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August 2016 Louisiana Flooding

ArcGIS Analysis of the Flooding in the Amite River Basin

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Contents

Table of Figures

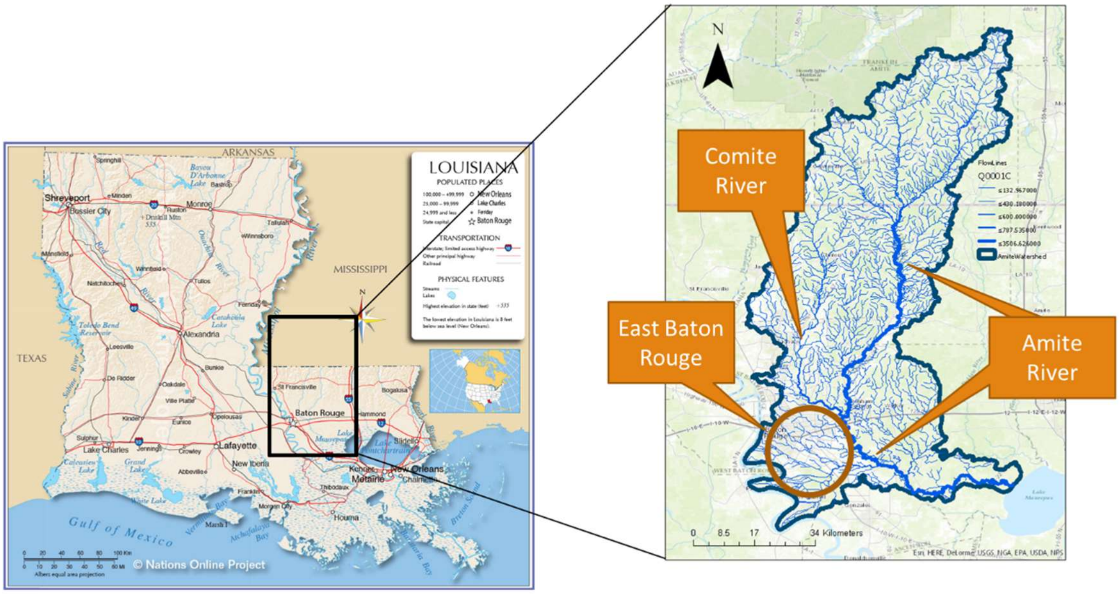
Introduction

In August, 2016 southern Louisiana experienced a staggering amount of rainfall within a very short period of time. Many of the rivers were unable to handle the massive amount of water, causing much of Louisiana to experience severe flooding for multiple days. Eight rivers in south Louisiana set stage records; one location along the Amite river beat its previous record by five feet (Barney, 2016). In some places, the water did not subside until eight days after the flooding began. Not only was there a lot of property damage, but, tragically, 13 people lost their lives. The Red Cross has labeled the event as the worst natural disaster to affect the United States since Hurricane Sandy in 2012 (Yan & Flores, 2016).

The purpose of this project was to utilize ArcGIS to analyze and understand the flooding event. Several resources, primarily provided by the United States Geological Survey (USGS) and the National Weather Service (NWS), were used to obtain data for the analysis. These resources included: precipitation, river stage, elevation, and high water mark datasets. By manipulating this data and mapping it in ArcGIS, several observations were made; these observations are presented in this report. Although a large area was affected by flooding, this project focuses on a single watershed in southern Louisiana: the Amite River Basin. This watershed was chosen as it was one of the most heavily impacted in the region, and it includes the capital of Louisiana, Baton Rouge.

Amite River Watershed Background

Most of the Amite river watershed is located in southern Louisiana. The northern portion of this watershed includes Amite county in Mississippi, and the bottom is found in Baton Rouge, Louisiana. As can be seen in Figure 1, the Amite river flows from the top of the watershed, all the way down to Lake Maurepas, and ultimately into Lake Pontchartrain and the Gulf of Mexico. Approximately 60 miles upstream from Lake Maurepas, the Amite river passes just northeast of Baton Rouge, where it merges with the second major river in the watershed, the Comite river. The watershed area is approximately 4900 square kilometers and the Amite river is 188 kilometers long.



Nations Online Project. *Map of Louisiana*. [Photograph]. Retrieved from http://www.nationsonline.org/oneworld/map/USA/louisiana_map.htm

Figure 1 The Amite River Watershed Location – Map of Louisiana (Left) (Nations Online Project, 2016); Delineated Stream Network (Right)

Analysis and Results

Quantifying the Precipitation

The first step in the analysis was to quantify the precipitation that fell over the period under consideration. It was found that most of the rainfall occurred within a 2-day period, August 12th-August 13th. The locations of USGS precipitation stations in the area and the total rainfall at each over this 2-day period were obtained. These data were then mapped and manipulated in ArcGIS to produce a precipitation map by Empirical Bayesian kriging. As can be seen in Figure 2, some areas experienced over 2 feet of

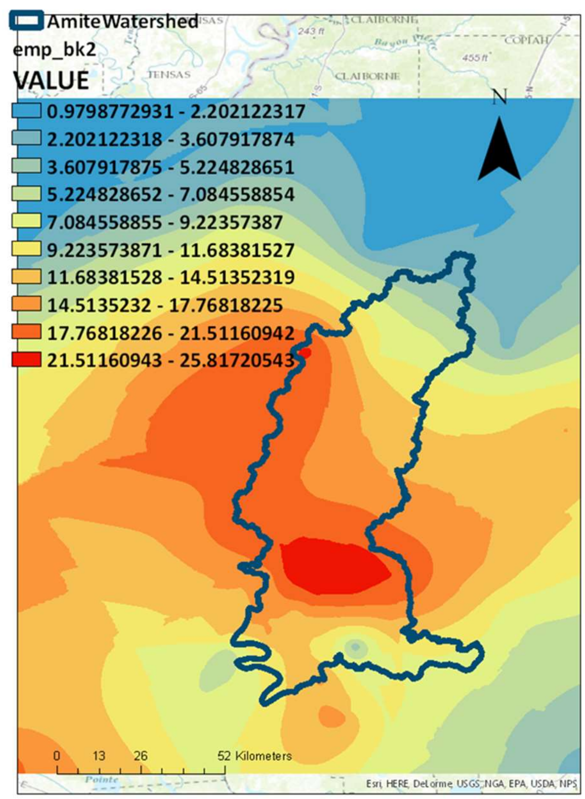


Figure 2 Precipitation Map in Inches (Aug 12 - Aug 13, 2016)

precipitation in just 2 days. This is an almost unbelievable amount of rainfall that corresponds to a 1000-year event.

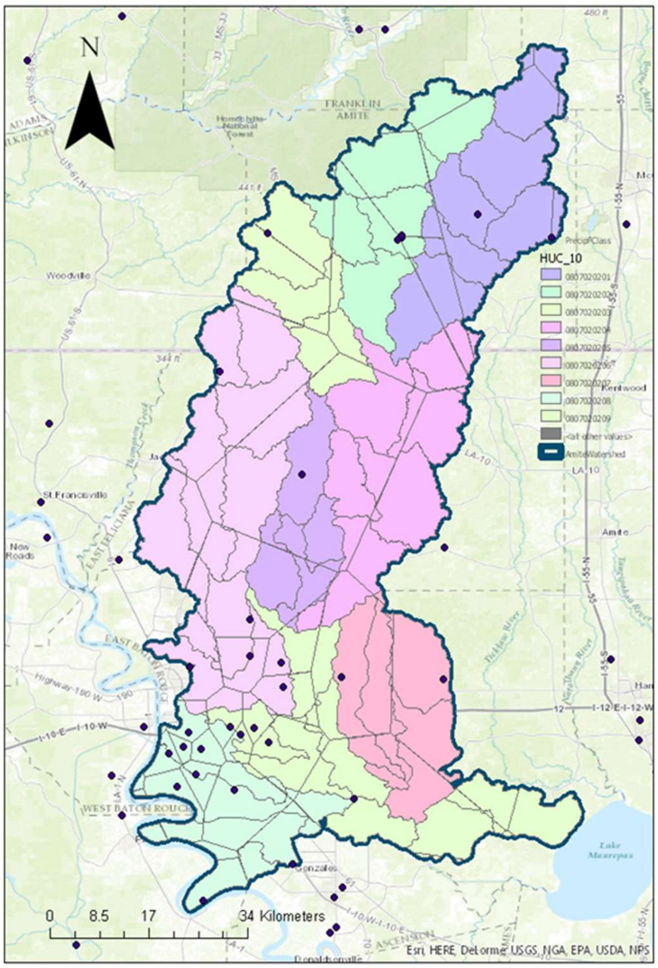


Figure 3 Precipitation Stations and Corresponding Thiessen Polygons

The total rainfall experienced over the 2-day period in consideration was approximated using Thiessen polygons. Figure 3 shows the locations of the stations, and how their corresponding polygons were divided. Using the precipitation amount from each station and the area of the polygon located within the watershed, it was determined that approximately 0.5 trillion gallons of water fell in these 2 days in the watershed.

According to J. Samenow, 7.1 trillion gallons fell in all of southern Louisiana, which is 3 times as much as was experienced during Hurricane Katrina in 2005 (2016). It's clear that this level of precipitation was essentially unprecedented, and it's easy to imagine that it would cause a lot of flooding.

Watershed Elevation Profile

When considering water flow after a precipitation event like this, it's important to understand the topography of the region. The slopes of the rivers and land influence how water will behave. One of the most important topographical characteristics of this region that helps explain this event is that south Louisiana is essentially flat. This fact is visualized in Figure 4.

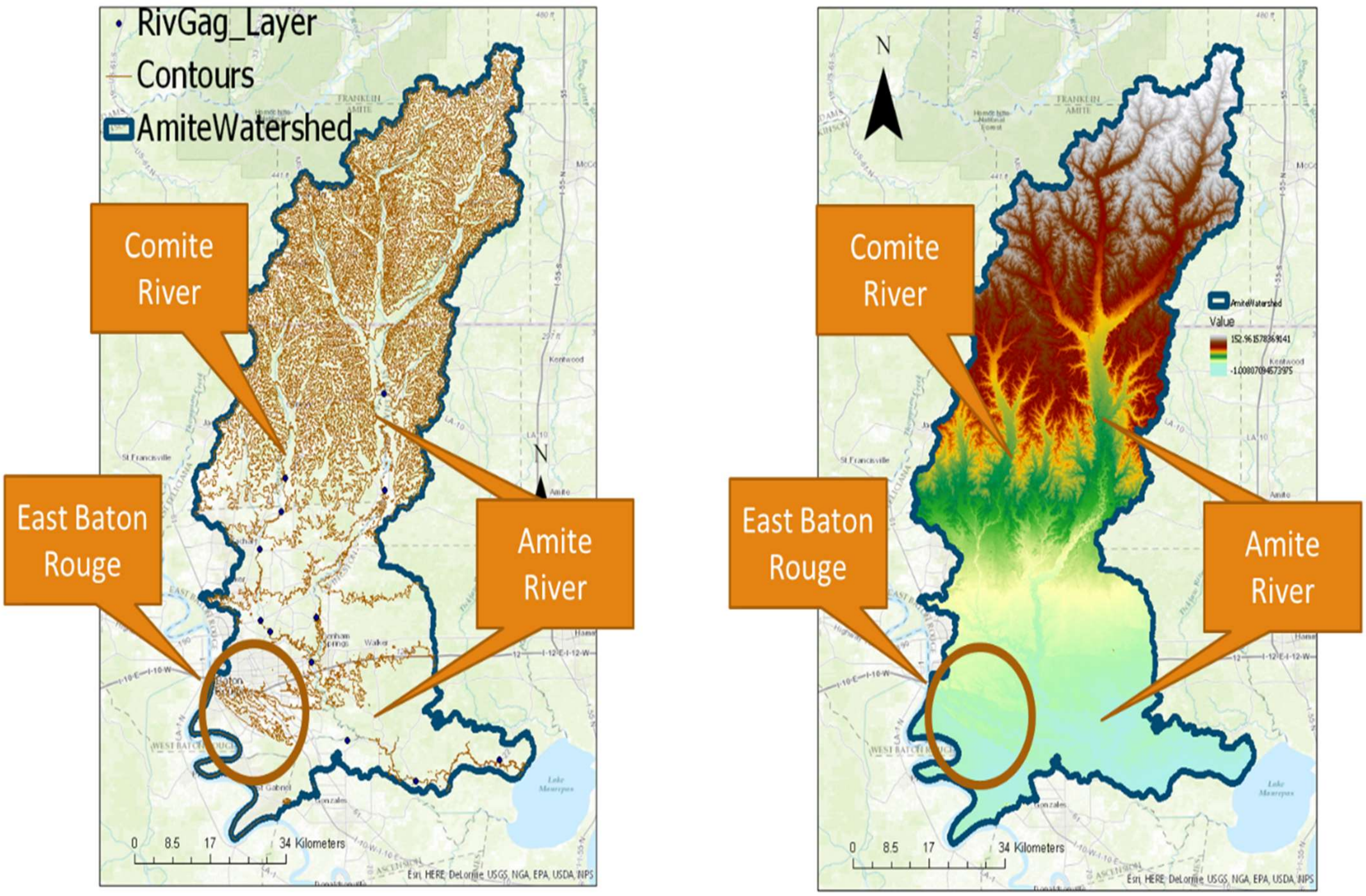


Figure 4 Contour Map (Left); Digital Elevation Model (Right)

As can be seen in Figure 4, although the top portion of the watershed appears to have normal elevation variations, the bottom portion is mostly flat. In the digital elevation model (DEM) to the right, it is nearly impossible to see any difference in elevation at the bottom. Some elevation variation can be seen in the contour map to the left, but the concentration of lines (which correspond to 10-meter elevation differences) is much lower in the south than in the northern portion of the watershed.

The slope of the Amite river is presented in Figure 5, and as expected, it corresponds to the DEM and contour maps. There is a clear downward bottom slope until around Baton Rouge, where the slope drastically reduces.

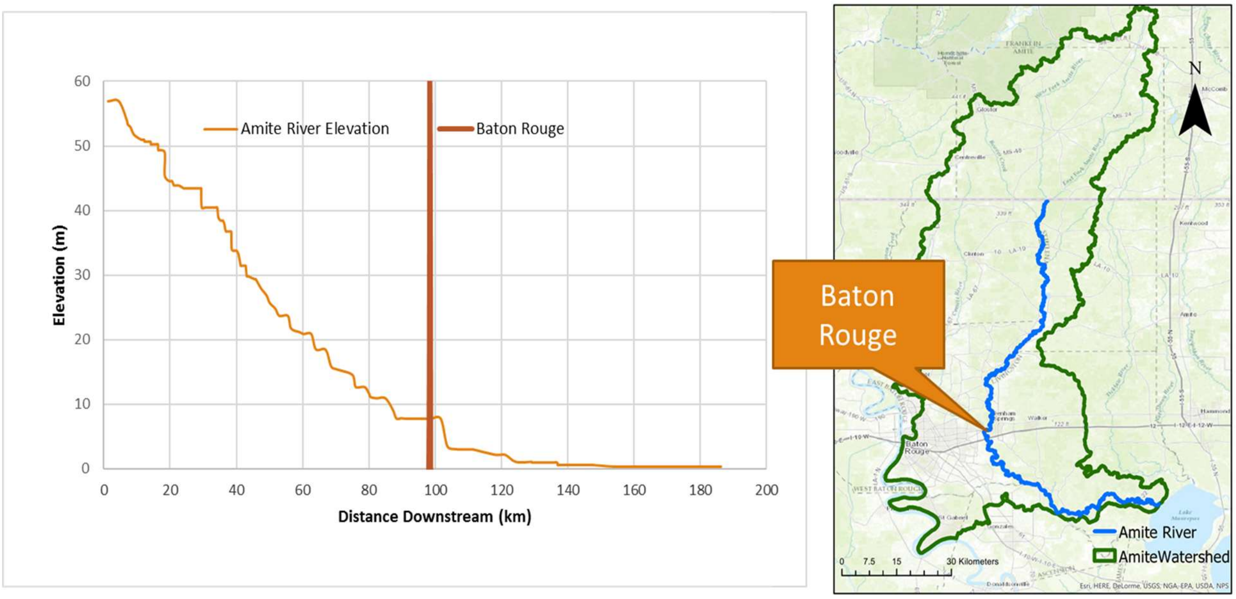


Figure 5 Amite River Slope

Because of the elevation profile of the river, water flow greatly reduces when it gets to the southern portion of the watershed. This can result in a pooling effect when a lot of water is presented to the system. Ultimately, this regional characteristic was a major contributor to why so much flooding occurred. Not only was the amount of precipitation historic, but the water was not able to quickly flow out of the region. Instead, it pooled at the bottom of the watershed due to the natural elevation and drained very slowly.

Consequences of Elevation Profile

Figure 6 visualizes how the Amite river stream gauges measured water depth. Three different river gauges and their river height data from the flooding time period are presented. The map on the right is helpful for understanding where the gauges are in relation to the watershed. Notice that the first (Upstream) gauge is immediately downstream of where the contour concentration begins to decrease. The second river gauge (Junction) is located right after the Comite and the Amite rivers meet near Baton Rouge. The third gauge (Tributary) is on a small tributary immediately off the Amite river and is positioned where the river slope has been very low for a while.

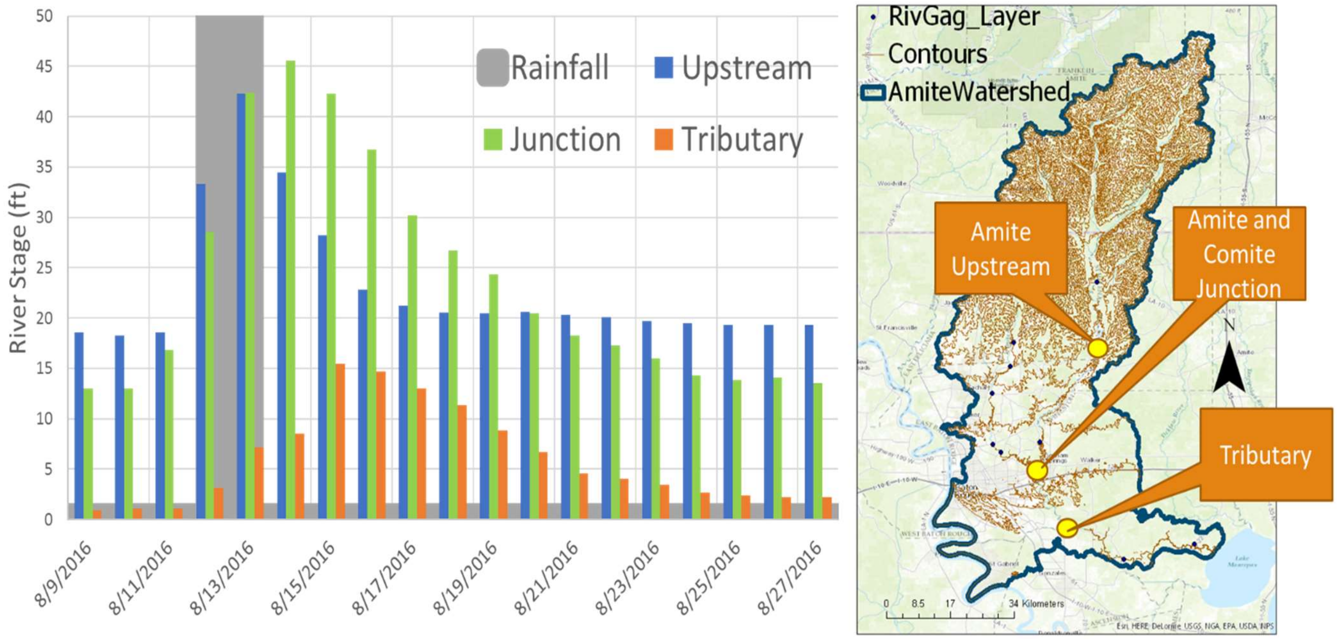


Figure 6 River Stage at Three Locations Over Time

On the bar chart in Figure 6 to the left, the gray box represents the 2-day period over which most of the precipitation occurred. Notice the Upstream gauge peaks in accordance with this rainfall and returns to a somewhat normal level within a few days. The other two gauges, however, peak after the main rainfall event and take longer to return to normal levels. The Junction gauge peaks before the Tributary gauge, and both take about the same time to normalize. Since the Tributary gauge is not located on the Amite river, it can be concluded that backwater flooding occurred. As the slug of water passed the tributary, water flowed back into the tributary causing flooding of the surrounding area.

This is further visualized in Figure 7 where all three gauges are compared to their flood stage over the same time period. Whenever the stage of the water is above the flood stage, flooding is expected to occur. The Upstream gauge only recorded one day above flood stage as the water came and went comparatively quickly. The Junction gauge spent 4 days above flood stage and the tributary experienced 8 days above flood stage. The flooding profiles behaved as expected, considering the geographic profile of the region discussed previously.

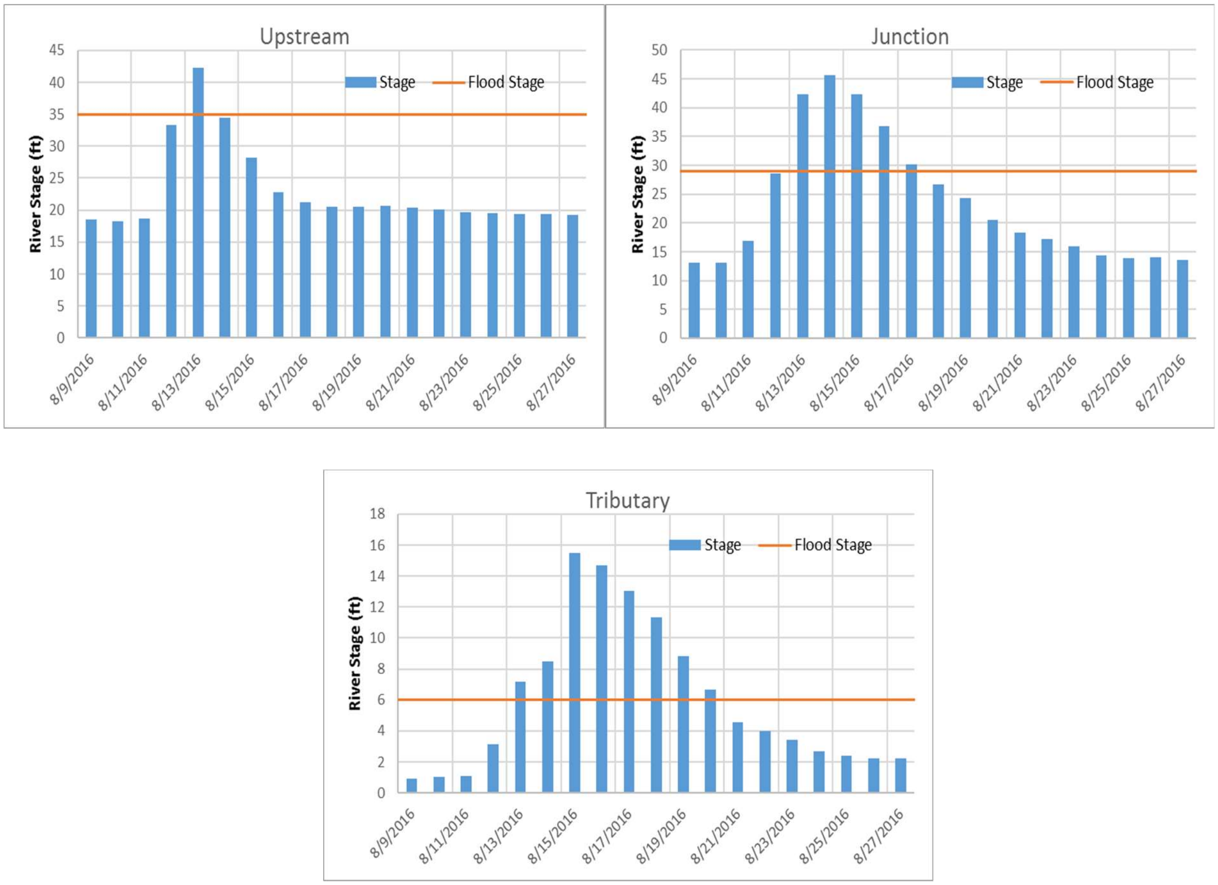


Figure 7 Flood Stage of Three Locations Along the Amite River

Extent of Flooding

The next thing considered was the extent of flooding throughout the watershed. Following the flooding, high water mark data was collected and this data was used to visualize the degree of flooding. Figure 8 shows high water marks measuring greater than 5 feet in the watershed. On the left, high water marks are mapped along with the delineated stream network. Flooding is shown to have occurred all along both the Comite and Amite rivers. As expected, there is a high concentration of high water marks close to the Comite and Amite river junction. On the right, the high water marks are mapped with the land cover data for the watershed. In the southwest, there is a high concentration of development, which corresponds to the city of Baton Rouge. While much of the developed area was spared from 5 feet of flooding, there are still parts of the city, and smaller cities in the watershed that suffered from a great deal of flooding.

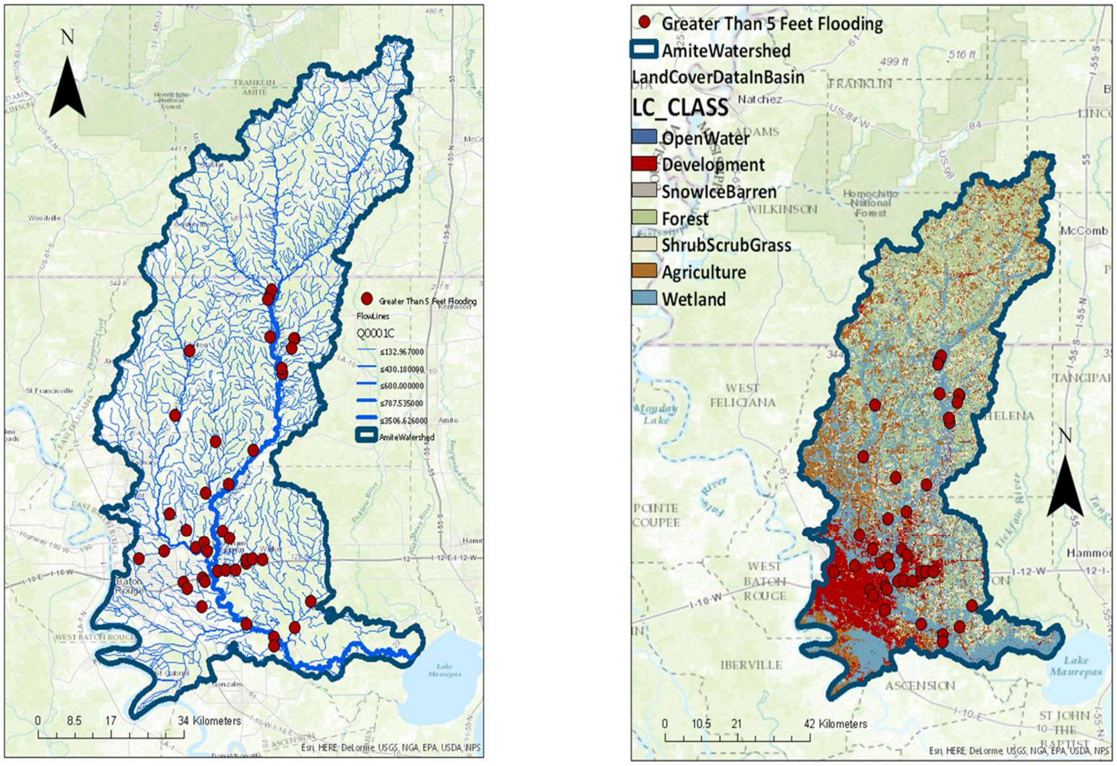


Figure 8 High Water Marks

Throughout southern Louisiana, many homes that were damaged are located outside of FEMA's "High-Risk Flood Zones." Because of this, unfortunately, many affected homeowners did not have flood insurance for their homes. (Ball, 2016). Since the precipitation was equivalent to a 1000-year event, most people probably did not expect an event like this to realistically occur. One important consideration not explored in this project is whether this event truly is a 1000-year event due to climate change. If events like this are more likely to occur in the near future than current models predict, it is imperative that FEMA reconsider its classification of flood risk zones to help homeowners more adequately understand the risk associated with their home location.

Since the flooding was so severe, and lasted for so long, the major interstates in the region were also negatively affected. Figure 9 shows the high water marks in relation to Interstate-10 and Interstate-12. It is clear that many high water marks are close to I-12. Although I-10 didn't experience flooding as severe as I-12, it was still closed for a period of time. In the Amite river watershed, both I-10 and I-12 were closed for 5 days from August 12th-August 16th. I-10 was closed for an additional 2 days further west of the watershed (Wells, I-10 reopens in Lafayette after historic flooding, 2016). This is a substantial amount of time for major roadways like these to be closed and made it difficult for emergency and response personnel to reach the impacted areas.

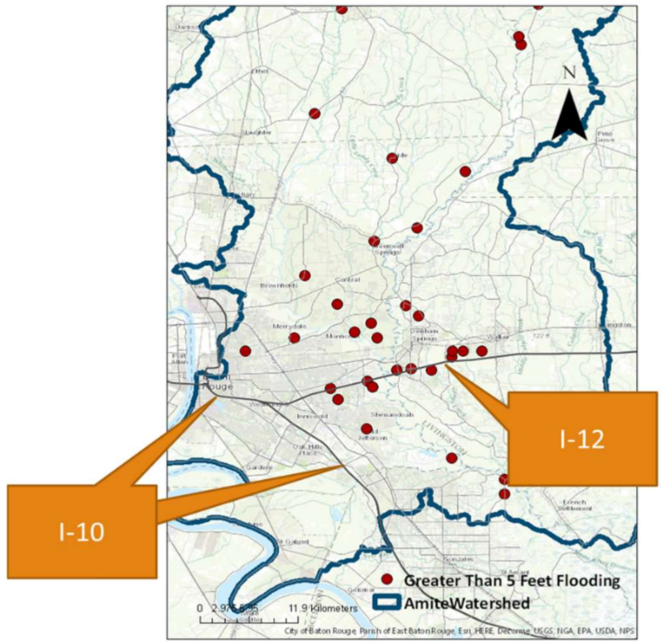


Figure 9 Interstate Flooding

HWMs and HAND

As the slope decreases at the bottom of the watershed, so does the Height Above Nearest Drainage (HAND) for most of the region. This is visualized in Figure 10. On the left, the HAND for the entire watershed is shown. As you go further south, the HAND gets incredibly small compared to the rest of the watershed. It's nearly impossible to differentiate between different points throughout much of the area. On the right, the frame is zoomed and the scale is changed to reveal smaller differences. In the figure on the right, over half of the area is less than 1 foot above the nearest drainage, and nearly all the area is less than 4 feet above the nearest drainage. There is a higher concentration of >5-foot high water marks in areas with a HAND of less than 1 foot. However, there are still portions of the map that experienced severe flooding despite having a HAND value between 3 and 4 feet. These differences in HAND are relatively small, especially when considering precipitation and flooding of this magnitude. It is not unreasonable to see how even the relatively “high” regions in the south of the watershed could still be subject to severe flooding in this scenario. What does seem clear is that HAND may not be a reliable method for predicting flood extent when considering geography like that of southern Louisiana.

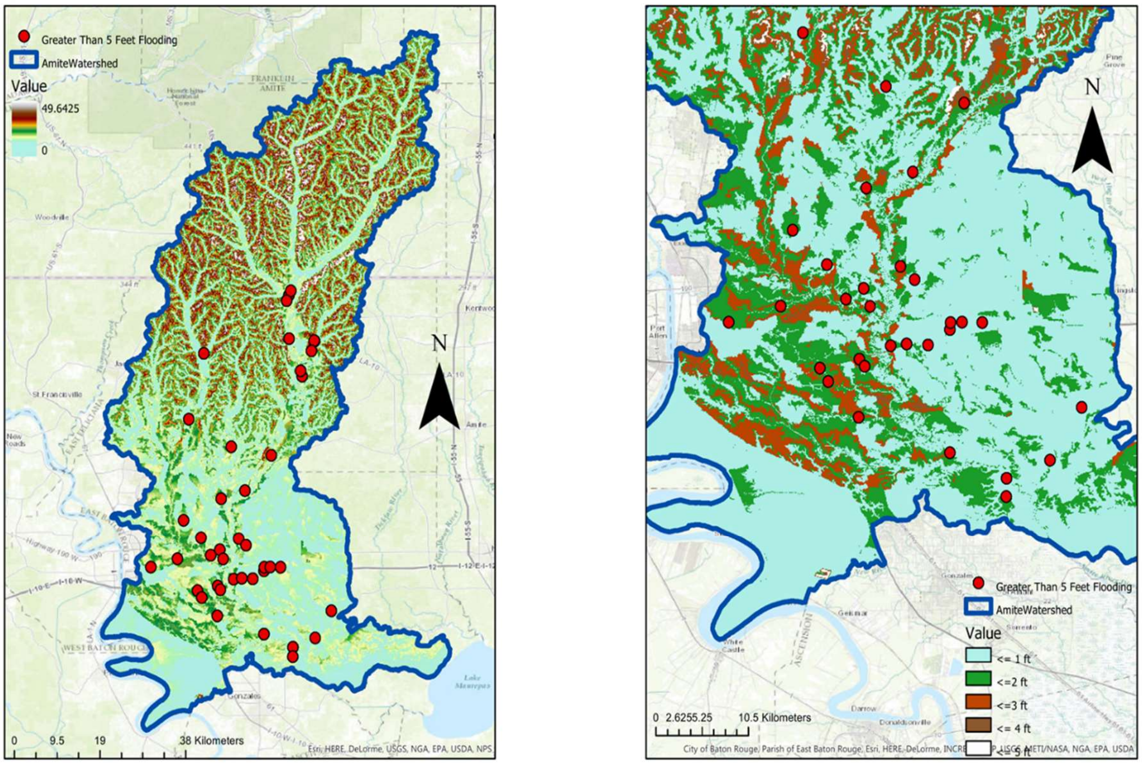


Figure 10 Height Above Nearest Drainage

Conclusions

As to be expected from a 1000-year rainfall event the unprecedented amount of precipitation was the main contributor to this tragic event. However, as this analysis demonstrates, the topography of the southern region of the Amite river basin greatly exacerbated the extent of the flooding experienced. It did not take long for the water to drain from the northern part of the watershed, but then it pooled in the southern part due to the flatness of the region. The huge amount of water caused many of the tributaries of the Amite river to experience backwater flooding, and the slow velocity of the water resulted in a week-long flood in some areas.

In the end, a great deal of damage was done, and several lives were lost. This event has shown how susceptible the area is to this amount of precipitation. Moving forward, it is important to understand if this event was truly a 1000-year occurrence, or if it is now more common due to climate change. If it is determined that such an event is more likely to occur than previously thought, steps must be taken where possible to mitigate risk and to educate homeowners of the risk they are subject to. Even though this work only scratches the surface of what ArcGIS is capable of, it has proven to be a powerful tool for analyzing and understanding this event.

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