From Sea to Sea: Saving The Dead Sea

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GEO 327G386G

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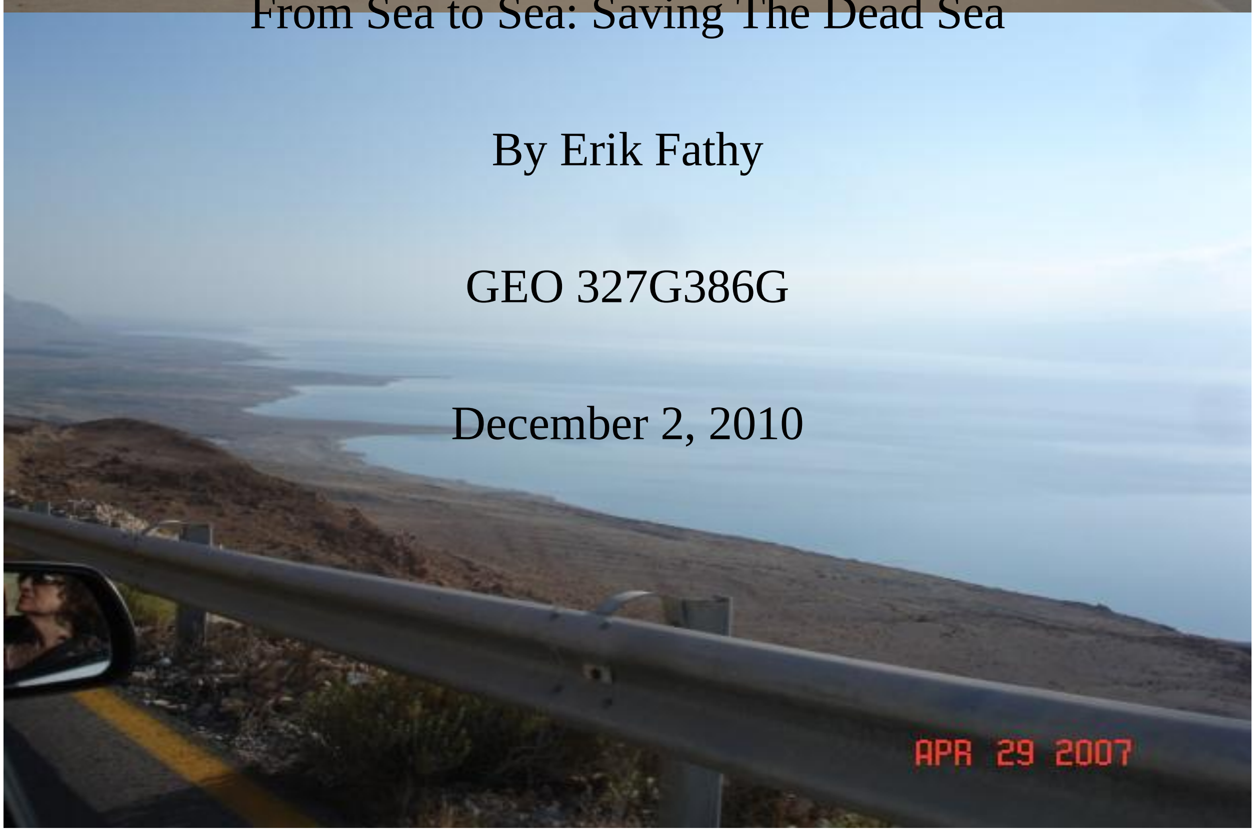

I. Introduction

A) Purpose: The main purpose of this project is to map the best possible path for a canal from the Mediterranean Sea to the Dead Sea that will produce power and replenish the dwindling water supply in the Red Sea. This problem is complicated further by the need to avoid the West Bank and the Gaza Strip.

B) Problem Formulation:

a. What is the best path for the canal?

b. How to plan the best route based on the elevation and territorial boundaries?

i. To find the answer to these questions one must find the elevation and political boundary data.

ii. It is necessary to import the information found to the area maps found on Google Maps and then convert the Asc files that store (x,y) locations and elevations to grid files that can be opened with arc map.

iii. The four raster files were then mosaiced into one raster file and the political country boundaries were added.

iv. The section of Israel was cut out of the mosaic with parts of the surrounding nations.

v. This raster data was then evaluated with the spatial analysis to produce the elevation data.

vi. It was necessary to look up the elevation of the shoreline of the Dead Sea to use the spatial analysis tool to create contour data at -393m so that it will be possible to make a polygon of the Dead Sea to show where it is located on the map.

vii. Using the resulting map, it becomes possible to project a path that would best fit the natural elevations and avoid the West Bank and Gaza Strip.

c. State the results of the project.

II. Data Collection

• SRTM Data of the Middle East

o http://srtm.csi.cgiar.org/

• Arc GIS Data and Maps/Political Boundaries

ArcGIS 9 ESRI Data and Maps DVD

• Map Images (not useful for project)

o http://brightearth.computamaps.com/Catalogue/?freedata

http://www.mapcruzin.com/free-israel-maps.htm

• Google Maps

It was very difficult to find data on the Middle East that would work with ArcGIS. It was found with the assistance of Dr. Mark Helper (many thanks). Political Boundaries came from Dr. Helper's ArcGIS 9 Media Kit.

III) Data Processing

1) At first, the data was downloaded from the CGIAR Website and was limited to use with Google Earth (was not yet compatible with ArcMap)**. See figure 1.**

Figure 1 shows the elevation data links from the CGIAR website loaded into Google Maps with links to be able to download the SRTM data from Israel.

2) After downloading the four SRTM data blocks, it was necessary to extract the data from the zip files.

3) After opening ArcCatalog, the Asc files that store (x,y) locations and elevations are able to be seen.

4) Open the Arc Toolbox and find ASCII to Raster, that are grid files that can be opened with arc map. **See figure 2a,b,c.**

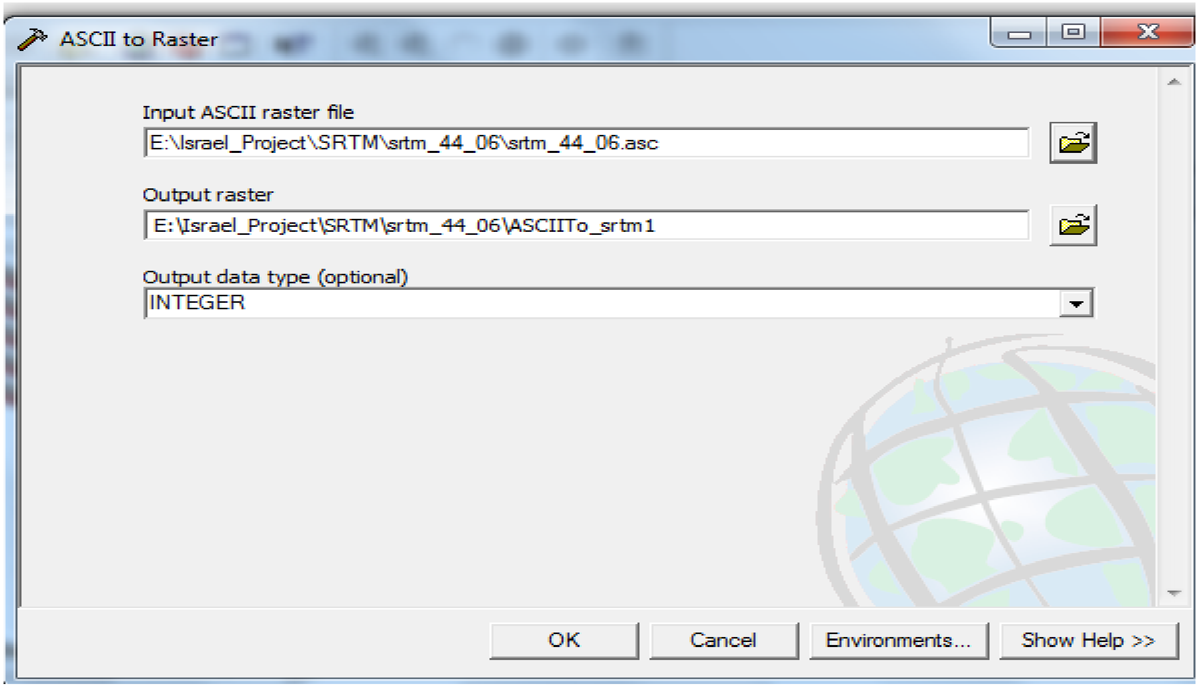

Figure 2a Showing how to convert the ASC files to Raster

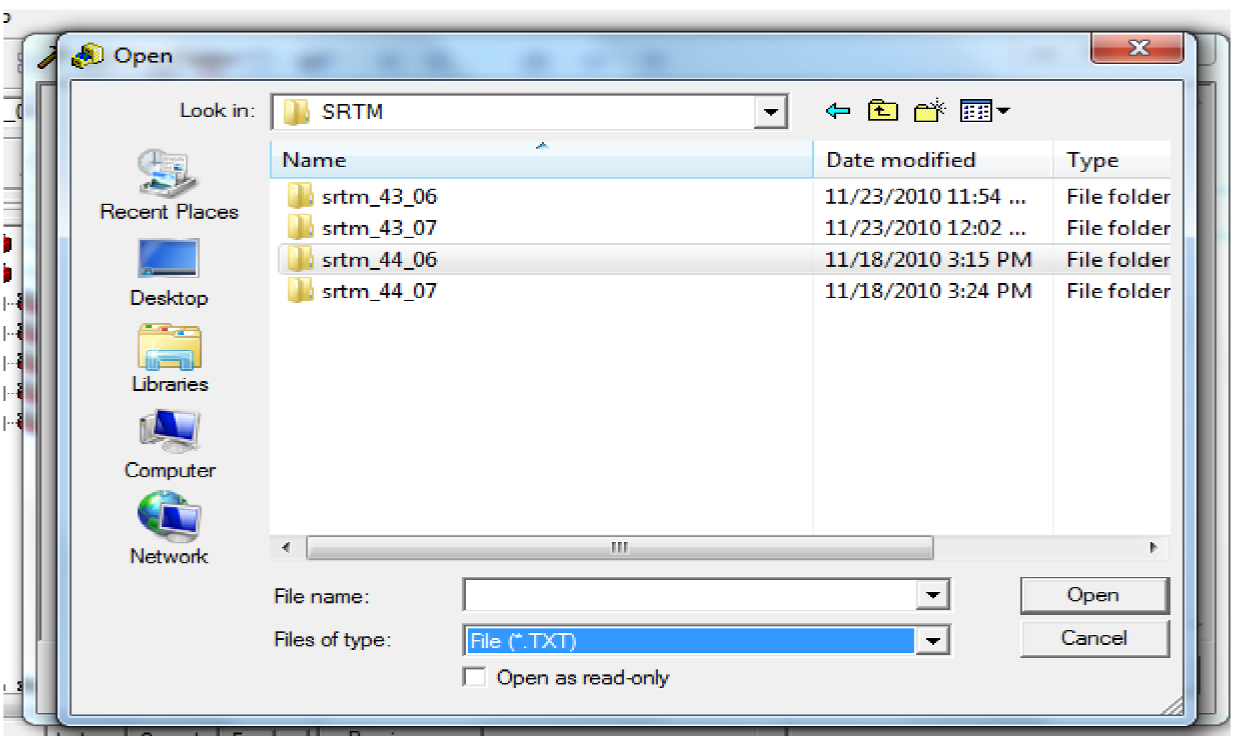

Figure 2b Showing the four files to be converted.

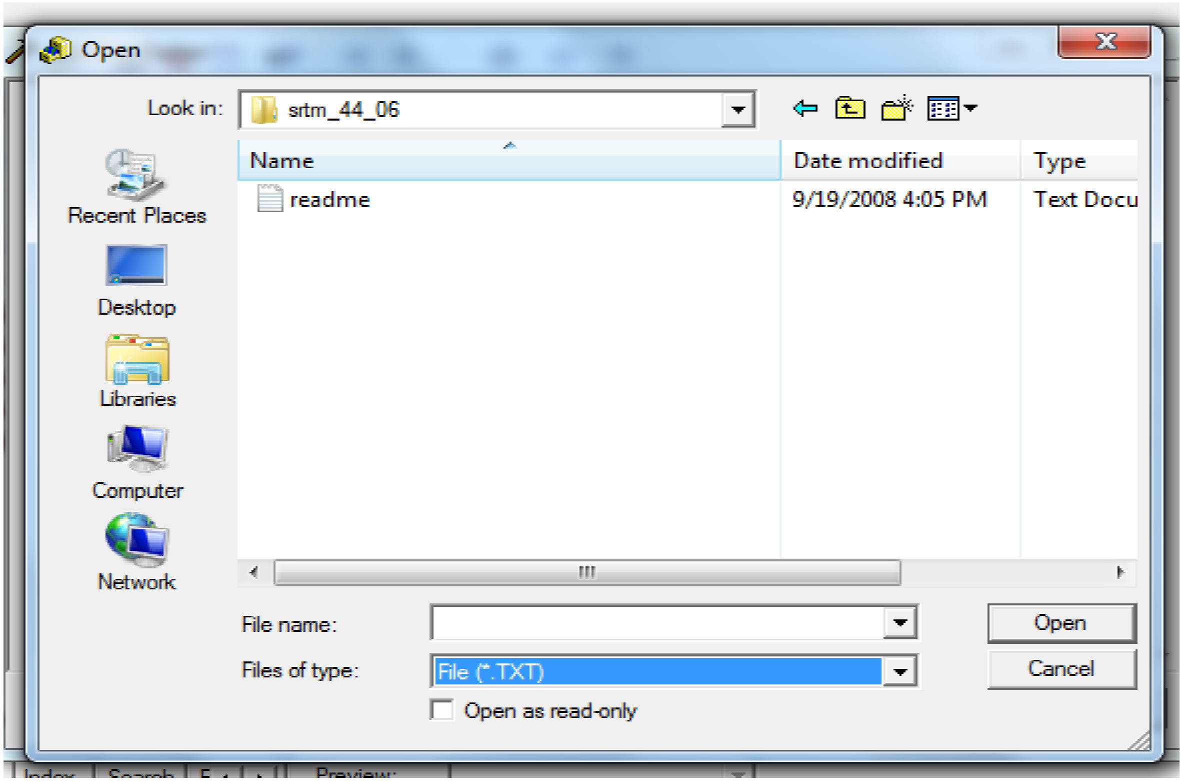

Figure 2c It is necessary to change "files of type" to all files from .TXT files so that you are able to see the ASC file to be converted.

5) Now that you have gathered the raster data, it is necessary to check the spatial data to see if it will be projected properly in ArcMap. Once you check the spatial reference, you will find that it says "undefined". **See Figure 3.**

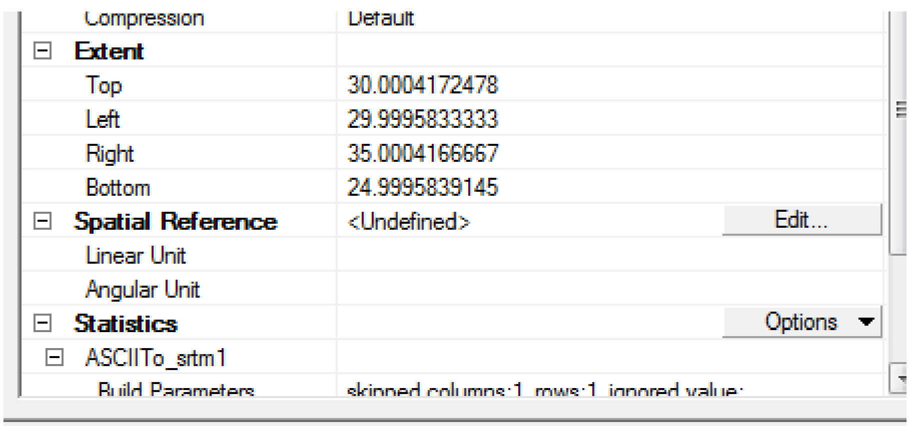

Figure 3 Showing the undefined spatial reference in properties of the new raster.

6) The process to define them is shown in **figure 4a, 4b, 4c, 4d.**

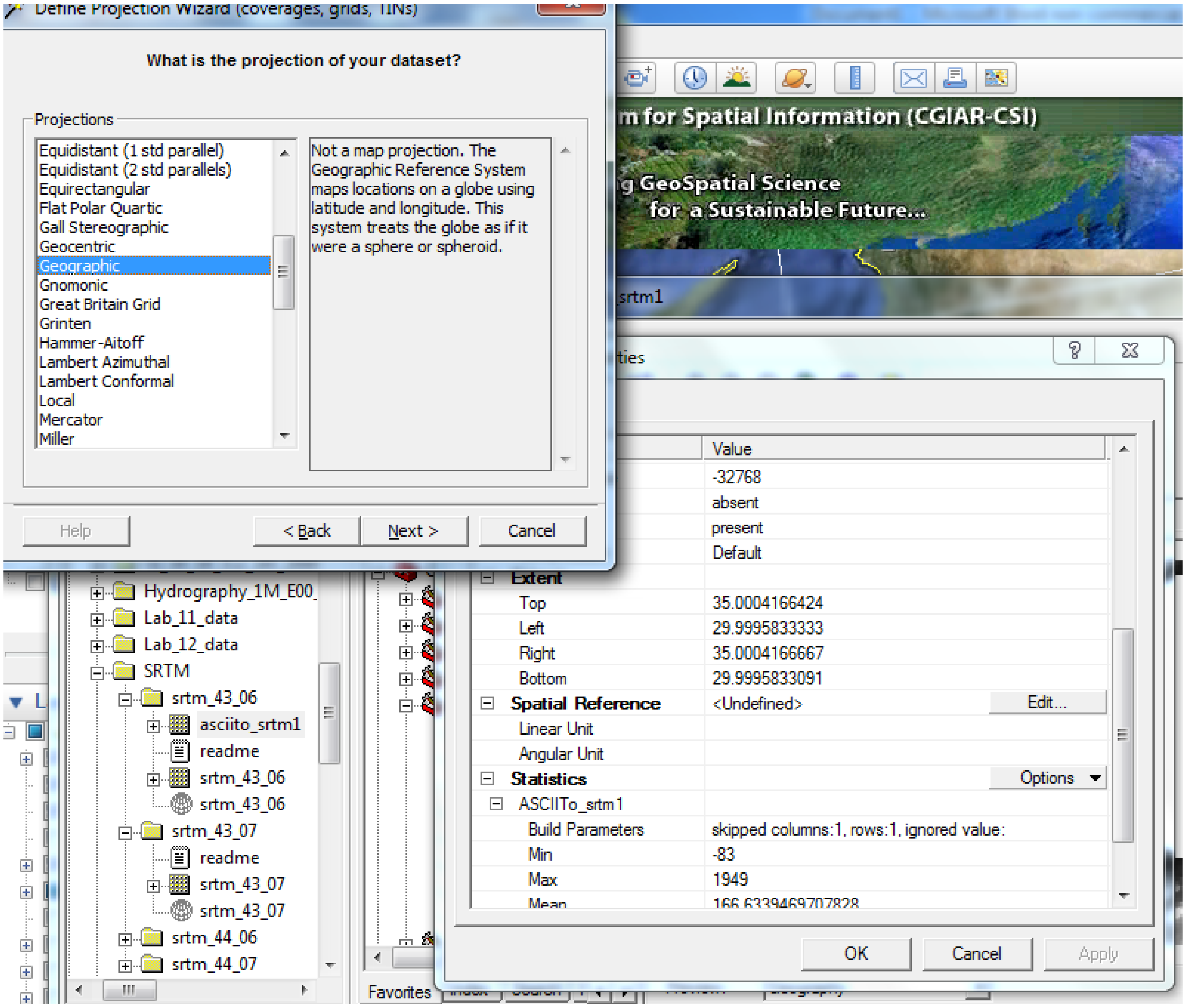

Figure 4a By pressing “Edit”, the window “Define Projection Wizard” is opened. Under “Projections”, hit “Geographic” then hit “Next”.

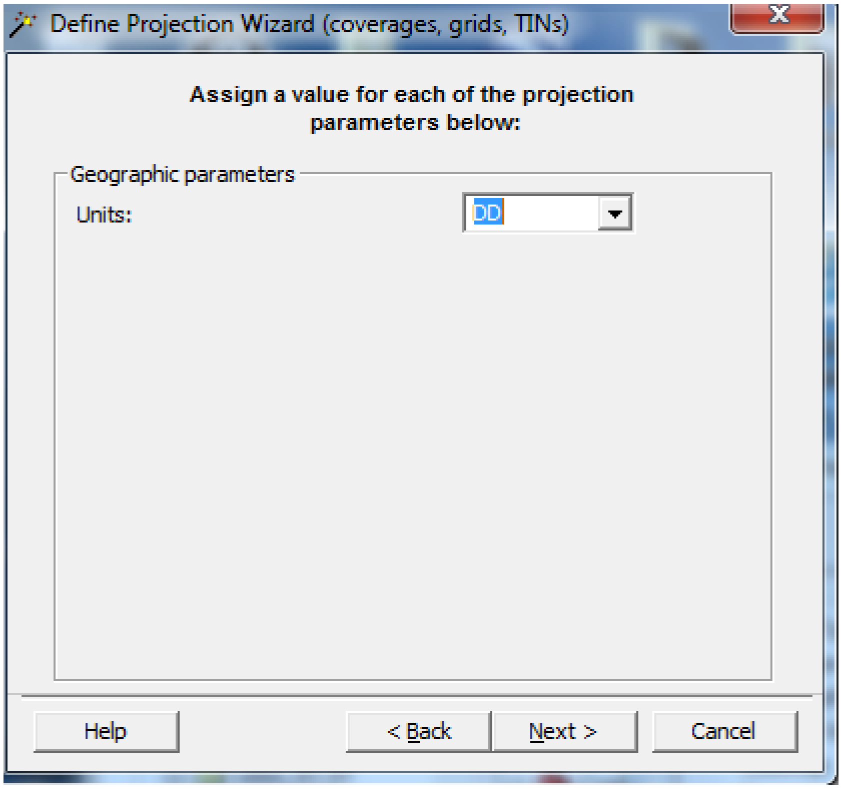

Figure 4b Under "Geographic parameters" choose decimal degree (DD) for the units. Hit "Next".

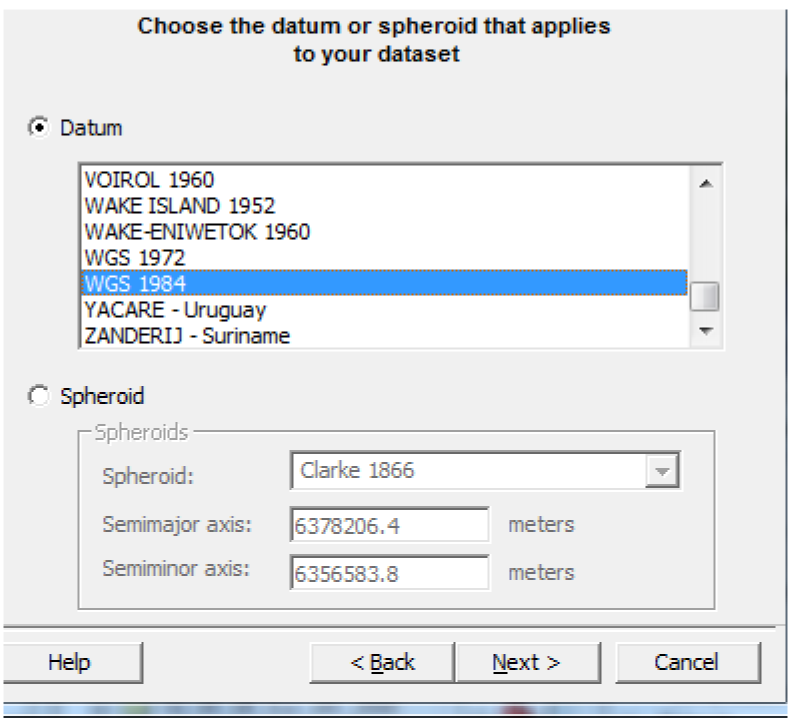

Figure 4c Choose the datum to be "WGS 1984". Hit "Next".

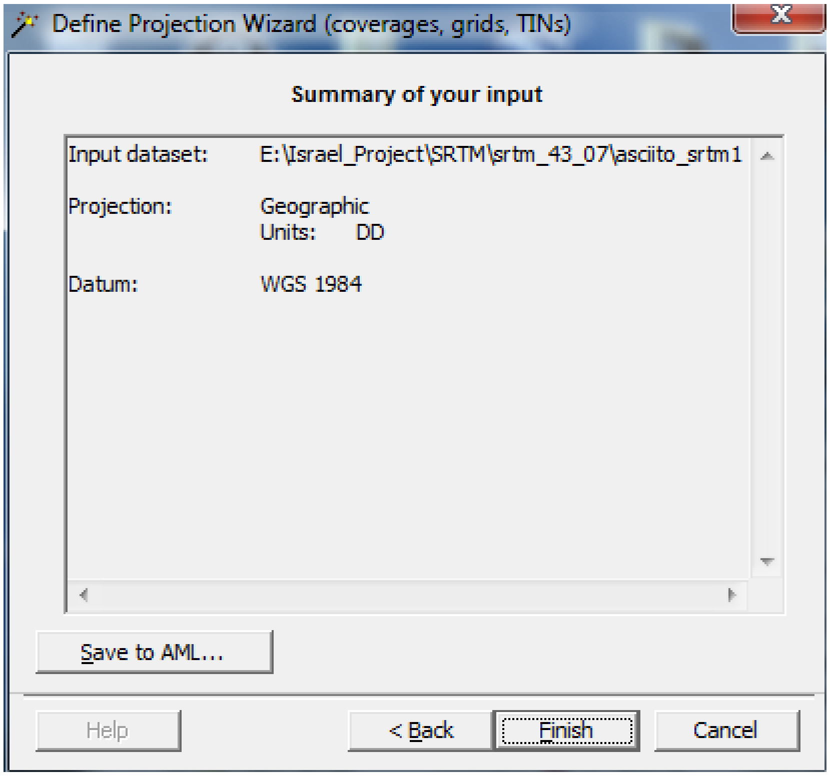

Figure 4d This shows the resulting summary of input. Hit "Finish". Repeat these steps for the other three rasters.

7) Open ArcMap, then create a new map adding the four images. **See figure 5.**

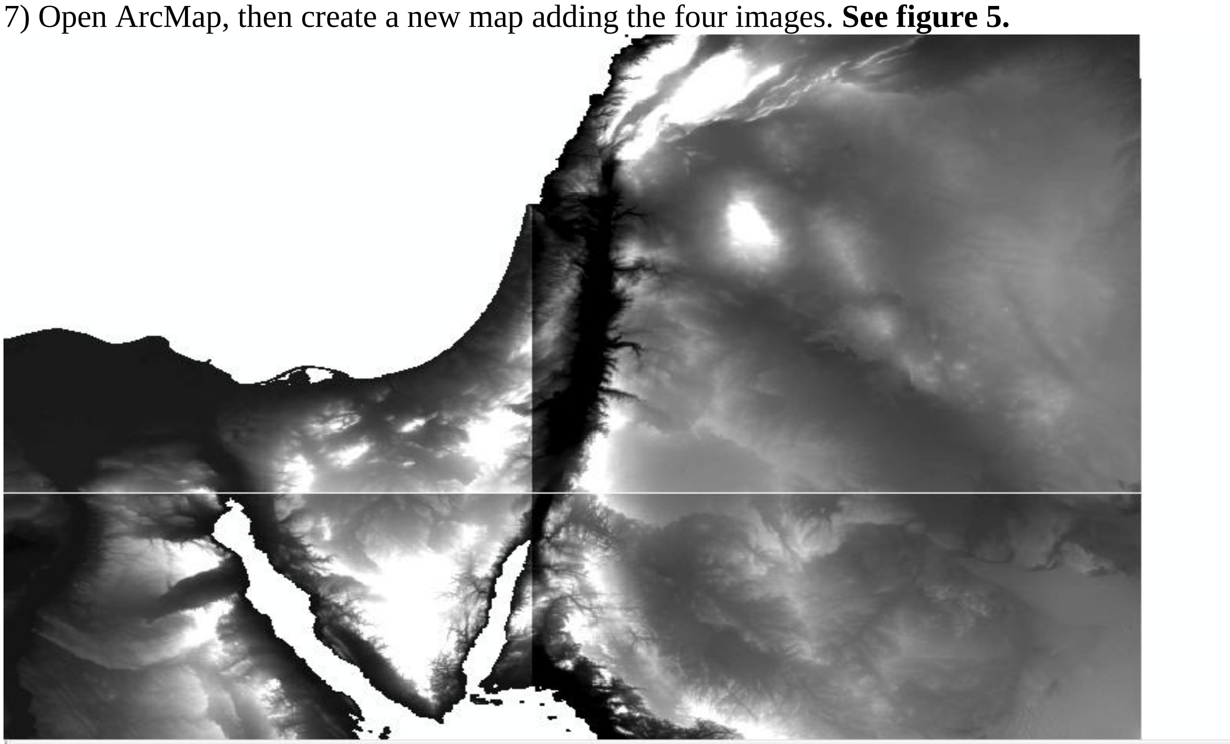

Figure 5 Unmosaiced images.

8) Open ArcToolbox in ArcMap and mosaic the four images together. **See Figure 6.**

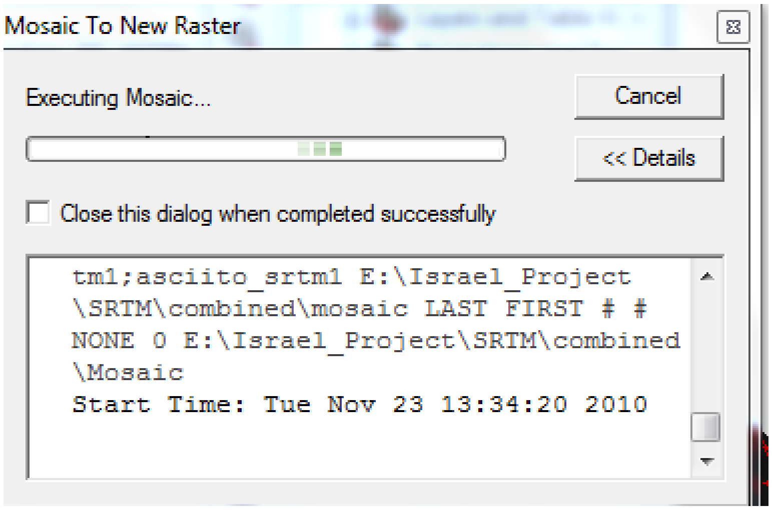

Figure 6 Executing mosaic process**.** (Did this four times).

9) Add in image of political country boundaries and cut out Israel and bordering countries and make hollow.

10) From the new layer that you have created of political country borders, use the dissolve tool to remove the country boundaries to be able to clip the mosaic. **See figure 7.**

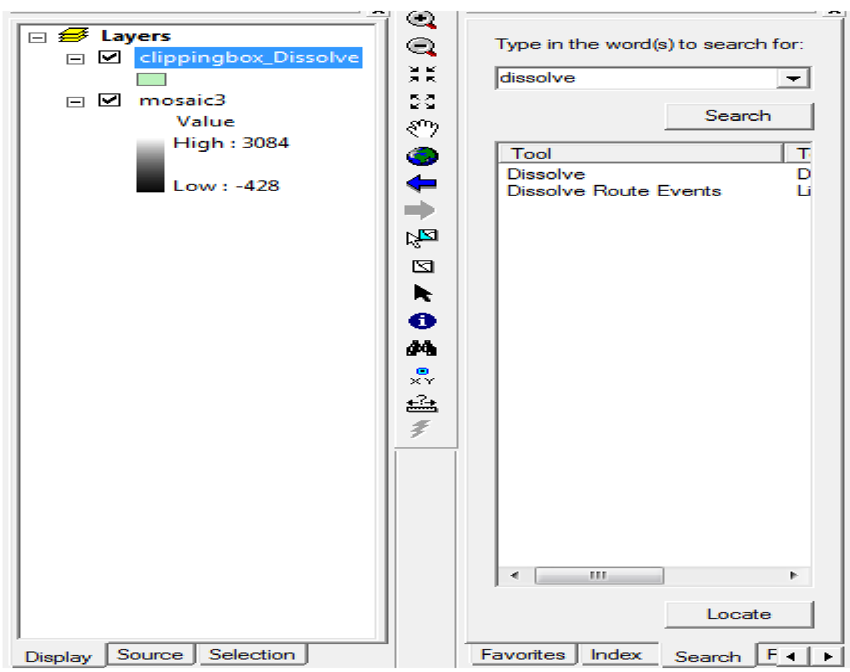

Figure 7 Shows the Table of Contents after the use of the dissolve tool.

11) Clipping the mosaic with the dissolved clipping box (Datamanagement/raster/clip) did not work because the polygon was corrupt, then we fixed the polygon by exporting it to a new shape file before clipping the mosaic again (Another thanks to Dr. Helper, without his help and brilliant mind, the project would have ended here :-).

12) Open spatial analyst and set the mask under options then use the raster calculator to make the new elevation file. This took multiple attempts.

13) Go back to Google Earth and find the elevation of the water level at the Dead Sea.

14) The spatial Analyst/ Surface Analyst/ Contours make the minimum contour at -393m below sea level, intervals of 3000m. Put this high interval in order to only show one contour at -393m. I did this three times, because the first time that I looked at Google Maps, I saw -400m at the beach, but upon a closer look, the other side of the sea, where the water is being dried out in pools for harvesting the salt and minerals, the elevation is actually -393m. **See figure 8.**

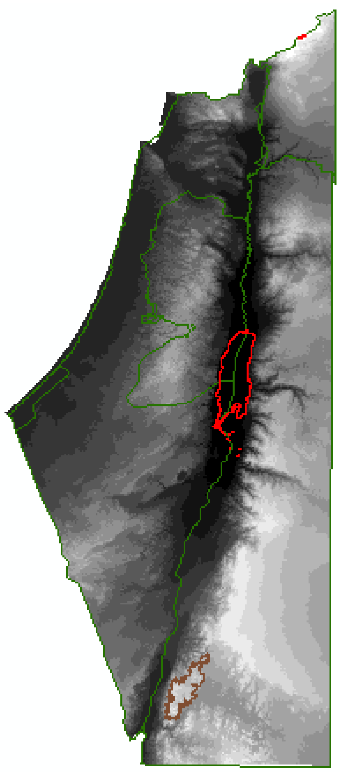

Figure 8 This figure shows the contour for the Dead Sea at -400 meters, -393m extends to the south.

15) Close ArcMap and open ArcCatalog.

16) Where you have saved your project, right click in that folder and create a new shape file.

17) Name that shape file “Dead_Sea”. In feature type, “select polygon”. Under Spatial Reference hit, “Edit”, then “Import” and click one of the shape or raster files that you have already created to keep the same coordinate system. Then hit “OK” twice to create your new polygon.

18) Reopen the saved map in ArcCatalog and add in the new polygon layer that you have created.

19) Hit “Start Editing” in the Editor Toolbar. Trace a polygon around the contour of -393 meters. **See figure 9.**

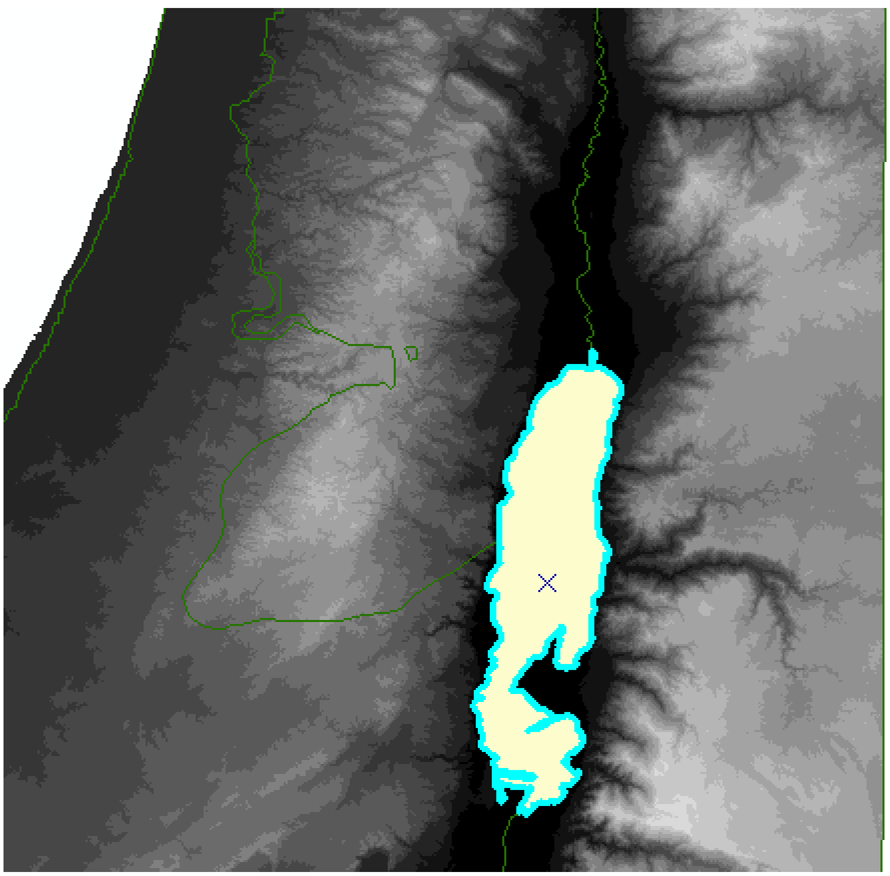

Figure 9 This figure shows the new figure that you have created for the outline of the Dead Sea.

20) Color all of the bordering countries and the Gaza Strip red and the West Bank beige to define the areas that are not available for the Canal.

21) At this point, I attempted to use Arc Desktop help to look up the “Least cost path tool” **See figure 10a, 10b.**

How to calculate the least cost path

1. Click the Spatial Analyst dropdown arrow, point to Distance, and click Shortest Path.
2. Click the Path to dropdown arrow and click your destination layer.
3. Click the Cost distance raster dropdown arrow and click the raster you want to use.
4. Click the Cost direction raster dropdown arrow and click the raster you want to use.
5. Click the Path type dropdown arrow and choose an option, depending on how many paths you want to find.
6. Type a name for the result, or leave the default to create a temporary result in your working directory.
7. Click OK.

Tip

- On the Spatial Analyst toolbar, click Options to set the working directory, extent, and cell size for your analysis results.

Figure 10a This shows the steps for using the least cost path through the spatial analyst.(This did not work).

- Cost Path can also be used to derive the path of least resistance down a digital elevation model (DEM). In this case, the DEM will be the input cost distance raster and the flow direction raster will be the input cost backlink raster. Valid flow direction raster values are 1, 2, 4, 8, 16, 32, 64, and 128; valid values in the backlink raster are 1, 2, 3, 4, 5, 6, 7, and 8. Both of these rasters are acceptable.

Figure 10b This shows the use of cost path to determine the path of least resistance, to find this I searched ArcToolbox and found cost path, but it also gave me an error while executing.

22) Find the best path by looking at the map of the elevation changes and following the elevation that shows the least amount of change. **See figure 11.**

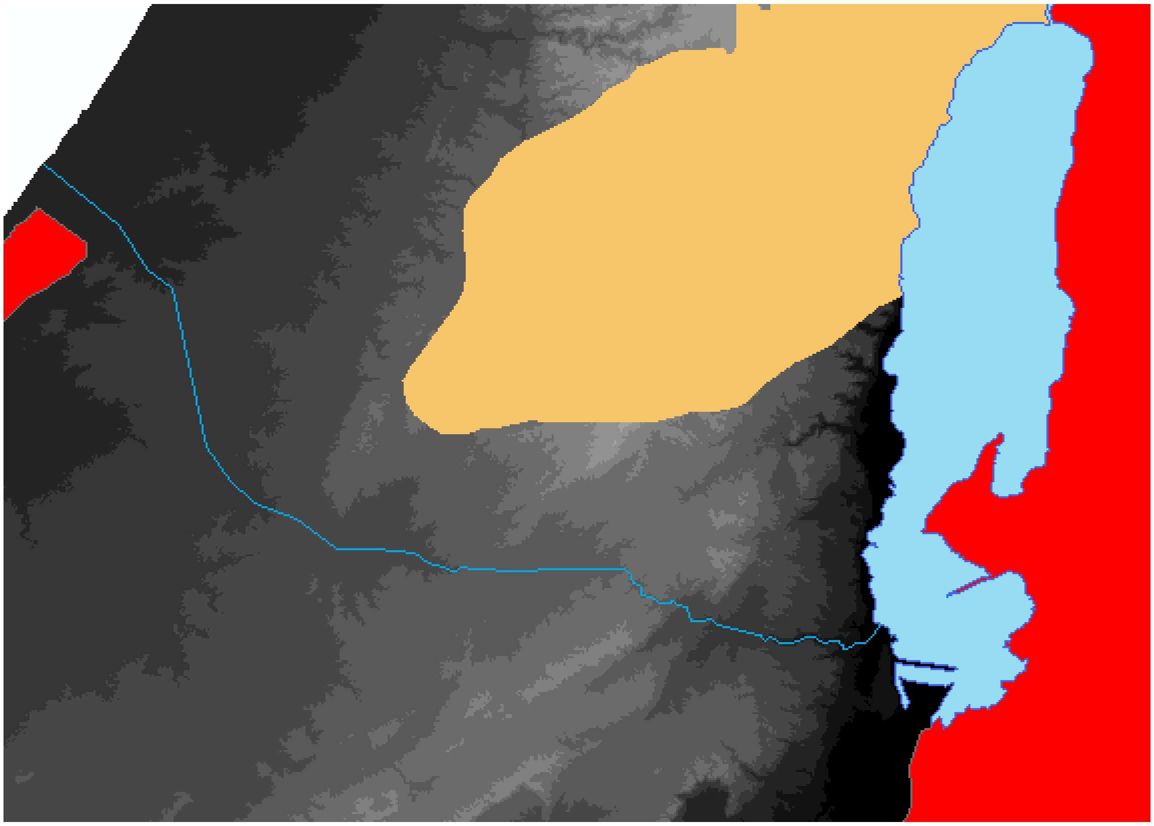

Figure 11 This figure shows the path based on least elevation change that follows a valley from the Mediterranean Sea to the Dead Sea.

23) Right click the country boundaries layer and go to "Properties", then "Display", change the transparency to 50%.

24) Create a new polygon in ArcCatalog the same way that you created the Dead Sea polygon, but this time label it "Mediterranean_Sea".

25) After creating the polygon for the Mediterranean Sea on the west border of Israel, use the "Label Manager" to label the Dead Sea, Mediterranean Sea, Israel, Gaza Strip, West Bank, Jordan and Syria. **See figure 12.**

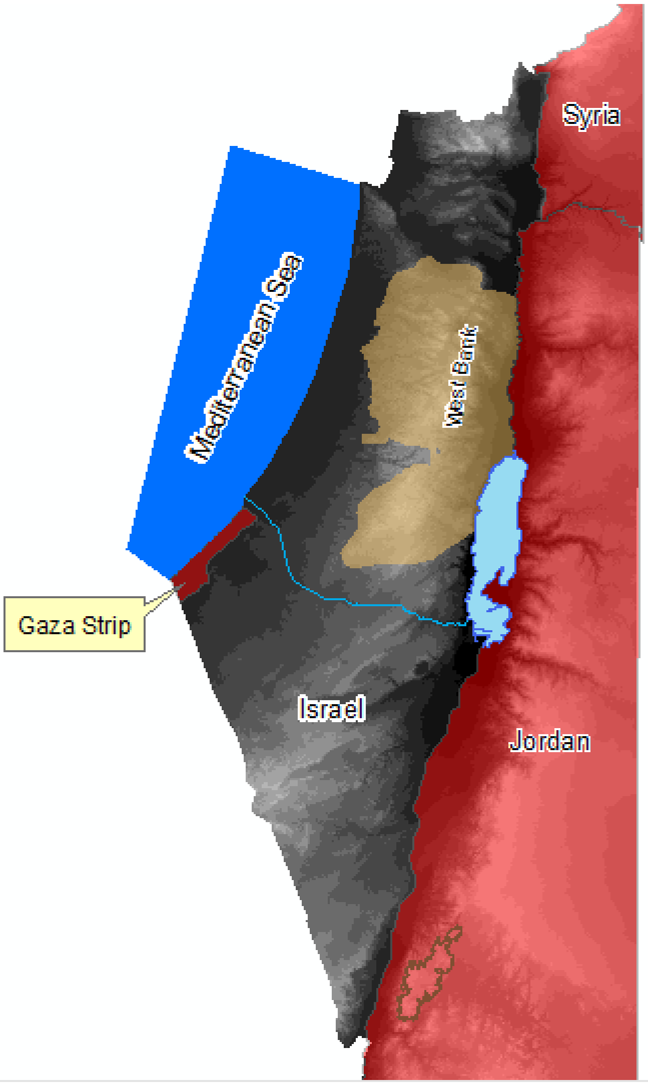

Figure 12 shows the labeling of everything except the Dead Sea (this is an example to show you not to forget to label the subject of your project). This also shows the 50% transparency of the country boundaries and shows the polygon for the Mediterranean Sea.

26) Build a map including the legend, the north arrow and the scale bar using the insert tool at the top of the screen. **See figure 13.**

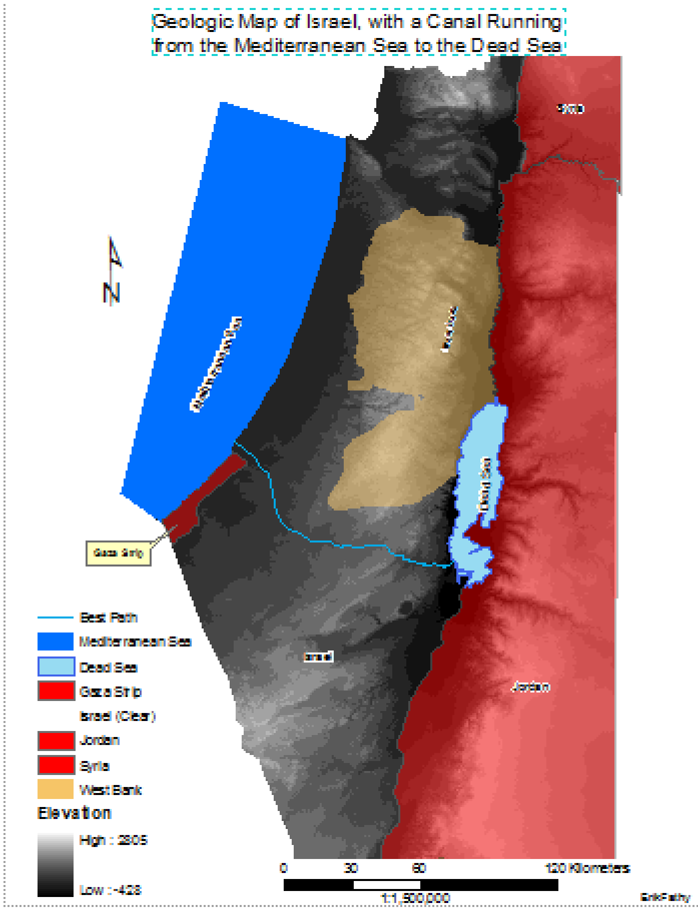

Figure 13 shows the completed map with a title, legend, north arrow and a scale bar.

27) Now that you have a map of the best possible path, you can find the amount of material that will need to be excavated to build the canal. To do this, you will need to build a buffer around the best path creating a polygon that you will use cut the DTM.

28) To create the buffer, open ArcToolbox “Analysis Tools”, choose “Proximity”, then choose “Buffer”. **See figure 14.**

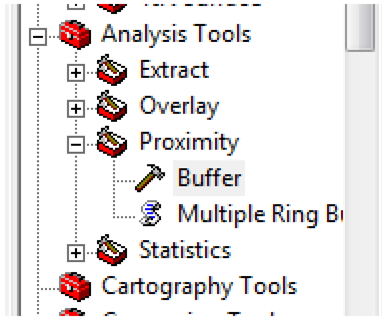

Figure 14 shows path to create buffer.

29) Inside the buffer tool, in the input feature, choose “Best Path” and for distance, choose “Linear Unit” and type in “50”(choose 50 because the data is at 90 meter resolution and 50 gives a view that is 100 meters wide so that you can view the data in the existing DTM). Change the units to “meters”. Hit “OK”. **See figure 15.**

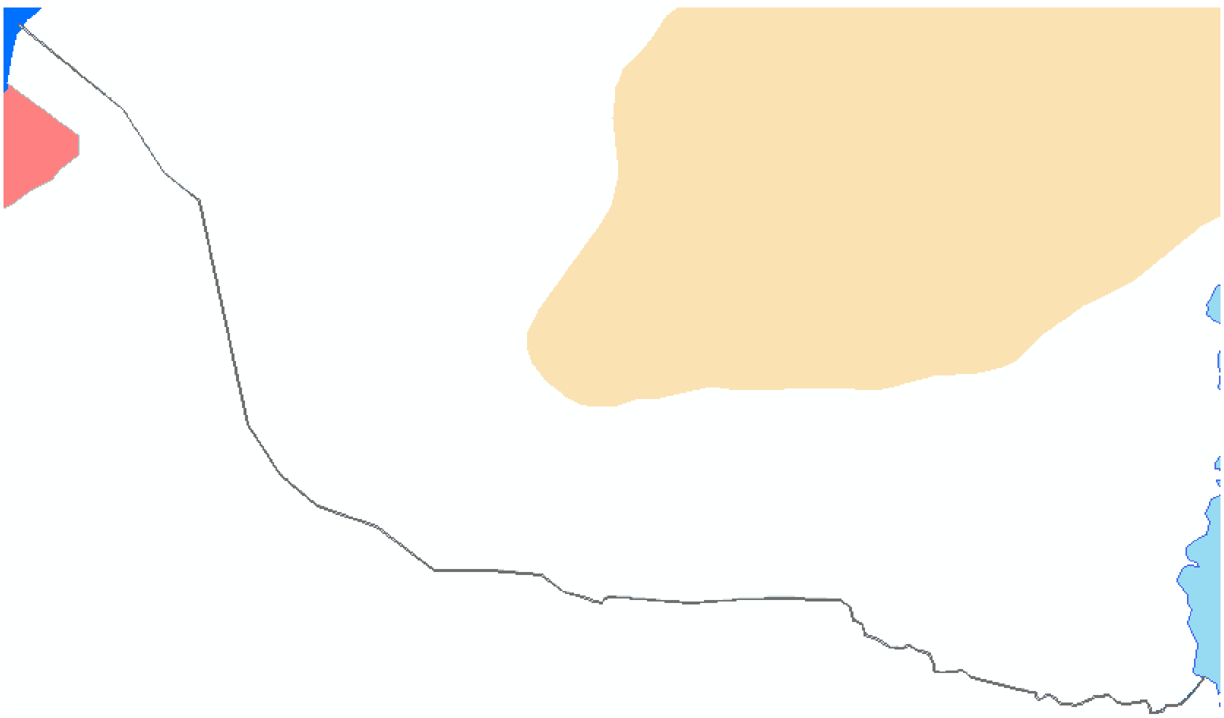

Figure 15 shows the newly created buffer layer.

30) Clip the DTM by this new buffer layer. This is done using the Spatial Analyst Tool. Click "Options", then "General", then, under Analysis Mask, choose "Best Path Buffer". **See figure 16.**

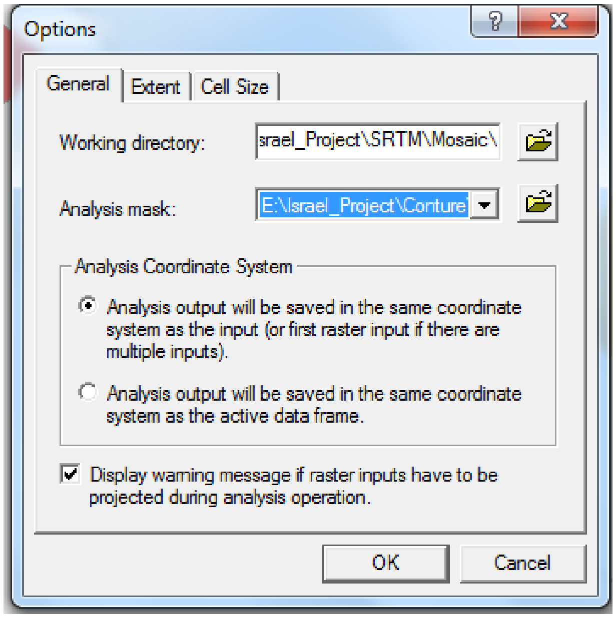

Figure 16 shows what to choose in the Analysis Mask.

31) Now go to the Spatial Analysis, hit "Raster Calculator", double click "Calculation"(which is your DTM), then hit "Evaluate". **See figure 17a, 17b.**

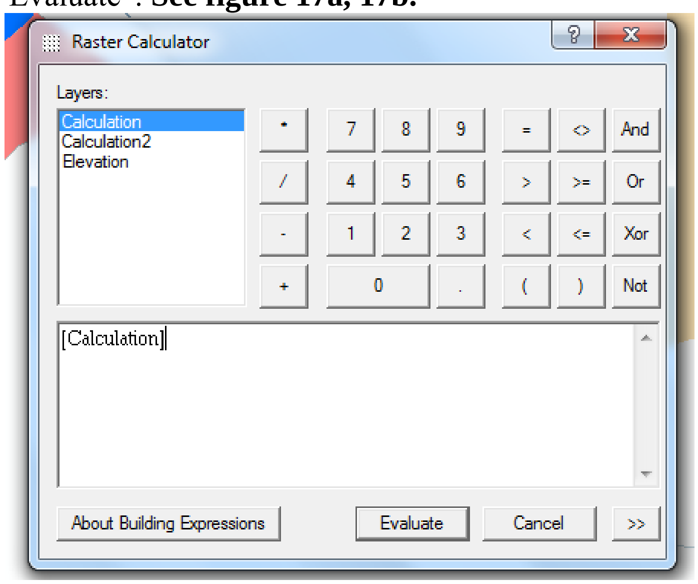

Figure 17a shows the Raster Calculator and the DTM that is about to be clipped by the new buffer layer that was created to represent the Canal.

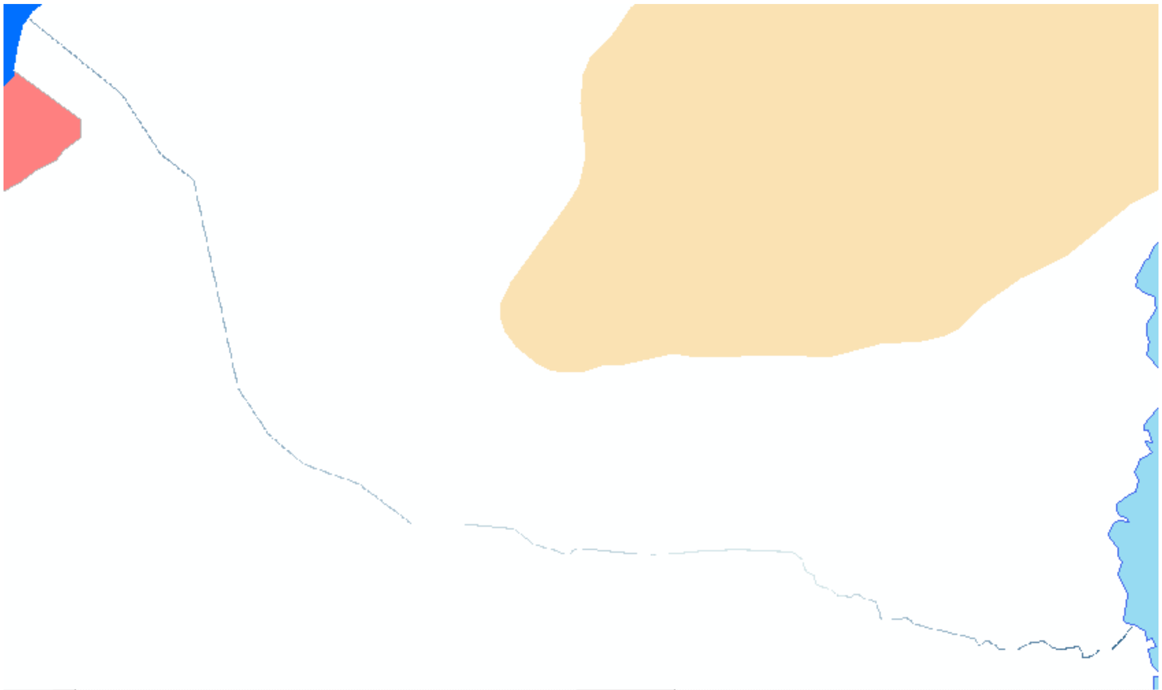

Figure 17b shows the new clipped DTM.

32) Now change the projection of the DTM from WGS 1984 (which is decimal degrees) to UTM Zone 38N (which is in meters). This is done by going to the ToolBox/Projections and Transformations/ Raster/Project Raster **See figure 18a, 18b.**

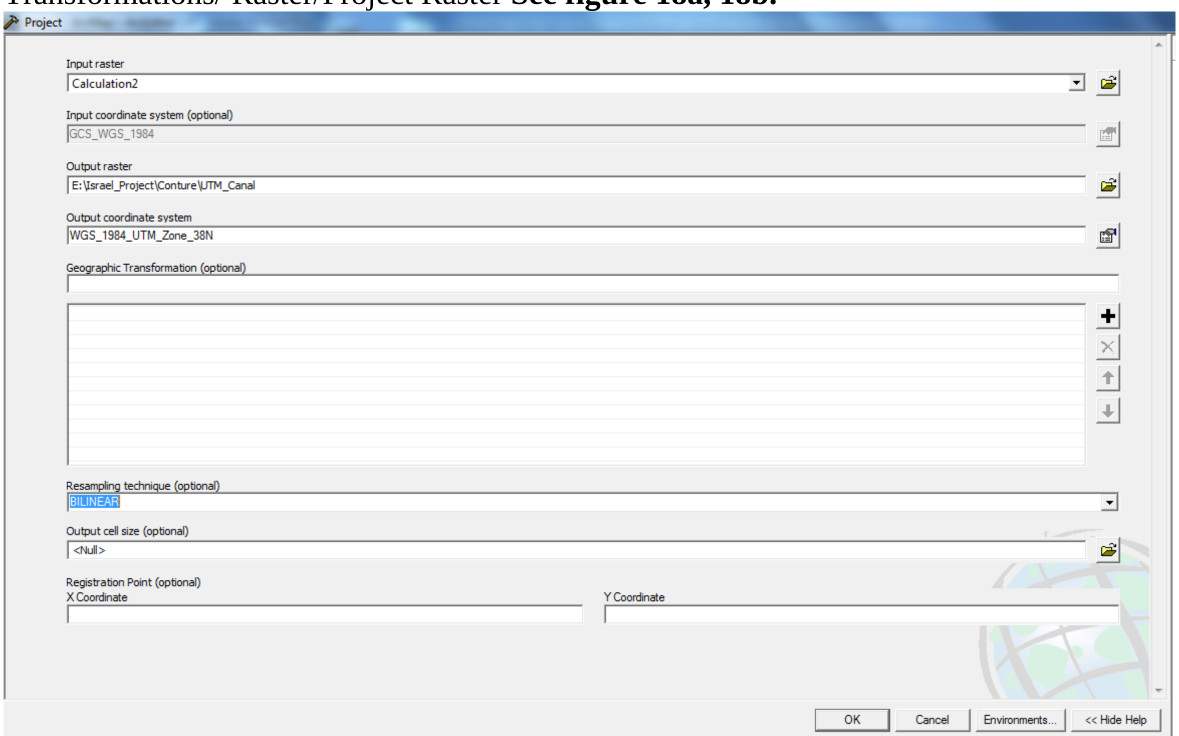

Figure 18a shows the Project Tool with all the fields filled in properly.

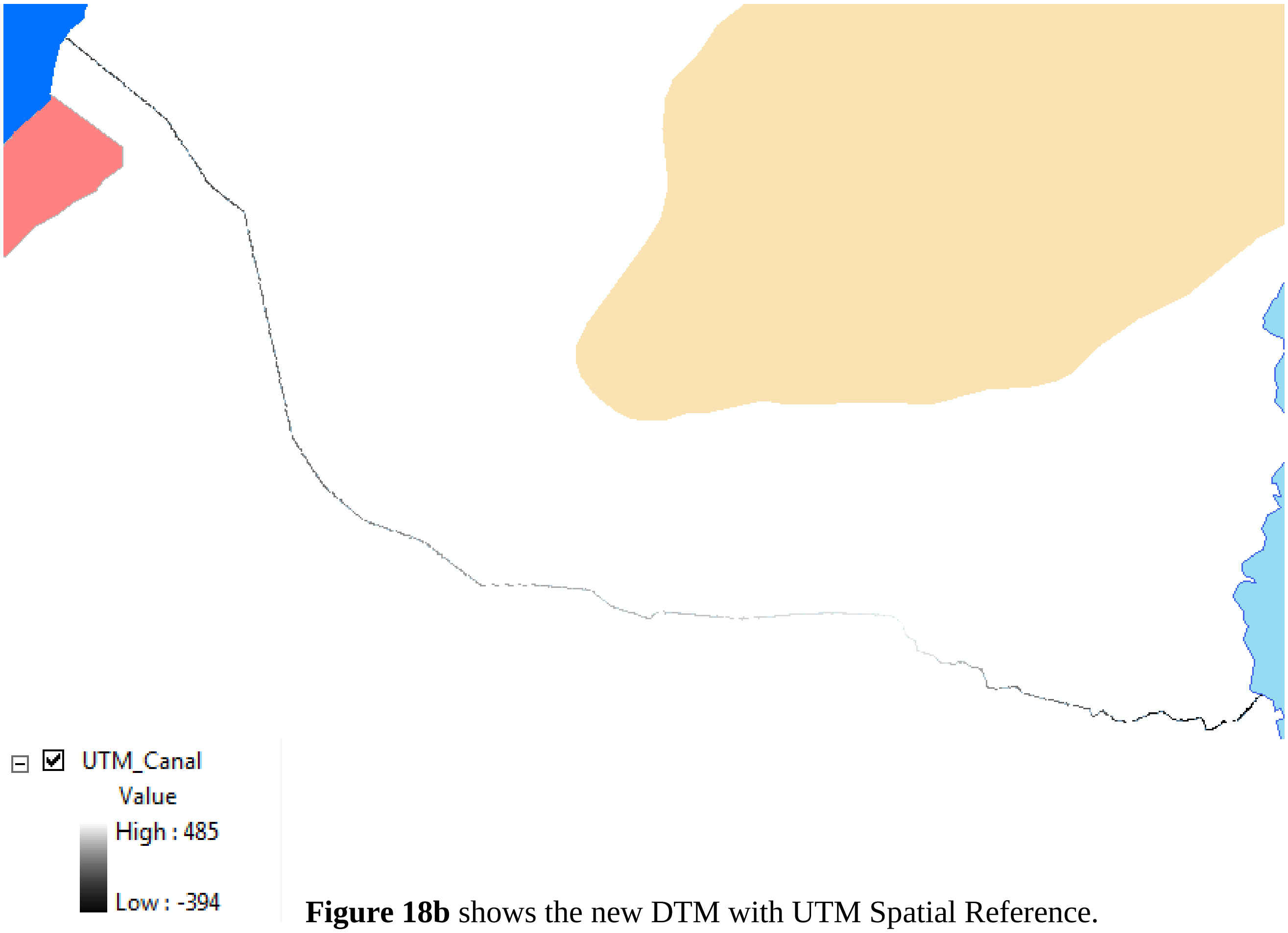

Figure 18b shows the new DTM with UTM Spatial Reference.

33) Now with the 3D Analyst Tool (**See figure 19a),** open the Area and Volume Statistics Tool. **See figure 19b** and use this example to fill the window in the like manner.

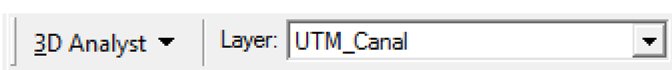

Figure 19a shows the 3D Analyst Tool.

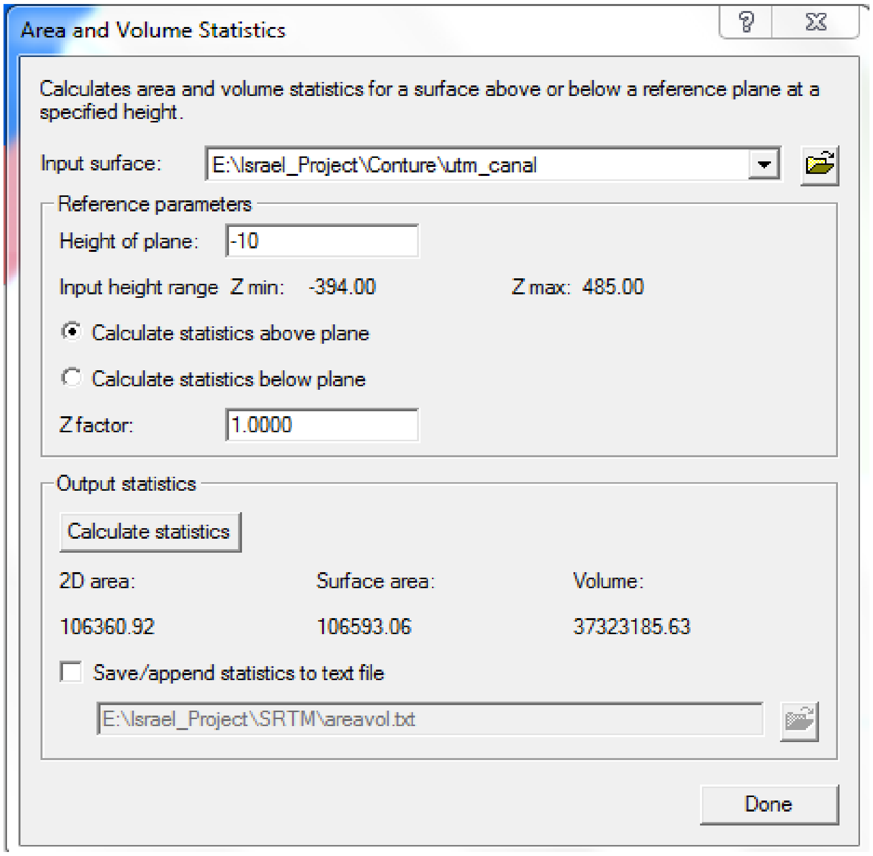

Figure 19b shows the Area and Volume Statistic Window and the way in which to fill it in. The reason that you start at a -10 elevation is that when you dig the canal, you slope the floor of the canal in order to assure that the water flows in the desired direction. The reason that it is not necessary to calculate the materials removed below the plane is that once the canal passes the ridge and the elevation drops, it is no longer necessary to remove material to slope the canal. The number that we seek for the amount of material to be removed is the Volume number, which is shown in m^3, and we are looking for km^3. We had to make the DTM layer 100 meters thick for the 90 meter resolution, so we now divide the km^3 by three in order to make the canal 33 meters wide. The quantitative number for the volume of material is 37,323,185.63 m^3 = 0.0373 km^3 divided by 3 = 0.0124 km^3. This is the approximate amount of material that will need to be removed in order to build the canal to fill the Dead Sea from the Mediterranean Sea.

Conclusion

Israel is a country that suffers from a lack of water. The Dead Sea was once fed from the overflow from the Sea of Galilee, which was replenished from the winter rains and the melting snow caps in the Golan Heights. As the population increased, the demand for water from the Sea of Galilee grew from both Israel and Jordan, creating a shortfall in the Sea of Galilee that greatly reduced the overflow. This was aggravated by several years of drought. The mineral rich Dead Sea, the source of many minerals that are purported to have healing powers, is literally disappearing. This has created a need for a second source of water. This project explored the option of building a canal from the Mediterranean Sea to the Dead Sea. I used ArcGIS processing tools to explore the area and create a map showing what I project to be the least cost path within the restrictions of avoiding the Gaza Strip and the West Bank. Though I attempted many times to use the Least Cost Path Tool, I was thwarted by error messages. However, by using the elevation patterns to find the valleys and the paths that have already been cut for roads, a path was created using the natural drop in elevation. Then using the area volume statistic, I was able to approximate the amount of material that will need to b e removed in order to build the canal, which is 0.0124 km^3. A secondary benefit from this canal is the possibility of using the water flow to create hydropower generation that could help to alleviate the power shortage and help Israel to go green.