

Analysis of the Pacific Coast near the Mouth of the Columbia River for Tsunami Hazard and Shelter Potential

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The goal of this project was to analyze the mouth of the Columbia River for areas that would be flooded in the event of a tsunami, and to look for topography that could act as a barrier or baffle to the incoming water. Many people live and work in this area and the Columbia River provides shipping access to the interiors of Washington and Oregon, so hazard analysis has immediate real-world applications.

Data:

DEMs were downloaded from the USGS Seamless Map Server. The grids are part of the National Elevation Dataset (NED) with a resolution of 1/3 arc-second (~10 m), in geographic projection with the NAD83 horizontal datum and the NAV88 vertical datum.

Methods:

The data were downloaded in ArcGrid format in 250 MB increments and had to be un-zipped before they could be loaded into ArcMap. Metadata did not transfer well, and had to be entered by hand (Fig. 1).

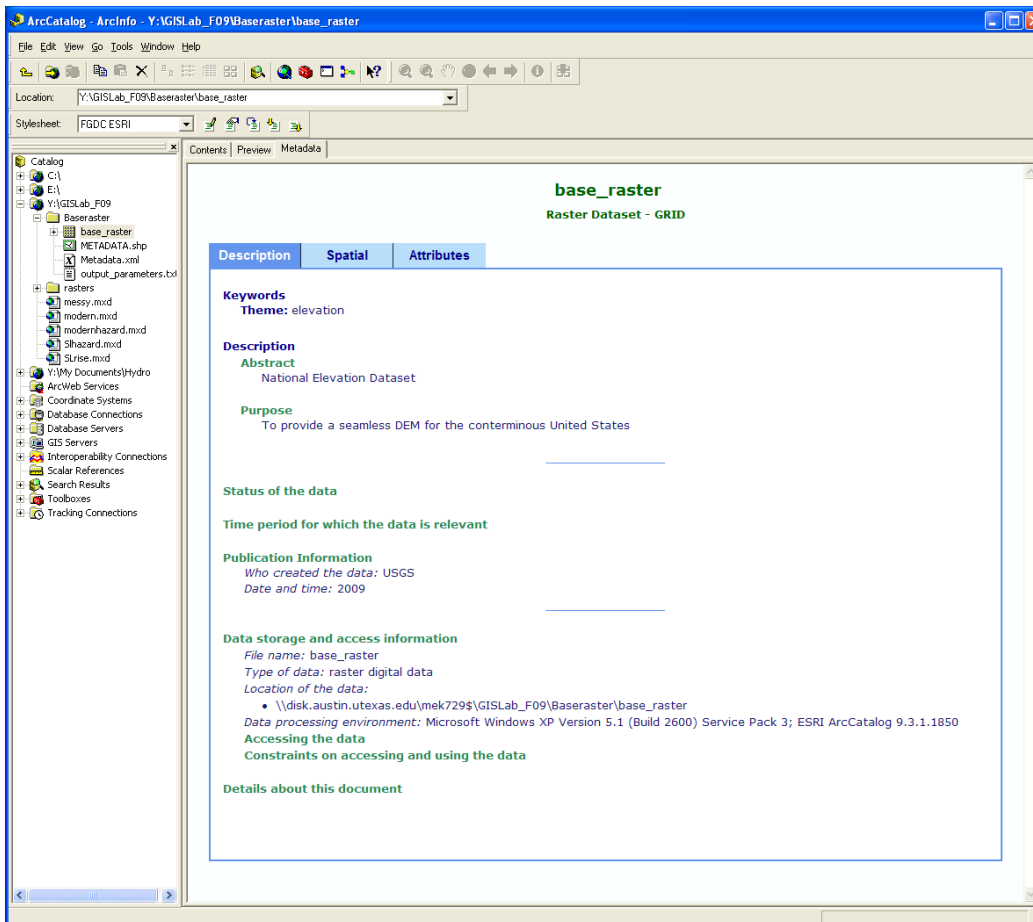


Figure 1: An example of metadata, for the base raster used in this project.

To construct a GIS it was necessary to mosaic the individual rasters together into one large raster. The Mosaic tool in ArcToolbox was the easiest option, and the resulting large raster extended from near Grayland, WA to Seaside, OR, and inland to near Westport, OR (Fig. 2).

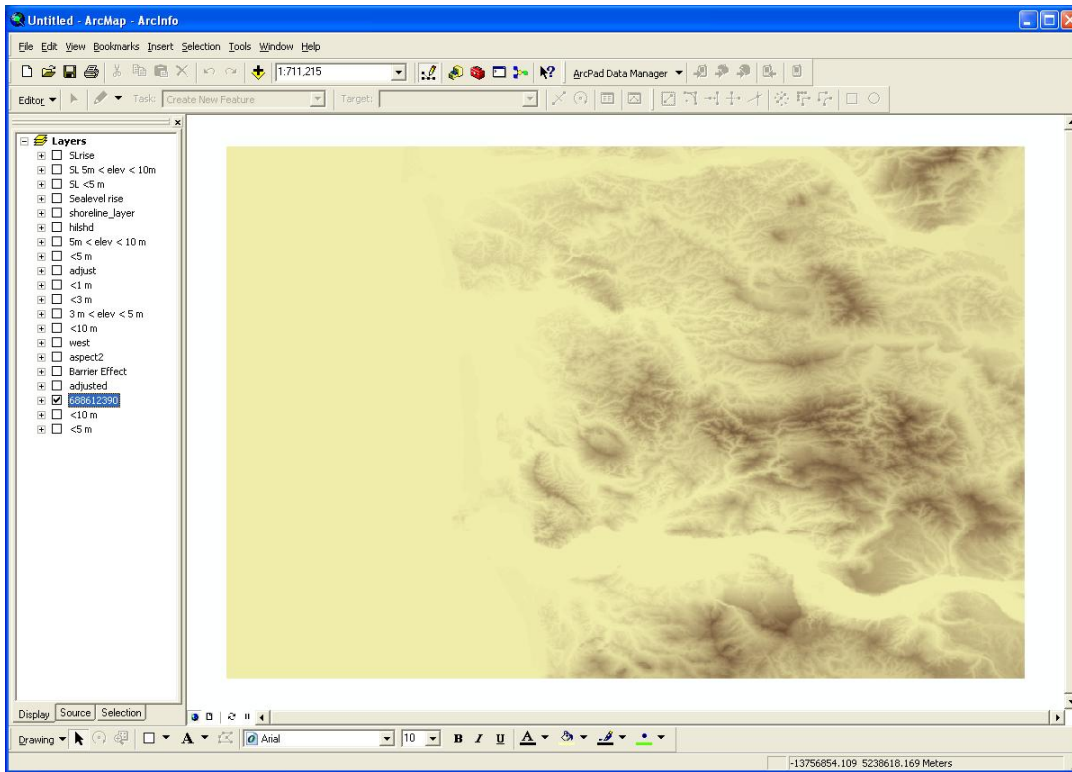


Figure 2: base raster, after being mosaic-ed and symbolized

The large raster was then reclassified using the Spatial Analysis tool to convert any cells below an elevation of zero to NoData – i.e., to create empty space where there was water (Fig. 3).

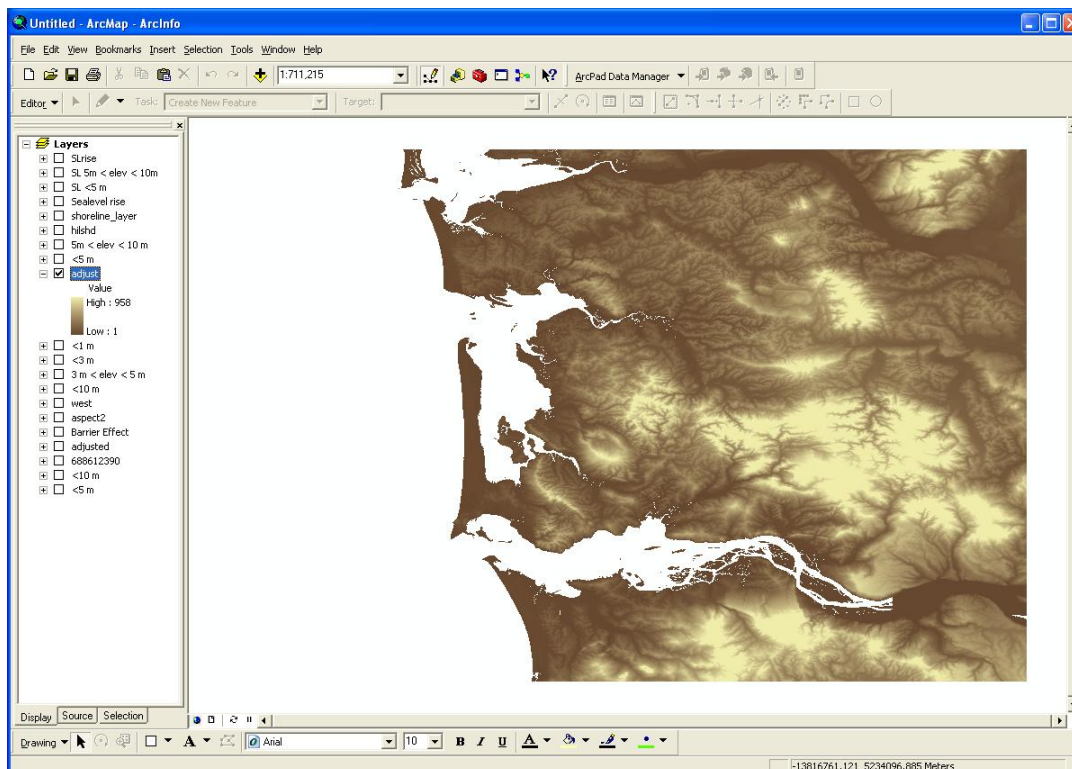


Figure 3: adjusted raster, with elevations less than zero reclassified as NoData and symbolized as nocolor.

The resulting adjusted raster was then set as the analysis mask for the remainder of the analyses performed.

To analyze areas that would be at risk in the event of a tsunami, it was necessary to create new rasters isolating areas below 5 meters in elevation. Current research into tsunami events puts the theoretical maximum tsunami height for the Pacific Northwest coast at 15 feet, or approximately 5 meters (geosociety.org). Therefore any coastal area under 5 meters in elevation is in severe danger of flooding.

To isolate these areas, the raster calculator presented the simplest option. A raster showing all elevations below 5 meters was created using the expression $\text{con}([\text{grid name}] \leq 5, 1)$. These are the areas that are most likely to flood during a tsunami (Fig. 4).

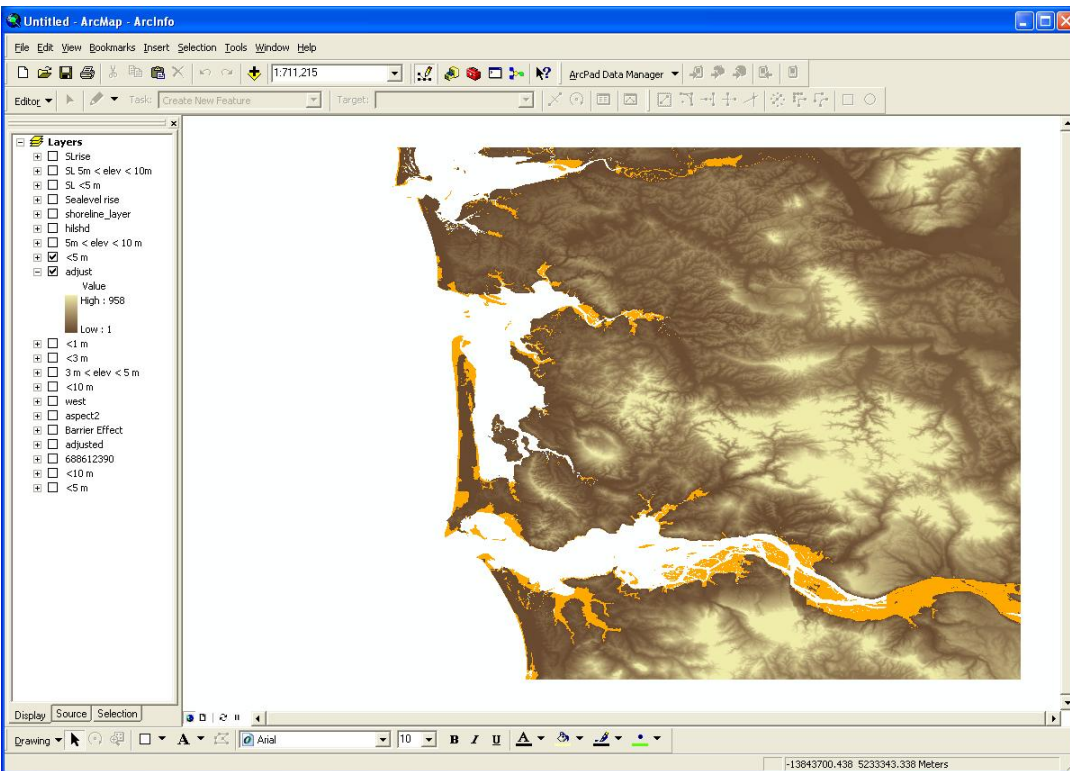


Figure 4: Areas less than 5 meters in elevation (orange).

Some of these areas (in orange) lie behind higher topography, however, assuming the tsunami approach is from the west. This approach is likely, since most tsunami along the Pacific Northwest coast are generated from distant earthquakes (geosociety.org). To analyze which areas might provide shelter from a tsunami, a second raster was overlaid on the 5 m raster, to isolate areas with elevations between 5 and 10 meters. The following expression was entered into the raster calculator: $\text{con}([\text{grid name}] > 5, 1) \ \& \ \text{con}([\text{grid name}] \leq 10, 1)$ (Fig. 5).

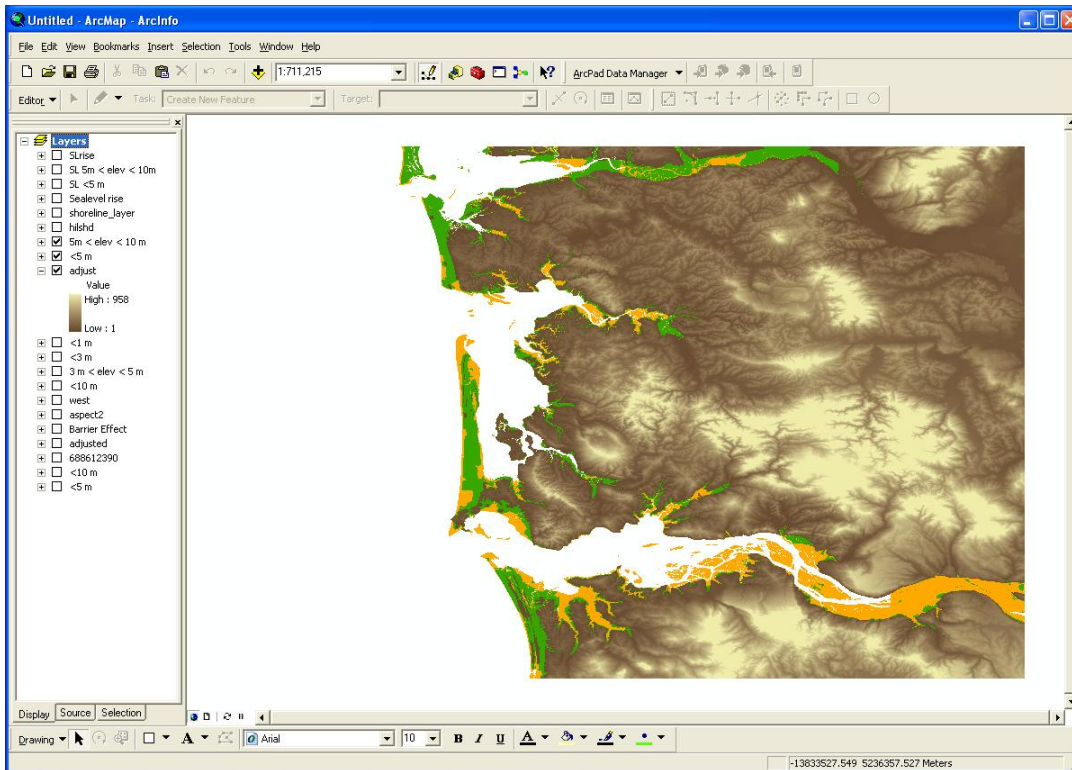


Figure 5: Areas less than 5 meters in elevation (orange) and between 5 and 10 meters in elevation (green).

While some of these areas (in green) will clearly have no sheltering effect, others may act as effective barriers or baffles to the tsunami, especially the north-south trending bars and spits at the mouth of the Columbia River.

With global warming and sea level rise as constant concerns, an analysis for this same area after accounting for projected sea level rise seems valuable. Models predict various amounts of sea level rise for the Pacific Northwest coast, but appear to average out at around 1.5 meters of rise.

To begin, it was necessary to construct a new base raster showing this increase in sea level. Rather than reclassify all cells below an elevation of 1.5 meters to NoData, all cells with elevations below 1.5 meters were isolated in a new raster and symbolized to match the water (Fig. 6).

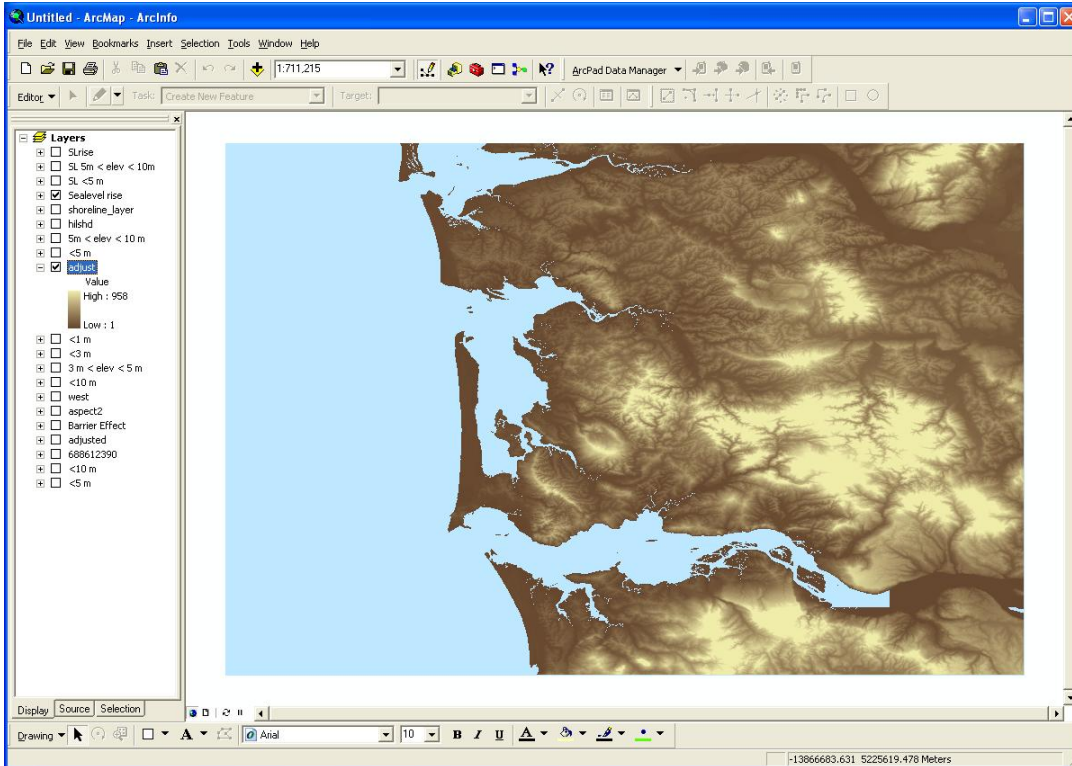


Figure 6: New base raster created by symbolizing all areas with elevations less than 1.5 meters in elevation to match the water (blue).

Then similar expressions were used to calculate areas under 5 m in elevation (Fig. 7) and areas between 5 and 10 meters in elevation (Fig. 8), measured from the new sea level: $\text{con}([\text{grid name}] \leq 6.5, 1)$ and $\text{con}([\text{grid name}] > 6.5, 1) \ \& \ \text{con}([\text{grid name}] \leq 11.5, 1)$

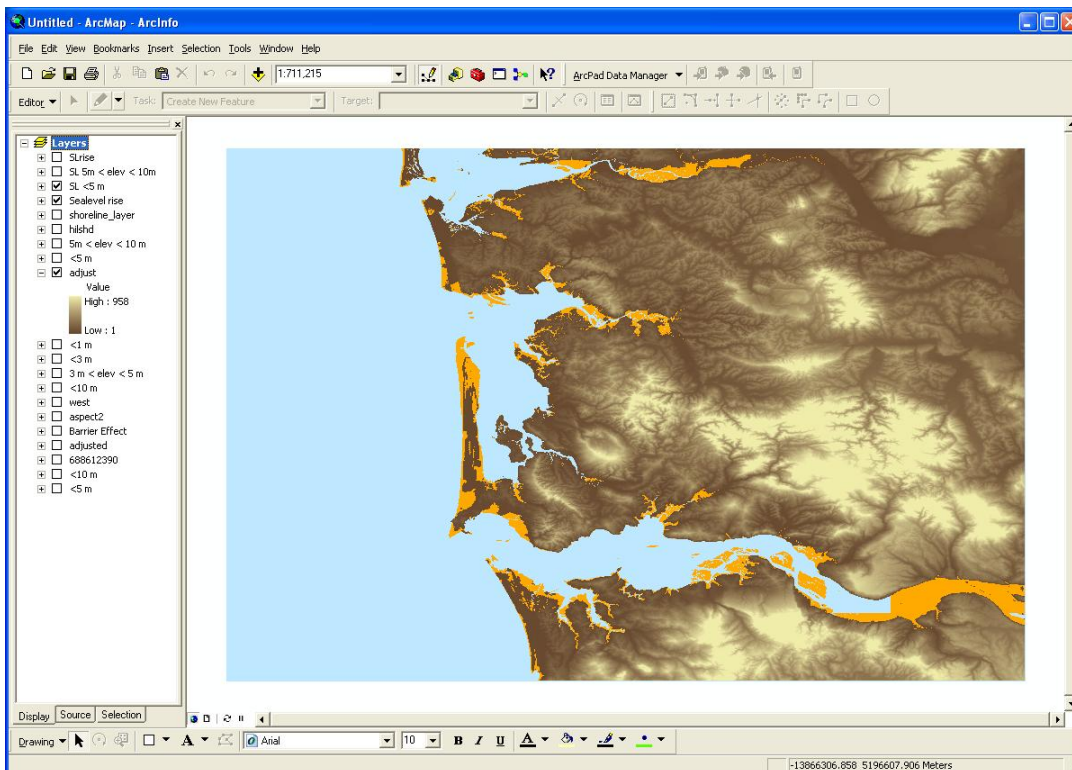


Figure 7: Areas less than 5 meters in elevation (orange) after a 1.5 meter sea level rise.

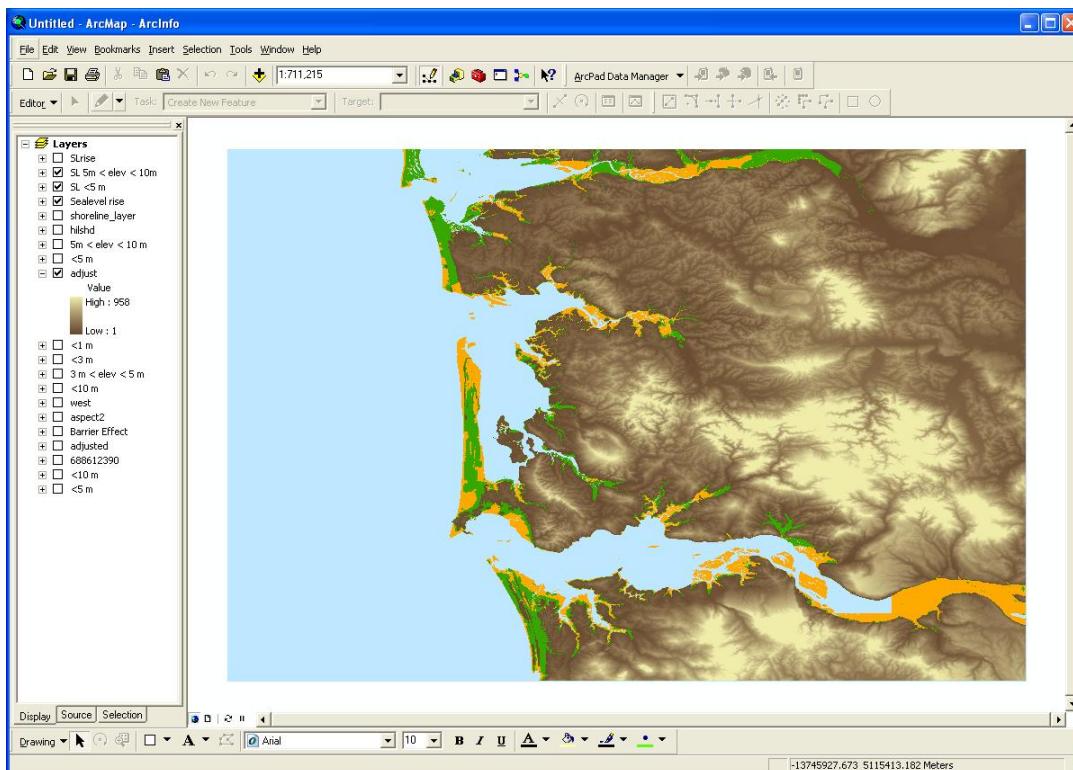


Figure 8: Areas less than 5 meters in elevation (orange) and between 5 and 10 meters in elevation (green), after a 1.5 meter rise in sea level.

Discussion:

The change in sea level does not appear to make a large difference in the areas at risk from a tsunami. Some of the smaller islands in the Columbia River mouth would be flooded completely and may not play as large a role in dissipating the incoming tsunami, increasing the potential for damage, but this is speculation. The higher topography that may act as a potential barrier to the tsunami, i.e. the north-south trending bars, are too high to be inundated by a sea level rise of only 1.5 meters, and thus would continue to exert the same baffling influence on the incoming wave.

Final maps are included below as Figs. 9-12.

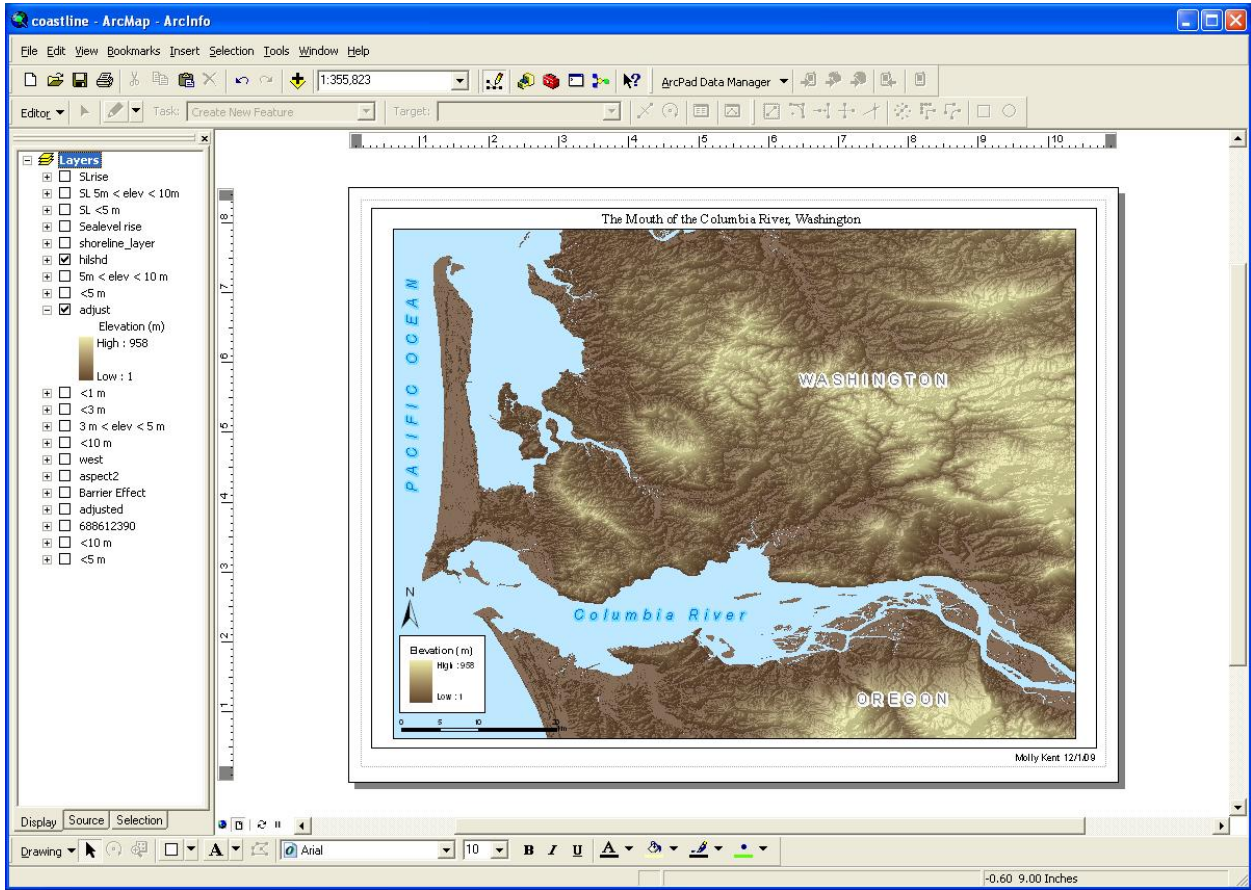


Figure 9: The mouth of the Columbia River at current sea level.

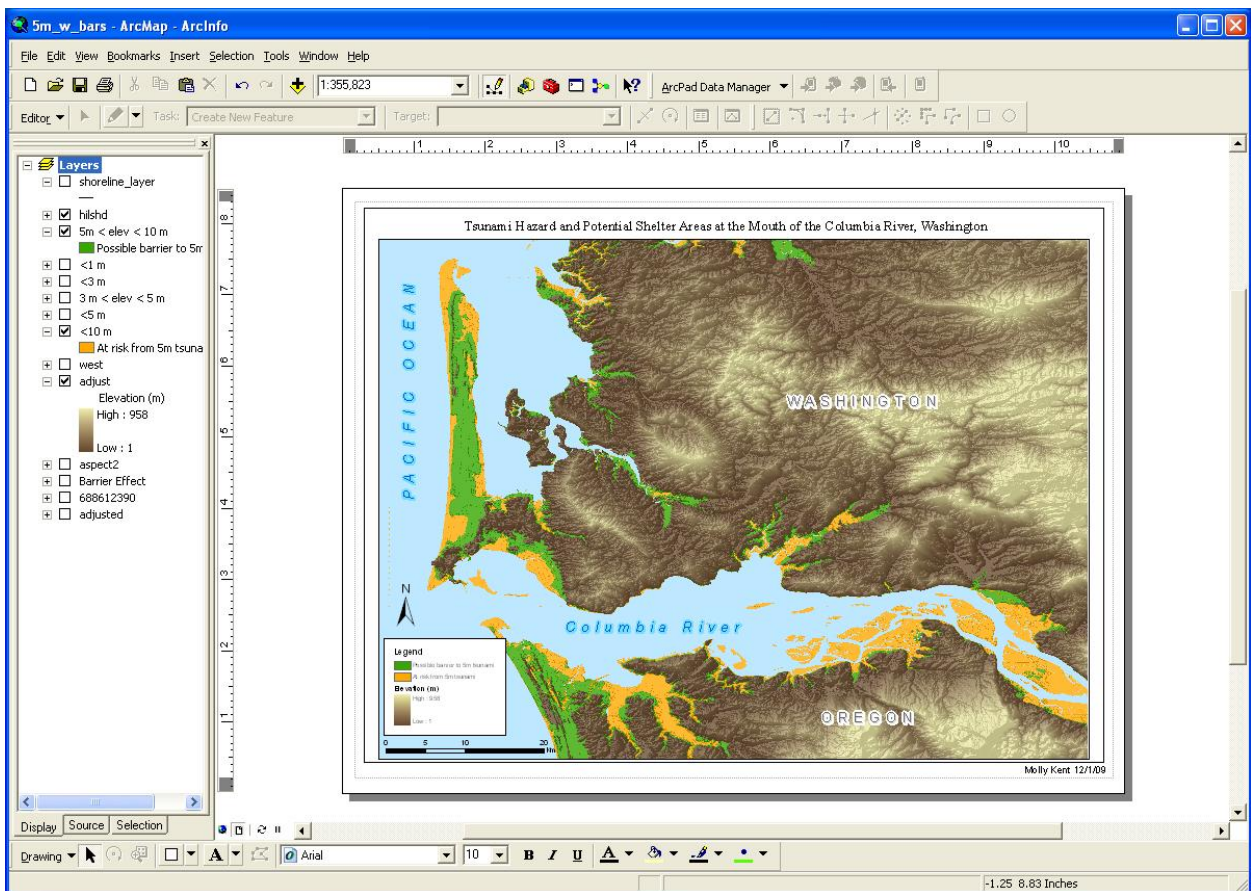


Figure 10: The mouth of the Columbia River at current sea level, with tsunami hazard and shelter areas highlighted.

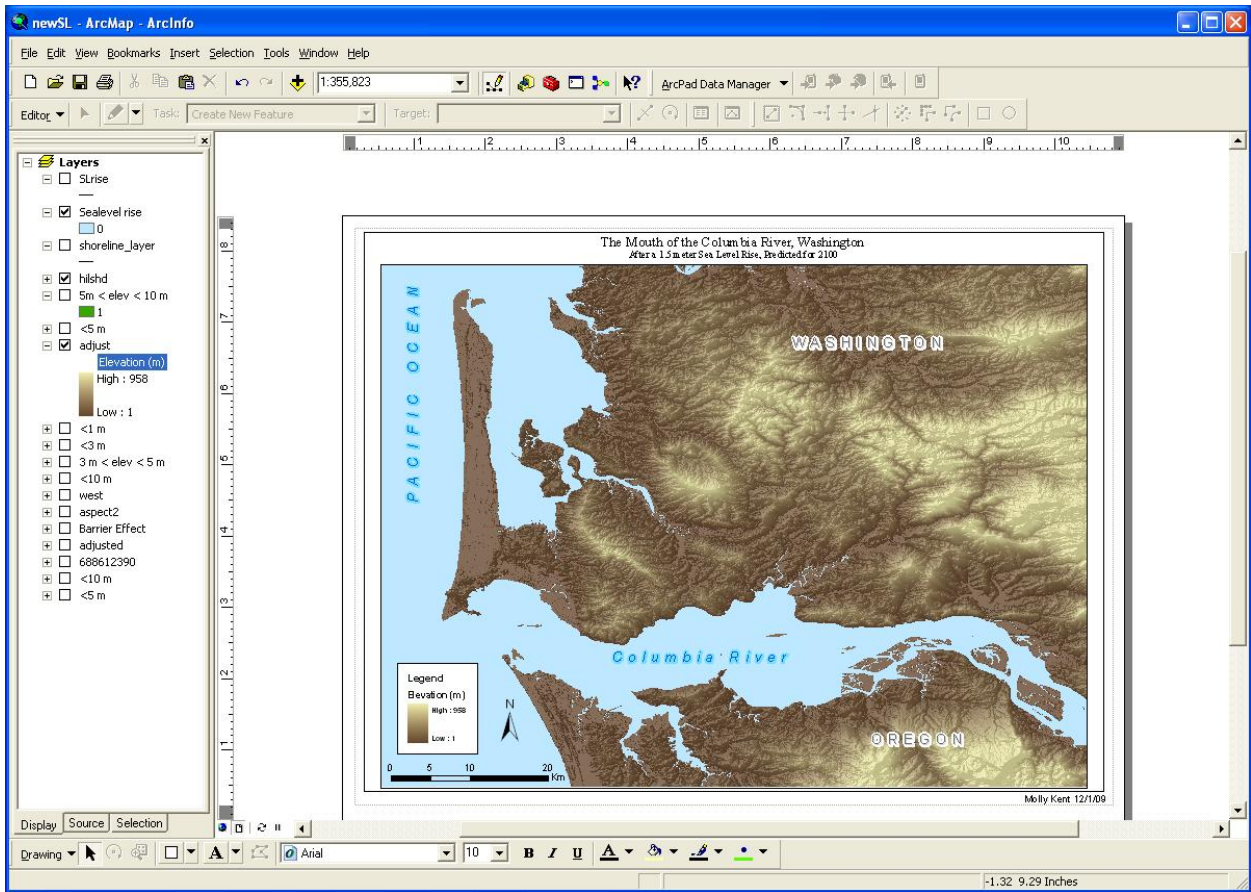


Figure 11:
The mouth of the Columbia River at 1.5 meters higher-than-current sea level.

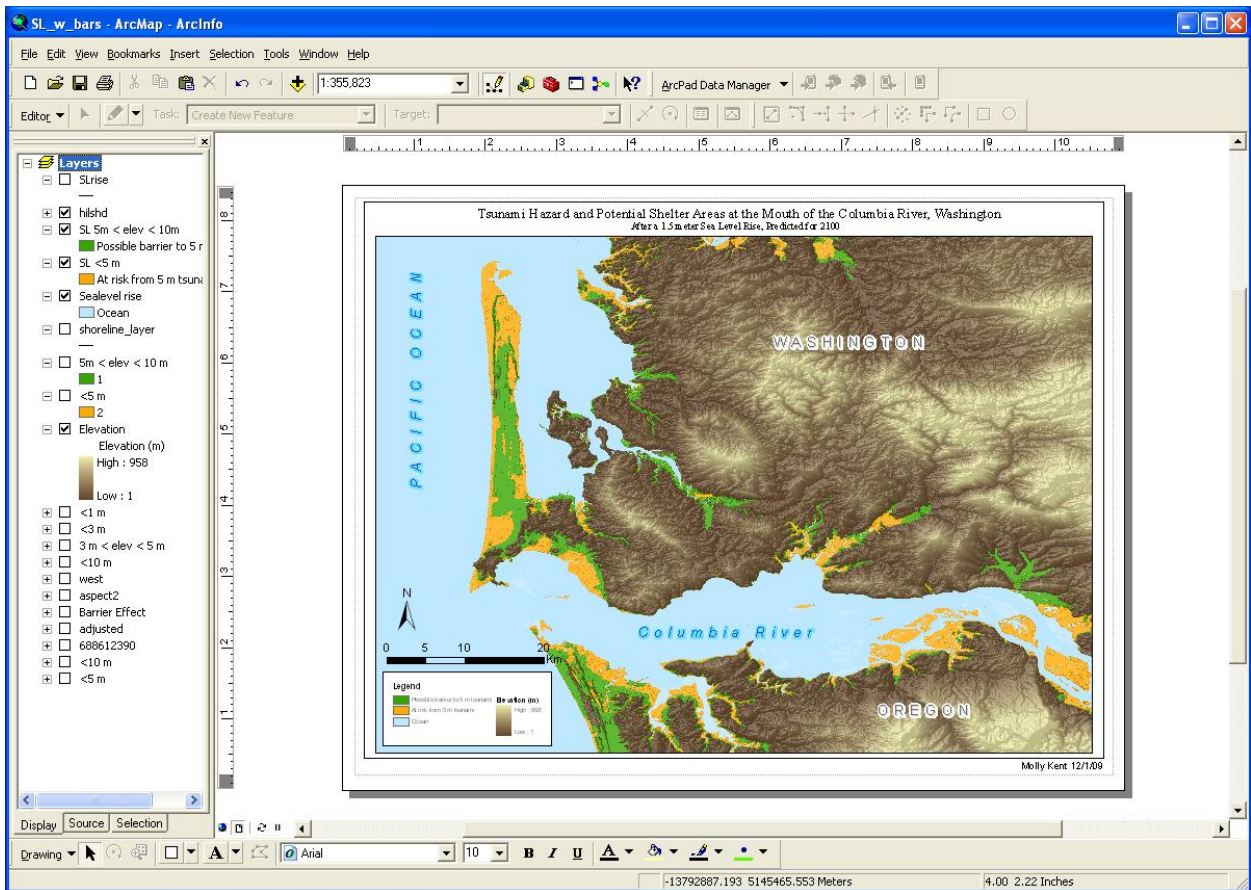


Figure 12:
The mouth of the Columbia River at 1.5 meters higher-than-current sea level, with tsunami hazard and shelter areas highlighted.

References:

Geological Society of America website 2009: <http://www.geosociety.org/news/pr/09-56.htm>

National Wildlife Federation website 2009: <http://www.nwf.org/sealevelrise/pdfs/PacificNWSeaLevelRise.pdf>

USGS Seamless Map Server website 2009: <http://seamless.usgs.gov/index.php>