Kooper Howerter

Lab 8 Report

Introduction:

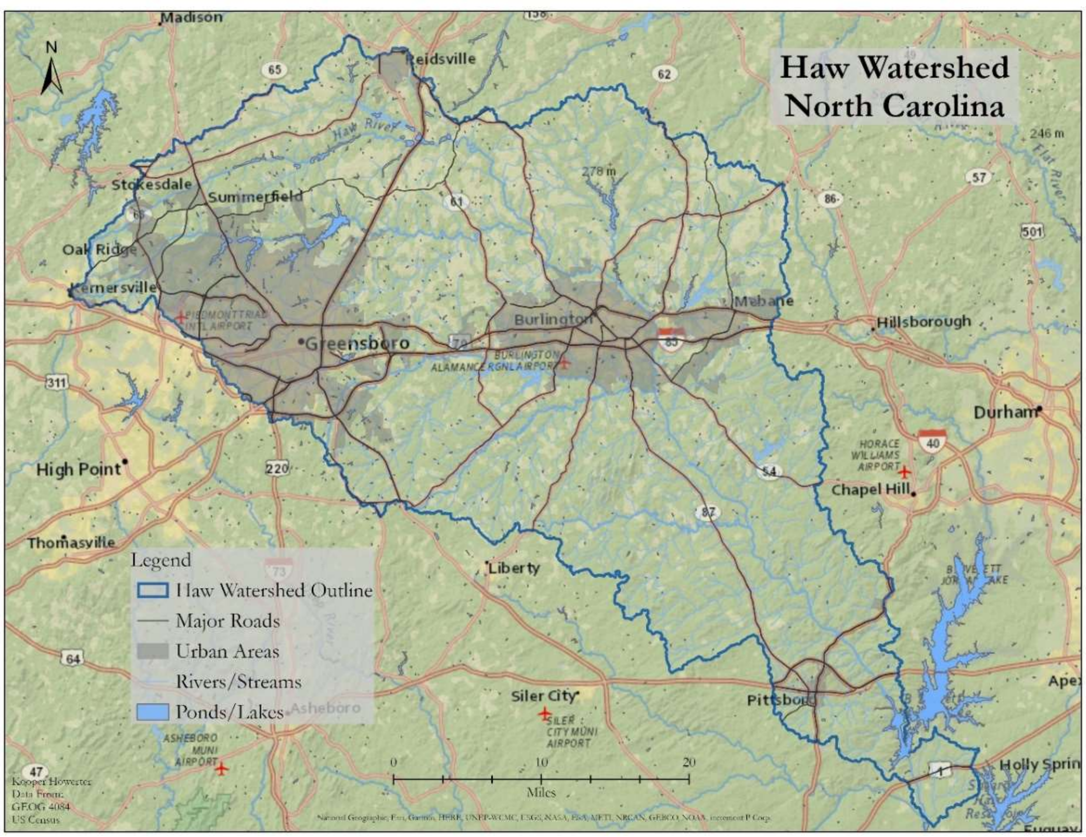
Hurricane Matthew affected large parts of the Greater Antilles in Early Fall, 2016. Most of the damage and destruction from the storm was felt by Haiti, Cuba, and the Bahamas, but it eventually reached the Southeastern United States, albeit with much smaller impacts. With large amounts of consistent rain in these affected areas of the US, the greatest risk was flash flooding. In low lying areas during a storm, especially those below the flow of a river or large stream, the amount of runoff coming in can become a natural disaster very quickly. From October 7-9, extensive rain and winds caused widespread flooding, power outages, around $6 billion in damages, and the loss of 47 US lives.

The goal of this lab was to use flood modeling tools in ArcGIS to analyze a specific watershed that was impacted by the hurricane to determine where the greatest flood risks were. The major factors that contribute to the analysis are landcover, soils, terrain, and precipitation. First, landcover affects runoff of water as different cover types prevent or increase the flow. For example, forest soil absorbs water while impervious roads increase the runoff. Next, the soils present are important, as different soils retain varying amounts of water. Sandy absorb large amounts of rainfall, while clays can be more impervious. Terrain impacts runoff potential as the shape and elevation of the landscape directs the water flow. Areas on hill tops have low risk for flooding, while in valleys there are greater risks. Lastly, precipitation is the most important variable for analyzing flood risks. Without unusually large amounts of rain, there is no severe risk for a flood. An increase in rainfall directly increases the risk of flooding. These variables together will allow us to analyze flood potential in our study area. The results could help to plan for, prevent, and stay safe from future flooding events in the area, potentially minimizing damages and lives lost.

Study Area:

The Haw watershed is located in north-central North Carolina and covers land in parts of ten different counties. The center of the watershed is the 110-mile-long Haw River that flows from the northwest to southwest corners of the area. There are also several large tributary streams connected to the Haw and several small to medium sized lakes, the biggest being Jordan Lake in the Southeast (excluded from study because drainage sink). As seen in the study area map (figure 1, page 2) the biggest urban area is Greensboro, North Carolina; a city of around 300,000 people with a metropolitan area of about double that. Other urban areas include Burlington, Reidsville, Mebane, and Pittsboro. During tropical storms and hurricanes these areas require the most attention, whether it is evacuating a large population, rebuilding after infrastructure damage, or rescuing/helping people in need.

Figure 1: Study Area



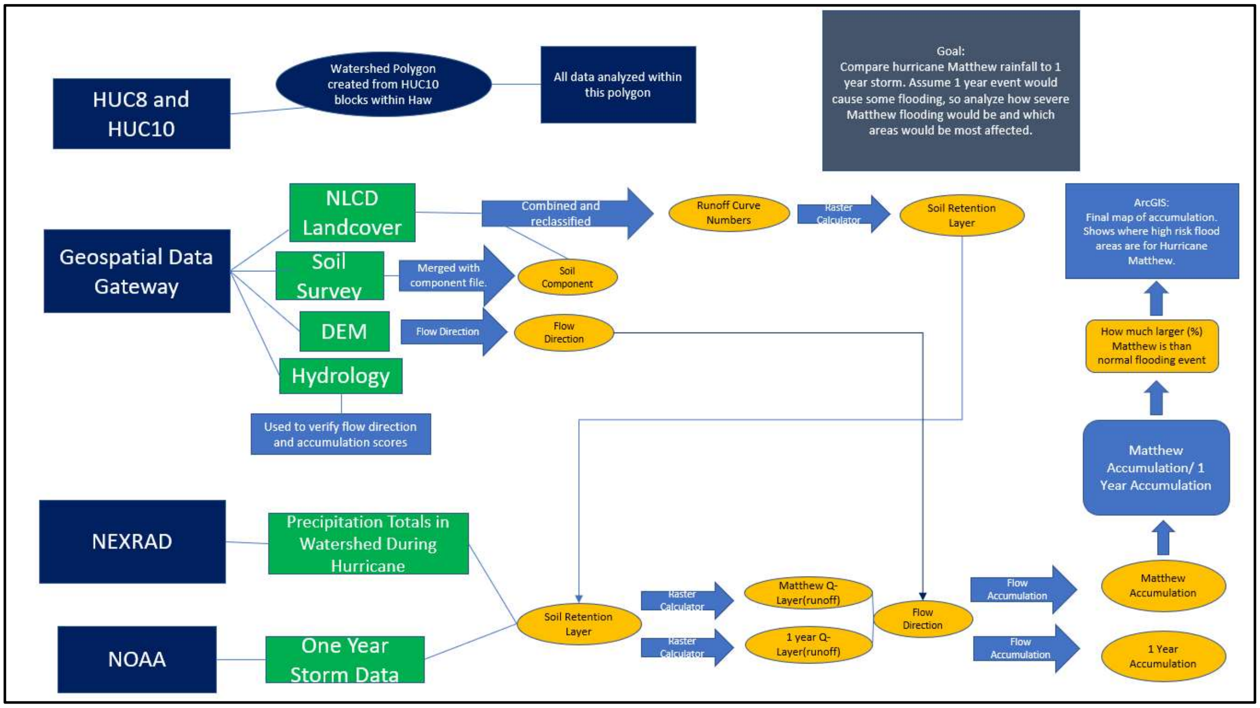
The watershed is pretty centrally located in the state, with population centers in most directions, so lots of major roads are present (figure 1). These roads should be carefully monitored during a storm, as water damage to them could be devastating to evacuation, rescue, and rebuilding efforts.

This area in North Carolina is diverse in a lot of aspects. There are some of the most affluent counties in the state (Orange, Wake) as well as some medium to low affluence areas (Caswell, Rockingham, etc.). It is important to note how the impacts of the storm can be multiplied in some of the less wealthy areas. Geographically, the area is diverse as well. There are urban areas, rural areas, and lots of water bodies. Overall, I would say that the watershed is pretty densely populated in comparison to the rest of the state. Even though most of the study area is over 100 miles from the coast, during Matthew torrential rainfall reached well into the area. The watershed is a good example of an area that did not get the absolute worst of the storm but was still greatly impacted.

Methods:

The first major step in the process to model the potential flooding in the Haw watershed was to collect all of the data needed for the area. A polygon for the watershed was needed to analyze all of the other data within it. The USDA Geospatial Data was extremely useful in providing landcover, soil, elevation, and hydrology data that we would need. NOAA and Nexrad gave us both the 1-year storm precipitation info and the data from Hurricane Matthew on October 8, 2016. After manipulating all of this data based on our study area polygon, we were able to start the analysis.

Figure 2:Flowchart of Process



By using the landcover and soil data together, we could create a runoff curve layer of the watershed that represents which areas have potential for the highest runoff. The lower numbers are typically areas with soil of good absorption combined with landcover types like forest that slow the flow of water, while the higher numbers tend to have fine grained soils that absorb less and/or landcover types with more impervious surfaces that contribute to runoff. Using these curve numbers, we then calculated the soil retention layer that showed how much precipitation could be held before flooding begins. This retention layer was used twice, first with the one-year-storm data, and then with the Nexrad hurricane data to produce a runoff layer (q) specific to each event. After creating flow direction using the elevation data, we could use the runoff layer (q) combined with flow direction to get the flow accumulation layer for both a 1-year-storm event and the hurricane. The final major step was dividing the Matthew accumulation layer by the 1-year-accumulation to show how much more flooding would occur during the hurricane compared to a ‘typical’ flooding event. For the sake of the analysis, it was assumed that the 1-year-event would cause light to moderate flooding, so we are using it as the base 'typical' flooding event to compare to. The results of this final step were displayed to show our final map for areas in the watershed most at risk for flooding. For more detail on the process used, see figure 2 on page 4.

Results and Discussion:

Figure 3:Final Flood Risk Map

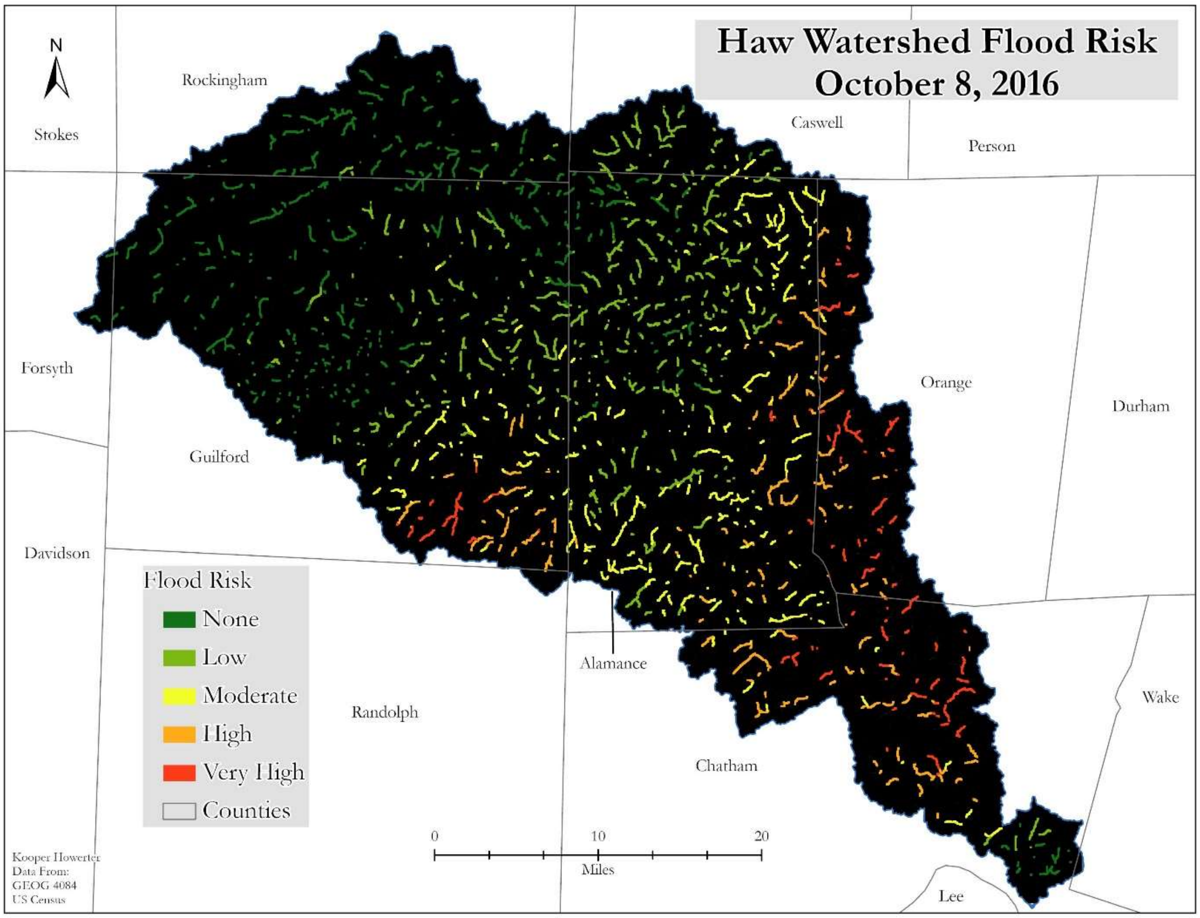


Figure 3 shows the final map displaying the flood risk areas of the Haw Watershed during October 8, 2016. An important note to make is that we are only showing the data for one watershed, so there is no information for the surrounding areas. However, this is not to say that the surrounding areas were impacted any more or less than this one. For example, we only see the western part of Orange County where there are several very high-risk areas. To see the risks of the rest of the county we would need to run the model again for another watershed.

The overall trend of the map is that the further East you look in the watershed, the more risk there is of flooding. The western portions typically have no or low risk, areas in the center mostly have moderate risk, and on the East, there is moderate to very high risk. This makes sense when we consider the broader geography of the region we are looking at. We are in the middle of the state, in an area that was about as far as the hurricane reached inland. It makes sense that we would see a gradual decrease in storm impact, including flooding, the farther West we look. This is also corroborated by the precipitation map (figure 4), that shows the heaviest rainfall was in the eastern part of the watershed, with significantly less in the northwest. We can also see the distinct positive relationship between rainfall and flood risk by comparing the two, as all of the high-risk areas (figure 3) received some of the highest rainfall amounts on the precipitation map (figure 4).

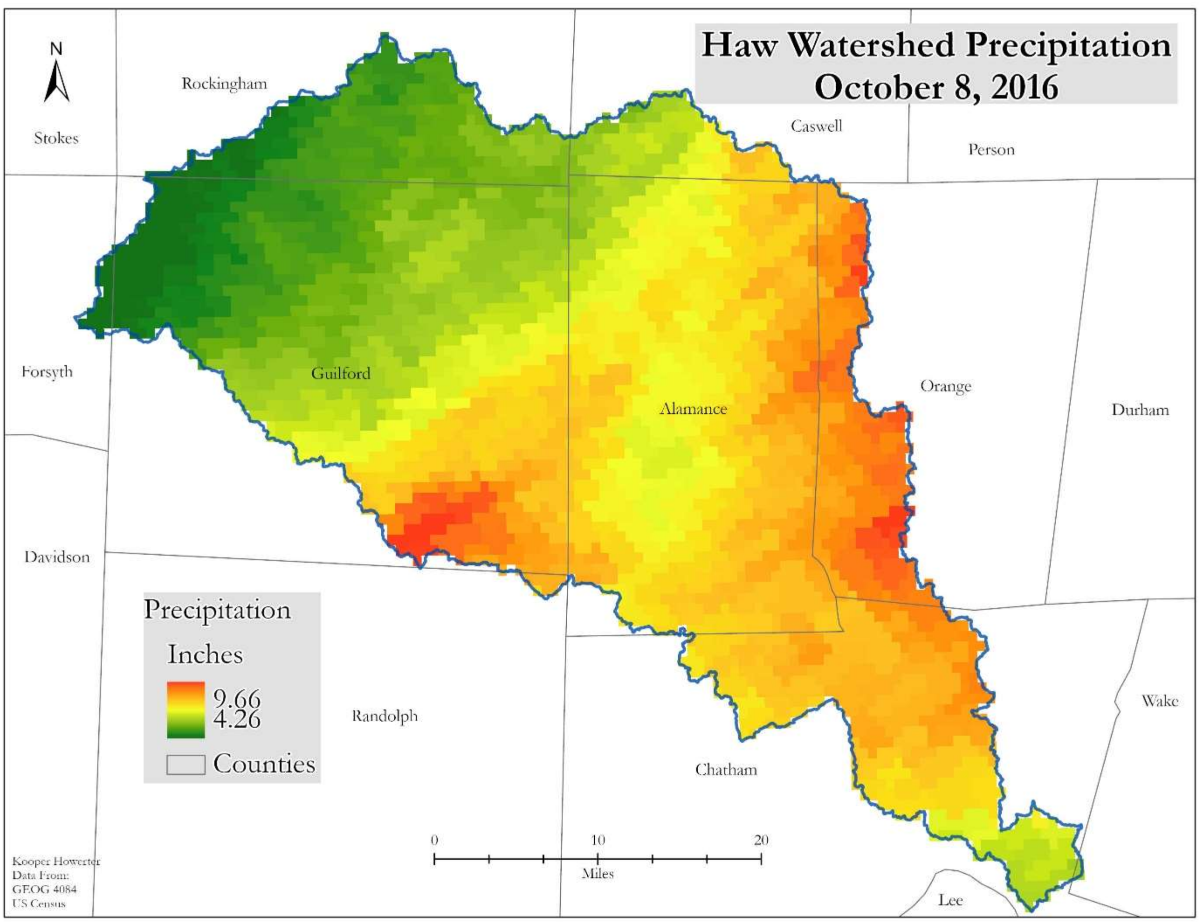
It is important to compare the results of the flood risk map (figure 3) to the overview of the study area (figure 1) so we can see which aspects of the area are most at risk. Greensboro, by far the most populated area in the watershed, is relatively safe from risk. Our flood map shows that in this urban area, there are no areas of high or very high risk, with most being no risk. However, smaller urban areas of Burlington, Mebane, and Pittsboro are located in areas with much higher risk. We can also see some of the major roads that are at risk for flooding and water damage, including Route 87 and Route 54.

Conclusion:

Based on our flood risk analysis, we can pinpoint which specific parts of the watershed were most at risk from the Hurricane Matthew's precipitation. In the Haw watershed, these were concentrated in the East. These places with higher risk generally have a combination of high precipitation, poor soil retention, landcover that increases runoff, and terrain that directs runoff towards the area. The results could be utilized in several ways. For one, response and rebuilding efforts could be focused based on the map, which would show where most of the damages were likely to occur. They could also be kept for use in the future. If a similar storm was predicted, the results could be used to plan which areas may need to be evacuated, which would be safe, and where the greatest danger for destruction and loss of lives would be. Unfortunately, 28 lives were lost in North Carolina alone due to the storm. Hopefully, the increasing knowledge and use of models like the one used in this lab can help to prevent future losses in similar situations.

Appendix:

Figure 4: Precipitation Map



References:

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Hurricane Matthew info: https://www.weather.gov/ilm/Matthew

https://en.wikipedia.org/wiki/Hurricane_Matthew

Nexrad: https://www.ncdc.noaa.gov/data-access/radar-data/nexrad

Haw Watershed: http://org.elon.edu/envstudies/BASIC/HRW_watershed_info.htm

Tiger Shapefiles: https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html