show present day sea level and a binary raster of all values from my DEM that were below 0 meters above sea level to represent water.

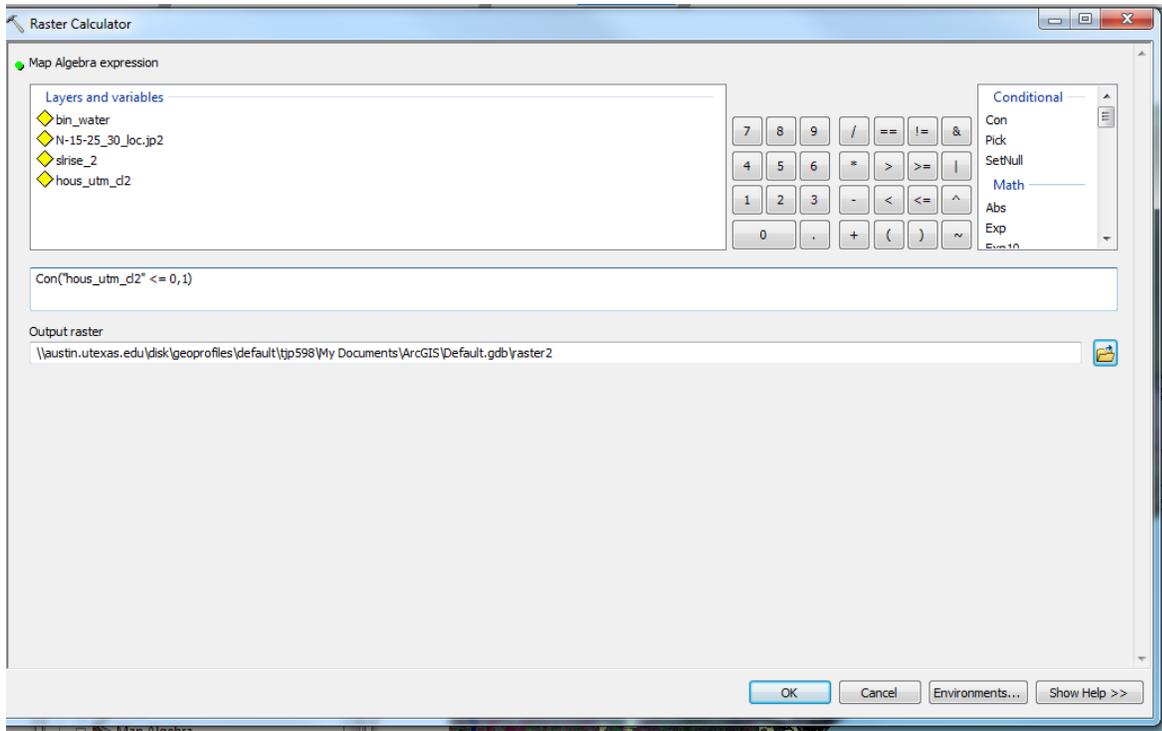


Figure 11. ( ArcToolbox > Spatial Analyst > Map Algebra > Raster Calculator) Binary Raster.

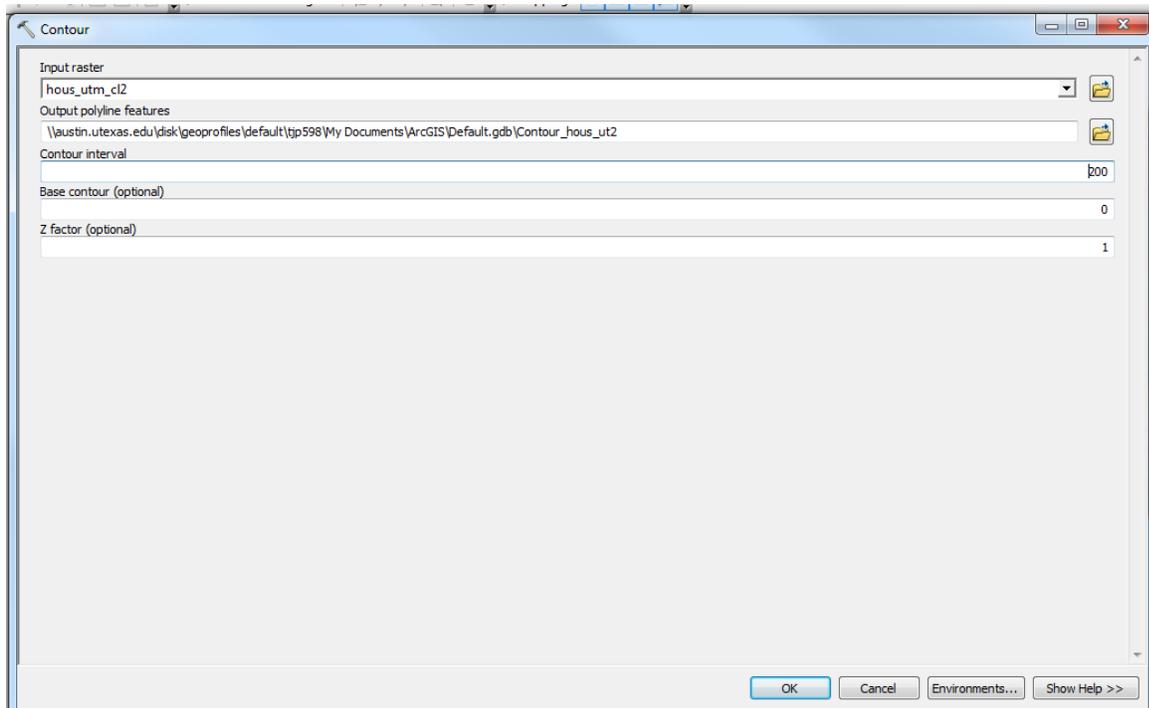


Figure 12. ( ArcToolbox > Spatial Analyst > Surface > Contour) Creating a sea level contour, 200 m interval to cover the highest point in the DEM.

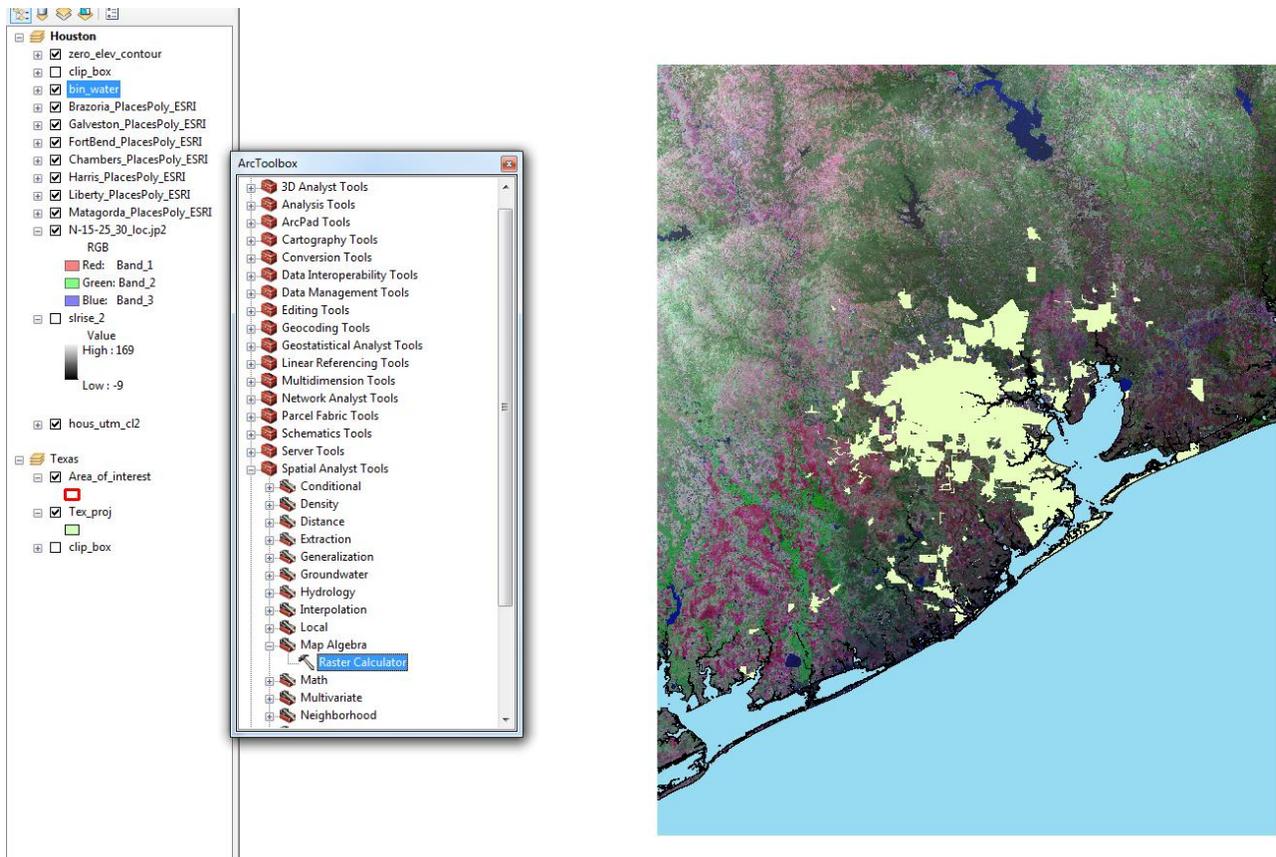


Figure 13. The binary raster and sea level contour.

10) I then used the raster calculator to subtract 2 meters to 6 meters ( in 2 m intervals) to model sea level rise and repeated the process of creating a new “shoreline” from the new zero level contour and a new “sea extent” using a binary raster for each case.

11) The final products are shown as maps with appropriate markup in the last 4 pages.

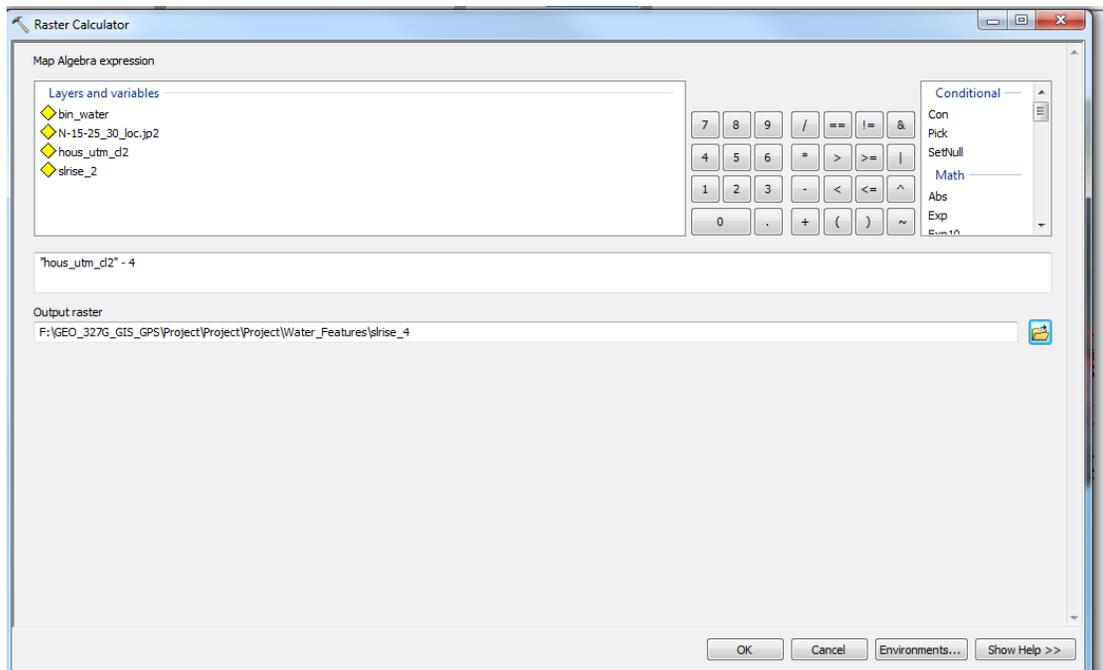


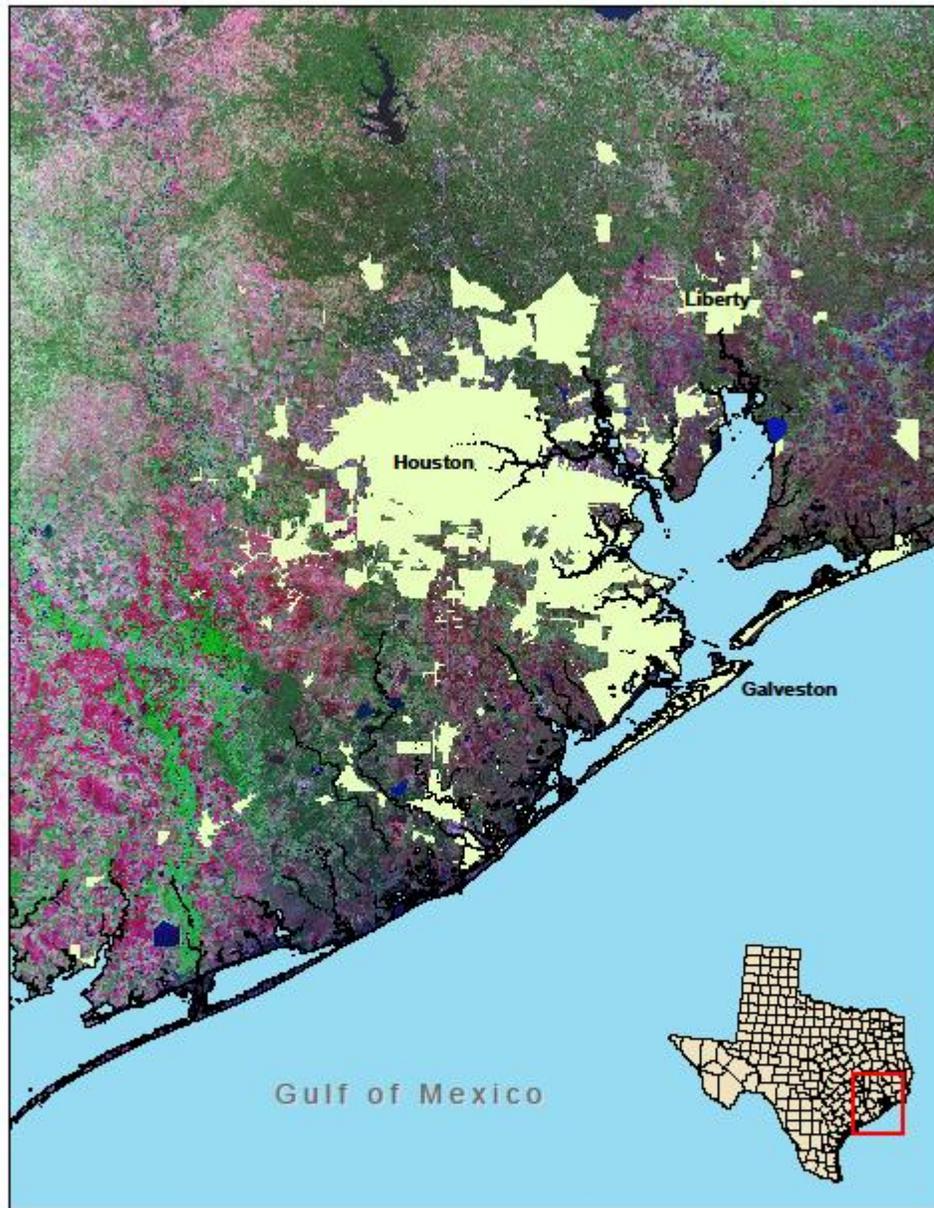
Figure 14. (ArcToolbox > Spatial Analyst > Map Algebra > Raster Calculator) Creating the new sea level by subtracting 2-6 meters.

## Conclusion:

ArcMap has allowed me to create a series of maps illustrating the impact of rising sea level on coastal Texas' urban centers. By combining raster and vector data, and utilizing the wide range of tools in ArcToolbox, I have provided an accurate hazard map for the region should the rate of current sea level rise remain the same or accelerate over the next century.

These final maps display present day sea level and subsequent rise in 2 meter intervals. In this series Galveston and Matagorda islands are entirely submerged and the coastal regions of Houston are obliterated by the Gulf of Mexico. This major population, transportation, and production hub of the world should plan for the eventual rise in sea level to remain as such.

# Present Day Sea Level for the Houston Metro Area, TX



## Explanation

- Sea Level - Present Day
- Water
- Greater Houston Metro Area

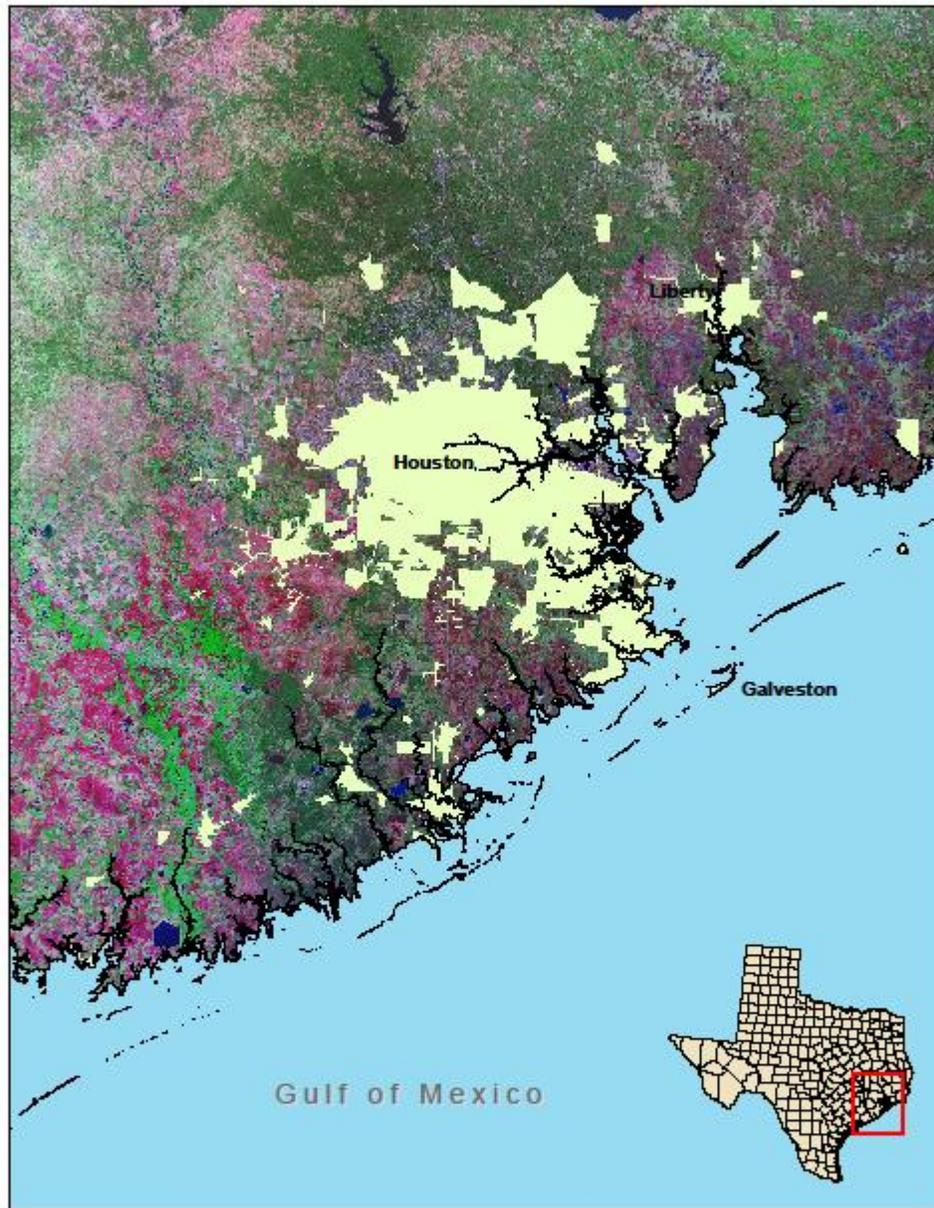
0 15 30 60 km

1:1,250,000

WGS84 UTM Zone 15N

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# Present Day Sea Level +2m for the Houston Metro Area, TX



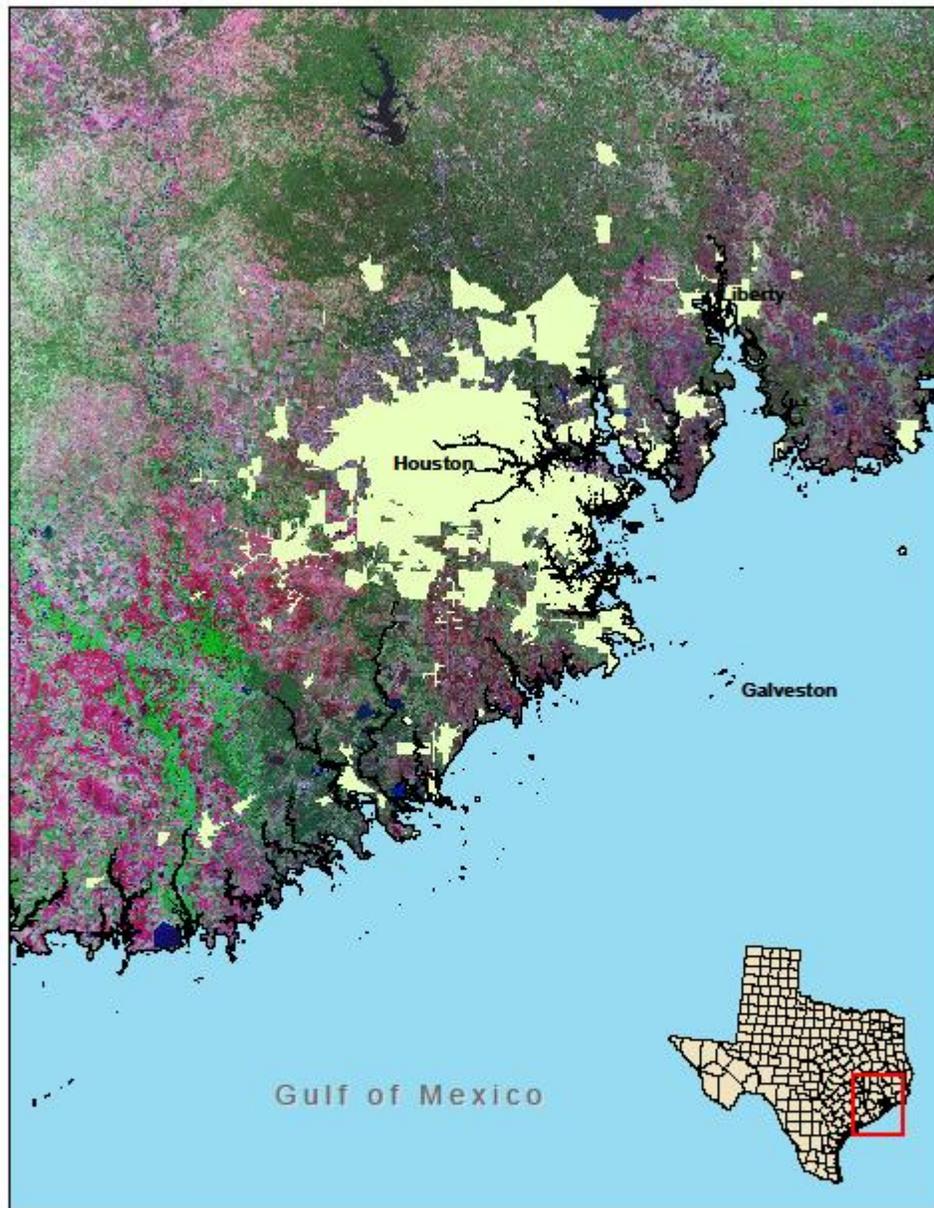
## Explanation

- Sea Level - Present Day + 2 meters
- Water
- Greater Houston Metro Area

0 15 30 60 km  
1:1,250,000  
WGS84 UTM Zone 15N

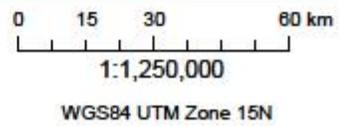
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# Present Day Sea Level +4m for the Houston Metro Area, TX



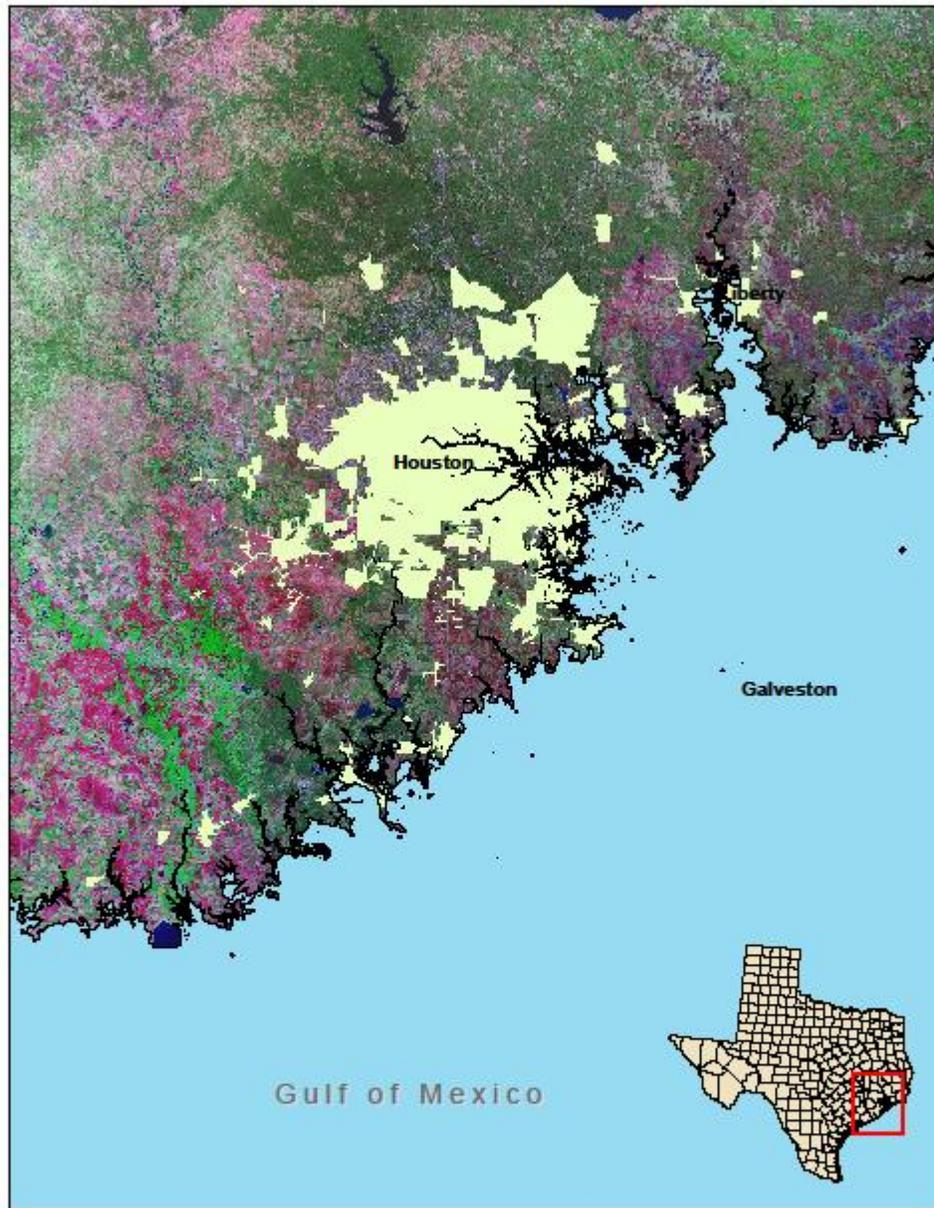
## Explanation

- Sea Level - Present Day + 4 meters
- Water
- Greater Houston Metro Area



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# Present Day Sea Level +6m for the Houston Metro Area, TX



## Explanation

- Sea Level - Present Day + 6 meters
- Water
- Greater Houston Metro Area

0 15 30 60 km  
1:1,250,000  
WGS84 UTM Zone 15N

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