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Fisheating Creek Case Study

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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, so making 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 focusses on the development procedures for a screening tool to assess risk in Fisheating Creek Basin, a basin located in south-central Florida that combines readily available data on topography, ground and surface water elevations, tidal data for coastal communities, soils, open space and rainfall to permit an assessment of the risk of inundation of property in the basin. Such knowledge permits the development of tools to permit local agencies to develop means to address high risk properties.

1.0 Introduction

Fisheating Creek basin is located in the southern part of Florida which is shown in Figure 1. The total area of the basin is 543350 Acres. The counties within this basin are Highland, Glades, Hendry and Okeechobee. The major source of water is a Fisheating river that flows into Lake Okeechobee in Florida. It is the second largest natural source for the lake Okeechobee, being the only remaining free flowing water course feeding into the lake. Fisheating creek is 40-51 miles long. It flows southward through Cypress Swamp area in the southwestern part of highland county and Glades county, turning a mile eastward to north county road and flows about 30 miles to Lake Okeechobee.

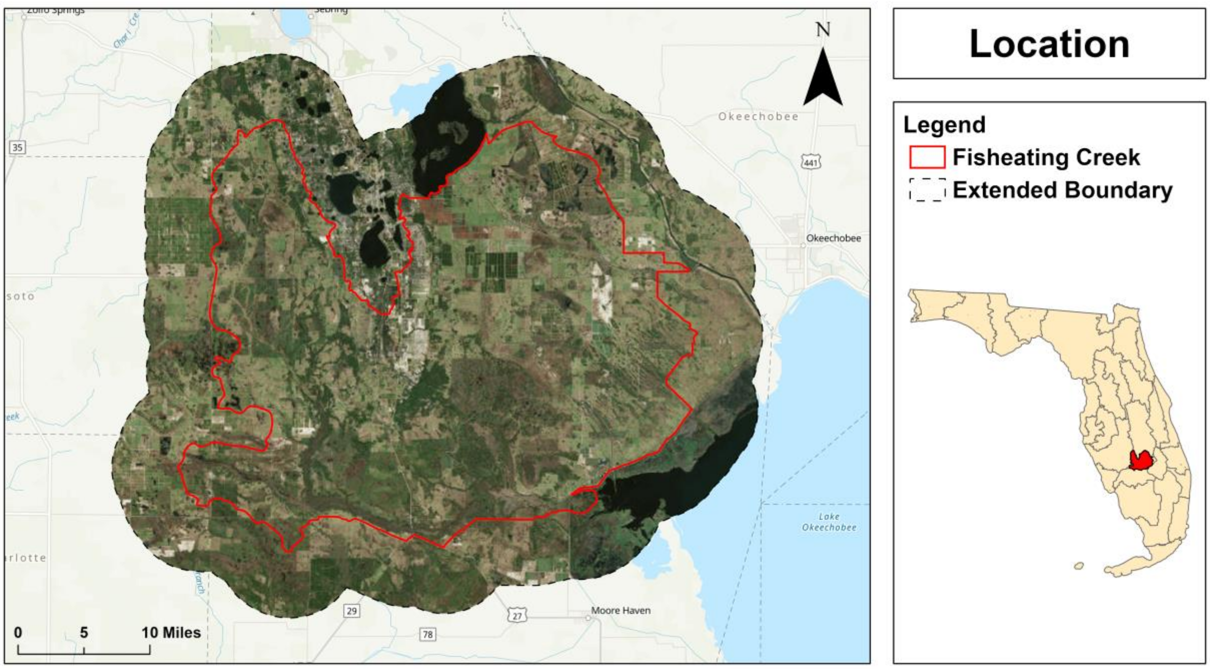

Figure 1: Location of Fisheating Creel Basin, FL

2.0 Summary of Watershed

2.1 General Description of Watershed

In South Florida, water supply, water quality, and health of the Everglades ecosystem are intrinsically linked. When attempting to evaluate the ecological health of Southeast Florida, one must look at the entire southern portion of the peninsula of Florida. Historically there were no barriers or canals to direct or control the path of water except a minor connection created by Native Americans between the Caloosahatchee and Lake Okeechobee for transportation purposes (Figure 2).

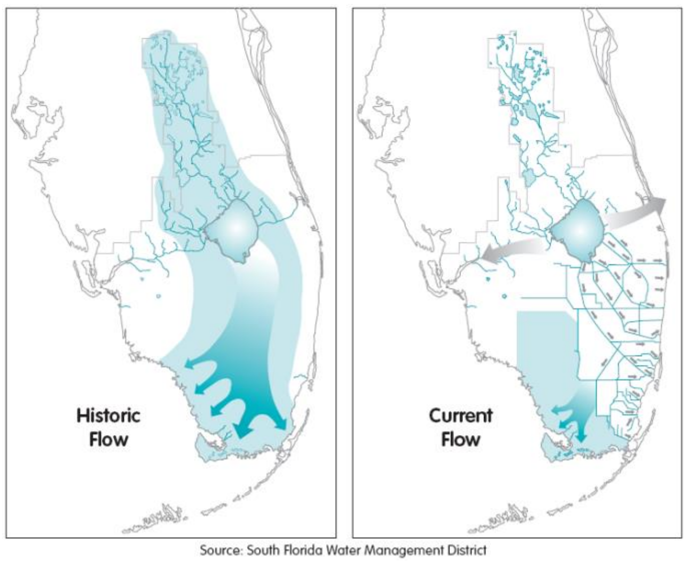

Figure 2: Change in natural flow paths in South Florida (SFWMD, 2020)

The next modifications to the South Florida landscape were constructed in the 1880s by Hamilton Disston with the dredging of the Caloosahatchee River and the creation of drainage canals in the Kissimmee Upper Chain of Lakes. The dredging was conducted in order to drain the land to facilitate agricultural production and urban development. The C-44 Canal and the associated locks and structures were constructed between 1916 and 1928. This canal provided a navigable connection between the east and west coasts of Florida. It connects Lake Okeechobee to the south fork of the St. Lucie River and makes the St. Lucie Estuary one of the major outlets for water draining from the Upper Kissimmee and Lake Okeechobee basins.

The first efforts to contain Lake Okeechobee involved construction of a low levee and three drainage canals running south from Lake Okeechobee, the Miami, North New River, and Hillsboro canals between 1913 and 1917. In 1930, during the aftermath of the Storm of 1928, which pushed water out of the shallow lake and drowned thousands of people, the federal government authorized the US Army Corps of Engineers (USACE) to build the Herbert Hoover Dike. Over the next seven years, a series of levees, culverts, and locks were built to contain the lake, including 67 miles of dikes along the southern shore, effectively halting natural waterflows out of the lake to surrounding areas. In 1938, the USACE began to regulate lake levels, and lake inflows and outflows were altered to include structures and channelization to more effectively move water in and out of the lake. Modifications to the outlets on the east and the west sides of the lake made the St. Lucie and Caloosahatchee rivers the primary outlets from the lake.

However, due to a series of back-to-back hurricanes in 1946 and 1947 and resulting significant flooding in South Florida, the need for additional features to manage excess water became evident. In response to these conditions, the State of Florida requested assistance from the federal government. As a result of that request, the Central and Southern Florida Flood Control Project (C&SF Project) was authorized by the U.S. Congress in 1948. Subsequently, the USACE produced a comprehensive water management plan for flood control that became the blueprint for the project to drain the land quickly to tide to allow for urban and agricultural development. It took approximately 20 years to implement the project features, canals, levees, pump stations, and other structures that were built in the 1950s and 1960s. The channelization of the Kissimmee River was completed in 1971.

By 1969, over 1800 miles of primary canals were constructed to reduced groundwater levels along the coast, which enabled the development that exists today. The canals serve as flood protection for low lying areas because the currently drain by gravity to the ocean. Figure 4 shows the canals in the SFWMD service area. These areas would be flooded in the summer months without the canals. However, as a result of the canals reducing groundwater levels, combined with lessened historical flows to the Everglades and less water standing in the Everglades during the summer months. In addition, the need to control Lake Okeechobee levels requires discharges through the

St. Lucie River and Caloosahatchee watersheds. The timing of these discharges are historically different than the natural system, creating disruptions in water quality and supply. Fisheating Creek is one of two major waterbodies that flow into Lake Okeechobee.

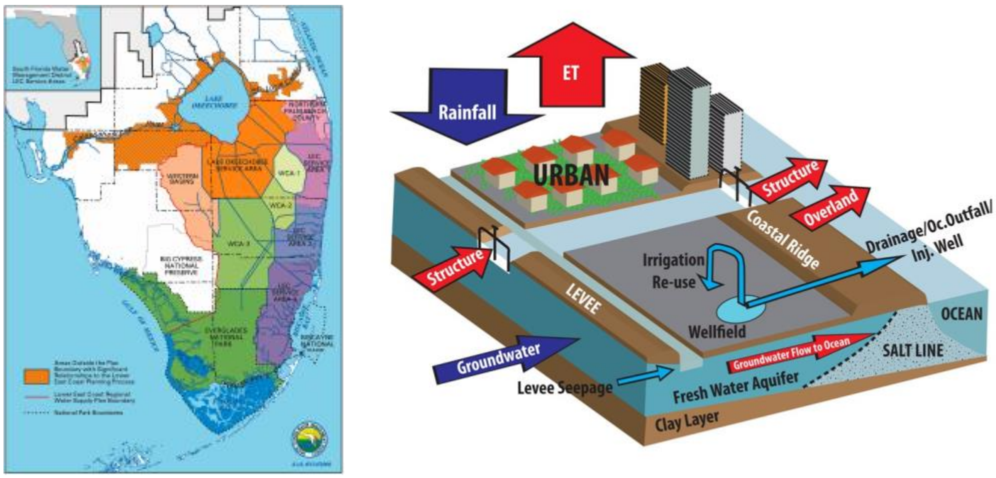

Figure 3: South Florida Water Management District LEC service area and drainage pattern after C&SF drainage improvements (SFWMD, 2020 for figure on the left)

As a result, south Florida and the Fisheating Creek watershed landscapes have been dramatically altered by construction of this elaborate system of canals, dikes, levees, flow control structures, pumps, and other water control facilities. These changes also allowed south Florida to be one of the largest metropolitan areas in the United States, and for the Fort Myers area to develop to nearly 1 million people at present.

The watershed also affects local flood management. Currently, rain falls on impermeable land where the water collects in pools or runs off rapidly where development has taken place. Stormwater is collected locally in neighborhoods in swales, ponds, small lakes, ditches and small canals. These are connected through canals and conduits to the secondary system under the jurisdiction of local drainage districts or city or county governments, which in turn connect to the major waterways controlled by SFWMD and USACE. The highly engineered stormwater drainage system and water control structures have effectively enabled management (lowering) of water tables to permit development.

2.1.1 Climate/Ecology

The climate of the basin area is humid subtropical with both dry and wet season. This basin has a hot and wet season from May to October, and a mild and dry season from November through April. In summer, the average temperature is 80 degrees and in winter the average temperature is 64 degrees. The annual rainfall for this area is 45 inches.

The basin area has improved pastures and planted pines interspersed with freshwater marshes, dense oak-palm hammocks and broad swaths of pine flatwoods. The Fisheating Creek watershed is home to rare species. The ecosystem of the watershed is considered critical for long term welfare of whopping cranes, black bears, crested caracaras, swallow-tailed kites, sandhill cranes, Florida panthers.

2.1.2 Topography and Soils

The study area has a unique topography. The lowest ground surface elevation in the basin is along the Okeechobee lake boundary which is below 20 feet NAVD88 and gradually increases moving north. The low elevations and gradual changes in topography may contribute to flooding as excess rainfall overflows from the river, imposing risk on nearby areas. According to 1999 land-use surveys, the watershed is made of 70% agricultural production, pastureland, or rangeland, while about 27% consists of wetlands and forest. The upper portion of the basin contains significant amounts of agricultural land and cattle pastures, while the lower basin is dominated by large wetland areas. Water tables greatly vary with topography and soil type.

2.1.3 Boundaries/Surface Waters

The study area boundary is defined by the total maximum daily load (TMDL) Fisheating Creek Basin. The adjacent basin is Kissimmee River Basin at north, Okeechobee Basin at east and Caloosahatchee Basin at south. The headwater adjoins Peace River/Charlotte Harbor basin on the west and the Kissimmee river basin by the higher lake region on the north and east. During droughts there is little or no flow in the creek, which is due to high evapotranspiration rates and lack of continued groundwater inflow. In the lower course Fisheating creek flows in an easterly direction for about 20 miles and enters lake Okeechobee on western shore at the settlement of lake, rather than to creek, thus making drainage boundaries indeterminate.

2.1.4 Hydrogeological Considerations

The three principal Florida aquifer systems—surficial, intermediate, and Floridan—are all present beneath the entire area of Fisheating Creek Basin. These aquifer systems are defined and separated based primarily on variations in lithostratigraphy. The surficial aquifer system is unconfined and recharged preliminary by rainfall. The basin occurs in the Tamiami Formation, Caloosahatchee/Fort Thompson Formations and undifferentiated sediments. The Intermediate Confining Unit is made up of Hawthorn group sediments. It consists of unconsolidated and poorly indurated sand and slit with phosphatic sand with gravel of Peace River Formation. The Floridian aquifer system is composed of primarily limestone and dolomite. It is one of the most fertile aquifers in the world. It is the major source for groundwater supply.

2.1.5 Special Features

The most important feature of this basin is that it is the only naturally flowing headwater of a large Everglades Ecosystem which plays important role in ecology, socio-economic of South Florida. Most of the part of the basin is covered by pasture and forest and have very less human settlement.

2.2 Socio-economic Conditions of the Watershed

2.2.1 Demographics

The census dataset of U.S. Census Bureau 2015 Census Block Groups for the State of Florida with selected fields from the 2014-2018 American Community Survey (ACS) is shown in Table 1.

Table 1. Demographic Statistics of Fisheating Creek

Attribute	Statistics
Total population	26110
Household	9227
Male	14603
Female	11507
White alone	18072
Black	1796
Native American	553
Asian	117
Hawaiian	0
Hispanic	4904
Other race	125
Multi race	543
Average Household size	2.36
Family household	9227
Average Family size	2.93
Age under 5	900
Age5-17	3039
Age 18-21	864
Age 22-29	1937
Age 30-39	2621
Age 40-49	3071
Age 50-64	5966
Age 65 above	7712
Age above 85	922
Median age for population	50.04
Median Household Income	$ 39567
Median Family Income	$ 46395

2.2.2 Property

Almost entire portion of the stream lies within the Fisheating Creek Wildlife Management Area.

Most of the lands surrounding the stream is either publicly owned or under conservation area.

2.2.3 Economic Activity/Industry

It is one of the largest uninhabited and least road-dense area in United States. The large number of people's primary occupation is agriculture.

3.0 Watershed Analysis

3.1 Data Sets

3.1.1 Topography

Topography is the most important parameter that influences many of the procedures involved in flood risk mapping. The Digital Elevation Model datasets with high spatial resolution was collected by the FAU Civil, Environmental and Geomatics Engineering and organized in a server accessible by all project members. The LIDAR DEM of 3-meter resolution tiles with +/- 4 inches of accuracy was used. This basin's 3-meter Lidar DEM did not have a full coverage therefore it was combined with 10-meter USGS one third arc second DEM to fill the voids. 3m and 10m DEM was merged using Mosaic to New Rater function in ArcGIS. The mosaic obtained was projected into NAD_88_UTM_Zone 17 N using Projection function in ArcGIS. Then the DEM was converted from meter to feet using Raster Calculator NAVD88. The lowest elevation in the basin is near the Lake Okeechobee which is below 20 feet. The highest elevation is the northern highland with elevation above 100 feet NAVD88. Figure 4 shows the topography of the Fisheating Creek Basin.

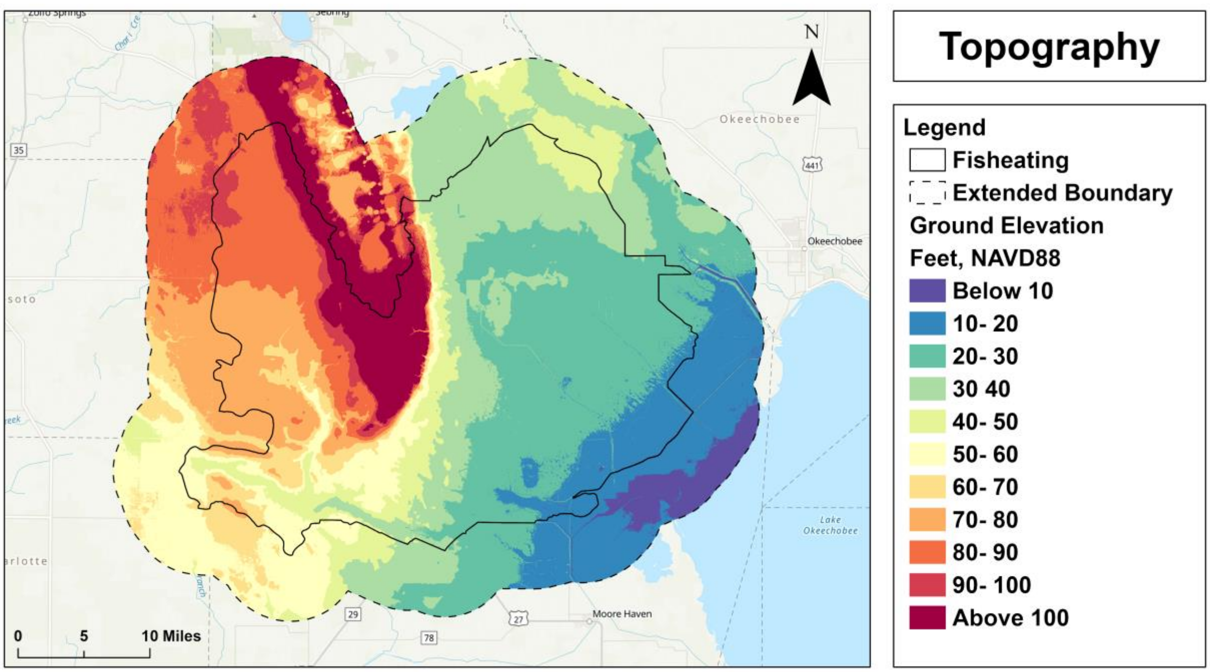

Figure 4: High Resolution Digital Elevation Model of Fisheating Creek Basin

3.*1.2* ***Groundwater and Surface Water***

The occurrence of flood events is greatly affected by the water present on the surface and in ground. The strong inter-relationship between groundwater and surface water was used to accurately map the water table elevation. The high groundwater table commonly associated with this region of Florida contributes to flooding as large portions of the soil layer are typically saturated at the start of rainfall events and cannot store any additional water, which would relieve flooding in many areas. Accurately mapping the groundwater table is possible through spatial interpolation and extrapolation techniques which utilize observed groundwater levels at monitoring stations to generate an elevation surface.

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to accurately map the groundwater table elevation.

The ground water stations and surface water station in Fisheating Creek Basin was difficult to find. Due to the shortage of data, it was not possible to use Kriging Interpolation method. Therefore, we followed the MLR model from the adjacent “Kissimmee River Basin” to derive the water table. Figure 5 shows the Water Table elevation in NAVD88 feet. The lowest water table elevation was found near Okeechobee. The highest water table was found in the northern highland.

While low land elevations and high groundwater table elevations influence flooding, the soil storage capacity will also greatly influence the watershed’s vulnerability to flooding. Open surface water bodies and frequently inundated land will be unable to store additional water during a rainfall event. Hence, when mapping the soil storage capacity across the watershed, these areas were set to zero storage capacity as there is no capacity for these areas to store additional water.

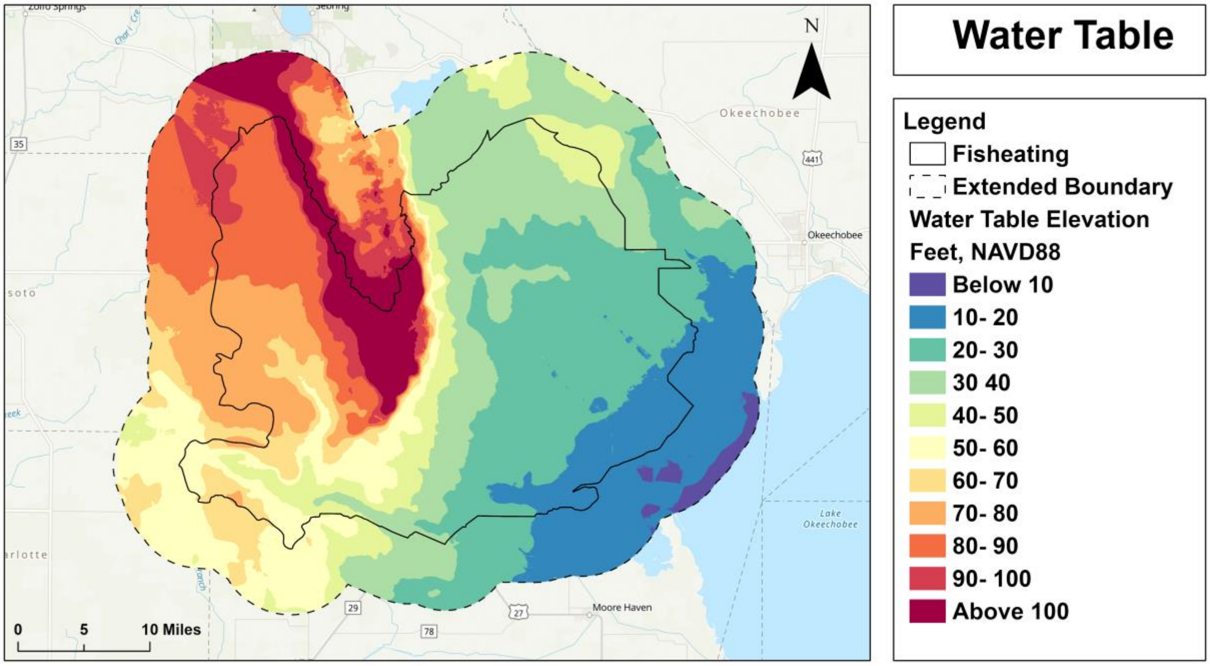

Figure 5: Water Table Elevation of Fisheating Creek Basin

3.1.3 Open Space

Another consideration in calculating the soil storage capacity is the land areas covered by impervious surfaces. 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 open space map is from the 2014 land use land cover dataset and the open lands are displayed in the map (Figure 6).

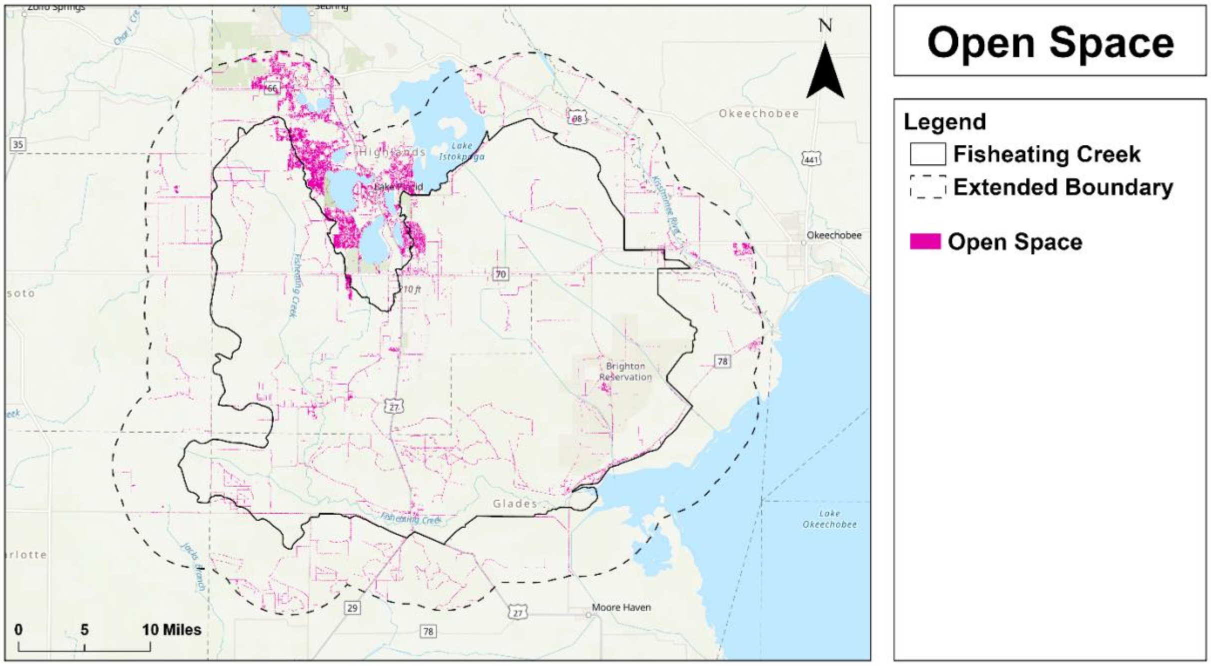

Figure 6: Open Space Map of Fisheating Creek Basin

3.1.4 Soil Capacity

Soil Capacity is the amount of water that a given soil can hold. Soil can take in water until the small pores present in the soil gets filled with water. It is important to know the water holding capacity of soil to find out the storage capacity of the soil. The vulnerability of flooding is greatly influenced by the soil storage capacity across the basin. Flooding events are induced by the poor ground storage capacity of soil. The water holding capacity of soil was calculated through the processing of data from USDA's Gridded SSURGO Database. This gSSURGO is considered a products of the National Cooperative Soil Survey (NCSS). The water holding capacity of the basin was used to calculate the total amount of water than can be stored in the soil. Figure 7 shows the water holding capacity of the basin.

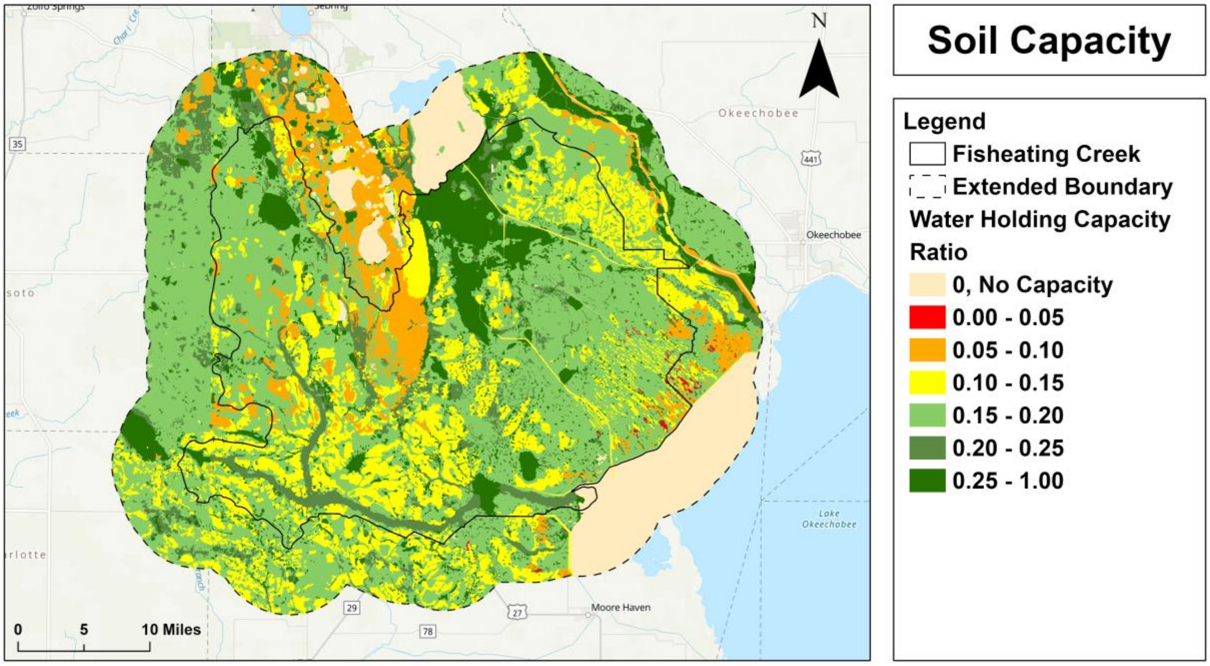

Figure 7: Soil Water Holding Capacity in Fisheating Creek Basin

3.1.5 Rainfall

The flooding events are greatly influenced by the amount of precipitation in the basin area. The selected design storm for FAU's simulation is based on the SFWMD 3-day, 25-year storm. The 3-day, 25-year rainfall map based on the NOAA Atlas 14 dataset is shown in Figure 8.

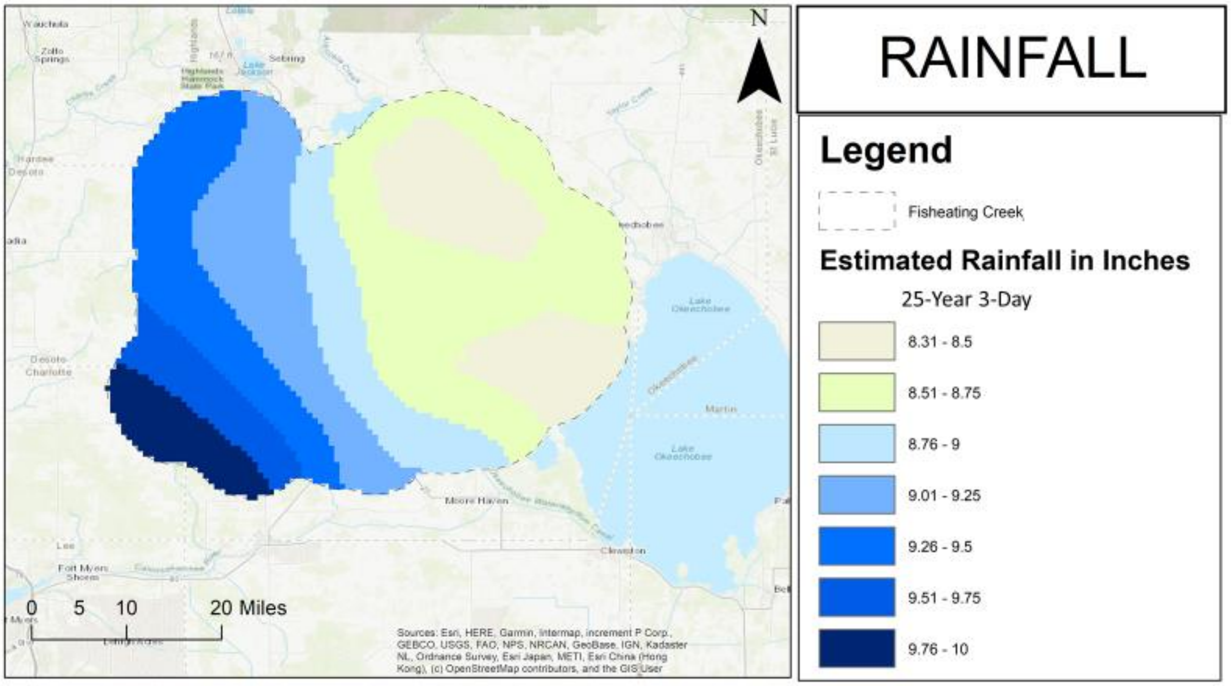

Figure 8: Rainfall During a 3-Day 25-Year Storm of Fisheating Creek Basin

3.2 Modeling Protocol

There are many contributing factors to flooding in the Fisheating Creek Watershed, 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 for the Caloosahatchee Watershed, 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.

For example, determining water table elevations throughout the watershed requires spatial interpolation and extrapolation methods as well as modeling. Since the high groundwater table greatly contributes to flooding in the region, it is necessary to expend the additional effort to incorporate this factor into the model. Observed water levels are only available at single locations, groundwater wells and surface water stations. The South Florida Water Management District's DBHYDRO database was used to access their station observation data. The groundwater wells are sparsely distributed, while surface water stations are distributed throughout the watershed along canals and in Lake Okeechobee. Additionally,

The modeling of the watershed was done using ArcGIS, Arc Hydro, and Cascade software. The datasets discussed earlier were created using ArcGIS software. They were used to calculate the input parameters to run Flood Simulation Model in CASCADE 2001. CASCADE 2001 is a multi-basin hydrologic/hydraulic routing model developed by the South Florida Water Management District (SFWMD). Characteristics of the model is unique to each watershed basin. Those characteristics includes topography, water table, soil type, land cover, and rainfall. The model develops solutions based on basin. A basin is defined as an area of land where precipitation collects and drains off into a common outlet. The areas of the basin, initial stage, ground storage, rainfall and the longest time it takes the runoff to travel to the most distance point to reach the point of discharge must be calculated.

The Water Table raster layer was generated using Multiple Linear Regression method in ArcGIS. The MLR model from adjacent basin was used due to the lack of water stations in this basin area. The MLR approach has been used widely for groundwater elevation estimation (Sepulveda, 2003; Chun and Rogers, 2012). It makes assumption that the exposed water surface like lakes, streams, rivers, and canals have the elevation of a local minimum water table referred as MINWTE. Groundwater Table is firmly related to MINWTE and the depth-to-MINWTE can be derived by subtracting MINWTE from DEM. Water Table elevation (WTE) is estimated by multiple linear regression model as:

$$WTE = B1(MINWTE) + B2(Depth\ to\ MINWTE) + E$$

Where WTE= Water Table Elevation Estimated(estimated)

E = Statistical error

The result of the Linear Regression;

$$WTE = 1.0051* (MINWTE) + 0.239* (Depth\text{-}to\text{-}MINWTE) + 2.0127$$

The water table generated is shown in Figure 5. The water table elevation layer created was subtracted from the topographic layer to generate unsaturated zone depth. The unsaturated zone is the portion of the subsurface above the water table. There will several feet distance between the land surface and ground water table. Water can seep into this layer and soil layers can hold the water. The thickness of this zone ranges from zero, where surface water is available, to hundreds of feet. The blue color indicates zero or no layer present and red color denote the unsaturated layer above 6 feet. Figure 9 shows the unsaturated zone depth in Fisheating Creek Basin. Most of the area is blue because most of the part of the basin's water table is higher than DEM and the negative value was converted to zero using conditional function in ArcGIS Raster Tool.

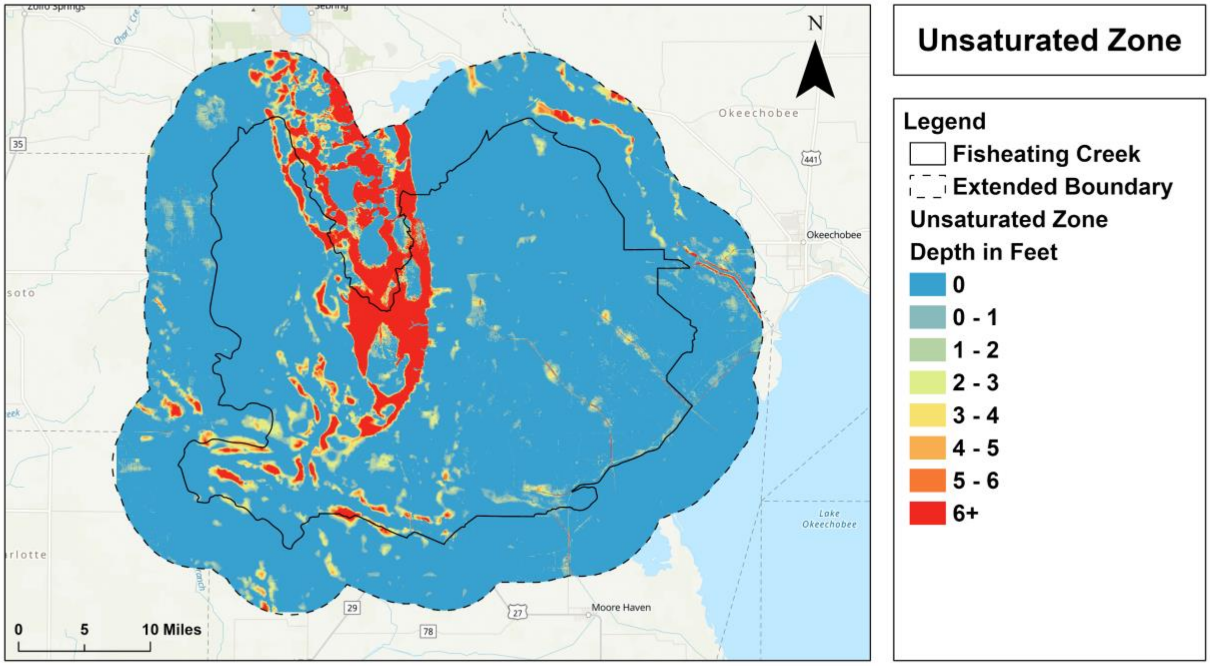

Figure 9: Unsaturated Zone Depth in Fisheating Creek Basin

The land surface with development infrastructures like roads, buildings do not permit water to percolate through them. To classify land as pervious or impervious surface the National Land Cover Database was used. The impervious surface was assumed to have zero soil storage capacity. Figure 10 shows pervious and impervious surface of the basin area.

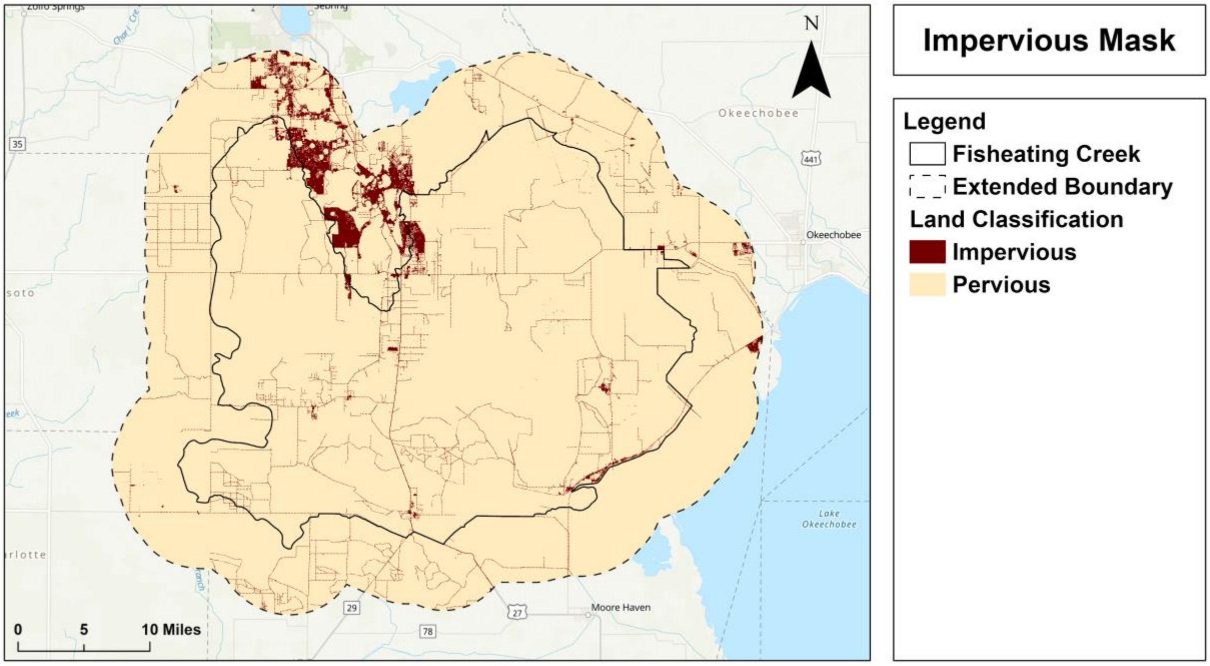

Figure 10: Impervious and Pervious Surface of the Fisheating Creek Basin

Also, the open surface water bodies will be unable to store additional water during the rainfall. Those area's soil is fully saturated due to presence of water throughout the year. Therefore, those area were also set to zero storage capacity. Those area were obtained from statewide land use land cover datasets and is shown in Figure 11. The flooding events most probably occurs on nearby area of the open surface water bodies. Both Pervious/Impervious and Water bodies surface were used for calculation of ground storage of the basin.

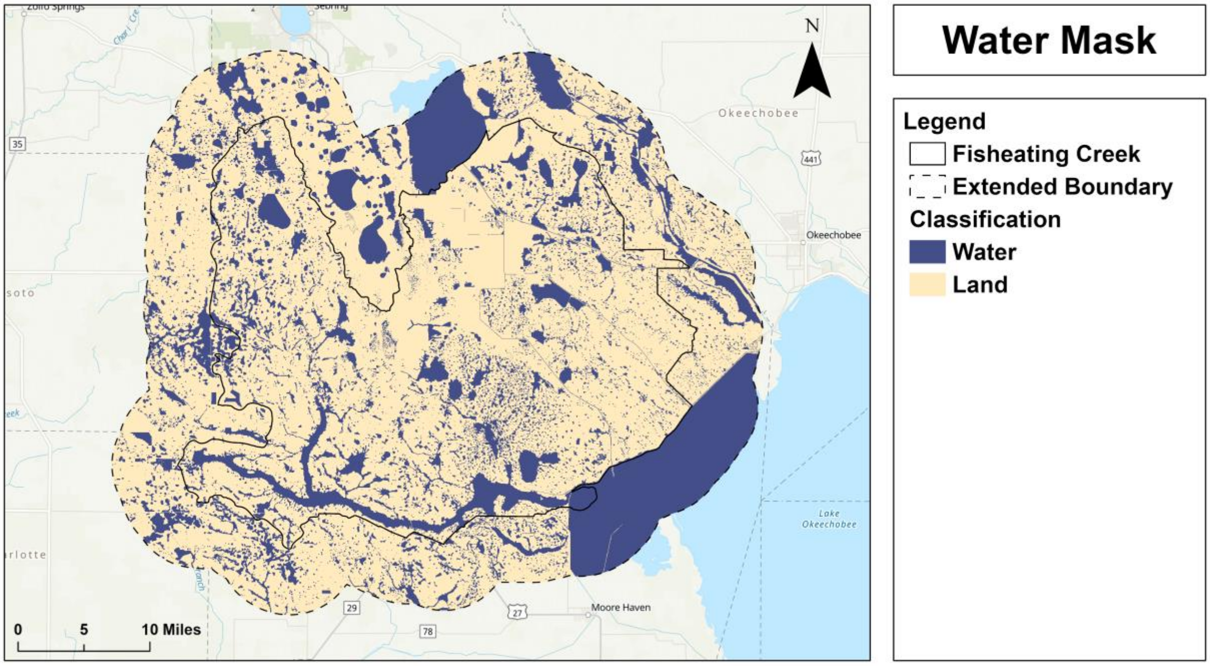

Figure 11: Water and Non-Water Surface of the Fisheating Creek Basin

The ground storage is another important input parameter for CASCADE 2001. This was created by using the expression {(DEM - groundwater layer) * 12 * soil storage capacity)}. It was calculated by multiplying water holding capacity layer with unsaturated zone layer using Raster Calculator tool in ArcGIS. The water mask and impervious mask was used to eliminate the area which would have no storage in real. The output layer contained some negative value in some area which was assigned zero value using Conditional function in Raster Calculator Function in ArcGIS. Figure 12 shows the soil storage obtained.

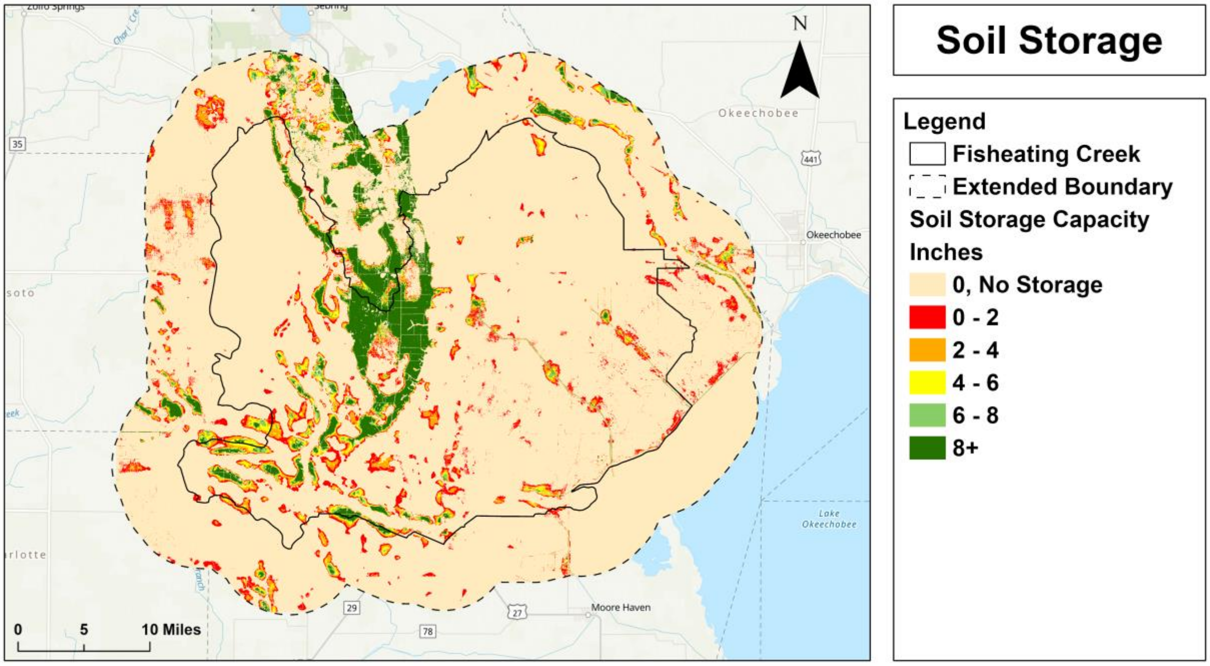

Figure 12: Soil storage Capacity of Fisheating Creek Basin

Several input parameters were required for CASCADE 2001 to simulate the characteristics of the watershed basin in order to determine the extent of flooding in the basin region. Software was installed after running of vcascade.exe. It created required subfolder in Windows Program files. New project file was created in CASCADE 2001 and then the necessary information was filled to define the time period, time intervals of the simulation. After input of Start and end date of the simulation for basin is September 06 2003, the total number of hours for the simulation was calculated automatically and displayed accordingly. New offsite receiving body information for the model was inserted and also the pair of time in hours and water stages in NGVD feet. The CASCADE also provides the parameter for the structures which control the water level in the basin. The structure information was obtained from the Atlas of flow computations at hydraulics structures provided by SFWMD.

3.3 Modeling Results

3.3.1 Watershed pathways

DEM discussed earlier in dataset was used to delineate the drainage line, drainage point and catchment within the basin boundary using ArcHydro tool in ArcGIS. Also, the direction of flow and the longest flow path was calculated using ArcHydro tool. Series of procedure were followed in order to obtain drainage points, line and catchment polygons. First of all, the terrain preprocessing was done where sinks were filled. The catchments and waterway flow paths that were produced can be seen in Figure 13.

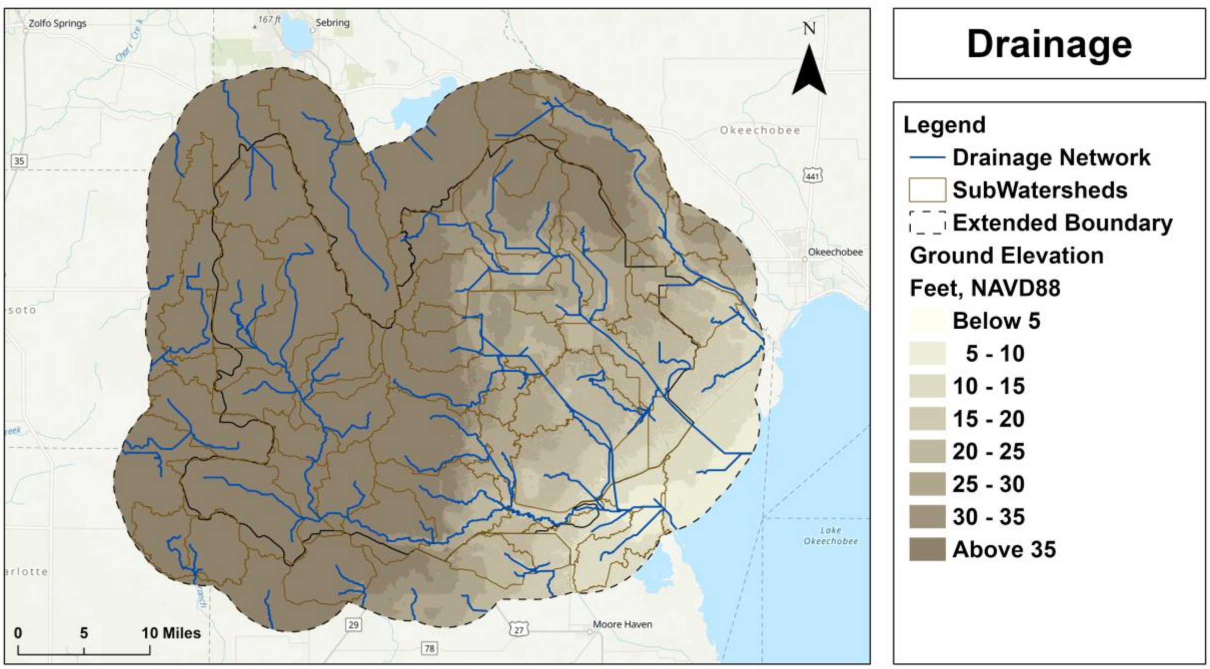

Figure 13: Catchments and Drainage Network in Fisheating Creek Basin

3.3.2 Cascade Results

After following FAU's modeling protocol, all required input parameters for CASCADE 2001 were calculated. The input parameters represent factors that influence flooding; for example, the topography, groundwater table elevation, and soil storage capacity. All required input parameters for CASCADE 2001 were calculated after following the FAU's modeling protocol.

- Initial Stage (ft NGVD) = 14.2
- Ground Storage (Inches) = 1.45 inches
- Rainfall for 25 Years, 3 Day (Inches) = 8.93
- Area (acres) = 543350
- Time of Concentration (hrs.) = 12.71 hours
- Structure Type: Gravity

  Weir: Sharp Crested, Crest Elevation = 8 ft NGVD, Length = 217 ft

  Bleeder: Circular, Invert Elevation = 6 ft NGVD, Diameter = 8 ft

  Default Coefficient: Weir Coefficient = 0.6, Orifice Coefficient = 0.6

  Pipe: None

The maximum headwater obtained was 21.27 feet (NAVD88).

Under these constraints, the CASCADE 2001 model simulates the rise of floodwaters during a 3-day 25-year storm. The goal is to obtain the maximum headwater height in each subwatershed as any land areas below this elevation will be flooded. The identification of flood-prone areas within the watershed is crucial to inform the decision-making process of prioritizing and allocating funding.

3.3.3 Vulnerability of Flooding

After identifying areas within the watershed that are prone to flooding, it is important to classify the risk associated with those flooded areas. The results of the CASCADE 2001 simulation provide insight into the Caloosahatchee Watershed's flood response to a 3-day 25-year storm. However, by further classifying flood risk as the probability of inundation, it is possible to improve the identification of critical target areas within the watershed. These areas are particularly vulnerable to flooding and are subject to further study. The probability of inundation surface was created by calculating Z-scores to describe the maximum headwater height's relationship to the ground elevations from the LiDAR DEM throughout the Caloosahatchee Watershed. Specifically, the ground elevation values were subtracted from the maximum headwater height value and then divided by 0.46, a value based on the combined effect of the Root Mean Square Error (RMSE) in the LiDAR DEM data and CASCADE 2001 model.

The uncertainties associated with the DEM vertical accuracy, estimated depths to groundwater table, and the modeling approach itself are incorporated in the RMSE computation. The formula for the calculation of the Z scores is.

Z-Score = [(high headwater height)-(Ground Elevation from LiDAR DEM)]/
SQRT(RMSE_LidaDEM2+RMSE_CRT2001Model2)

Z - Score = ((Headwater Height –LIDAR DEM Elevation)/ 0.46

After Z Score raster surface was calculated using Raster Calculator from ArcGIS, reclassified into 4 classes using Reclassify tool in ArcGIS as noted in Table 2.

Table 2: Obtaining Zscore

Risk of Flooding	**Range of Corresponding Z values**
Low-Moderate Risk (Below 50%)	<-1.282 to 0
Moderate-High Risk (50%~75%)	0 to 0.675
High Risk (75%~90%)	0.675 to 1.282
Higher Risk (Above 90%)	>1.282

. The risk of flooding in the Caloosahatchee Watershed is shown on the map in Figure 14.

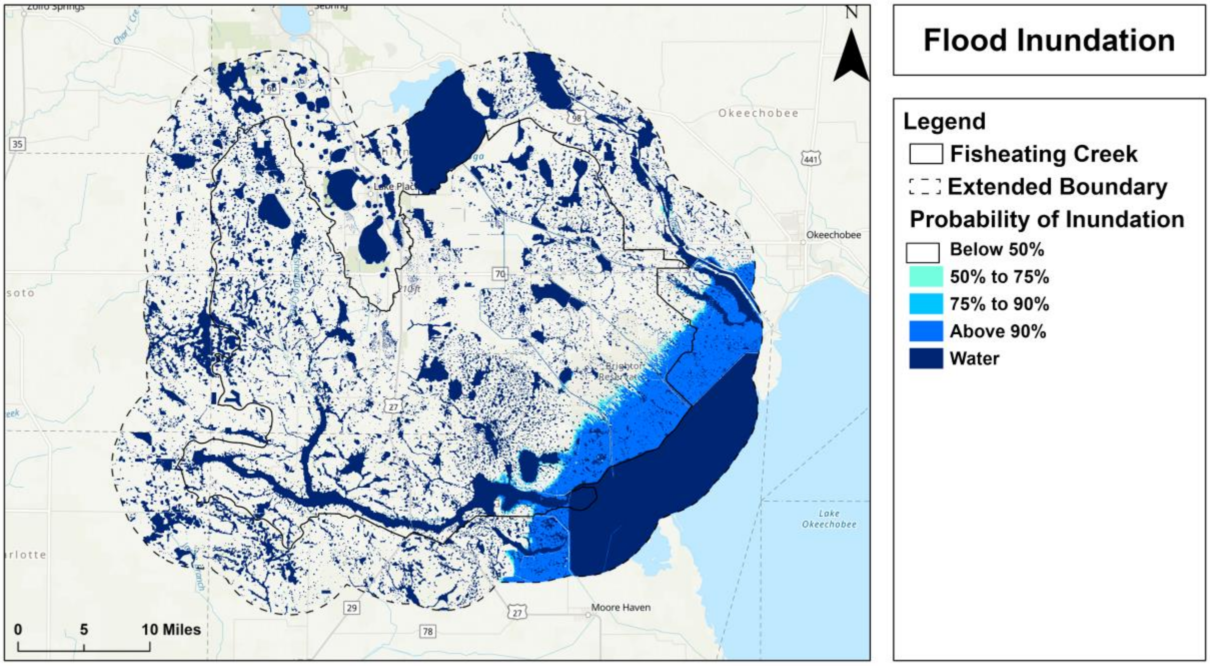

Figure 14: Flood Inundation in Fisheating Creek Basin

3.3.4 FEMA Flood map comparison

Figure 15 contains the risk of flooding for the basin based on FEMA estimations of flood risk. The Federal Emergency Management Agency (FEMA) is an agency of United states Department of Homeland whose main purpose is to coordinate the response to Flood disaster and to manage Flood Insurance Program. The 1-percent annual chance flood is also referred to as the base flood or 100-year flood. Special Flood Hazard Areas (SFHAs) are labeled as Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone A99, Zone AR, Zone AR/AE, Zone AR/AO, Zone AR/A1-A30, Zone AR/A, Zone V, Zone VE, and Zones V1-V30. And the 500-year flood events where there is a 0.2% annual chance of flooding are regarded as moderate flood hazard areas, and they are labeled as Zone B or Zone X. We had no intention to replicate FEMA datasets. Although the mapping strategies are different, this map can still be a good reference to verify our result. FAU used the 3 day-25-year precipitation scenario. Table 3 is the comparison between FEMA identified 1% flooding region and CRT modeled region with a high probability for inundation (above 90%) in Fisheating Creek Basin. FAU's mapping noted less area in the middle of the basin at risk for flooding.

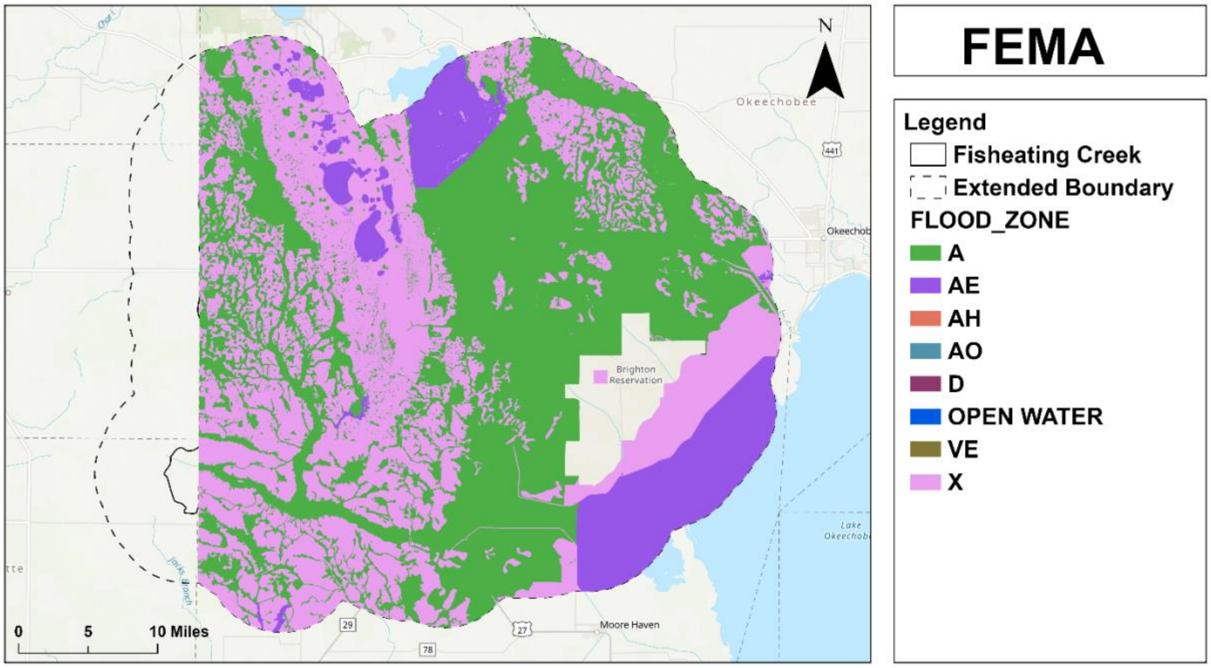

Figure 15: FEMA based Flood Areas in Fisheating Creek Basin

Table 3: Comparison between FEMA identified 1% flooding region and CRT modeled region with a high probability for inundation (above 90%) in Fisheating Creek Basin.

FEMA and our protocol	Results
FEMA 1% flood area (total: km$_2$)	2120.14
Our estimated area (total: km$_2$)	711.43
Overlapped area (total: km$_2$)	225.69
Percentage of overlap to FEMA (%)	10.61%
Percentage of overlap to our model (%)	31.72%

3.3.5 Repetitive loss comparison

Figure 16 shows a comparison of the flood map and repetitive loss property locations for the basin. There were minimal losses in the basin, but the few loss areas coincide with the areas predicted by the FAU model as being at risk for flooding. In contrast the FEMA, FAU's mapping noted less area in the middle of the basin at risk for flooding which is similar to the repetitive loss data.

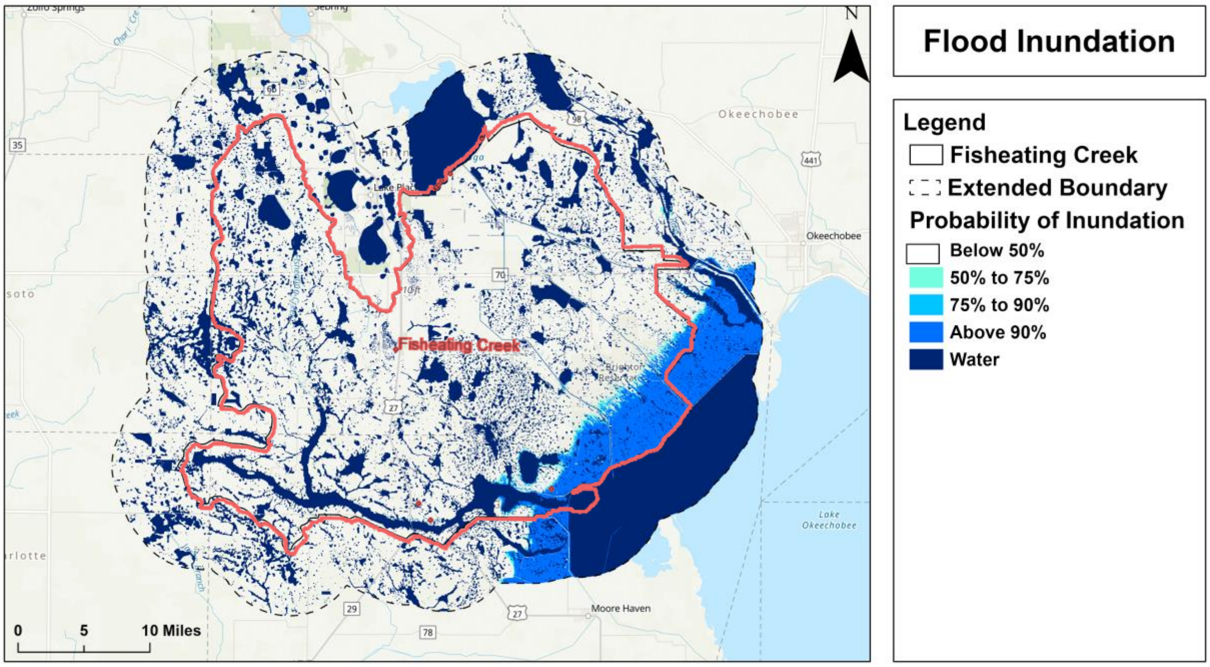

Figure 16:Repetitive loss areas from 2004 -2014 superimposed on the flood risk map created by FAU.

3.4 Drill down in Developed Areas Loss

There are no municipal communities or areas of critical importance from a flood perspective in the watershed so a drilldown was not found to be necessary.

4.0 Conclusions

The MLR approach was applied to generate the water table which was further used for Cascade. Modeling. MLR coefficients derived from the adjacent Kissimmee River Basin was used. The Cascade Modeling resulted the headwater height for the Final Flood Map which can be used as the references for flood control-related works. The modeling and analysis of the Okeechobee basin can be used to support the development of a watershed management plan which will inform locals and the stakeholders to prioritize funding for future mitigation and resiliency planning to protect flood susceptible communities. Due toe the lack of developed property and limited flood potential, this is a low priority basin.

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