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Suitability Analysis of Solar-Powered Brackish Groundwater Desalination, Texas

Problem Formulation

As the population of Texas grows, and with it the demand for water, we will need to develop new and innovative strategies to augment Texas' water supplies. One such strategy is brackish groundwater desalination, whereby brackish groundwater is extracted, desalinated, and used to supplement the municipal water supply. However, brackish groundwater desalination is not without its difficulties. Desalination is an energy-intensive process, and it is therefore very expensive. One possible method for reducing the cost of brackish groundwater desalination is utilizing intermittent solar-energy to power desalination. For my project, I will conduct a suitability analysis to determine where in Texas it is most viable to pursue solar-powered brackish groundwater desalination. In order to do so, I will retrieve GIS data on brackish groundwater and photovoltaic potential in Texas. After preprocessing the files, I will then convert them to raster files and reclassify them appropriately. This will allow me use the raster calculator to combine the raster files, and thereby determine where in Texas major areas of photovoltaic potential coincide with brackish groundwater. This will give me a general idea of where in Texas solar-powered brackish groundwater desalination is most viable, thus providing insight into further economic or political research.

Data Collection

In order to conduct my suitability analysis, I retrieved 3 files from online:

“Texas_Brackish_Aquifers”

- Retrieved from the Texas Water Development Board
- (<https://www.twdb.texas.gov/innovativewater/bracs/GISdata.asp>)
- A shapefile that displays areas of Texas underlain by brackish aquifers

“US_Solar_Data”

- Retrieved from the National Renewable Energy Laboratory
- (http://www.nrel.gov/gis/data_solar.html)
- A shapefile that displays photovoltaic potential in kWh/m²/Day by 10 km squares

“TX_Boundary”

- Retrieved from www.landsat.com
 - (<http://www.landsat.com/texas-free-gis-data.html>)
 - A shapefile that displays the Texas boundary
-

Data Preprocessing

After retrieving the project files, I opened them in ArcCatalog. I then opened the “Batch Project” tool (located in Data Management Tools>Projections and Transformations). Because my analysis spans the full extent of Texas, I chose to convert all of the project files to “NAD_1983_Texas_Statewide_Mapping_System” (see Figure 1). Lastly, although this may not qualify as preprocessing, I created a copy of “TX_Boundary” named “TX_Append,” which I would use later for rasterizing the “Texas_Brackish_Aquifers” data. I then organized all of these newly projected files in a folder named “New_Projections” (see Figure 2).

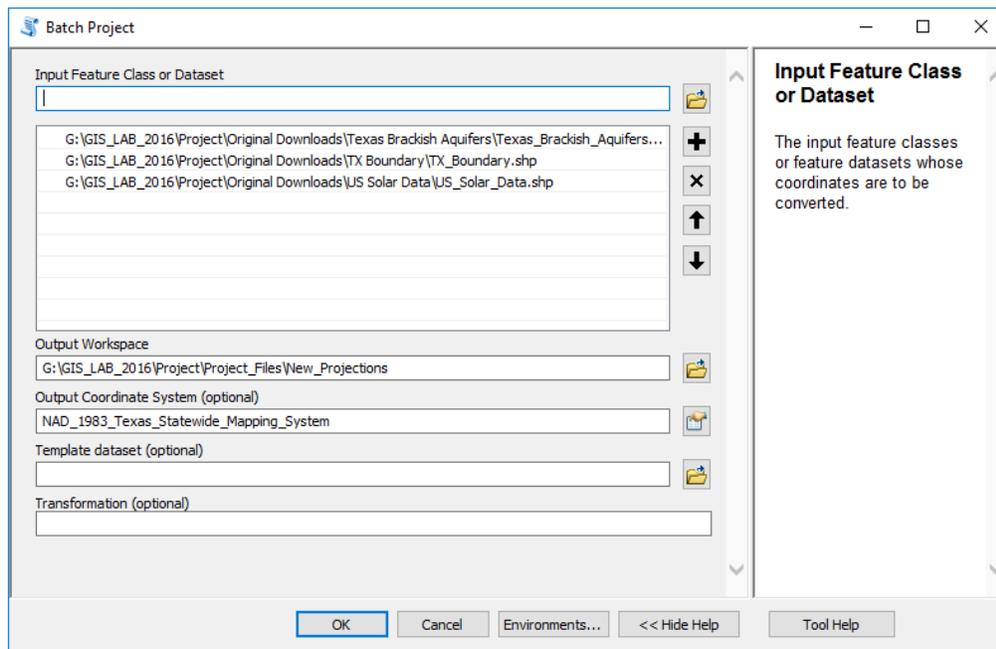


Figure 1: Using the “Batch Project” tool to convert the original files to a new coordinate system.

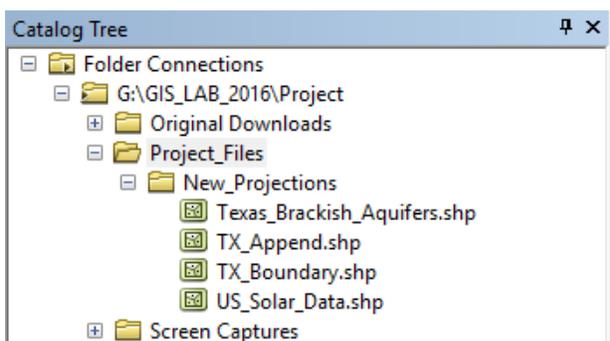


Figure 2: All of the project files organized into a folder.

ArcMap Processing

Part I: Rasterizing the Texas Brackish Aquifers Shapefile

In order to rasterize the “Texas_Brackish_Aquifers” shapefile, I first added it and “TX_Append” to ArcMap. Because the “Texas_Brackish_Aquifers” shapefile does not include a Texas boundary, I appended it to “TX_Append”, which is a shapefile of the Texas boundary (see Figure 3). The resulting shapefile is displayed in Figure 4.

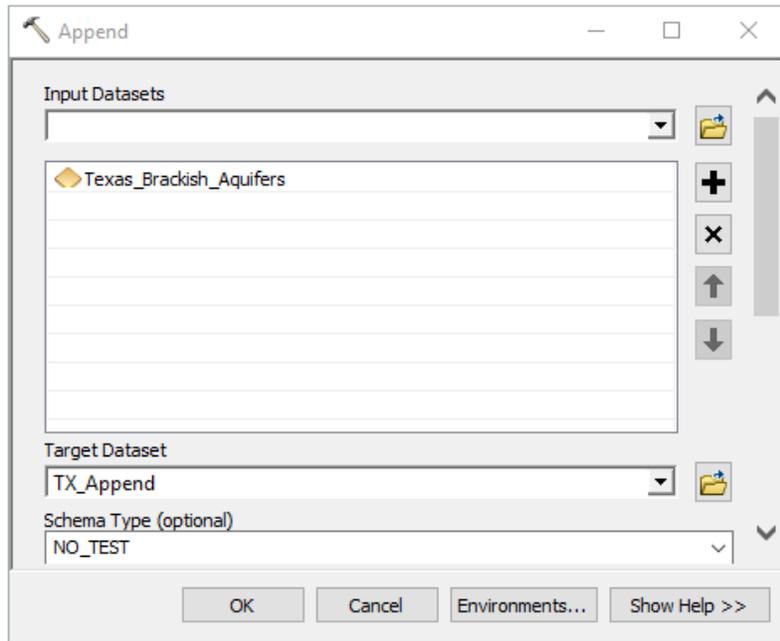


Figure 3: Using the “Append” tool to append “Texas_Brackish_Aquifers” to “TX_Append.”

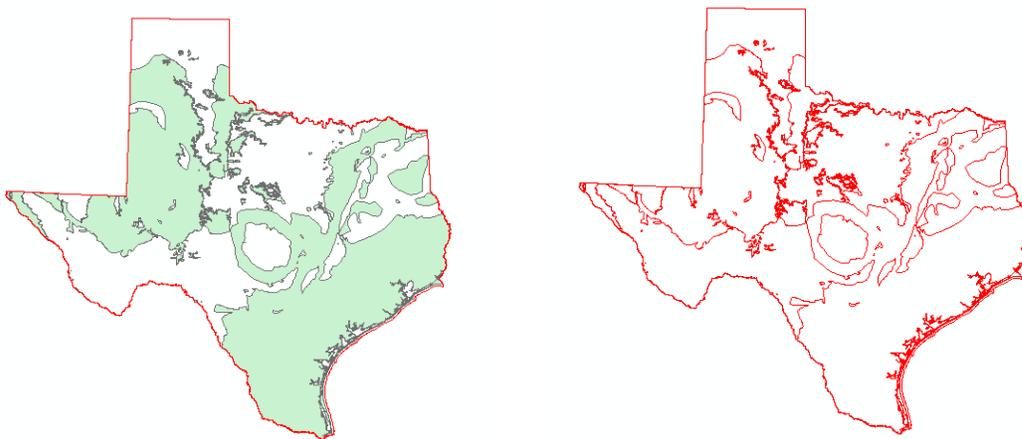


Figure 4: “Texas_Brackish_Aquifers” and “TX_Append” in ArcMap before appending (Left). “TX_Append” after appending (Right).

Next, I opened editor and started editing “TX_Append”. With the edit tool, I selected the outline of the Texas brackish aquifers. I then selected clip from the dropdown menu of the editor toolbar, accepted the default options, and pressed OK (see Figure 5).

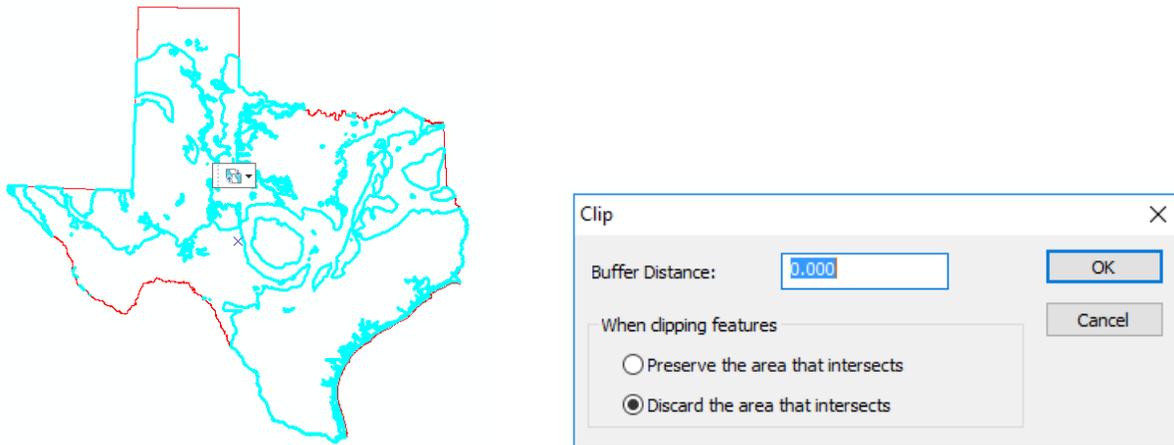


Figure 5: Selection of brackish aquifers outline (Left). Selecting “Clip” from dropdown editor menu (Right).

Lastly, I opened the “Feature to Raster” tool (located in Conversion Tools>To Raster), and converted the “TX_Append” shapefile to a raster using the field “FID” and specifying an output cell size of 10,000 meters (see Figure 6). I specified an output cell size of 10,000 meters in order to match the “US_Solar_Data” cell size of 10 kilometers. The resulting raster file named “TX_Brackish” displays areas that are NOT underlain by brackish groundwater as 0, and displays areas that ARE underlain by brackish groundwater as 1 (see figure 7).

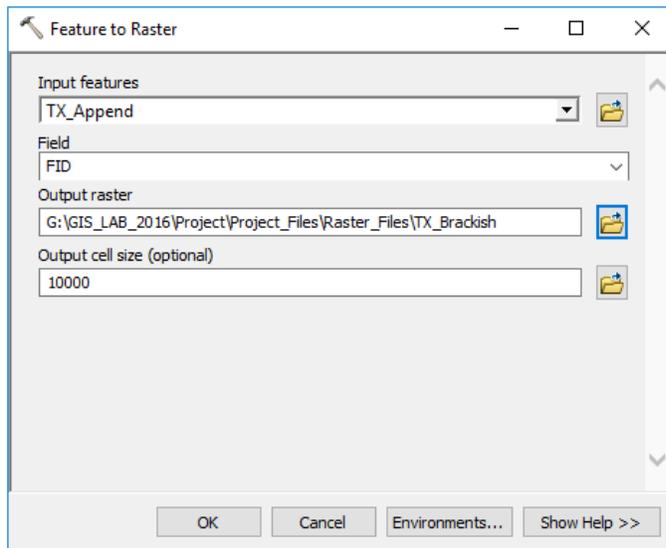


Figure 6: Using the “Feature to Raster” tool to create a raster file.

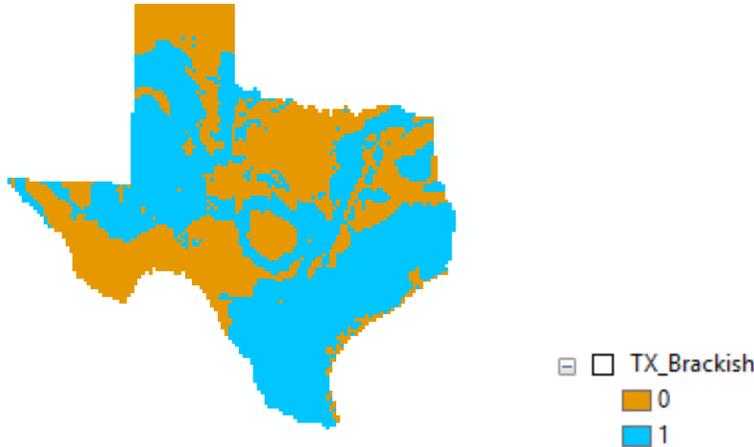


Figure 7: New “Texas_Brackish” raster file.

Part II: Rasterizing the US Solar Data Shapefile

In order to rasterize the “US_Solar_Data” shapefile, I first added it and “TX_Boundary” to ArcMap. I then went to Geoprocessing>Environments>Raster Analysis, and set the “Mask” to “TX_Boundary.” Then, I went about symbolizing the data to display more appropriately. I began by navigating to the symbology tab of “US_Solar_Data.” There, I selected quantities and specified the value as “ANN_LATILT.” Then, under classify, I set a defined interval of 0.5. Lastly, I set the color ramp to “Yellow to Red” (see Figure 8). The resulting display is much more informative (see figure 9).

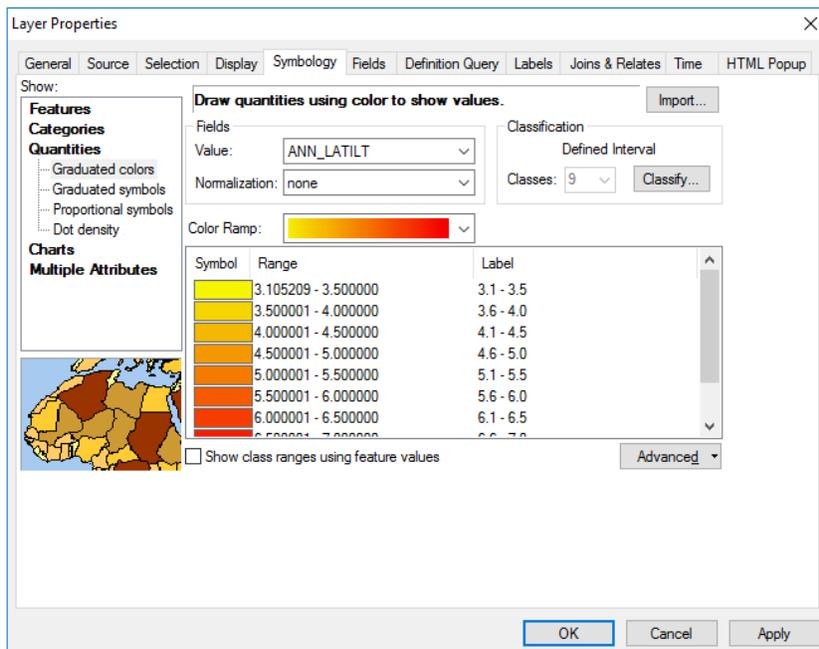


Figure 8: Symbology for “US_Solar_Data”.

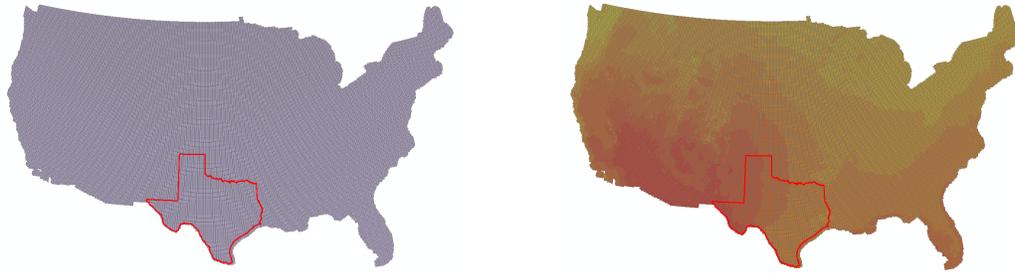


Figure 9: The “US_Solar_Data” shapefile before and after new symbology.

Following this, I then opened the “Feature to Raster” tool and converted “US_Solar_Data” to a raster file using the field “ANN_LATILT” and specifying a cell size of 10,000 meters (or 10 kilometers—the same cell size as used in the original shapefile). I named the resulting raster file “US_Solar”. I then used the “Extract by Mask” tool (located in Spatial Analyst Tools>Extraction), setting the input raster as “US_Solar” and the mask as “TX_Boundary” (see Figure 10). I named the output raster “TX_Solar”, and symbolized it as done previously (see Figure 11).

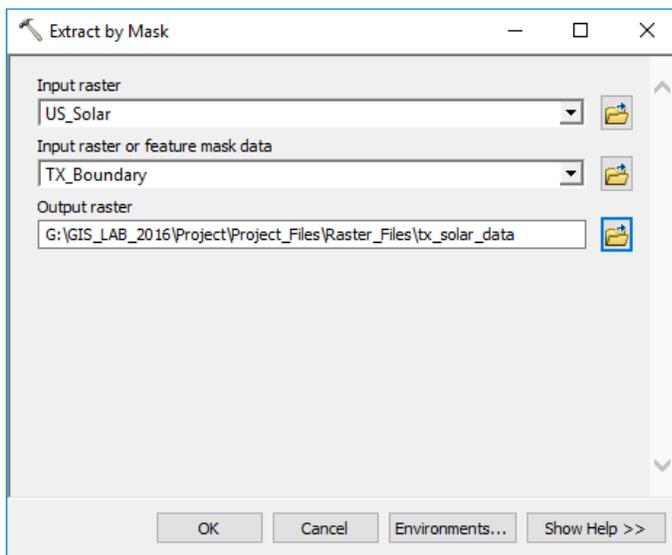


Figure 10: Using the “Extract by Mask” tool.

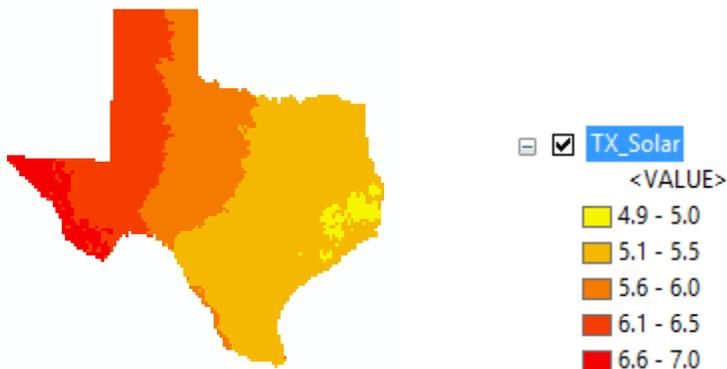


Figure 11: New “TX_Solar” raster file.

Part III: Reclassifying the Solar Raster File

After creating the brackish and solar raster files, I chose to leave the brackish raster file classified as is (i.e., a binary raster). However, I reclassified the solar raster file using the reclassify tool (located in Spatial Analyst Tools>Reclass) (see Figure 12). I named the output raster “TX_Solar_Re” (see Figure 13).

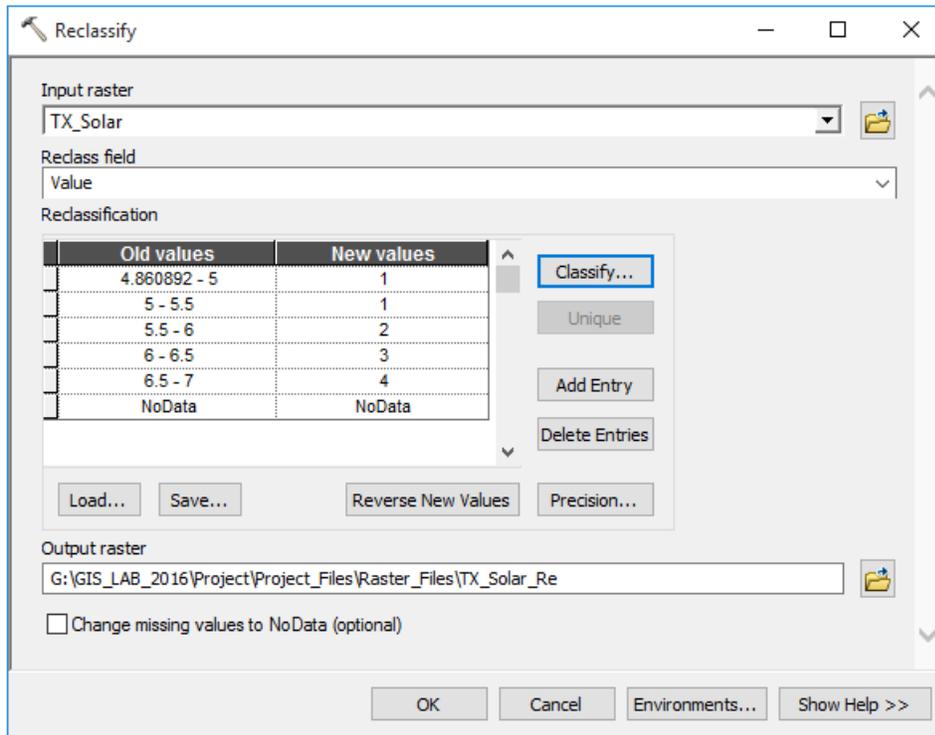


Figure 12: Using the “Reclassify” tool to reclassify the “TX_Solar” raster file.

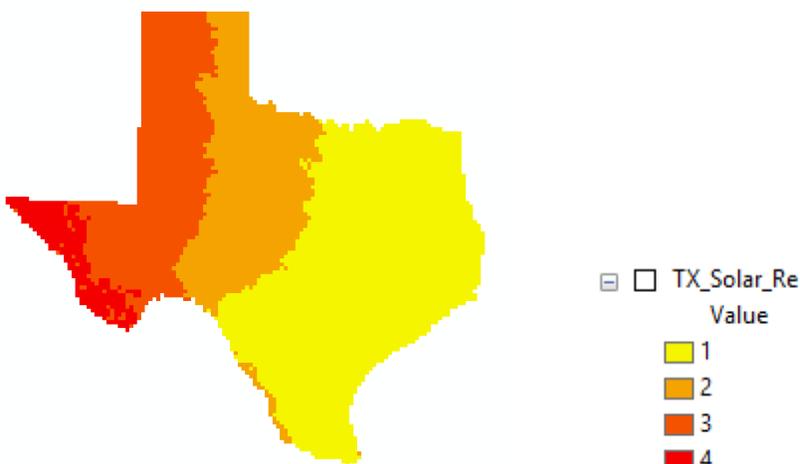


Figure 13: New “TX_Solar_Re” raster file.

Part IV: Combining the Raster Files

After I finished creating the two raster files for the suitability analysis, “TX_Brackish” and “TX_Solar_Re”, I set about creating the final suitability analysis. To do so, I opened raster calculator (located in Spatial Analyst Tools>Map Algebra) and added “TX_Solar_Re” and “TX_Brackish” (see Figure 14). I named the output raster “Analysis”, and assigned an appropriate symbology (see Figure 15). Now, based on the two factors I employed, 10-kilometer squares are ranked 1-5 based on their viability to install brackish groundwater desalination, with 5 representing the most viable areas.

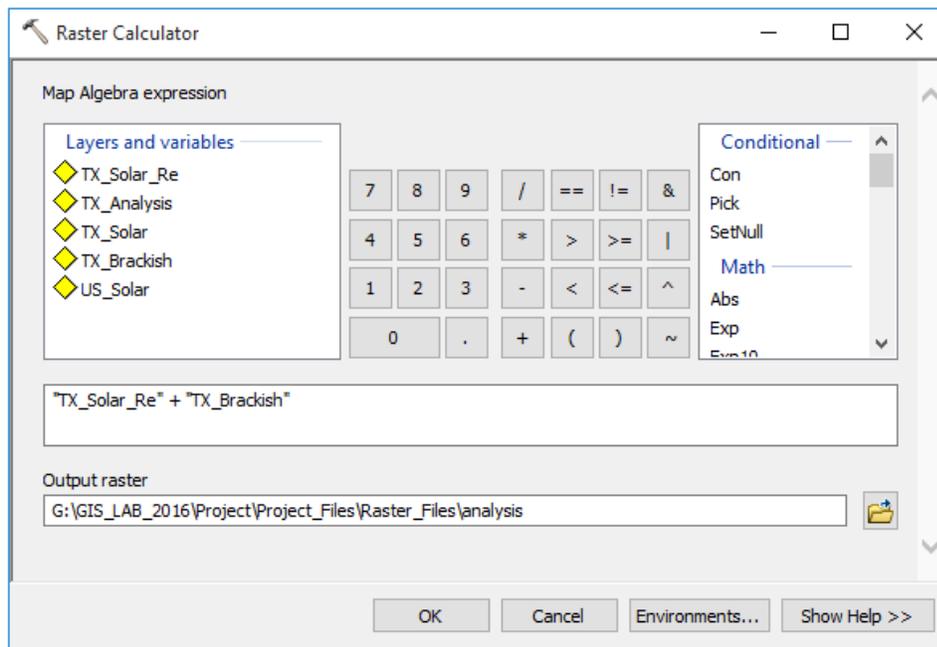


Figure 14: Using “Raster Calculator” to combine “TX_Solar_Re” and TX_Brackish”.

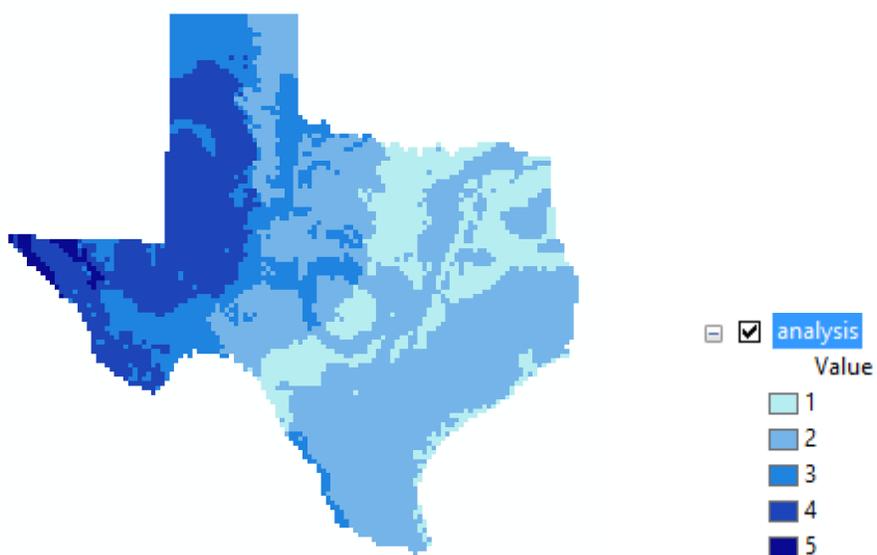
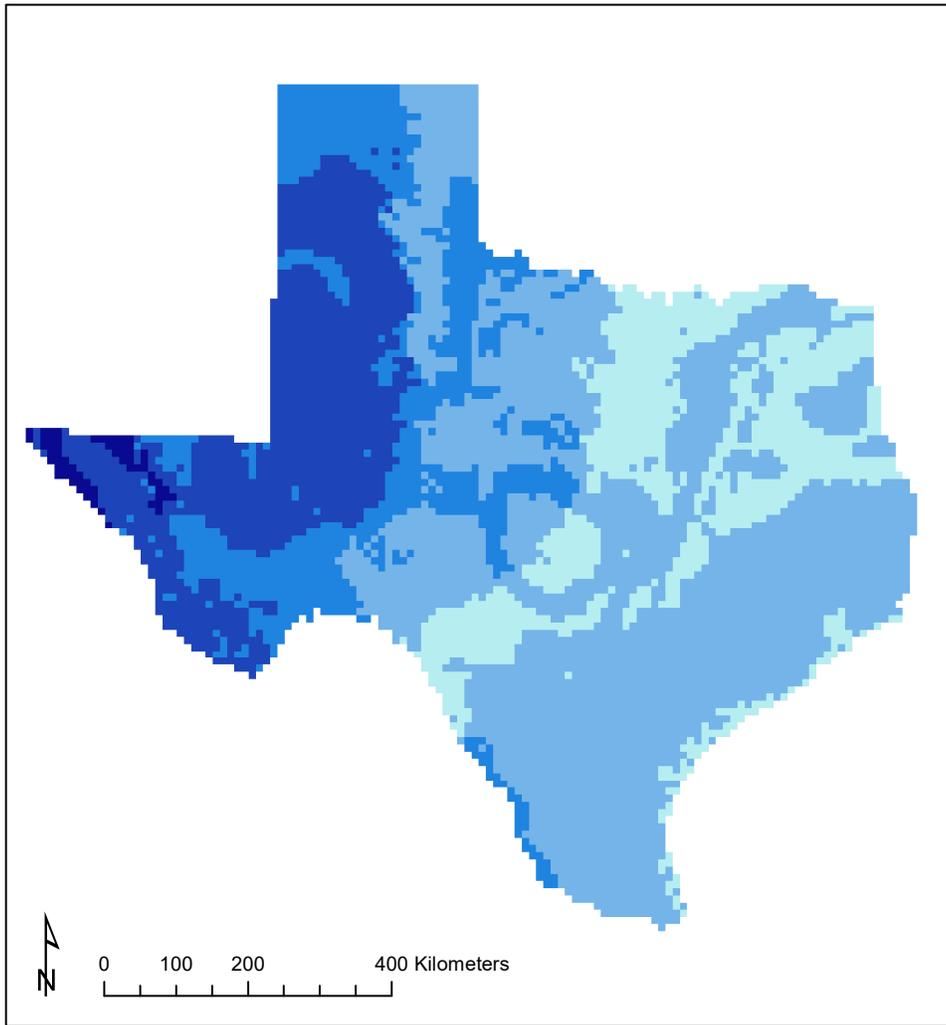


Figure 15: New “Analysis” raster file.

Final Presentation of Data

Matt Saenz - 12/5/2016

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Explanation	
Lightest Blue	1
Light Blue	2
Medium Blue	3
Dark Blue	4
Darkest Blue	5

NAD 1983 Texas Statewide Mapping System
1:8,000,000

Conclusion

Based on my suitability analysis, I have determined that the areas of Texas where solar-powered brackish groundwater desalination are most viable include the Hueco Bolson area, as well as parts of West Texas and the Pan Handle. Viability generally increases moving from the South East to the North West. This makes sense, given that photovoltaic potential increases in the same direction, and that a significant portion of Texas' brackish groundwater is concentrated in the North West area. Overall, this study was a good learning experience, although more descriptive brackish groundwater data would have helped created a more informative final product. Additionally, I only considered two factors: Photovoltaic potential and areas underlain by any groundwater considered brackish. In reality, however, a myriad of other factors would also be relevant. Still, I think my suitability analysis proved to be an informative exercise, and that a simple analysis such as this at least provides a basis for further, more localized research. Further areas of research could be economic and political considerations, which would also be important factors that help or hinder solar-powered brackish groundwater desalination in a given area.