Panhandle Watershed Case Study
TMDL BASINS 02

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Executive Summary

Flooding is the most common and costly disaster in the United States. Over 98% of counties in the entire United States having experienced a flood and just one inch of water causing up to $25,000 in damage (FEMA 2018). Flooding can impact a community’s social, cultural, environmental and economic resources; therefore, producing sound, science-based, long-term decisions to improve resiliency are critical to future prosperity and growth. To meet the longer-term goals to protect life and property, in 1990, FEMA created the National Flood Insurance Program’s (NFIP) Community Rating System (CRS) program, a voluntary program for recognizing and encouraging community floodplain management activities. Nearly 3.6 million policyholders in 1,444 communities participate in the CRS program, but this is only 5% of the over 22,000 communities participating in the NFIP.

The Florida Department of Emergency Management (FDEM) contracted with FAU to develop data to enable local communities to reduce flood insurance costs through mitigation and resiliency efforts by developing watershed management plans. There are several steps to address the development of watershed plans including the development of a watershed planning template and development of support documents to establish risk associated with community risk within the watershed.

The effort discussed herein focuses on the development procedures for a screening tool to assess risk in the Panhandle TMDL 02 area of Florida. The watershed located in Northwest Florida combines readily available data on topography, ground and surface water elevations, tidal data for coastal communities, open space and rainfall to permit an assessment of the risk of inundation of property within the TMDL 05 Basin. Such knowledge permits the development of tools to permit local agencies to develop means to address high risk properties.
1.0 Introduction
In 1972, the Florida Legislature created the Northwest Florida Water Management District (NWFWMD) within the passage of the Water Resources Act (Pratt et al., 1996). The NWFWMD encompasses an area of about 11,200 square miles. The Panhandle Basin borders the Suwannee River Water Management District. The Panhandle consists of 5 TMDLs, and this report will focus on the western basin, TMDL 02; it is home to the City of Pensacola. The basin is coastal, so flood risks from rainfall, wet season thunderstorms and tropical storm activity are concerns for local officials and the nearly 400,000 people who live in the watershed. Figure 1 depicts the Pensacola, TMDL 02, shown in red, within the Panhandle region.

The Panhandle is the least populated and most lightly visited portion of Florida and is closer in appearance to its Deep South neighbors than the tropical backdrop that characterizes the rest of the state.

![Figure 26. Location of Panhandle](image-url)
2.0 Summary of Watershed

2.1. General Description of Watershed

2.1.1. Climate/Ecology

Nature reigns supreme in North Florida; forests, preserves and parks remain home to wildlife such as black bears, bald eagles and the rare Florida panther (smilingglobe.com, 2020). Cool freshwater springs can be seen throughout the panhandle area allowing for some recreational opportunities such as tubing, cave diving, etc. Normal annual rainfall ranges from about 55 to 67 inches per year; the average annual rainfall is generally highest in the western portion of the NWFWMD and lowest in the eastern portion (Pratt et al., 1996). There are two distinct rainy seasons each year, the first resulting from frontal storm systems during the winter and early spring, and the second occurring during the summer as a result of afternoon and evening thunderstorms.

2.1.2. Topography and Soils

The regions rolling, hilly terrain more closely resembles areas within Alabama or Georgia than peninsula Florida. Elevations in the highlands area range from 50 to 345 feet above sea level. The highest point in Florida, at 345 feet, is located near the town of Lakewood, which is almost on the Alabama border (smilingglobe.com, 2020). The major physiographic features include the Northern Highlands, and the Coastal Lowlands (Pratt et al., 1996). Panhandle beaches are famous for their white ‘sugar sand’, composed of quartz washed down from the Appalachian Mountains by ancient rivers. Elevations are low, ranging from sea level to about 100 feet above sea level. The native soil and topography create an environment that is highly permeable and can absorb a significant amount of water into the soil; however, the change in the land use has resulted in the flow of water leading to impermeable land where the water collects in pools or runs off rapidly where development has taken place, in direct contrast to the natural condition. The land in many areas is poorly drained due to a flat topography and associated high water table.

2.1.3. Boundaries/Surface Waters

Drained by several large rivers, the region has extensive pine and hardwood forests, springs and swamps. Barrier islands, beaches, and tidal marshes border most of the Gulf Coast
The key elements of the watershed include the bays (Pensacola Bay and Choctawhatchee Bay), a few lakes, the rivers (Escambia River), the canal system and the rainfall over the area. Figure 2 depicts the TMDL 02 subdivided into 4 HUCs that will later be analyzed individually through the use of CASCADE.

2.1.4. Hydrogeological Considerations

In northwest Florida, the hydrogeologic framework is divided into four groups of sediments that constitute distinct hydrogeologic systems, and each system is a compilation of lithologic beds that have similar hydrogeologic characteristics. (Pratt et al., 1996). Systems are defined by their ability to accelerate or hinder the flow of water and, thus, are not constrained by lithologic or stratigraphic boundaries. In descending order from land surface, the four systems are: Surficial Aquifer System, which includes the Sand-and-Gravel Aquifer; Intermediate System; Floridan Aquifer System; and Sub-Floridan System. In northwest Florida, the Ad Hoc Committee recognized three aquifer systems, which includes the surficial aquifer system, the intermediate aquifer system and the Floridan aquifer system, and two confining units, which includes the intermediate confining unit and the sub-Floridan confining unit. The subsurface characteristics of each system vary both
laterally and with depth. The nature of the variability determines ground water availability or the degree of detention for the respective system at any given location.

2.2. Socio-economic Conditions of the Watershed

2.2.1. Demographics (US Census, 2010)

As of the 2010, the 2 counties that make up the TMDL 02 Basin had a total population of 395,051 people and 138,748 households. The average household size for the TMDL 02 was 3 people per household. The population consists of roughly 22% under the age of 18, 16.3% who were 65 years of age or older. The racial makeup of the county was 84% White, 8.5% Black or African American, 2.7% Asian, 0.80% Native American, 0.20% Pacific Islander. As of the 2010, the median income for a household in the county was $64,145, and roughly 11.10% of the population were below the poverty line.

2.2.2. Property

According the US Census, the median property valuation, as of 2018, is roughly near $200,000.

2.2.3. Economic Activity/Industry

As of 2018, the total number of employments within the TMDL 02 area is 44,295, with roughly 4,145 establishments. The total retail sales are roughly $4 million (US Census, 2018). Cool freshwater springs bubble up everywhere, affording recreational opportunities such as tubing, swimming, snorkeling, cave diving and sightseeing on glass-bottom boats (smilingglobe.com, 2020). Outdoor enthusiasts can canoe wild and scenic rivers, camp on an open prairie, cycle along the Gulf of Mexico, catch their own scallops, kayak past centuries-old forts and more.
3.0 Watershed Analysis

3.1 Data Sets

3.1.1 Topography

Figure 3 depicts the results of the LiDAR DEM, using 3-meter tiles, processed conducted for the Panhandle Basin. The highest points are approximately 521 feet above sea level near border of Alabama, and the lowest points are 0 feet at sea level shown along the coast of the panhandle.

![Topography of TMDL 02 based on Lidar DEM](image)

The area with the highest elevation belongs to Upper Yellow River (HUC_103) at 134 feet, which are located within the State of Alabama, seen in Table 1. The largest area is also Upper Yellow River. The catchments were separated by the bodies of water within them, as well as by the location of water stations.
3.1.2. **Groundwater**

Figure 4 depicts the ground water levels within the Panhandle region. The highest point reaches 230 feet near the Alabama border, and the lowest point is at 0 feet along the coastline.

![TMDL 02 Groundwater](image)

*Figure 29. TMDL 02 Groundwater*

The area with the highest groundwater level occurs within the Upper Yellow River (HUC_103) and Upper Black water (HUC_104) at 229 feet, as seen in Table 2.
3.1.3. **Impervious Areas**

Figure 5 represents the impervious areas, primarily roads in the Panhandle region. These are areas where water cannot seep into the soil and as a result seep to unsaturated areas. Most of the impervious areas are located near the coastline.

Figure 30. TMDL 02 Impervious Areas
Figure 6 is the water holding capacity. The highest capacity is at 0.74 feet and the lowest is at zero feet.

![TMDL 02 Water Holding Capacity](image)

Figure 31. Pensacola Water Holding Capacity

3.1.4. Ground Storage

Figure 7 represents the ground storage within the Panhandle region. The highest levels of ground storage are located in the northern portion and stretch south within HUC_305. The lowest levels are concentrated near the coast.
The area with the highest ground storage level occurs within the Upper Yellow River (HUC_103) at 95 feet, seen in Table 3.

<table>
<thead>
<tr>
<th>HUC_103</th>
<th>Precipitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUC_104</td>
<td>Precipitation</td>
</tr>
<tr>
<td>HUC_105</td>
<td>Precipitation</td>
</tr>
<tr>
<td>HUC_305</td>
<td>Precipitation</td>
</tr>
</tbody>
</table>

3.1.5. Precipitation

Figure 8 depicts the precipitation values within the panhandle region. Precipitation rates drop from north to south. The 25-year/3 day precipitation for northern portions of the watershed is around 11
inches of rainfall while the southern portion can experience up to 14.5 inches of rain. The southern portion is adjacent to the Gulf of Mexico.

Figure 33. Pensacola Precipitation

Carpenter Creek (HUC_105) and East Bay River (HUC_105) experiences the largest amount of rainfall with roughly 14.5 inches of rainfall, seen in Table 4. Both Carpenter Creek and East Bay River are located in the southwest portion of the Panhandle region. The area with the lowest rainfall, nearly 9.5 inches, is located near Big Escambia Creek.

Table 8. TMDL 02 Precipitation

<table>
<thead>
<tr>
<th>HUC_103</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Table 8. TMDL 02 Precipitation</strong></td>
</tr>
<tr>
<td><strong>HUC_103</strong></td>
<td><strong>Table 8. TMDL 02 Precipitation</strong></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Table 8. TMDL 02 Precipitation</strong></td>
</tr>
<tr>
<td><strong>HUC_104</strong></td>
<td><strong>Table 8. TMDL 02 Precipitation</strong></td>
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<td></td>
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<tr>
<td></td>
<td><strong>Table 8. TMDL 02 Precipitation</strong></td>
</tr>
<tr>
<td><strong>HUC_105</strong></td>
<td><strong>Table 8. TMDL 02 Precipitation</strong></td>
</tr>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Table 8. TMDL 02 Precipitation</strong></td>
</tr>
<tr>
<td><strong>HUC_305</strong></td>
<td><strong>Table 8. TMDL 02 Precipitation</strong></td>
</tr>
</tbody>
</table>
3.1.6. Surface Waters

Figure 9 shows the location of existing water stations. The data provided from each water station will justify the results obtained from CASCADE. Some HUCs did not contain any existing water stations, however due to the flow of the rivers, the data collected from the basin upstream will be used to prove the validity of the results.

Figure 34. TMDL 02 Water Stations

3.1.7. Open Space

While the soil may have the capacity to store water, the type of land cover will either allow or prevent soil infiltration. If an area is covered by impervious surfaces, the rainfall will not infiltrate the soil causing surface runoff and increased flooding. Only those areas classified as open space, or pervious land, will minimize surface runoff, promoting soil infiltration and storage in the unsaturated zone. Therefore, incorporating impervious surfaces into the calculation of soil storage capacity is important. The National Land Cover Database was used to classify land as either
pervious or impervious. Then, impervious surfaces were assigned a value of zero to designate all impervious areas as having no soil storage capacity since rainfall will simply runoff along the surface without any soil infiltration, preventing storage in the unsaturated zone. Figure 10 depicts the open spaces using a binary system. The open spaces are scattered across the TMDL.

![Figure 35. TMDL 02 Open Space](image)

### 3.2. Modeling Protocol

There are many contributing factors to flooding, including the low land elevations, high groundwater table, and low soil storage capacity. To accurately identify land areas within the watershed that are vulnerable to flooding, all these factors were included in the flood risk model. The previously discussed datasets were used to calculate input parameters needed to run a flood simulation model called CASCADE 2001, which was developed by the South Florida Water Management District. The advantage of this model is that it incorporates several characteristics unique to each watershed, including the topography, groundwater, surface water, tides, soil type, land cover, and rainfall. By following FAU’s modeling protocol, all the necessary input parameters to run CASCADE 2001 were either directly calculated or derived from existing datasets. Several
surfaces were derived from the data and used to determine characteristics of the watershed, which represent the primary contributing factors to flooding. While a contributing factor such as the land elevation in the watershed can be directly observed using data collection methods such as LiDAR, other factors require further data processing and modeling.

CASCADE 2001 is a multi-basin hydrologic/hydraulic routing model developed by the South Florida Water Management District (SFWMD). The model develops solutions by basin. A basin is defined as an area where all the water that falls via rainfall stays in an area and travels to an outlet. The areas of the basin and the longest time it takes the runoff to travel to the most distance point to reach the point of discharge must be estimated. Rainfall is also needed. The waterway flow paths from ArcHydro as in Figure 11.

![Figure 36. TMDL 02 Flow Paths](image)

The inputs required by the model were prepared based on datasets of DEM, water table, soil storage, and rainfall. The steps are.

1. Area: Basing this information on the DEM values, which were derived from merging the smaller catchments into larger ones, the area was determined and converted to acre-ft.
2. Offsites: These were given to each catchment. Which offsite, was determined by where the water body drained into.

3. The initial stage: This was determined by finding the outlets

4. Ground storage: Data came from soil storage/ ground storage tables

5. Time of concentration: determined by dividing the longest river length by 3600

6. Rainfall: Data was used from precipitation tables

7. Stage-Storage relationship:

8. Structure: Initial stage values were used for gravity structures.

Figure 12-22 are examples interface of the simulation for one catchment in Cascade 2001

Figure 37. Upper Yellow River Cascade (HUC_103)

Figure 38. Shoal River Cascade (HUC_103)
Figure 39. Lower Yellow River Cascade (HUC_103)

Figure 40. Upper Blackwater River Cascade (HUC_104)

Figure 41. Big Coldwater Creek Cascade (HUC_104)
Figure 42. Lower Blackwater Creek Cascade (HUC_104)

Figure 43. Carpenter Creek Cascade (HUC_105)

Figure 44. Mulatto Bayou Cascade (HUC_105)
3.3. Modeling Results

3.3.1. Vulnerability to Flooding

Figure 23 displays the estimated flood risk for the Pensacola Watershed (TMDL Basin 02) based on a 3-day, 25-year rainfall. The highest risk is found along the coast and the lower portion of the four rivers that drain into Pensacola Bay and East Bay. The area is not densely populated but
includes a large urban cluster along the coast. The largest city in the metropolitan area is Pensacola. Other urban settlements include Crestview, Century, and Fort Walton Beach. The highest flooding risk is found in and around the cities of Pensacola and Fort Walton Beach.
3.3.2. **FEMA Flood Map Comparison**

For comparison, FEMA flood hazard areas identified on the Flood Insurance Rate Map are identified as a Special Flood Hazard Area (SFHA). SFHAs are defined as the area that will be inundated by the flood event having a “1-percent chance” of being equaled or exceeded in any given year. The 1-percent annual chance flood event is also referred to as a 100-year flood event. SFHAs are labeled as Zone A, Zone AE, and Zone VE. Figure 24 compares the flood risk zones based on the CASCADE results with the maps provided from FEMA. It shows an overlay of the estimated flood risk map with the FEMA’s 100-year floodplain. Table 5 provides a summary of the overlay statistics.
Figure 49. FEMA Flood Map Comparison
Table 5. Comparison between FEMA identified 100-year flood event and the CRT modeled flood region with a high probability for inundation in TMDL Basin #2.

<table>
<thead>
<tr>
<th>Category</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEMA 1% flooding (total area: km²)</td>
<td>432.9</td>
</tr>
<tr>
<td>Modeled flood risk (total area: km²)</td>
<td>367.3</td>
</tr>
<tr>
<td>Overlapping area (total area: km²)</td>
<td>255.7</td>
</tr>
<tr>
<td>Percent of overlap (FEMA flood zone, in percent)</td>
<td>84.8%</td>
</tr>
<tr>
<td>Percent of overlap (estimated flood risk, in percent)</td>
<td>69.6%</td>
</tr>
</tbody>
</table>

3.3.3. **Vulnerability to Flooding**

The Pensacola TMDL Basin drains includes the Pensacola Metropolitan Area, which incorporates the City of Pensacola (with a population of 52,975, as of 2019) and several unincorporated census-designated places, the largest of which is Navarre (with a population 42,300). The total population of the Pensacola metropolitan area as of 2019 was 502,629. The area is highly vulnerable to flooding as it drains four rivers (Escambia, Blackwater, Yellow, and East Rivers). It is also part of the Pensacola Bay estuarine system, which also includes Escambia Bay, Pensacola Bay, Blackwater Bay, East Bay, and portions of Santa Rosa Sound. Figures 25, 26, and 27 highlight locations vulnerable to flooding in the western, central and eastern parts of the Pensacola Bay estuarine system.
Figure 25. FEMA Flood Map Comparison for Escambia Bay and Blackwater Bay
Figure 26. FEMA Flood Map Comparison for Pensacola Bay,
Figure 27. FEMA Flood Map Comparison for Fort Walton/ Santa Rosa Sound
3.3.4. Repetitive Loss Comparison

Figure 28 shows a comparison of the flood map and repetitive loss property locations for the basin. The loss areas coincide with the areas predicted by the FAU model as being at risk for flooding.

![Figure 28. Repetitive loss areas from 2004-2014 superimposed on the flood risk map created by FAU](image-url)
4.0 Conclusion

FDEM contracted with FAU to develop a screening tool of flood risk areas for 29 watershed basins. The effort discussed herein focuses on the development procedures for a screening tool to assess risk in the Panhandle area of Florida. The effort discussed herein focusses on the development procedures for a screening tool to assess risk in the Apalachicola watershed basin. The watershed located in Northwest Florida combines readily available data on topography, ground and surface water elevations, tidal data for coastal communities, open space and rainfall to permit an assessment of the risk of inundation of property within the Panhandle Basin.

The basin shows widespread flooding along the beach due to low elevation proximity to the Gulf of Mexico coast and extensive sensitive areas that currently received extensive environmental protection. A drilldown to the local community showed it was are flood prone. The repetitive loss maps confirmed FAU’s modeling. Such knowledge permits the development of tools to permit local agencies to develop means to address high risk properties. Solutions to improve flood resiliency in the is basin will yield long term benefits.
References