

Chambers County, TX in 2100 – Sea Level Rise Projections

Question

What will Chambers County, TX look like at the end of the 21st Century given various global sea level rise projections? How much Chambers county land will be lost?

Methodology Outline

I will initially establish the coordinate system of the data from: NAD_1983_UTM_Zone_15N. From TNIRIS and USGS's "The National Map", I will acquire the highest quality DEM data available for Chambers County (1/3 arc second). I will use TNIRIS Chambers County data, simplified with the "dissolve" tool, to create my Chambers County Boundary Polygon. I will use "Extract by Mask" to clip all raster data (DEM, photomosaics) to this boundary polygon. I will then collect Minimal, Moderate, and Extreme projections of Global Sea Level Rise by 2100 from a reputable scientific paper. I will utilize the "raster calculator" tool to create new DEM data for Chambers county based on these varying projections (subtract sea level rise from each elevation datapoint). Again using "Raster Calculator", I will isolate the modern sea level from each DEM dataset (Modern, Minimal Rise, Moderate Rise, Extreme Rise) using a conditional statement. I will vectorize the resulting binary raster data (representing Modern, Minimal Rise, Moderate Rise, and Extreme Rise sea levels) using the "vector to polygon" tool. I will then add an area field for each polygon and collect total area data in square meters using the "statistics" function on the Area class. I will then have the area of Chambers' current water body, the area of its water body in each sea level rise scenario, and the total (land and water body) area of Chambers County. With this data, I can find Terrestrial area of Chambers in 2100 for each scenario by subtracting the water area for that scenario from the total area of Chambers. I can find the Land percentage lost since present by dividing the terrestrial area in 2100 for each scenario from the terrestrial area at present, subtracting 1 from that number, and multiplying by 100. I can find land lost in meters for each scenario by subtracting the terrestrial area for each scenario from the terrestrial area of Chambers at present.

Sourcing Sea Level Rise Projections

In "Climate Change Impacts in the United States: The Third National Climate Assessment", it suggested that global sea level rise can be expected represent a .2 meter to 2 meter rise by (Melillo et al., 2014). I am using .2 meters as the Minimal Sea Level Rise Projection, 2 meters as the Extreme Sea Level Rise Projection, and 1.1 meters, the average of the two, as the Moderate Sea Level Rise Projection.

Hypothesis

I do not expect the minimal Global Sea Level rise projection (.2 meters) to be visible from a county-wide map scale. I expect a .05% land loss with .2 meters Sea Level rise, a 2% land loss with 1.1 meters Sea Level rise, and approximately 5% land loss with 2 meters sea level rise.

Process

Adding Chambers County Boundary Polygon

Using TNRRIS, I accessed Imagery and GIS Data from Chambers County. I then downloaded and unzipped the "US Census – 2010 data" under "Boundary". After adding this data to ArcMap, I accessed the "Dissolve" tool, input the "US Census – 2010 data" layer and saved the resulting layer as "CountyLines".

Set Coordinate System

In Layer Properties, I navigated to and selected "UTM zone 15N" and clicked apply.

Box around Chambers County

I accessed the "Minimum Bounding Geometry" tool. Input the "US Census – 2010" layer file. Set Geometry Type to "RECTANGLE_BY_AREA" and Group Option to "All". Saved as "CountyBox". I then set the symbol to "Hollow".

Chamber's County Digital Elevation Model

Using USGS's "The National Map", selecting "Data Download", and by searching for "Elevation Products" of "Chambers County, TX" I found 1/3 arc-second DEM data (10 meter resolution). As this data does not cover all of Chambers County (as defined by our *Chambers County Polygon*), it was necessary to add bordering 1/3 arc-second DEM data from USGS's "The National Map".

Merging DEMs

Under "Data Management Tools", "raster", "raster dataset", I selected the "Mosaic to New Raster" tool. I input the Chamber's County DEM and its contiguous (west) DEM and chose an output location that would be easily accessible in the future. I named the output raster, set the Pixel Type to "32_BIT_FLOAT", the number of bands to "1", set the Mosaic Operator to "LAST", the Mosaic Colormap Mode to "FIRST", and ran the tool. My Merged digital elevation model, spanning the entirety of Chamber's County was then added to my table of contents.

Project Chambers County Line to match data frame

As the projection for the Chambers County Line did not match the projection of DEM data or Image data, it was necessary to use the “project” tool to create a new county boundary in the appropriate coordinate system. The “project” tool is found under “data management tools” and further under “projections and transformations”. Chambers County Boundary was the Input Dataset, UTM zone 15N was the output coordinate system, and the output location/name was established. Running this tool generated the Chambers County Boundary in the destination folder, from which I was able to add the data. I then removed the incorrectly projected county boundary.

Clipping DEM to Chambers County Boundary Polygon

Under “Data Management Tools”, “spatial analyst tools”, “extraction”, I selected the “Extract by Mask” tool. I selected the previously merged DEM for the “input raster” and the Chamber’s County Boundary Polygon for “Feature Mask Data”. I selected the output name and assigned the output location to an accessible storage location. After running the tool, the DEM was cropped to the county line of Chamber’s County, TX.

Creating Hillshade Raster

It is useful to create a shaded relief map, with which I will be able to make my DEM, once transparent, look three dimensional. I expanded the “3D analyst tools” toolbox, navigated to “Raster Surface”, and selected “Hillshade”, my clipped DEM was the input and the output location and name for the raster hillshade were established before running the “hillshade” tool to produce a hillshade of Chamber’s County.

Hillshade/DEM Overlay

Symbolizing the new hillshade raster with a Stretch Type of 2 Standard deviations, putting it below the DEM layer in the TOC, and setting the transparency of the DEM layer to 40% yielded elevation data that appears three dimensional.

Creating Binary Raster

Within “Spatial Analyst tools”, then under “Map Algebra”, and by selecting “Raster Calculator”, we can begin to isolate water from the DEM based on Elevations at or below 0. I wrote the following conditional statement: $\text{Con}(\text{"ClipDEM"} \leq 0, 1)$. I then defined my output location and name, ran the Raster Calculator, yielding a binary raster isolating water from land. After formatting the resulting raster, the resulting overlain data is shown in **Figure 1**.



Figure 1 – Chambers County, TX at modern day

Creating a Contour Line

In ArcToolbox, I navigated to “Spatial Analysis Tools”, followed by “Surface, before selecting “Contour”. I set the “Input Raster” to my clipped DEM data and the “Output polyline features” to the name “zero_cont”. I set the “Contour interval” to 37, and the “Z factor” to 1 before clicking OK. I then symbolized the output.

Extreme (2 meter) Sea Level Rise Projection Map – Chambers, TX [2100]

Subtracting 2 meters (“ClipDEM” - 2) from the Cropped DEM raster using “raster calculator” yields a new DEM raster topographically 2 meters below the original. I then created a hillshade of this new raster using the “hillshade” tool. I, again, used a conditional statement, `Con("2100Exag" <= 0,1)`, in raster calculator to isolate a water polygon from the new DEM raster.

Moderate (1.1 meter) Sea Level Rise Projection Map – Chambers, TX [2100]

Subtracting 1.1 meters ("ClipDEM" – 1.1) , as this the average of our exaggerated and minimal projection (Melillo et al., 2014) , from the Cropped DEM raster using "raster calculator" yields a new DEM raster topographically 1.1 meters below the original. I then created a hillshade of this new raster using the "hillshade" tool. I, again, used a conditional statement, Con("2100Mid" <= 0,1), in raster calculator to isolate a water polygon from the new DEM raster.

Minimal (.2 meter) Sea Level Rise Projection Map – Chambers, TX [2100]

Subtracting .2 meters ("ClipDEM" - .2) from the Cropped DEM raster using "raster calculator" yields a new DEM raster topographically .2 meters below the original. I then created a hillshade of this new raster using the "hillshade" tool. I, again, used a conditional statement, Con("2100Low" <= 0,1), in raster calculator to isolate a water polygon from the new DEM raster.

Decreasing 2016- Compressed Country Mosaic File Size

On TNRIS, with Chambers county queried, under "Compressed Country Mosaics", I downloaded "2016 National Agriculture Imagery Program 1m NC". As "2016 National Agriculture Imagery Program 1m NC" was a whopping 9.5 Gb, it was necessary to resample the raster prior to mask extraction. By selecting "export data" for the layer, increasing the cell size (from 1x1 to 10x10), setting the output format to TIFF and Compression Type to JPEG, and finally clicking Save, we can bring the file size down to about 200 Mb, which is much easier to work with.

Clipping 2016- Compressed Country Mosaic to Chambers County Boundary Polygon

Under "Data Management Tools", "spatial analyst tools", "extraction", I selected the "Extract by Mask" tool. I selected the "2016 National Agriculture Imagery Program 1m NC" Mosaic for the "input raster" and the Chamber's County Boundary Polygon for "Feature Mask Data". I selected the output name and assigned the output location to a reasonable storage location. After running the tool, the mosaic was cropped to the county line of Chamber's County, TX. After formatting the resulting raster, the resulting overlain data is shown in **Figure 2**.

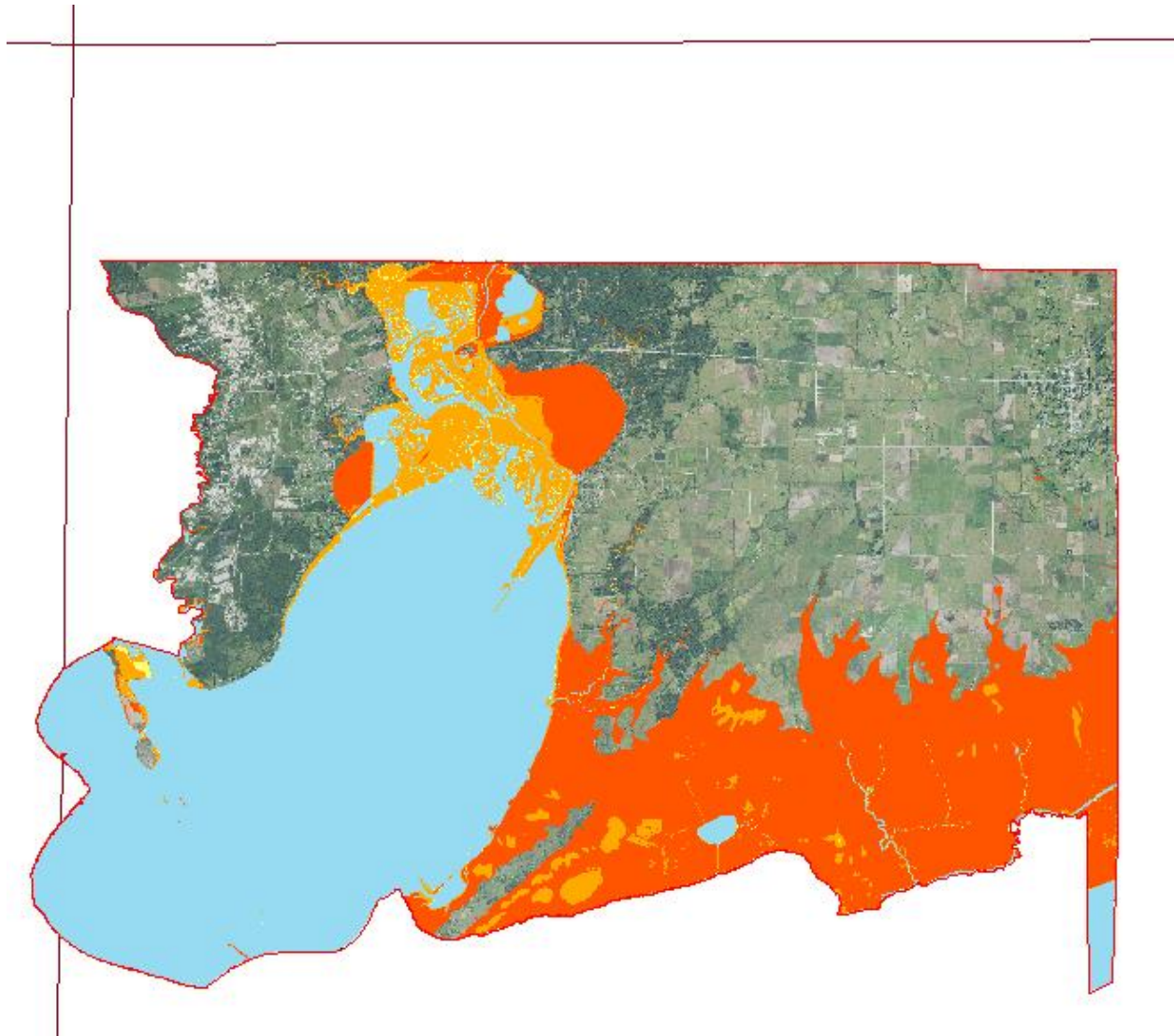


Figure 2 – Chambers County, TX w/ various raster Sea Level Projections

Converting Raster Data to Vector Data (For Analysis)

When analyzing data and seeking to quantify spatial relationships, it is generally useful to vectorize raster data. Under “Conversion Tools”, “from raster, I selected the “Raster to Polygon” tool. I input each binary, sea-level raster, selected an appropriate output name/location and ran the “Raster to Polygon” tool. After formatting the resulting polygons, the overlain data is shown in **Figure 3**.

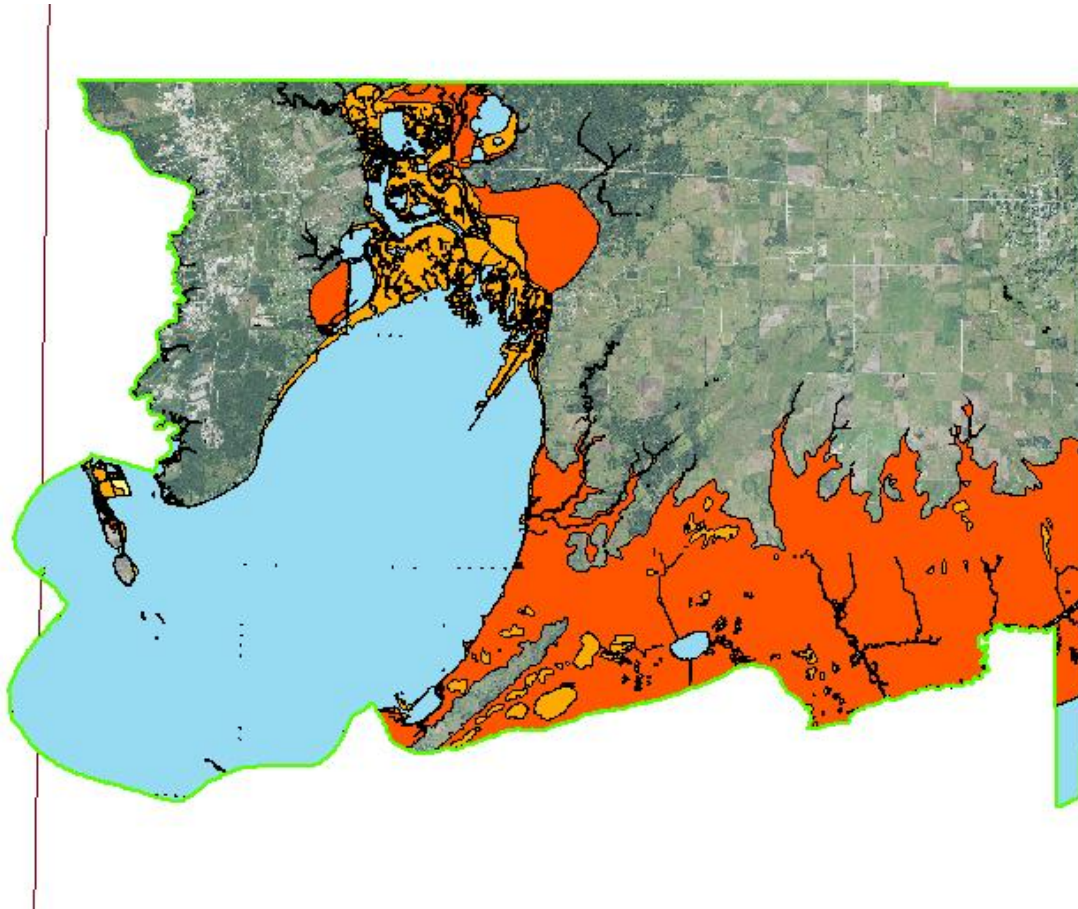


Figure 2 – Chambers County, TX w/ various vector Sea Level Projections

Add Area Field for Vector Data (For Analysis)

In the attribute tables for the modern sea level, the three sea level projections, and the Chambers County polygons I “added Field” named “Area”. I then “Calculated geometry for the new “Area Fields” in UTM zone 15N with square meters as the unit.

Adding Area Values Within Each Polygon

Selecting the “Area” Field, containing thousands of area values, and then selecting statistics allows us to rapidly find the total area of a polygon. This step was not necessary for the Boundary polygon as the polygon was represented by a single value. This yielded the following data:

Chambers County, Water – Today = 642155510.802005 sq. meters

Chambers County, Water – 2100 Minimal Projection = 651205641.754689 sq. meters

Chambers County, Water – 2100 Moderate Projection = 763928848.207348 sq. meters

Chambers County, Water – 2100 Extreme Projection = 1219600151.211201 sq. meters

Chambers County, Water and Land – Today = 2256026936.59 sq. meters

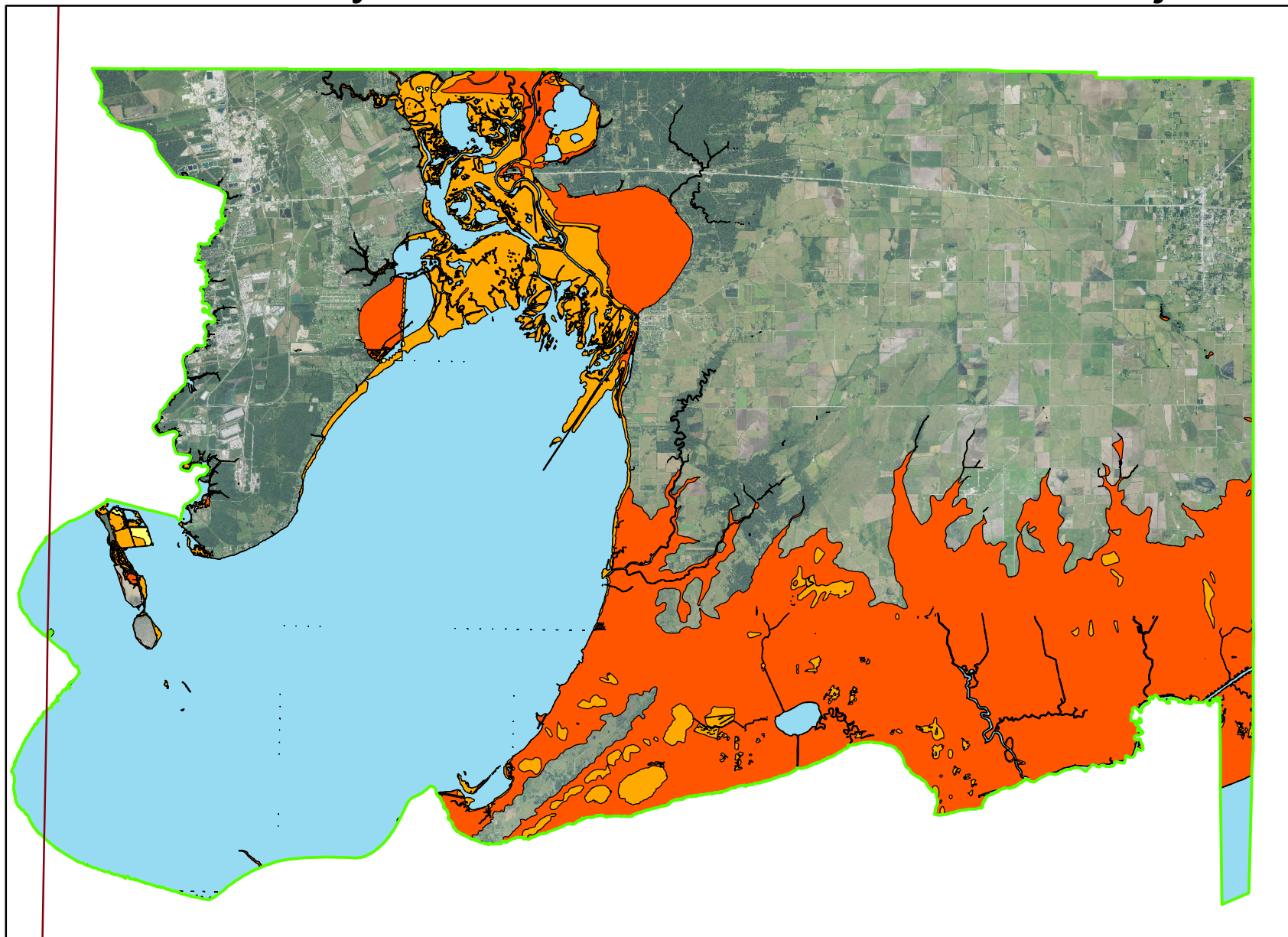
From this data, acquired through vector analysis, I calculated the following statistics in Excel:



Chambers County, TX - Modern	
Water Area (sq. meters)	Terrestrial Area (sq. meters)
642155510.8	1613871426




Chambers County, TX - 2100				
Projected Global Sea Level Rise	Water Area (sq. meters)	Terrestrial Area (sq. meters)	Land Percentage Lost since Modern	Land Lost (sq. meters)
Minimal (.2 meters)	651205641.8	1604821295	0.560771497	9050130.953
Moderate (1.1 meters)	763928848.2	1492098088	7.545417526	121773337.4
Extreme (2 meters)	1219600151	1036426785	35.78008949	577444640.4

Specific Methodology for Calculation: I found Terrestrial area of Chambers in 2100 for each scenario by subtracting the water area for that scenario from the total area of Chambers. I found the Land percentage lost since present by dividing the terrestrial area in 2100 for each scenario from the terrestrial area at present, subtracting 1 from that number, and multiplying by 100. I found land lost in meters for each scenario by subtracting the terrestrial area for each scenario from the terrestrial area of Chambers at present.

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 County Boundary
 Modern Sea Level

 Extreme Sea Level Rise (2m)
 Moderate Sea Level Rise (1.1m)
 Minimal Sea Level Rise (.2m)

0 3 6 12 18 24 Kilometers

1:300,000 NAD_1983_UTM_Zone_15N



References

Melillo, J.M., T.C. Richmond and G.W. Yohe, Eds. (2014), Climate Change Impacts in the United States: The Third National Climate Assessment, U.S. Global Change Research Program, 841 pp., doi:10.7930/J0Z31WJ2