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GEO 327G

Calhoun County, Texas Under 5 Meter Sea Level Rise

PROBLEM AND PURPOSE: Sea level rise is threat to all coastal areas. Although natural sea level rise happens at a very slow rate, hurricanes can create a storm surge with pressure and wind that pushes water well above normal sea level causing severe flooding in the areas near where it makes landfall. For example, in 2005 Hurricane Katrina produced a storm surge with an estimated height of 7.6 meters (25ft) according to the Federal Emergency Management Agency (FEMA). An early projected path of this storm predicted landfall over Pass Cavallo in the southeast corner of Calhoun County, near the town of Port O'Conner, Texas. The purpose of this project is to determine some of the effects of a similar rise in sea level on Calhoun County. The goal is to determine the total area of land that would be flooded by a 5 meter storm surge and what percentage of the roads in the county would be under water.

DATA: The data for this project has been collected from the National Map Seamless Server which can be found online at http://seamless.usgs.gov/website/seamless/view.htm. The files and short description of each as listed below.

- 1. DEM file – USGS digital elevation model with a 10 meter resolution. This raster file displays the elevations of land above sea level.
- 2. Counties Shapefile – A shapefile containing polygons of county boundaries.
- 3. Bureau of Transportation Roads Shapefile – A shapefile with vector data of all roads within the area of interest.

METHODS:

1. Project all data into a common predefined coordinate system, NAD_1983_UTM_Zone_14N.
2. Clip all data within a polygon that represents the county line border.
3. Use the Spatial Analyst tool to create new rasters and polygons.
4. Use various tools and methods (ex. 3d Analyst) to do calculations based on new rasters and files that were created.
5. Summarize the calculations.

PROCESS:

1. First step after downloading the data is to project all the files to the same coordinate system in ArcCatalog. The two shapefiles can be projected using ArcToolbox > Projections and Transformations > Feature > Project. The DEM file can be projected using ArcToolbox > Projections and Transformations > Raster > Project Raster. The data will be projected to NAD_1983_UTM_Zone_14N. After projecting the data load it into ArcMap.

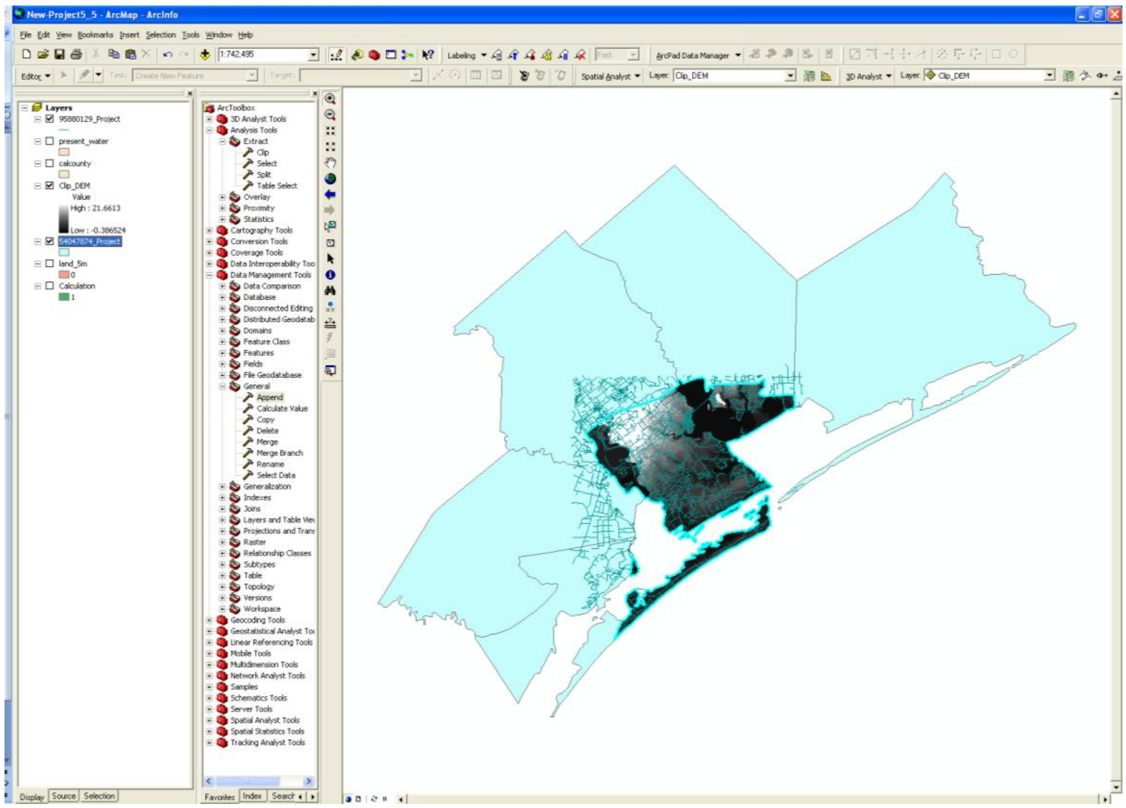

Figure 1 – ArcMap data view displaying all data from web projected correctly (DEM clipped to Calhoun County line).

2. Next, select the polygons for Calhoun County using Selection > Select by Attribute. The layer used is the county shapefile selecting all counties with “COUNTY” name = “Calhoun County.” Export the data as a shapefile to be used as analysis mask.

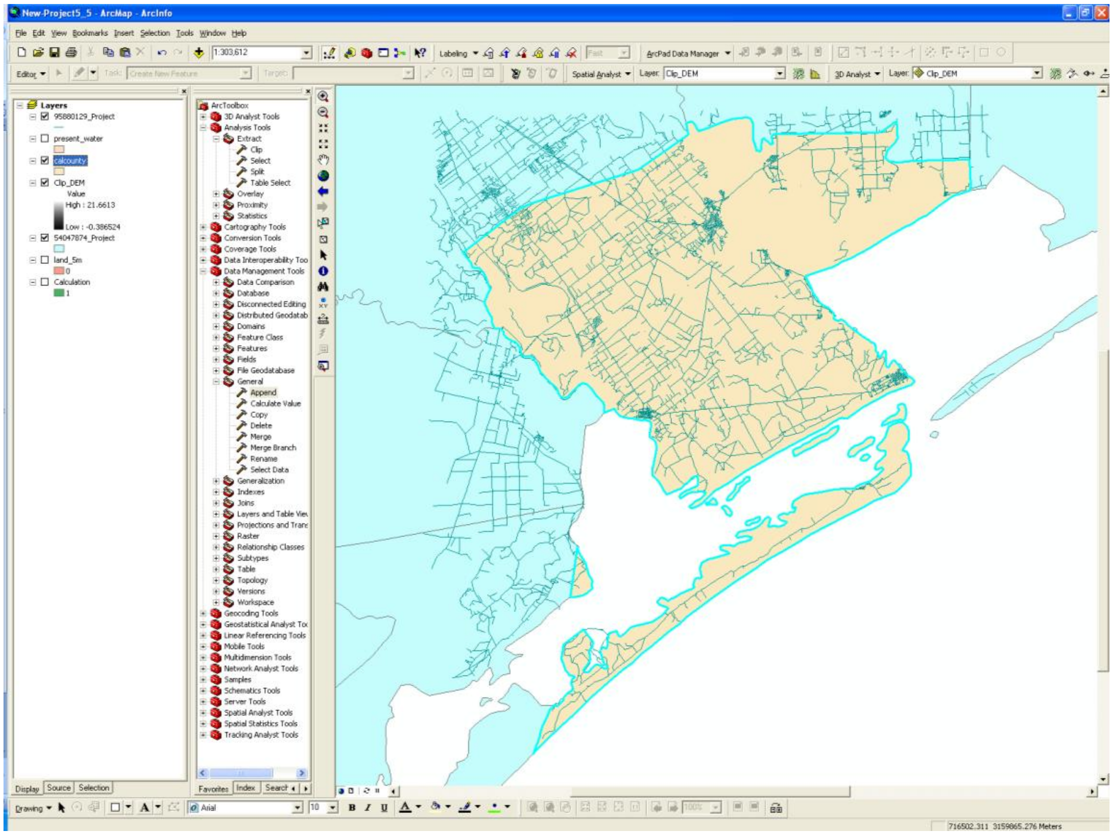

Figure 2 – ArcMap data view displaying Calhoun County polygon to be used for analysis mask.

3. Next, clip the roads shapefile to show only roads that lie within Calhoun County. This is done with ArcToolbox > Analysis Tools > Extract > Clip. The input feature is the roads shapefile, clip features is the county polygon, and it will be saved as “clip_roads.” Once finished hide the original roads shapefile and display only the clipped file.

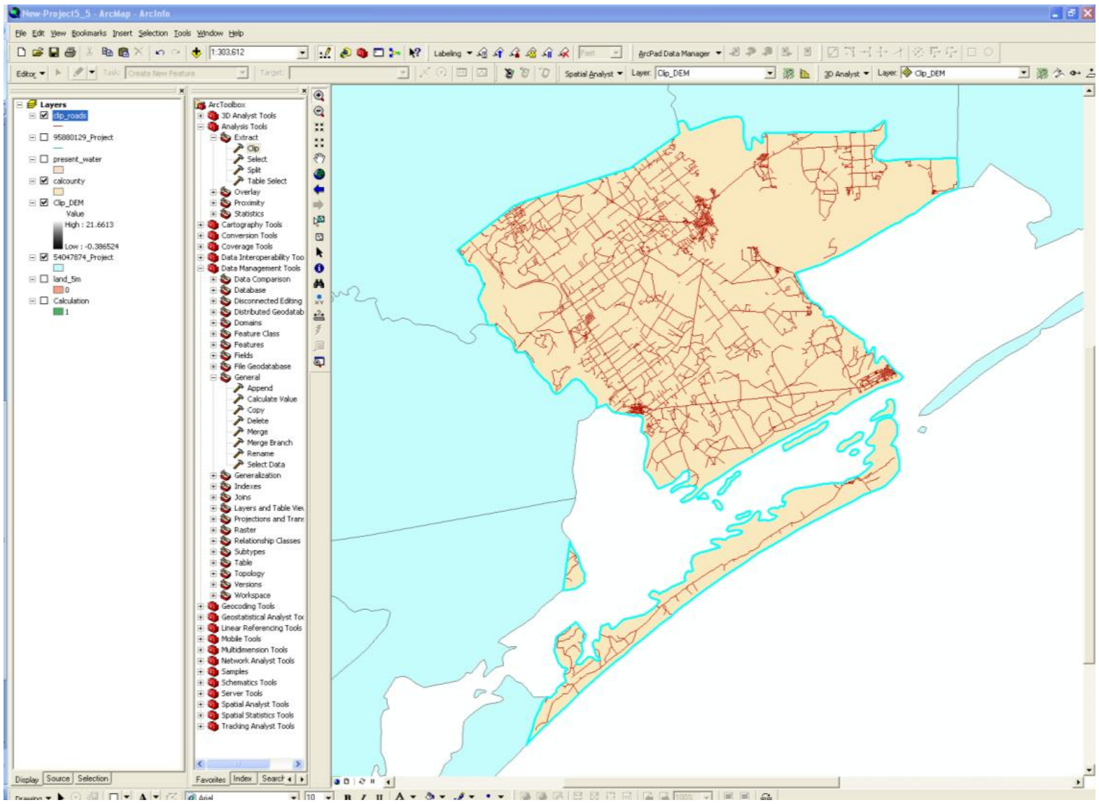

Figure 3 – ArcMap data view displaying the “clip_roads” shapefile.

4. Next, clip the DEM with the county shapefile using the Spatial Analyst > Raster Calculator. Before doing so set the analysis mask as the Calhoun county shapefile and set a working directory. In raster calculator simply double click the DEM file and hit evaluate.

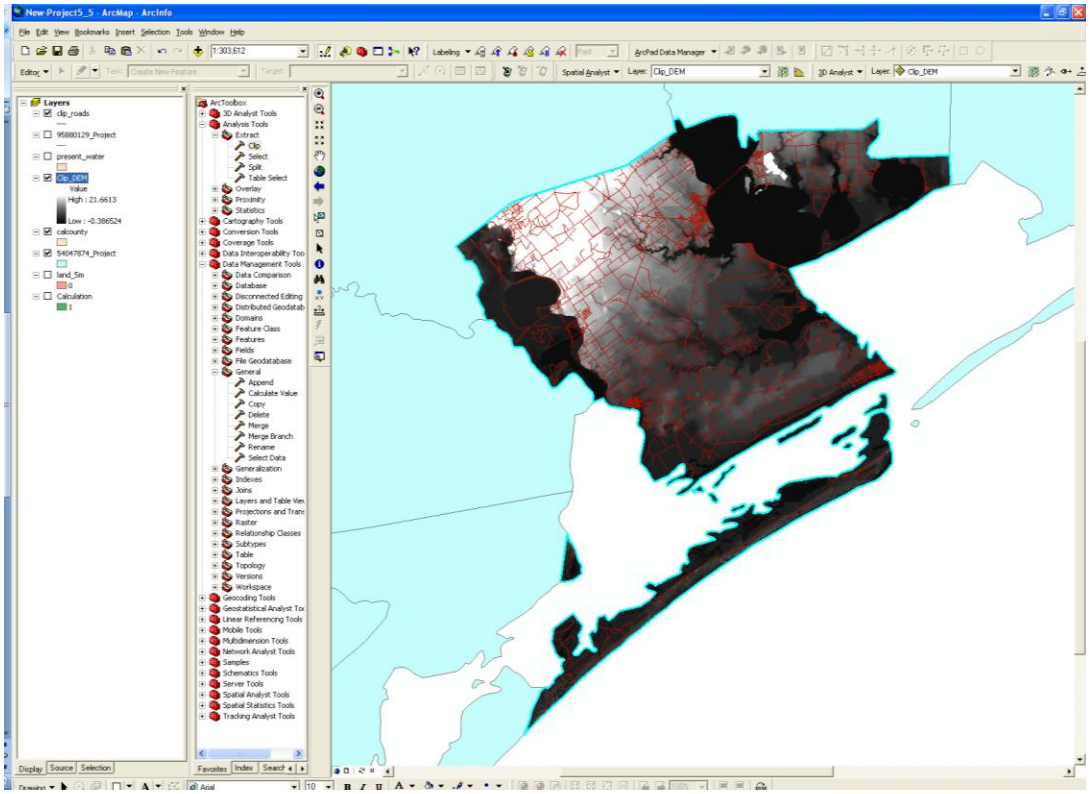

Figure 4 – ArcMap data view showing clipped DEM and clipped roads within the Calhoun County boundary.

5. Next, using the raster calculator again, create 2 binary rasters, one to display all land above sea level and one to display all land that is higher than 5 meters above sea level. The conditional statements used will be con([Clip_DEM]>0,1) and con([Clip_DEM)]>5,1). After the rasters are made make the data permanent and rename them.

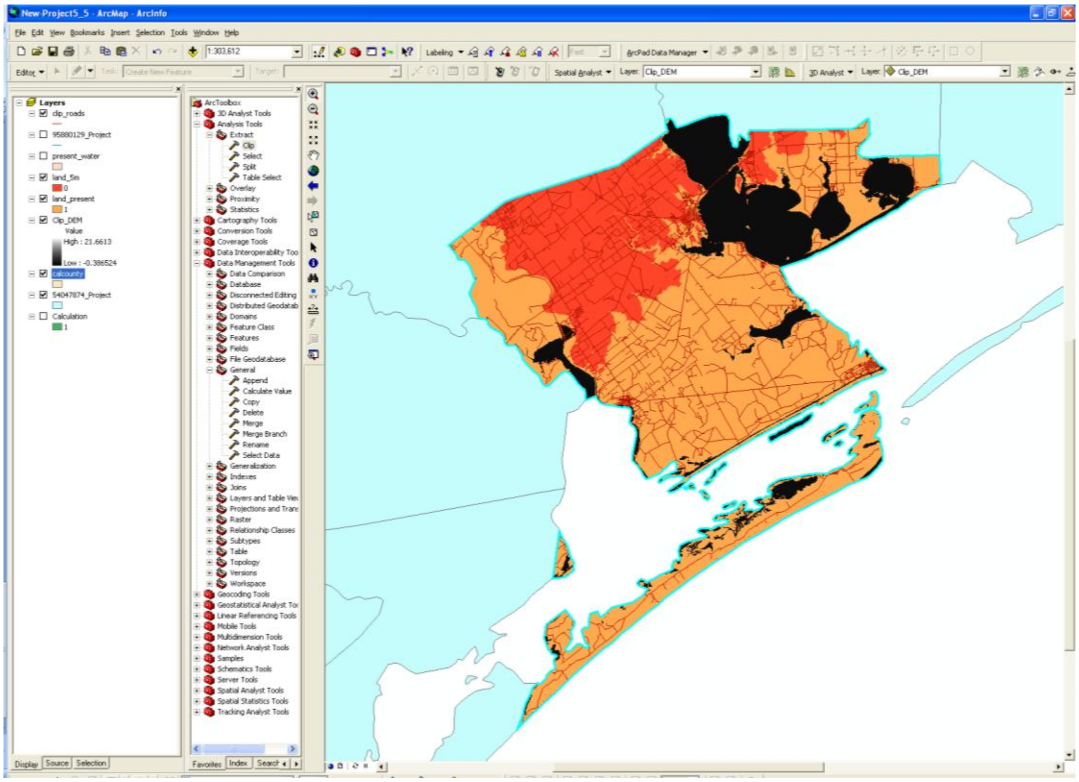

Figure 5 – ArcMap data view display the two binary rasters placed on top of the DEM. The orange raster represents all land above the current sea level and the red raster represents all land greater than 5 meters above sea level.

6. Based on these two rasters, use the 3D Analyst tool to calculate the land area in square meters. With the layer of choice selected, go to 3D Analyst > Surface Analyst > Area and Volume. The input surface should be whichever raster's area is being calculated and the height of the plane should be set to 0. Click the calculate statistics button and save the text file to be used later in analysis.

7. To determine the amount of roads which will be covered by water following the sea level rise, first convert to binary rasters into polygons. These new polygons will serve as a mask to determine the length of roads that fall within the county and within the land area above 5 meters. This is done using Spatial Analyst >Convert > Rasters to Features.

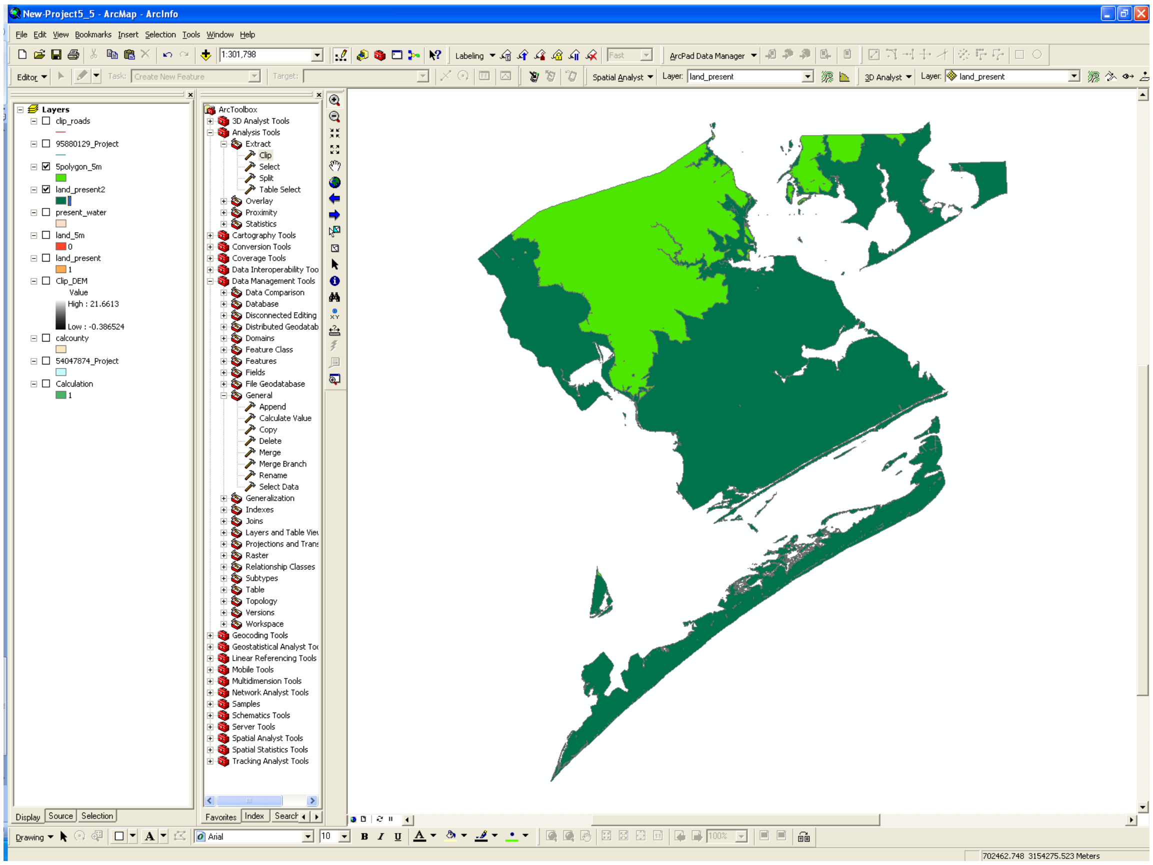

Figure 6 – ArcMap data view of polygons for current land area (blue) and land area after 5 meter sea level rise (green).

8. To determine the length of roads which are not flooded by the sea level rise, clip the roads shapefile to the new 5m polygon. The process is the same as step 3, ArcToolbox > Analyst Tools > Extract > Clip.

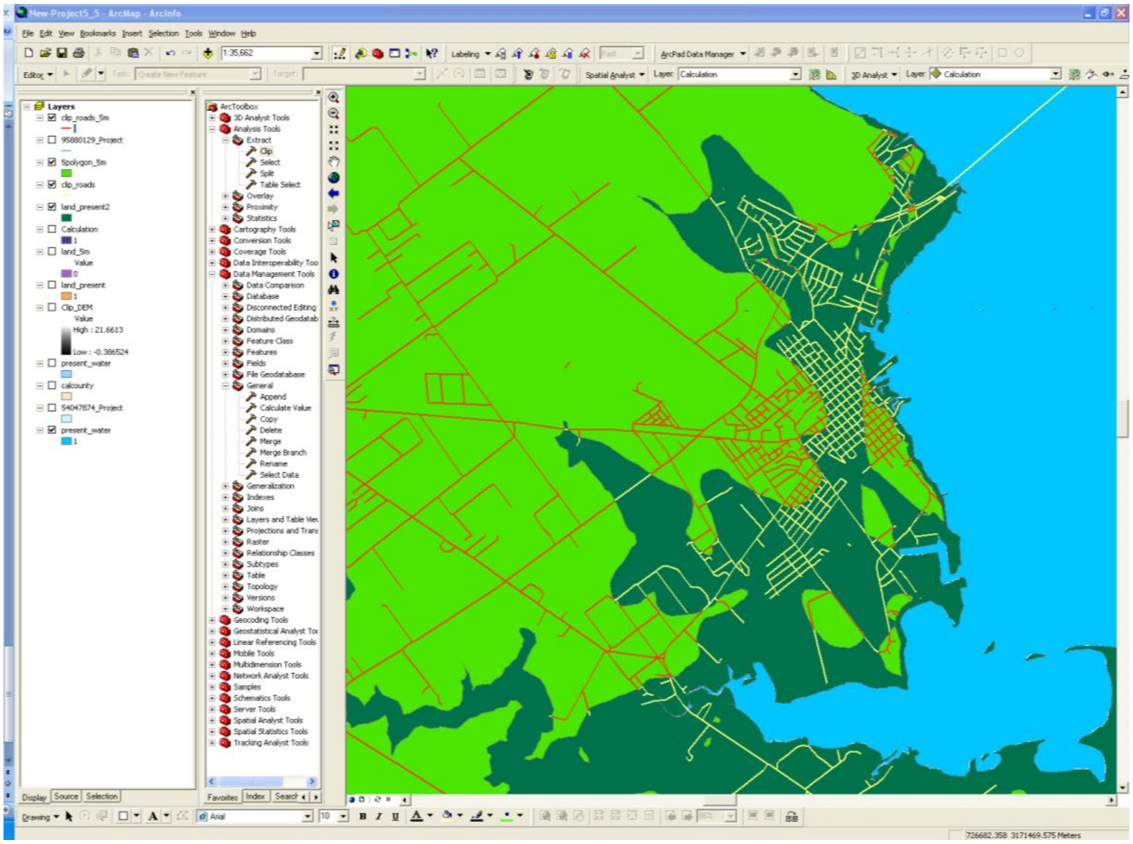

Figure 7 – Zoomed in ArcMap data view displaying roads not affected (red), roads flooded by the rise (yellow).

9. The length of all roads and length of roads not affected by sea level rise can be calculated by adding a new field to each attribute table and calculating geometry for each. Once calculation is done right click on the new field for length and select "Statistics." This gives the sum of the length of the selected roads in meters.

RESULTS:

1. **Land Area –** The calculations for total land area and land are not affected by sea level rise can be computed in 2 different ways. The results of each with be averaged to give these areas in kilometers squared.
    a. The first way to determine area is taking the total number of cells in each binary raster and multiplying it by 100. This would render results in square meters.

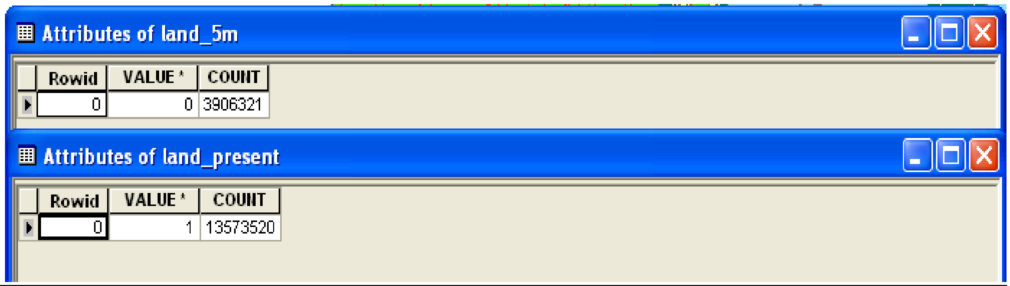

Figure 8 – Attribute tables for 2 binary rasters – COUNT = amount of cells.

b. The second way to calculate the area is to use the 3d Analyst Tool > Surface Analyst > Area and Volume. This will be done to for each of the two rasters with the plane height set to 0.

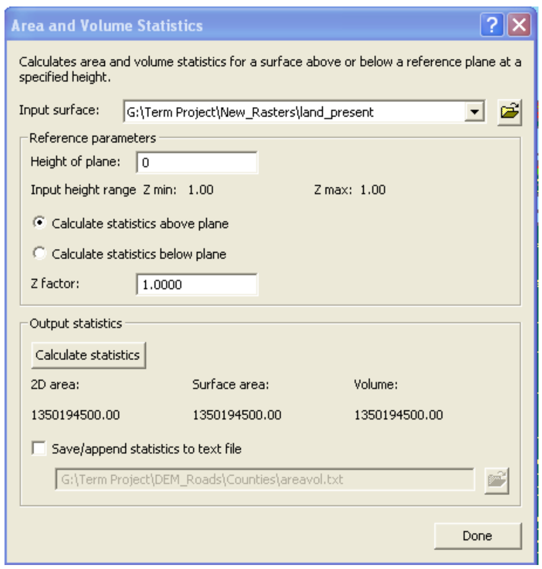

Figure 9 – 3d Analyst Tool

c. The results were averaged to produce the following 2D areas:
   i. Total Land = 1353773250 square meters = 1353.77325 square kilometers
   ii. Land Not Affected = 389491700 square meters = 389.4917 square kilometers

2. **Total Length of Roads in county and total length not flooded** – The calculations for the lengths of roads in the county and roads above water after sea level rise will be calculated by using the attribute tables of both of the road shapefiles. In each attribute table a new field for length will be create and geometry will be calculated for both. The “Statistics” feature will sum up the results in meters.

Attributes of 95880129_Project

FID	Shape *	FNODE_	TNODE_	LPOLY_	RPOLY_	LENGTH	BDT_ROADS6	BDT_ROADS_	PREFIX	NAME	TYPE	SUFFIX	FCC	FIPS	Data
0	Polyline	23173	23163	0	0	0.009922	0	26285		UNNAMED STREET			A41	48007	1070
1	Polyline	1492930	1492928	0	0	0.001728	0	1755861		UNNAMED STREET			A41	48469	171
2	Polyline	1492922	1492923	0	0	0.000349	0	1755853		UNNAMED STREET			A41	48469	38
3	Polyline	1492904	1492881	0	0	0.007649	0	1755836		UNNAMED STREET			A41	48469	816
4	Polyline	1492224	1683331	0	0	0.024723	0	2231160		STUBBLEFIELD	RD		A41	48469	2513
5	Polyline	1492210	1492204	0	0	0.000605	0	1755107		UNNAMED STREET			A41	48469	67
6	Polyline	1492259	1492210	0	0	0.00622	0	1755155		UNNAMED STREET			A41	48469	682
7	Polyline	1492200	1492193	0	0	0.002571	0	1755096		UNNAMED STREET			A41	48469	263

Attributes of clip_roads_5m

FID	Shape *	FNODE_	TNODE_	LPOLY_	RPOLY_	LENGTH	BDT_ROADS6	BDT_ROADS_	PREFIX	NAME	TYPE	SUFFIX	FCC	FIPS	DATA
0	Polyline	201286	201155	0	0	0.014476	0	233088		UNNAMED STREET			A41	48057	1484
1	Polyline	201118	201173	0	0	0.002389	0	232937		UNNAMED STREET			A40	48057	252
2	Polyline	1492655	200705	0	0	0.000534	0	1755612		UNNAMED STREET			A40	48469	57
3	Polyline	200680	200670	0	0	0.001043	0	1941779		UNNAMED STREET			A40	48057	110
4	Polyline	201573	201598	0	0	0.004845	0	233421		UNNAMED STREET			A40	48057	510
5	Polyline	201247	201228	0	0	0.003029	0	233033		UNNAMED STREET			A41	48057	316
6	Polyline	201246	201233	0	0	0.000758	0	233031		UNNAMED STREET			A41	48057	78
7	Polyline	200649	200637	0	0	0.002014	0	232269		UNNAMED STREET			A40	48057	205
8	Polyline	200619	200618	0	0	0.002772	0	232234		UNNAMED STREET			A40	48057	290
9	Polyline	201385	201329	0	0	0.010941	0	1941917		UNNAMED STREET			A40	48057	1092
10	Polyline	201096	201040	0	0	0.002131	0	232836		UNNAMED STREET			A40	48057	225
11	Polyline	200677	200658	0	0	0.001395	0	1941780		UNNAMED STREET			A41	48057	154
12	Polyline	200774	200743	0	0	0.002683	0	232409		UNNAMED STREET			A41	48057	273
13	Polyline	200743	200759	0	0	0.001297	0	232389		UNNAMED STREET			A40	48057	133
14	Polyline	200658	200612	0	0	0.003236	0	232279		UNNAMED STREET			A41	48057	357
15	Polyline	201419	201462	0	0	0.005026	0	1941943		UNNAMED STREET			A41	48057	527
16	Polyline	200846	200685	0	0	0.014636	0	232505		UNNAMED STREET			A40	48057	1531
17	Polyline	201927	202050	0	0	0.02788	0	1942094		STATE HWY 35			A30	48057	2828
18	Polyline	201583	201582	0	0	0.001479	0	233408		UNNAMED STREET			A41	48057	159
19	Polyline	201284	201184	0	0	0.012307	0	233084		UNNAMED STREET			A41	48057	1254
20	Polyline	201297	201244	0	0	0.017364	0	1941902		UNNAMED STREET			A41	48057	1757
21	Polyline	200685	200688	0	0	0.002142	0	232313		UNNAMED STREET			A40	48057	212
22	Polyline	201965	201902	0	0	0.024494	0	233806		UNNAMED STREET			A41	48057	2500
23	Polyline	201448	201244	0	0	0.013836	0	1941913		UNNAMED STREET			A41	48057	1436
24	Polyline	201177	201169	0	0	0.00086	0	232942		UNNAMED STREET			A41	48057	86
25	Polyline	201680	201616	0	0	0.015407	0	1941996		UNNAMED STREET			A41	48057	1569
26	Polyline	201516	201487	0	0	0.004497	0	233340		UNNAMED STREET			A41	48057	453

Record: 0 Show: All Selected Records (0 out of 1725 Selected) Options

Figure 10 – Attribute tables for roads files showing new field for lengths in meters.

- The resulting lengths were as follows:
    a. Length of all roads in County – 3129933 meters = 3 129.933 kilometers
    b. Length of roads within 5m polygon – 753070 meters = 753.07 kilometers

SUMMARY OF RESULTS:

The results of this project show a 5 meter sea level rise's enormous effect on Calhoun County. The total land area of the county was reduced from **1353.77325 square kilometers** down to **389.4917 square** kilometers. This means that under a 5 meter rise in sea level approximately **28%** of the original land area would not be affected. The total length of all roads in Calhoun County was **3129.933 kilometers** and the total length of roads not flooded was **753.07 kilometers**. This shows that nearly **76%** of all roads within the Calhoun County boundary would be flooded by a 5 meter sea level rise.

This project assumes a hypothetical storm surge cause by a hurricane causing a 5 meter rise in the current sea level. Data and statistics acquired through studies such as this can be very useful in evacuation planning and damage estimations. There are numerous other statistics that could be extracted by adding more data to this project and using similar methods to produce the desired results.