MBNEP

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# West Fowl River Watershed Study

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# 1. Executive Summary

The study on the West Fowl River watershed was performed to gain an understanding of the watershed's response during rain events. It was also performed to generate a baseline hydrologic model that can be used for determining discharges for the design of future restoration projects and their impact on the watershed. The model can also be utilized for future stormwater planning and management. The method of analysis used for the study employed the use of the Gridded Surface Subsurface Hydrologic Analysis (GSSHA) model. This two-dimensional overland flow model was calibrated to available rain events from September 2018 to June 2020.

During the evaluation period, the largest rainfall the basins in the West Fowl River watershed experienced was classified as a 2-year event. Four events were utilized for calibrating the model and are as follows. A 1-year 3-hour rainfall event on September 4, 2018, just under a 1-year 12-hour event on July 13, 2019, a 2-year 6-hour rainfall event on August 26, 2019, and over a 1-year 12-hour rainfall event on June 7, 2020.

Results of the findings for the West Fowl River watershed indicate that storm events less than or equal to a 2-year recurrence interval produce discharges less than its determined recurrence interval for a rural basin. With the lack of development and the very mild topographic relief, there is ample opportunity for storage. Road crossings within the watershed provide areas where storage volume can accumulate. This is visually evident in the attenuation of the water surface elevation plots at the gauged crossings.

For rain events (2-yr or less), the currently calibrated GSSHA model can be used as a management tool for determining bank forming discharges throughout the watershed. Future restoration projects may be able to utilize these discharges for bankfull analysis. For larger flood events, recalibration of the model will most likely be necessary to account for changes in storage capacity and timing within the watershed.

# 2. Introduction

## 2.1. Description

West Fowl River is a tidally influenced coastal river located in southern Mobile County, AL (Figure 2-1). The West Fowl River Watershed is defined by the U.S. Geological Survey (USGS) 12 digit hydrologic unit code (HUC) as HUC031700090103 and drains a portion of southern Mobile County. Its headwaters are located near the community of Delchamps and flows southwest to Fowl River Bay (Cook, 2017). The drainage area of West Fowl River is approximately 11.6 square miles. There are multiple unnamed tributaries that contribute to West Fowl River. The main tributary that flows from the west into the upper part of West Fowl River is Bayou Jonas. Just above the confluence with Bayou Jonas and West Fowl River is an area named the “Narrows”. The “Narrows” is a 2 mile long stream that connects East and West Fowl River. Delchamps Bayou flows from the east into the “Narrows” (Figure 2-2). Due to its close proximity to Mobile Bay and the Gulf of Mexico, the watershed is tidally influenced. This study analyzes the tributaries that drain into West Fowl River.

## 2.2. Climate

According to the West Fowl River Watershed Management Plan prepared by Dewberry (2019), “The Watershed is located in a humid, subtropical climate region and is characterized by temperate winters and long, hot summers with rainfall that is fairly evenly distributed throughout the year. Annual temperatures range from below freezing to over 100 degrees Fahrenheit, with a normal mean annual temperature of 68 degrees Fahrenheit along the coast (USACE 2014). Average annual precipitation is 68.1 inches (Summersell 2008).”

The WMP continues to state, “Summer temperatures are generally warm, being moderated by sea breezes, and are influenced to a considerable extent by the mild water temperatures of the Gulf of Mexico. Prevailing southerly winds provide moisture for high humidity from May through September. Winter temperatures are relatively mild, and are greatly influenced by seasonal cold fronts. The area averages 15-20 cold fronts per year, occurring from October through March. The cold fronts bring cold air and strong, predominantly northerly winds with speeds that can exceed 25 to 30 knots (Vittor and Assoc. 2007).”

**Figure 2-1**
**West Fowl River Location Map and Study Area Boundary**

**Figure 2-2**
**Location Map Indicating the West Fowl River Sub-watersheds**

## 2.3. Physiography

The West Fowl River Watershed Management Plan (WMP) states, “The West Fowl River Watershed is classified as primarily coastal lowlands, with upper areas of the Watershed lying within the Southern Pine Hills physiographic district.” The Southern Pine Hills is an upland area while the Coastal Lowlands is a flat to very gently undulating area that is locally swampy.

The WMP also states, “Soils within the Watershed consist of varying associations. There are two primary soil associations (associations with greater than 10% watershed coverage) identified in the Watershed: the Axis mucky sandy clay loam (26.7%) and the Bayou-Escambia association (66.3%). The lower portion of the Watershed primarily consists of Axis mucky sandy clay loam while the upper portion of the Watershed is primarily the Bayou-Escambia association.” Bayou soils are on broad flats adjacent to poorly defined drainageways, while Escambia soils are on slightly higher, gently undulating ridges. The surface of both of these soils consists typically of a dark gray sandy loam.

## 2.4. Land Use

The majority of the West Fowl River Watershed is covered in wetlands and forests. According to the 2019 WMP wetlands make up roughly 73% of the total watershed. These wetlands can be classified as woody or non-woody with coverage of 39% and 34%, respectively. Developed areas cover about 3% of the total watershed area and are composed of residential development, roadways, and petrochemical facilities. The remainder of the watershed consists of forested areas, agricultural lands, and open space. Open water covers about 5% of the total watershed area which includes streams, lakes, and ponds.

# 3. Hydrologic Model

## 3.1. General

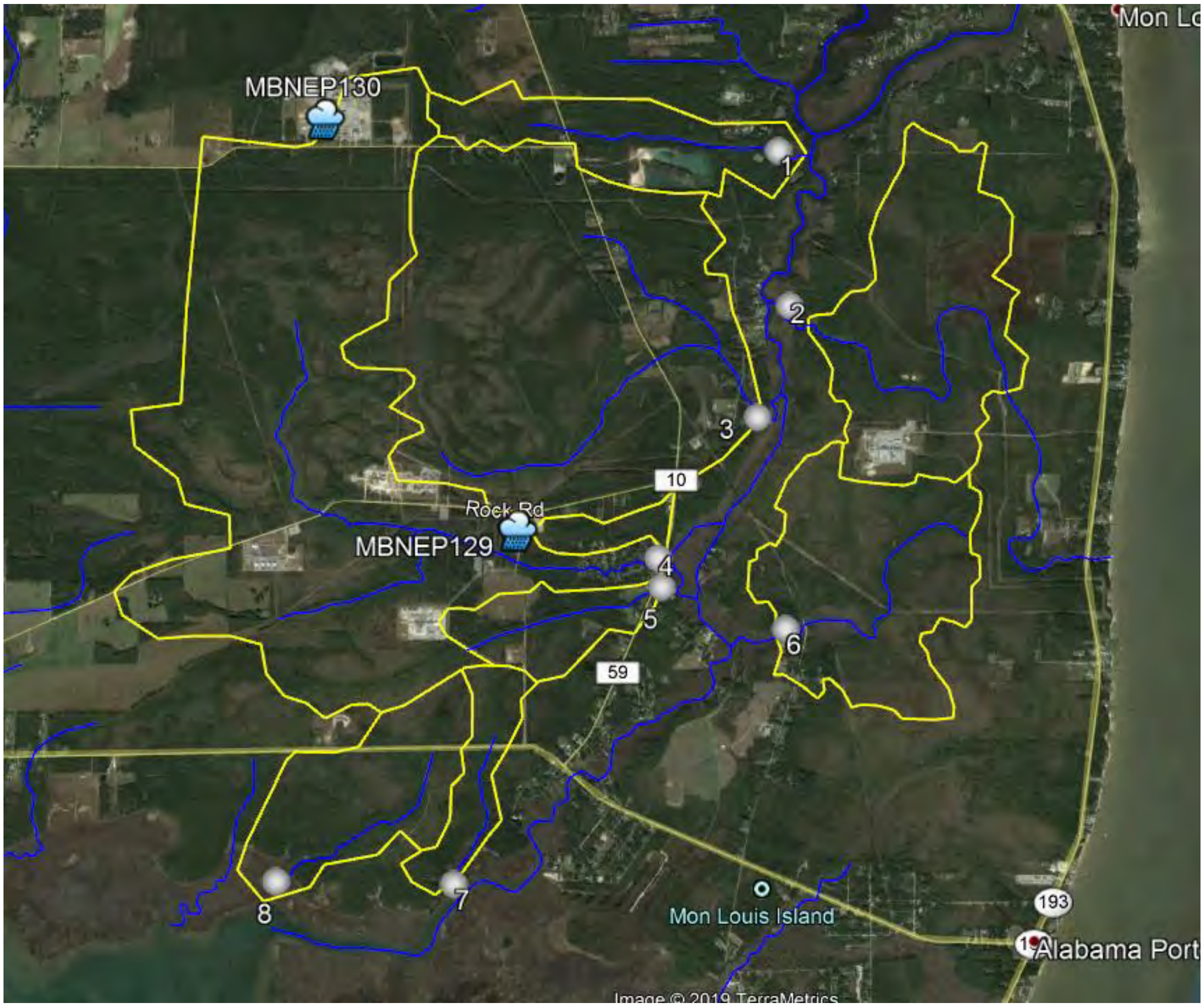
The hydrologic model used to evaluate the West Fowl River watershed is the Gridded Surface Subsurface Hydrologic Analysis (GSSHA) model. GSSHA was developed and is maintained by the US Army Engineer Research and Development Center (ERDC) Hydrologic Modeling Branch, in the Coastal and Hydraulics Laboratory. GSSHA is a physically-based, distributed parameter hydrologic model with sediment and constituent fate and transport capabilities. Features include two dimensional (2-D) overland flow, 1-D stream flow, 1-D infiltration, 2-D groundwater, and full coupling between the groundwater, shallow soils, streams, and overland flow. Sediment and constituent fate and transport are simulated in the shallow soils, overland flow plane, and in streams and channels. GSSHA can be used as an episodic or continuous model where soil surface moisture, groundwater levels, stream interactions, and constituent fate are continuously simulated. Parameters used to generate a GSSHA simulation include rainfall data, digital terrain data, land use data, and soils data. The interface employed for building the GSSHA model is the Water Modeling System (WMS) developed by Aquaveo.

## 3.2. Rainfall Data

One of the strengths of the GSSHA model is the ability to perform long-term simulations utilizing rainfall distributions longer than just a 24-hour storm. A key element in forecasting discharges for future storm occurrences depends upon good rainfall data. For the rainfall component used in the simulations, Hydro-Engineering Solutions (Hydro) obtained storm data from two different monitoring sources.

The first source for gathering rainfall data was from weather stations that Hydro deployed throughout the watershed (Figure 3-1). On August 10, 2018, two weather stations were installed. The first weather station (MBNEP 129) was installed off of Rock Road at an ExxonMobil facility. The second weather station (MBNEP 130) was installed off of Deakle Road also at an ExxonMobil facility.

**Figure 3-1**
**Weather Station Locations**




The Davis Instruments, Corp.'s Vantage Pro 2 Precision Weather Station was used for data collection. Information collected from this weather station include: rainfall, temperature, humidity, wind speed, and barometric pressure. The data is sent to Weatherlink.com, which is Davis' global weather network. Data can be transferred using a wireless console connected to a nearby computer with internet or via Davis' Vantage Connect®. According to the website, Vantage Connect® is a "cellular-based, solar-powered unit that sends remote weather station data to the internet." Weatherlink software was used for data retrieval for each station. After a storm event, data would be retrieved and then processed for use in the GSSHA model.

The second source of data was obtained from Gridded Binary (GRIB2) rainfall data provided by the National Weather Service. GRIB2 is the second version of the World Meteorological Organization's (WMO) standard for distributing gridded data. The major advantages of the GRIB files are that they are typically 1/2 to 1/3 the size of normal binary files (floats), the fields are self-describing, and GRIB is an open, international standard. A decoder is required to view or use the information. Once decoded, the GRIB2 data is in 2-minute increments which provide a good rainfall distribution for calibrating the timing aspect of the model. When there is a lack of information between the installed Hydro weather stations or any Wundermap gauges, GRIB2 data was utilized to get storm distributions. Oftentimes the total rainfall accumulation is low and needs to have a correction factor applied to it. Rainfall totals from other sources (e.g. Hydro Weather Stations, Weather Underground, NWS maps, etc) are used to correct the rainfall amounts when necessary.

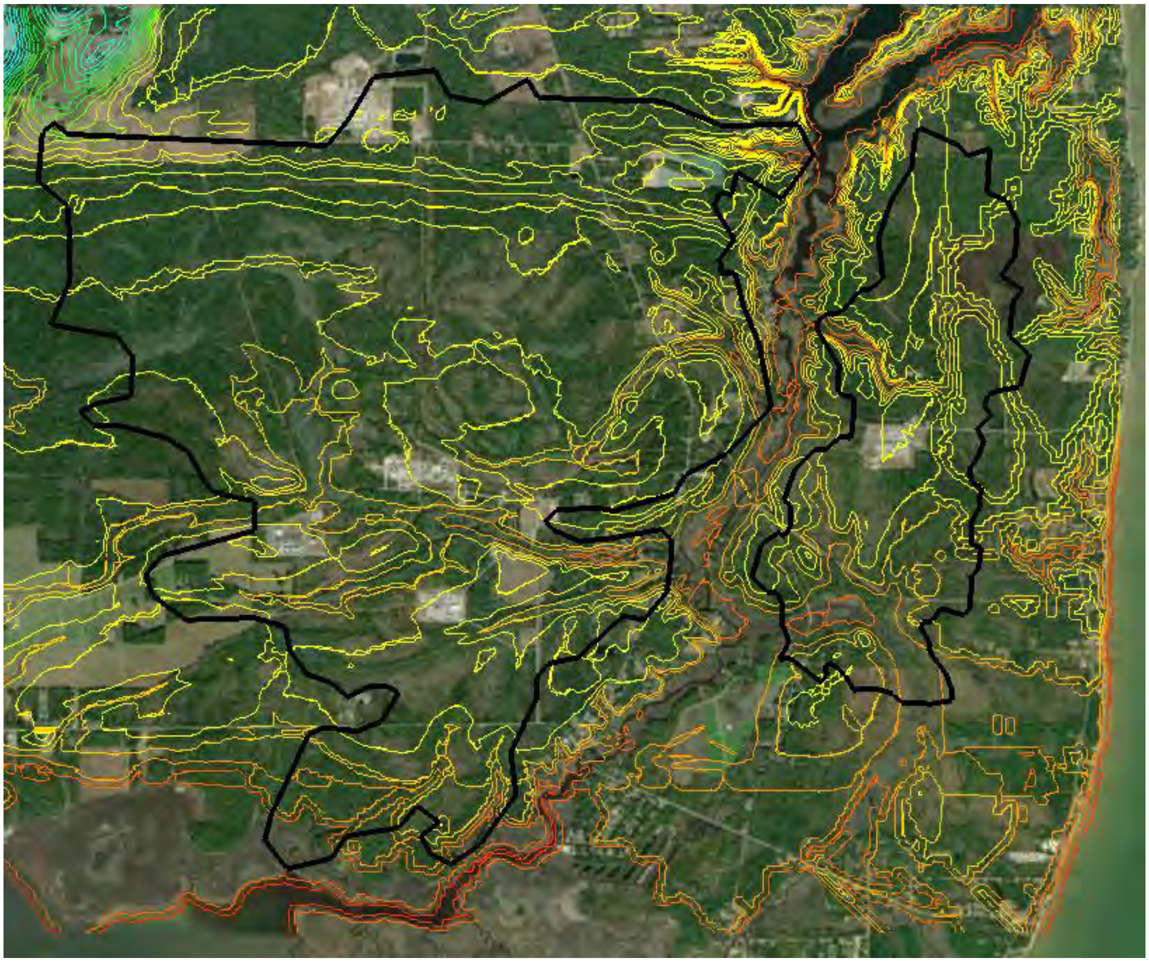
## 3.3. Digital Terrain Data

The GSSHA model uses digital terrain data to incorporate topography into the hydrologic model. For the model, Light Detection and Ranging (LiDAR) data was obtained from the 2014 Mobile County Lidar DEM (AL) dataset. This information is warehoused by the Office of Coastal Management of the National Oceanic and Atmospheric Administration (NOAA). The raster data is saved as a .tif file, with each file encompassing approximately 1.29 square miles (6000' x 6000'). The coordinate system for the raster data is to State Plane AL-W and the units are in feet. The information can be found at the following web address: https://coast.noaa.gov/htdata/raster2/elevation/Mobile_DEM_2014_5169/.

In order to get digital elevation data for basin delineation, each .tif was converted individually to a DEM. Each conversion utilized a 40-foot point spacing. For easier data manipulation, the individual DEM was converted to a .dwg. Once all of the individual DEM files were converted to a .dwg, they were merged into one file using Microstation. The complete basin .dwg was then imported back into WMS for a conversion back to a single DEM.

The GSSHA model requires all units to be in the International System of Units. It was therefore necessary to convert the State Plane AL-W data to UTM Zone 16 data. The units were also converted from feet to meters. After proper conversion, the DEM data can be used for automatic delineation of the basin, as well as, for generating cell elevations for the gridded model. Figure 3-2 shows the topographic data that was used in each model.

**Figure 3-2**
**West Fowl River Watershed with Topographic Data**



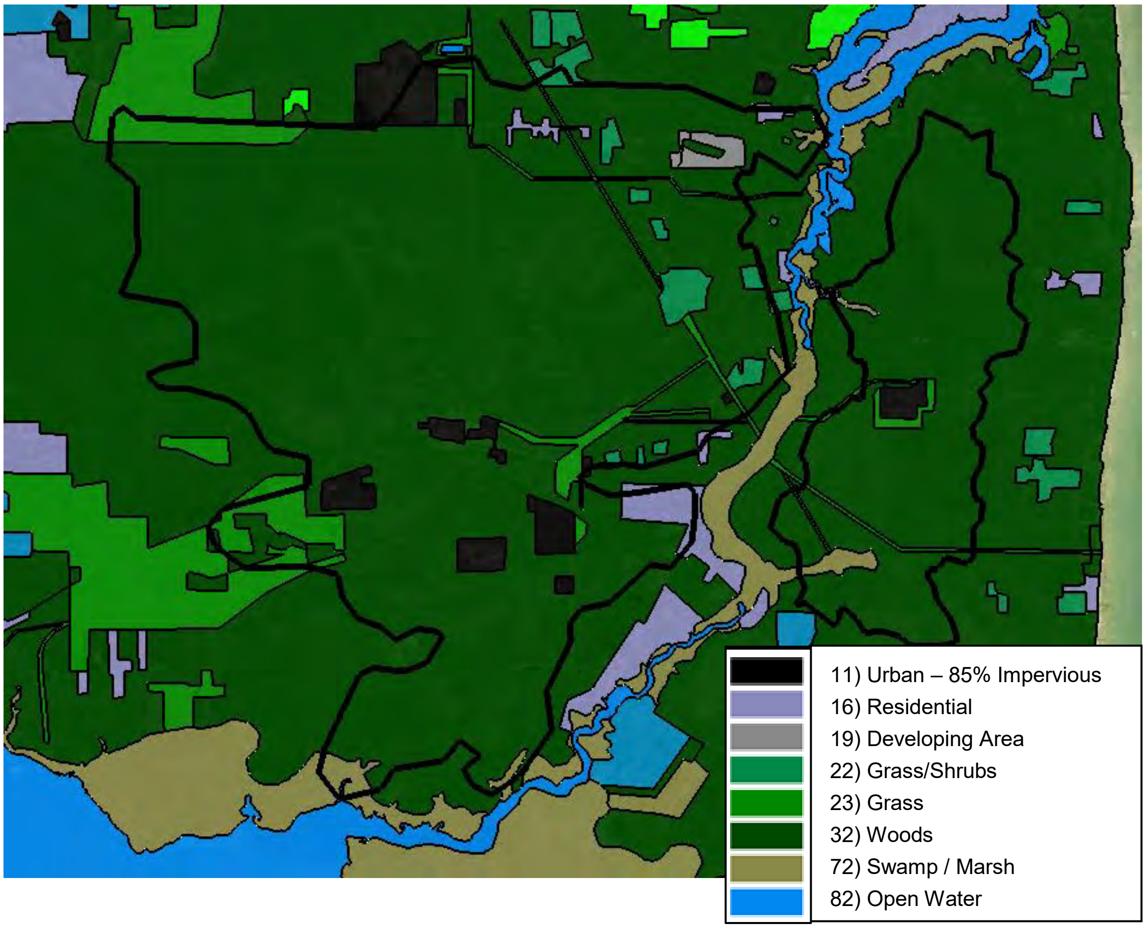
## 3.4. Land Use

The land use component of the model is necessary to define the various overland flow types throughout the basin. Land use was delineated using geo-referenced aerial imagery. WMS was used to automatically import the latest version of Esri's World Imagery map. (more information can be found at http://services.arcgisonline.com/ArcGIS/rest/services/World_Imagery/MapServer) The GSSHA model utilizes the land use coverage by assigning a value to describe the overland roughness. The roughness of each land use type is described by an overland Manning's 'n' value. Table 3-1 lists the land use types and the respective 'n' values assigned to them. Figure 3-3 indicates the digitized land use for the watersheds.

**Table 3-1**
**Land Use and Manning's 'n' Values**

| GSSHA ID | Land Use | Manning's 'n' |
|---|---|---|
| 11 | Urban – 85% Impervious | 0.011 |
| 16 | Residential | 0.050 |
| 19 | Developing Area | 0.025 |
| 22 | Grass / Shrubs | 0.150 |
| 23 | Grass | 0.150 |
| 32 | Woods | 0.200 |
| 72 | Swamp / Marsh | 0.250 |
| 82 | Open Water | 0.011 |

**Figure 3-3**
**West Fowl River Watershed with Digitized Land Use**




## 3.5. Soils

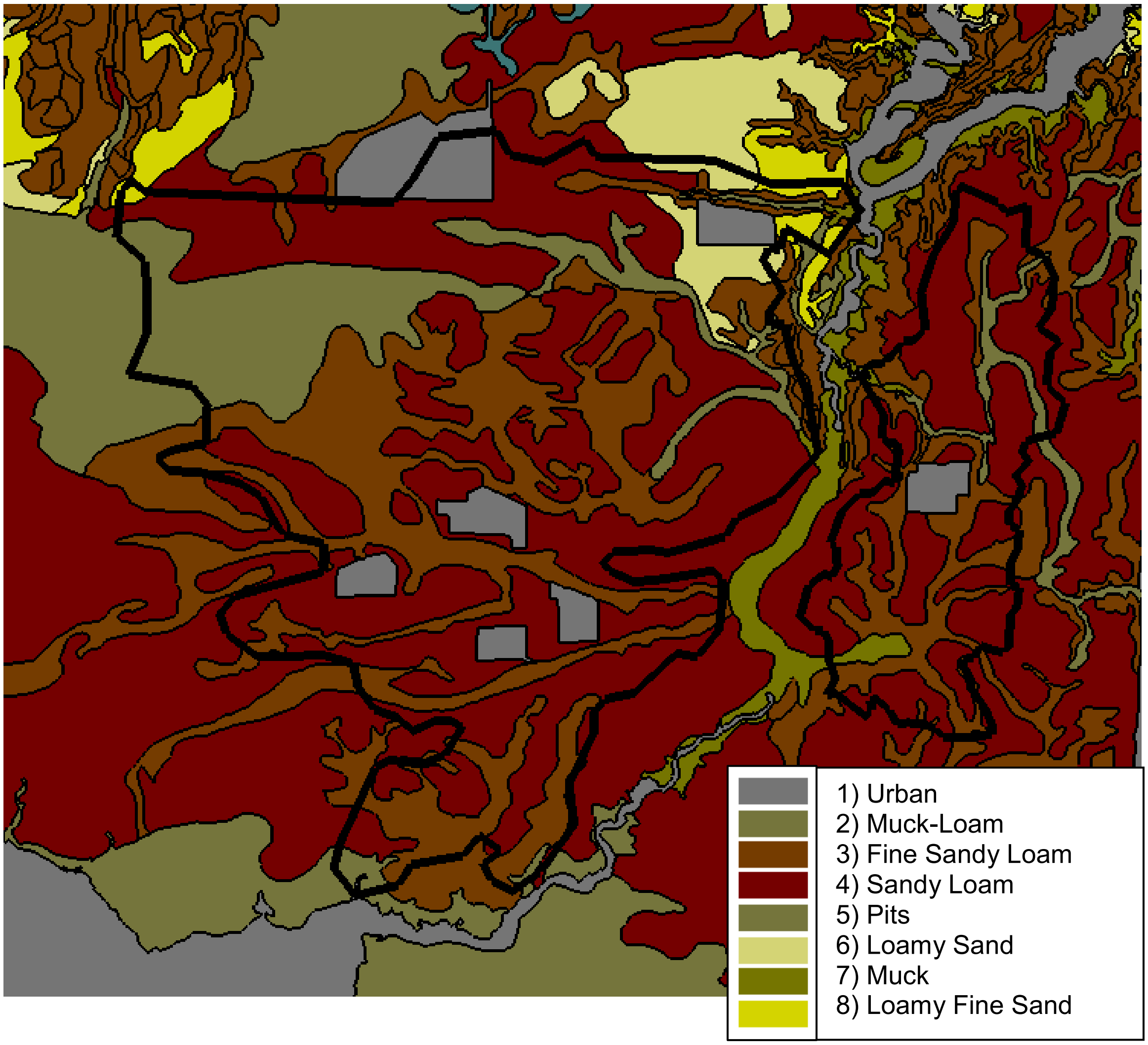
Similarly to the land use, the GSSHA model has the capability to incorporate specific characteristics of the soils located within a drainage basin. The soils coverage can be used for defining infiltration into the soil or setting the initial soil moisture. Table 3-2 indicates the different soil assignments for each sub-basin within the West Fowl Watershed study area. Green and Ampt (G&A) with soil moisture redistribution was used for determining the infiltration of rainfall throughout the basin. Soil parameters used by the G&A method include hydraulic conductivity, porosity, capillary head, pore distribution index, residual saturation, and field capacity. These infiltration values allow the GSSHA model to evaluate the soil's ability to infiltrate stormwater for calculating peak discharge and volume of storm events.

Soils data shapefiles were provided by the Mobile Bay National Estuary Program (MBNEP). According to the metadata provided with the shapefiles, this soil survey is an update to the 1980 soil survey of Mobile County. According to the metadata, "The Soil Survey information was updated using the latest advanced geospatial software ArcGIS 10.3 ArcInfo…. The U.S. Department of Agriculture, Natural Resources Conservation Service, should be acknowledged as the data source in products derived from these data." Figure 3-4 indicates the soil data that has been incorporated into the GSSHA model. Infiltration can be defined through the soils coverage alone or through a combined land use/soils data coverage.

**Table 3-2**
**West Fowl Watershed – Basin Soil Types**

| Basin No. | Soil Types in Basin |
|---|---|
| 1 | Muck/Loam, Fine Sandy Loam, Sandy Loam, Loamy Sand, Loamy Fine Sand, Clay Loam |
| 2 | Clay Loam, Muck/Loam, Sandy Loam |
| 3 | Muck/Loam, Fine Sandy Loam, Sandy Loam, Loamy Sand, Pits, Muck, Clay Loam |
| 4 | Clay Loam, Muck/Loam, Sandy Loam |
| 5 | Clay Loam, Fine Sandy Loam, Sandy Loam |
| 6 | Sandy Loam, Muck |
| 7 | Fine Sandy Loam, Muck |
| 8 | Clay Loam, Fine Sandy Loam, Sandy Loam, Muck/Sandy Clay Loam |

**Figure 3-4**
**West Fowl River Watershed with Digitized Soil Type**




## 3.6. Combined Coverage

A combined land use / soils coverage layer can be generated in order to incorporate a more detailed way to specify infiltration. Instead of defining the infiltration parameters with just soils, it can be defined based on a soil type and specific land use. For example, a sandy loam may have woods described as the land use in one part of the watershed and a parking lot in another. Instead of applying the infiltration values for just a sandy loam, a combined coverage can utilize an infiltration value for the woods and a separate one for the parking lot. This can help better replicate the timing and infiltration related to the ground cover and soil type.

## 3.7. Gridded Model

Once all of the variables mentioned above have been incorporated into the model, it was necessary to divide the model into individual grid cells. As mentioned previously, the settings for GSSHA require the units to be in the International System of Units (SI). Table 3-3 lists the basin number, grid cell size, drainage area, and number of grid cells for each of the eight West Fowl River subbasins. Figures 3-5 to 3-52 indicate the watershed boundary, elevation data, gridded elevation data, gridded soil type data, gridded land use data, and combined land use / soils type data for each basin.

**Table 3-3**
**Grid Cell Summary of Basins**

| Basin | Grid Cell Size | | Drainage Area | Number of Grid Cells |
|---|---|---|---|---|
| | (Meter) | (Feet) | (Sq Miles) | |
| 1 | 10 | 32.8 | 0.76 | 19816 |
| 2 | 14 | 45.9 | 1.61 | 21332 |
| 3 | 22 | 72.2 | 3.71 | 19899 |
| 4 | 28 | 91.9 | 6.20 | 20507 |
| 5 | 7 | 23.0 | 0.41 | 21891 |
| 6 | 13 | 42.7 | 1.41 | 21550 |
| 7 | 7 | 23.0 | 0.35 | 18657 |
| 8 | 11 | 36.1 | 0.86 | 18316 |

**Figure 3-5**
**Basin 1 – Watershed Boundary**

**Figure 3-6**
**Basin 1 – Watershed with Elevation Data**

**Figure 3-7**
**Basin 1 – Watershed with Gridded Elevation Data**

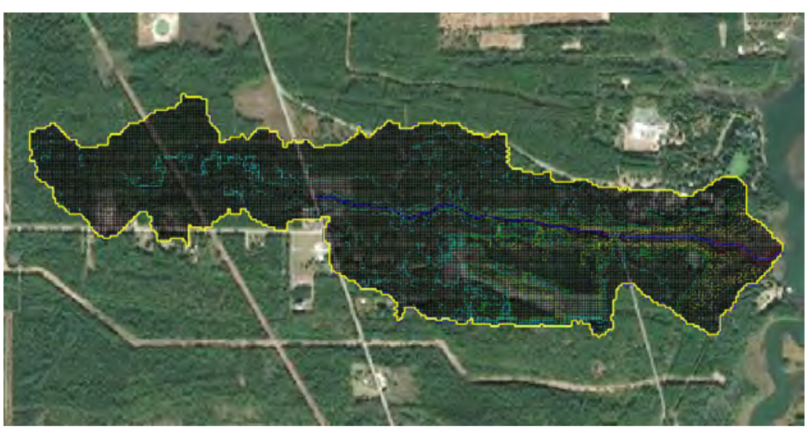


**Figure 3-8**
**Basin 1 – Watershed with Gridded Land Use Data**

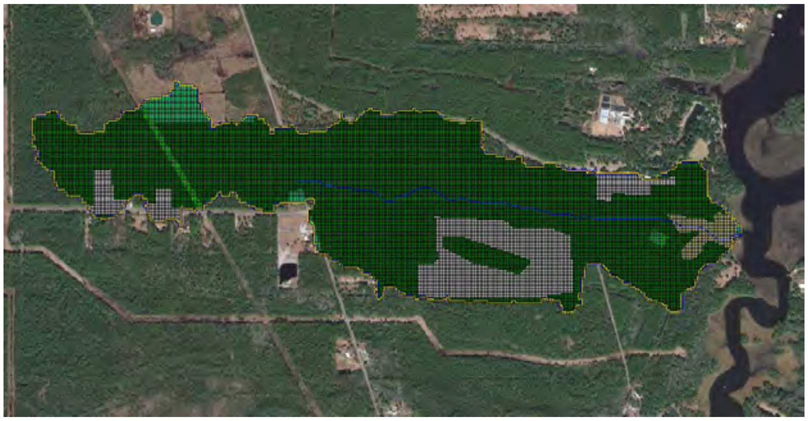


**Figure 3-9**
**Basin 1 – Watershed with Gridded Soil Type Data**

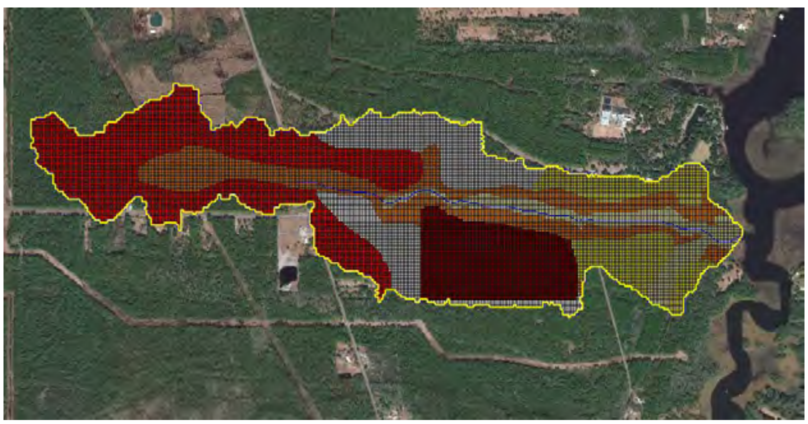


**Figure 3-10**
**Basin 1 – Watershed with Gridded Land Use/Soil Type Combined Data**

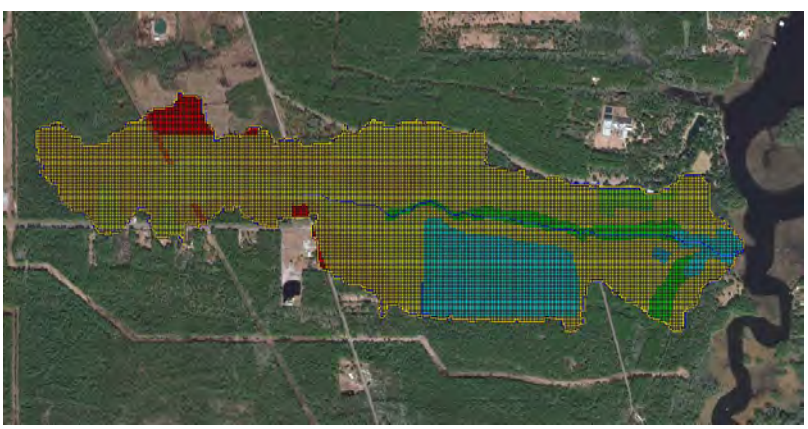


**Figure 3-11**
**Basin 2 – Watershed Boundary**

**Figure 3-12**
**Basin 2 – Watershed with Elevation Data**

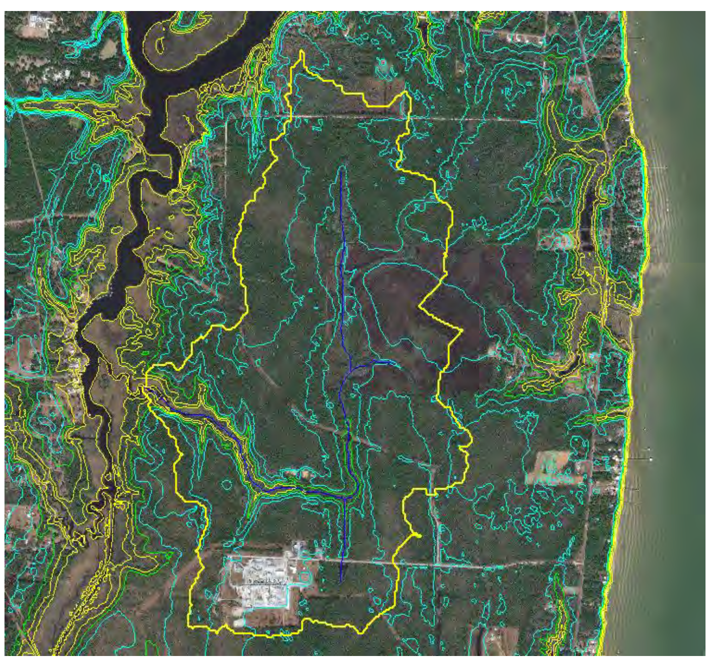


**Figure 3-13**
**Basin 2 – Watershed with Gridded Elevation Data**

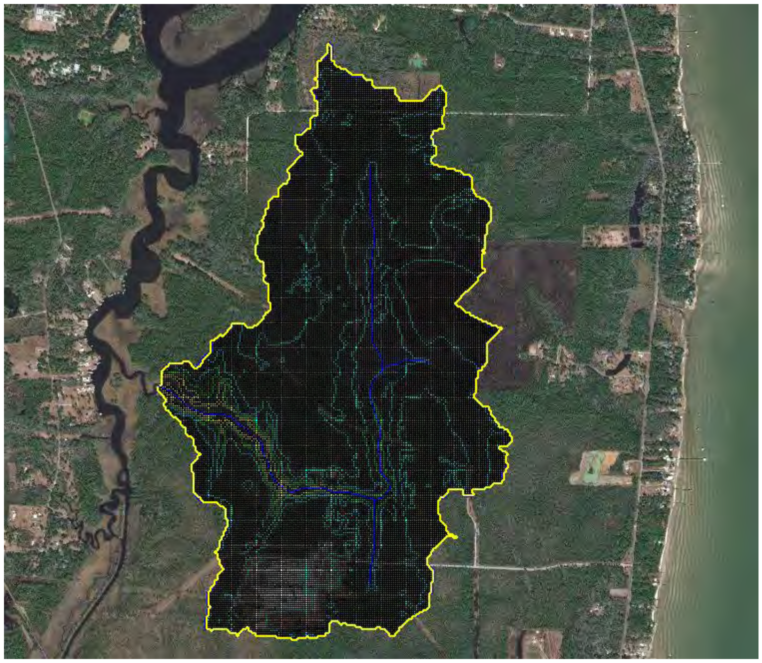


**Figure 3-14**
**Basin 2 – Watershed with Gridded Land Use Data**

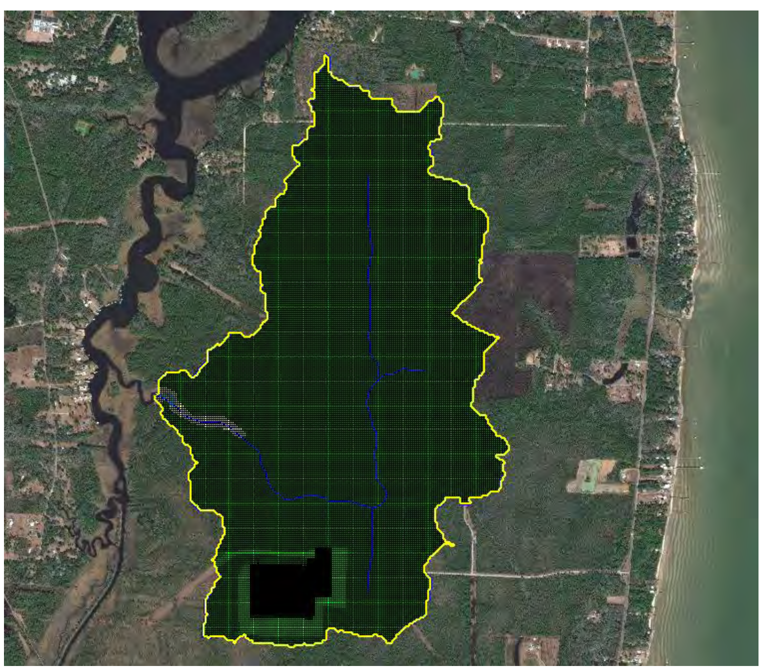


**Figure 3-15**
**Basin 2 – Watershed with Gridded Soil Type Data**

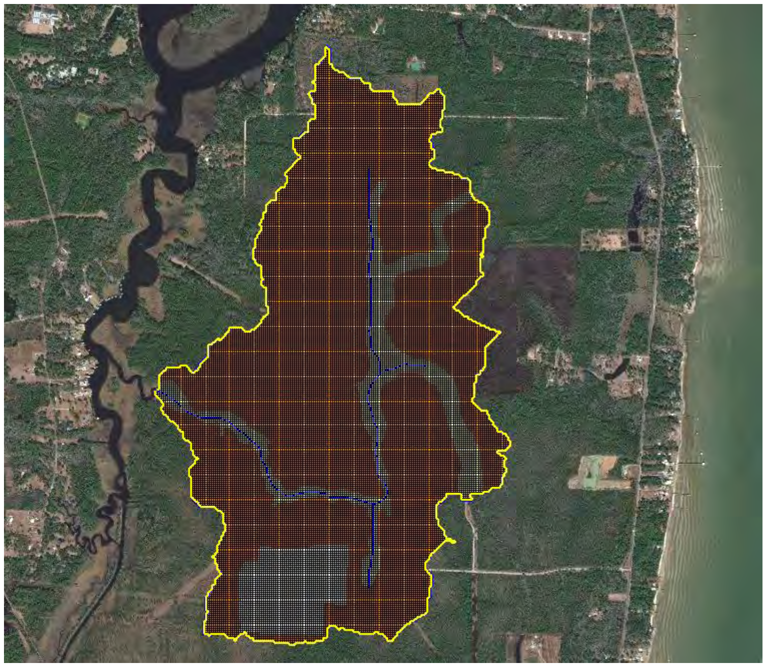


**Figure 3-16**
**Basin 2 – Watershed with Gridded Land Use/Soil Type Combined Data**

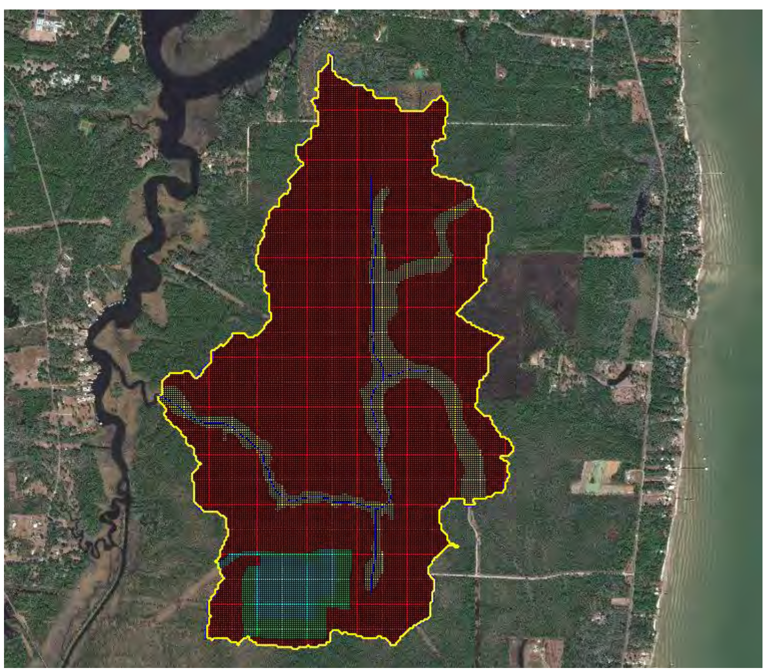


**Figure 3-17**
**Basin 3 – Watershed Boundary**

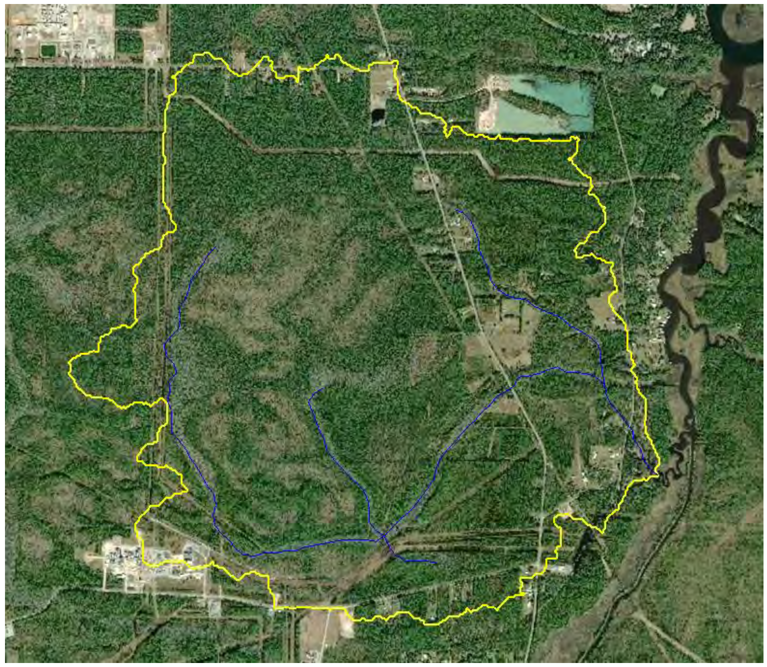


**Figure 3-18**
**Basin 3 – Watershed with Elevation Data**

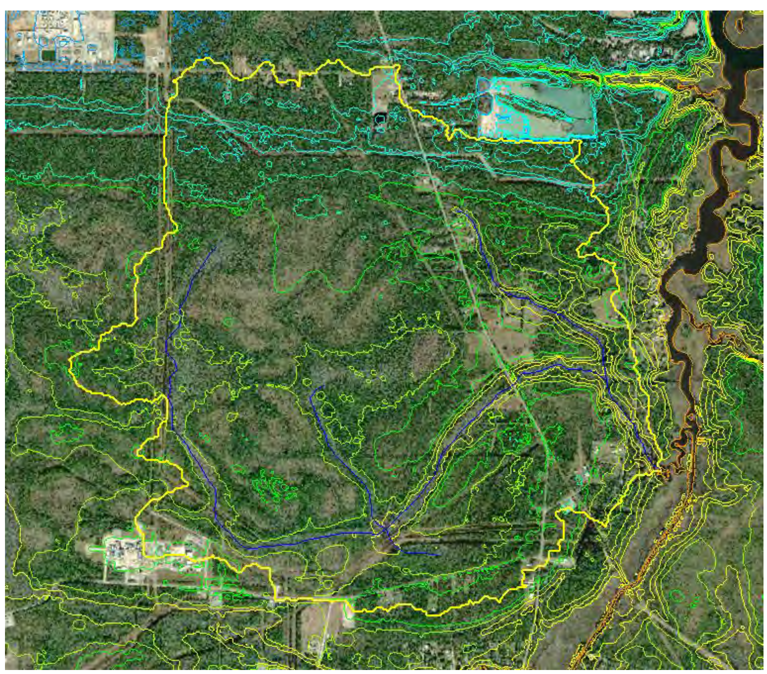


**Figure 3-19**
**Basin 3 – Watershed with Gridded Elevation Data**

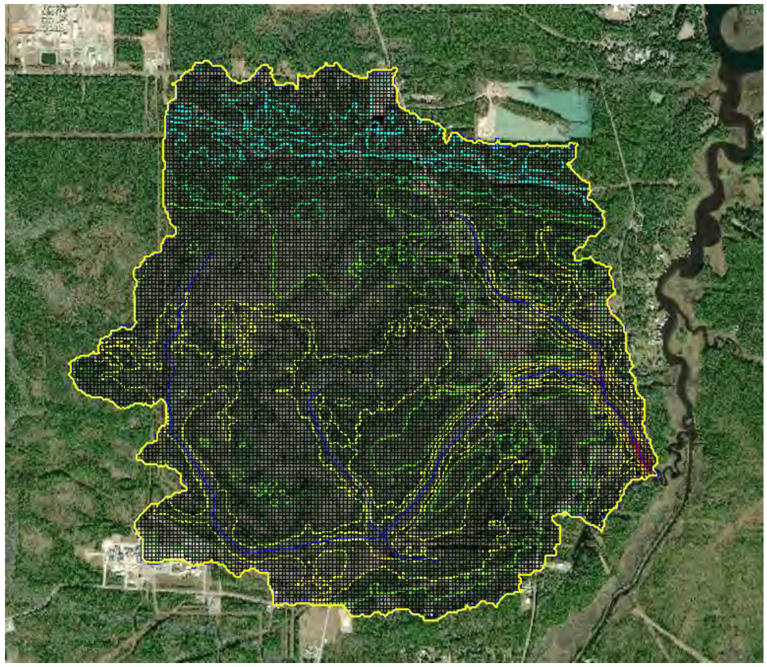


**Figure 3-20**
**Basin 3 – Watershed with Gridded Land Use Data**

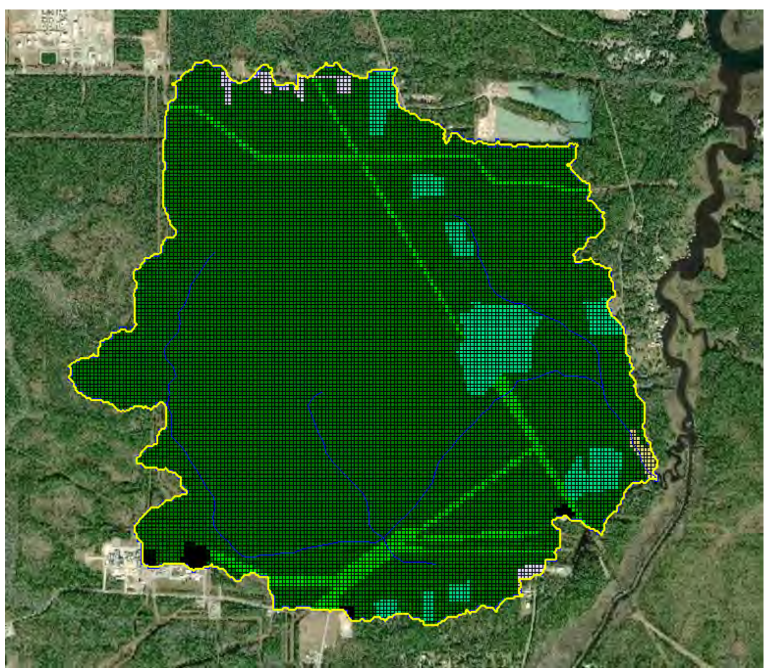


**Figure 3-21**
**Basin 3 – Watershed with Gridded Soil Type Data**

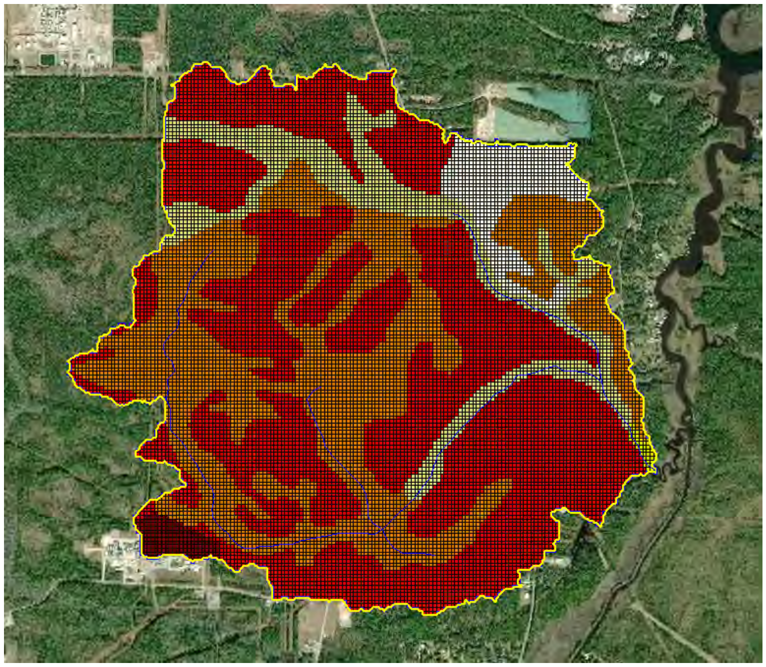


**Figure 3-22**
**Basin 3 – Watershed with Gridded Land Use/Soil Type Combined Data**

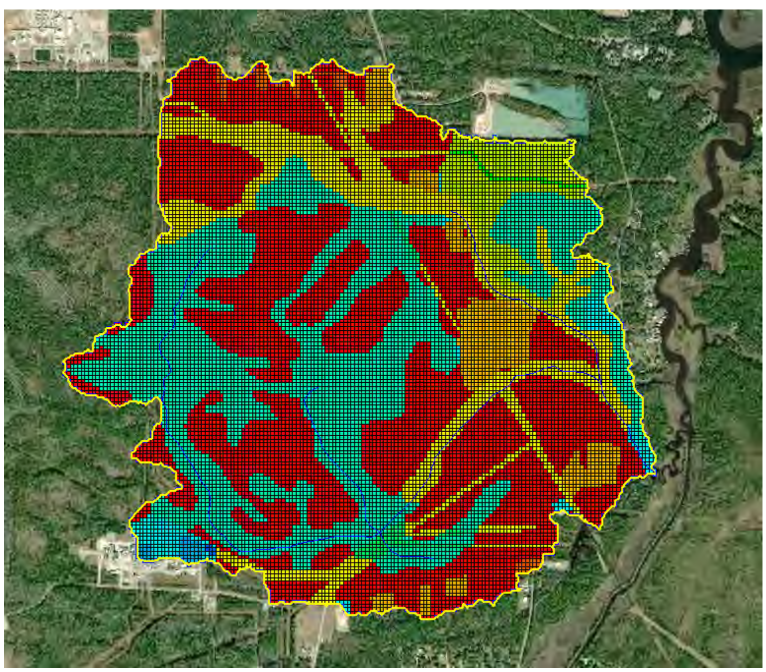


**Figure 3-23**
**Basin 4 – Watershed Boundary**

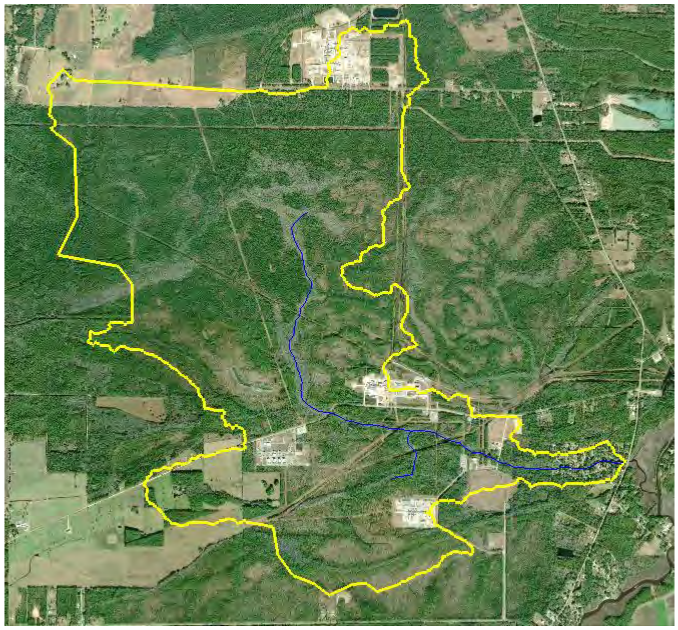


**Figure 3-24**
**Basin 4 – Watershed with Elevation Data**

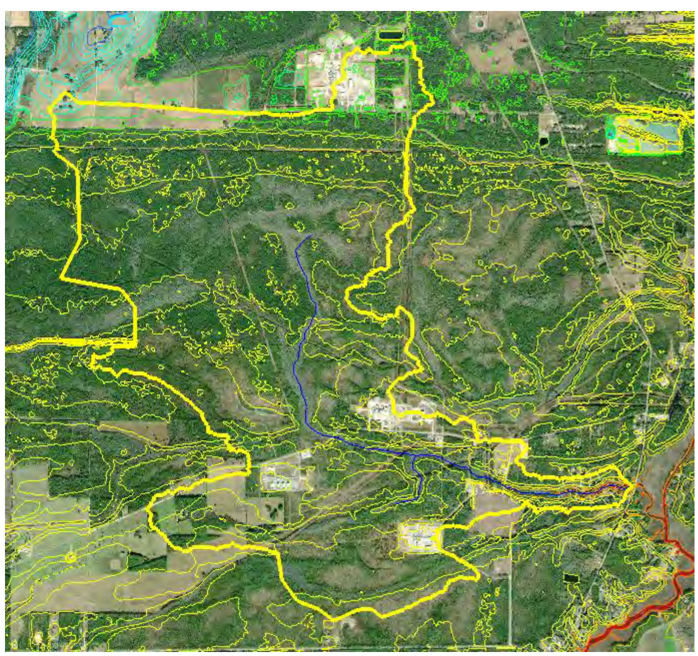


**Figure 3-25**
**Basin 4 – Watershed with Gridded Elevation Data**

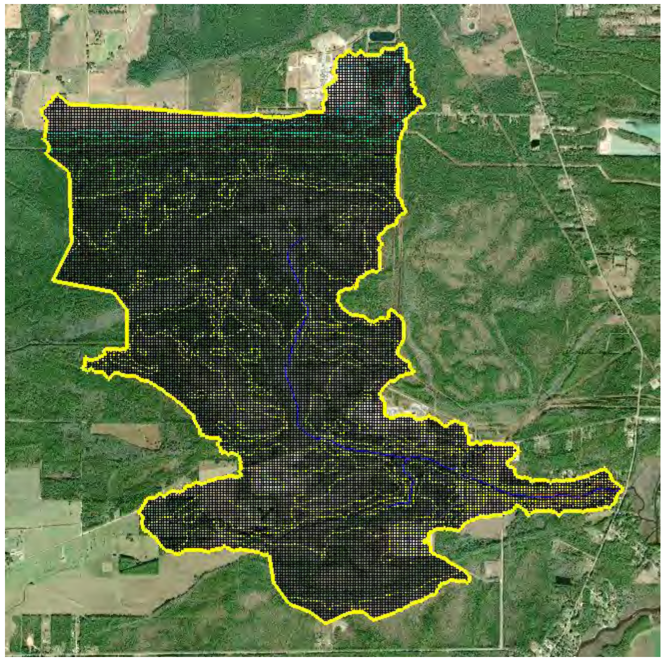


**Figure 3-26**
**Basin 4 – Watershed with Gridded Land Use Data**

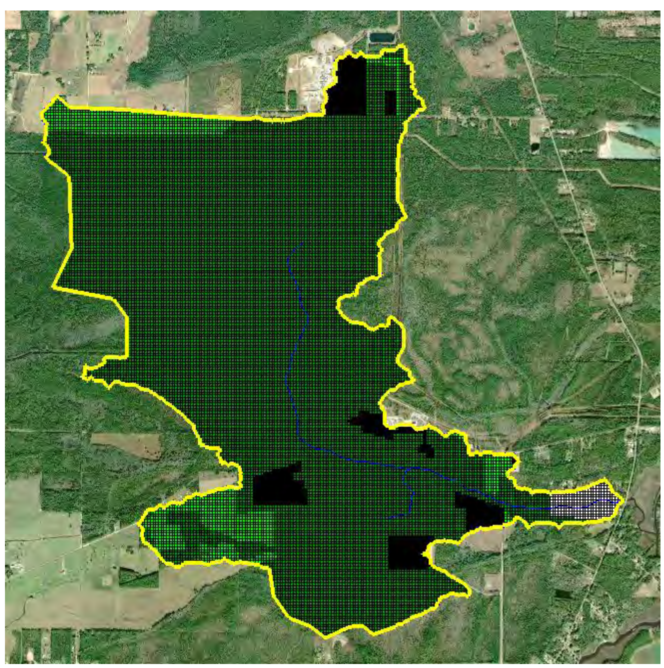


**Figure 3-27**
**Basin 4 – Watershed with Gridded Soil Type Data**

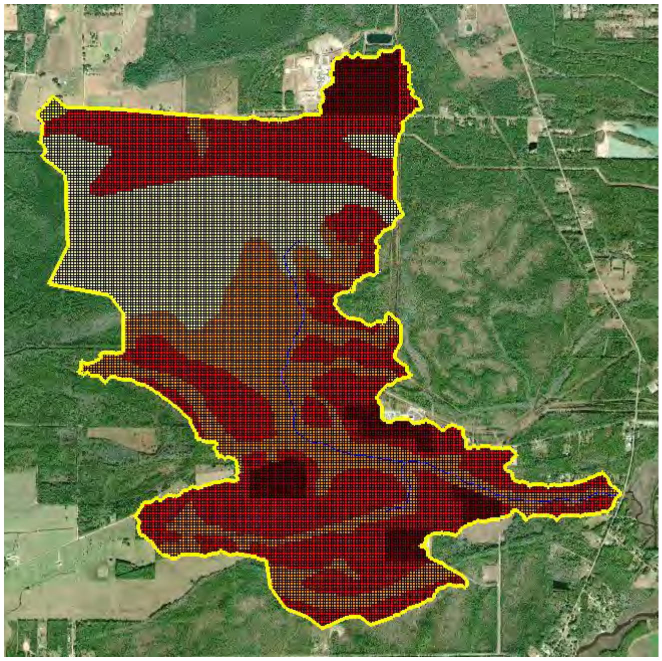


**Figure 3-28**
**Basin 4 – Watershed with Gridded Land Use/Soil Type Combined Data**

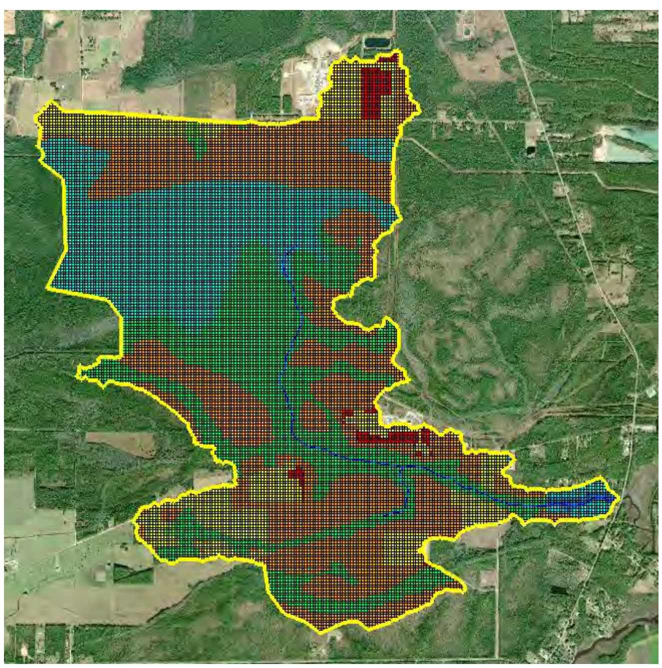


**Figure 3-29**
**Basin 5 – Watershed Boundary**

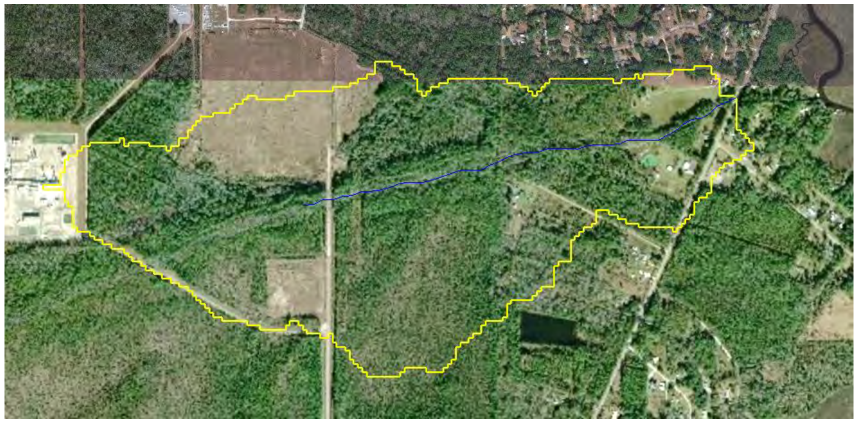


**Figure 3-30**
**Basin 5 – Watershed with Elevation Data**

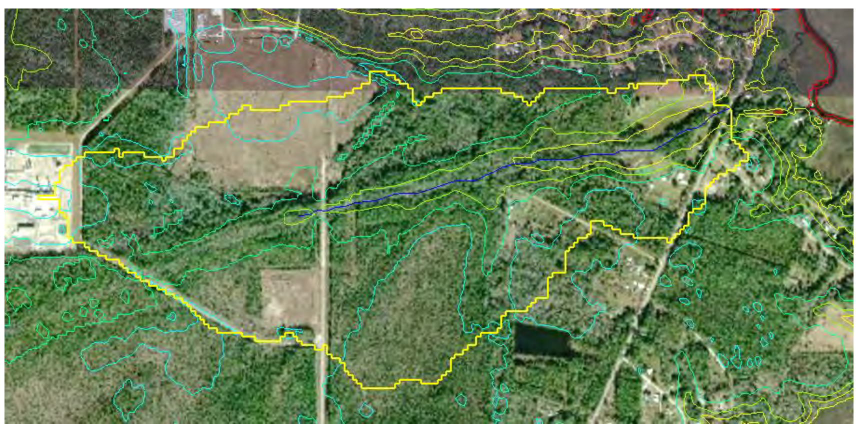


**Figure 3-31**
**Basin 5 – Watershed with Gridded Elevation Data**

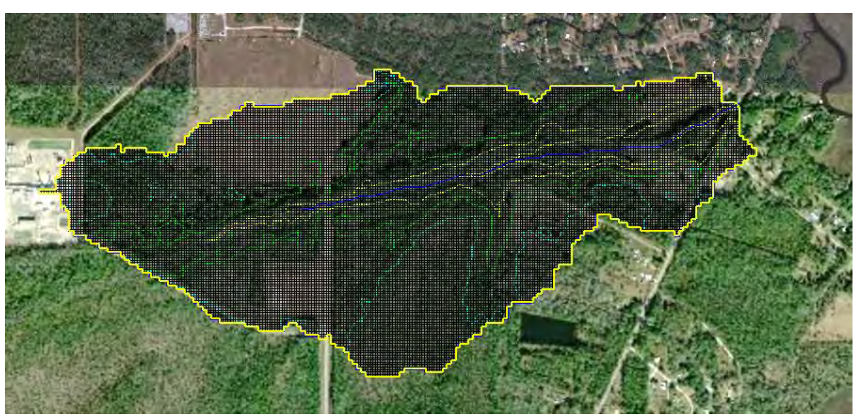


**Figure 3-32**
**Basin 5 – Watershed with Gridded Land Use Data**

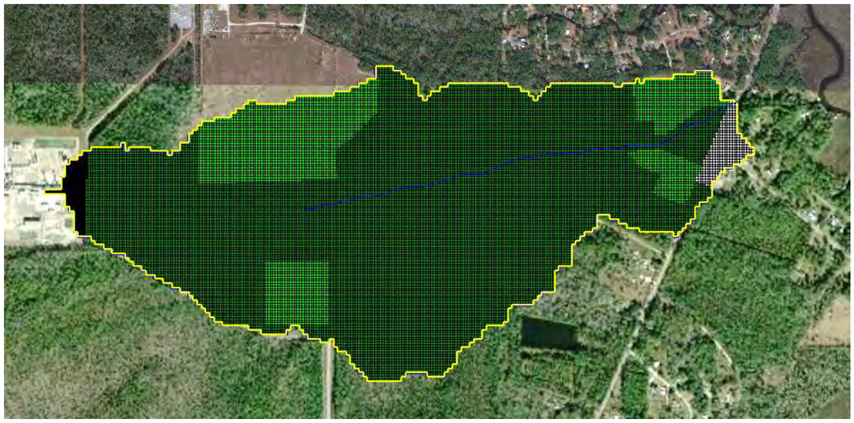


**Figure 3-33**
**Basin 5 – Watershed with Gridded Soil Type Data**

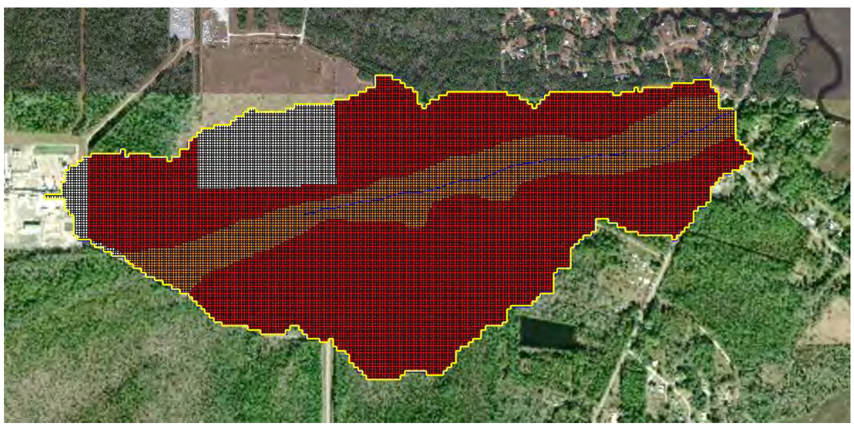


**Figure 3-34**
**Basin 5 – Watershed with Gridded Land Use/Soil Type Combined Data**

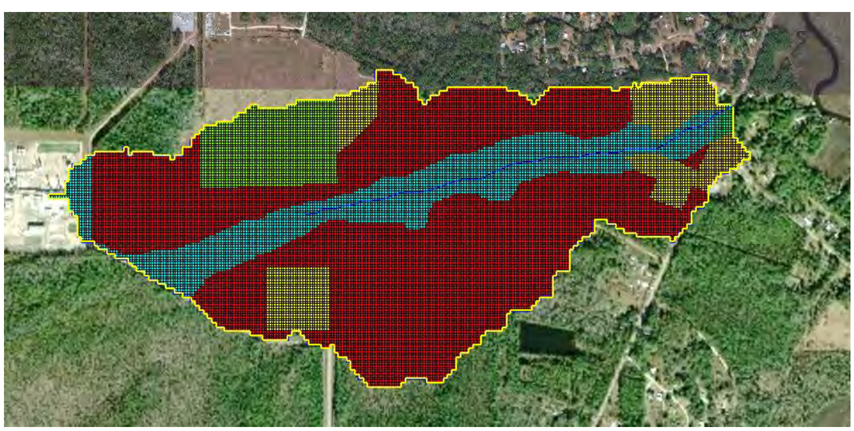


**Figure 3-35**
**Basin 6 – Watershed Boundary**

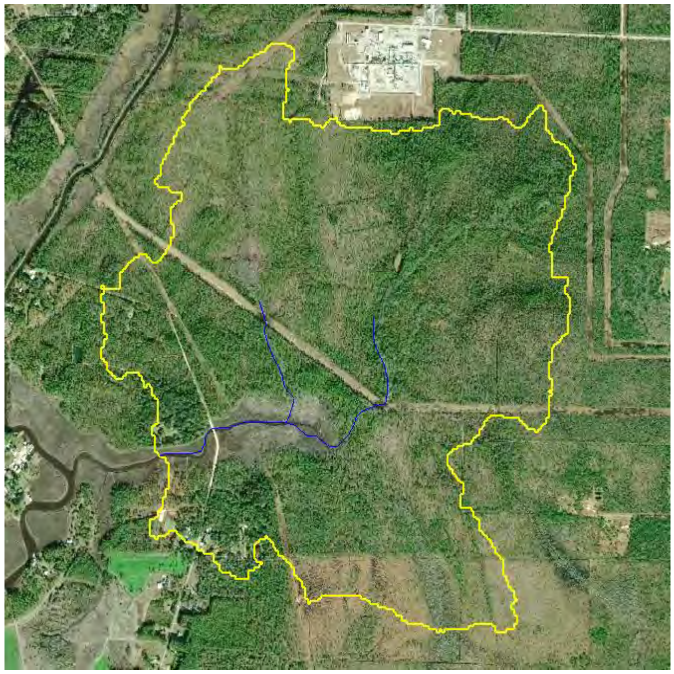


**Figure 3-36**
**Basin 6 – Watershed with Elevation Data**

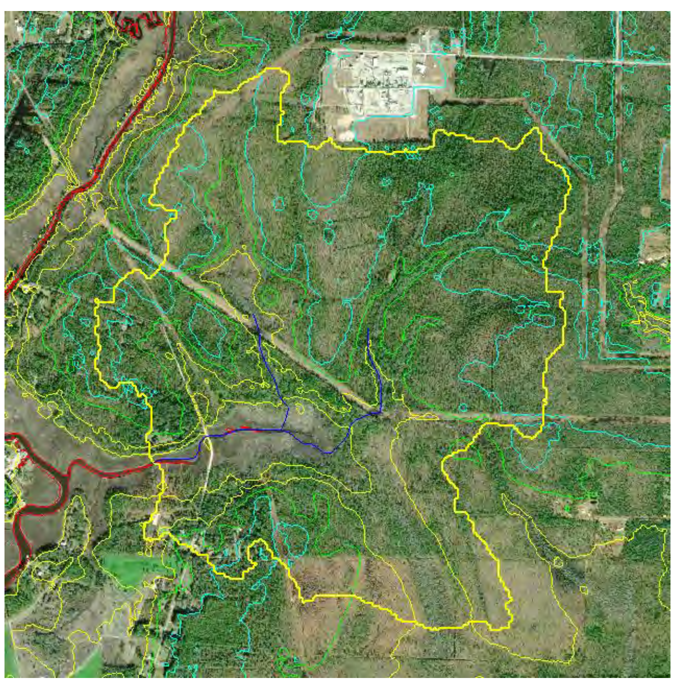


**Figure 3-37**
**Basin 6 – Watershed with Gridded Elevation Data**

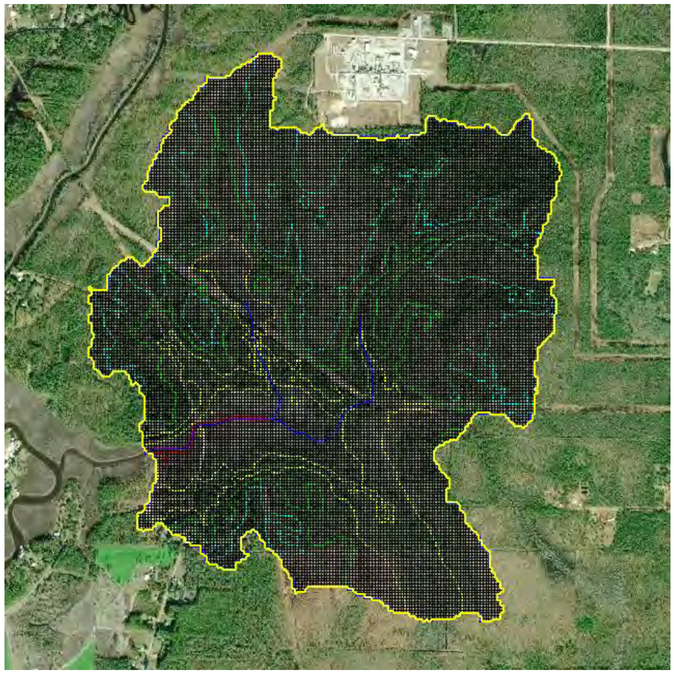


**Figure 3-38**
**Basin 6 – Watershed with Gridded Land Use Data**

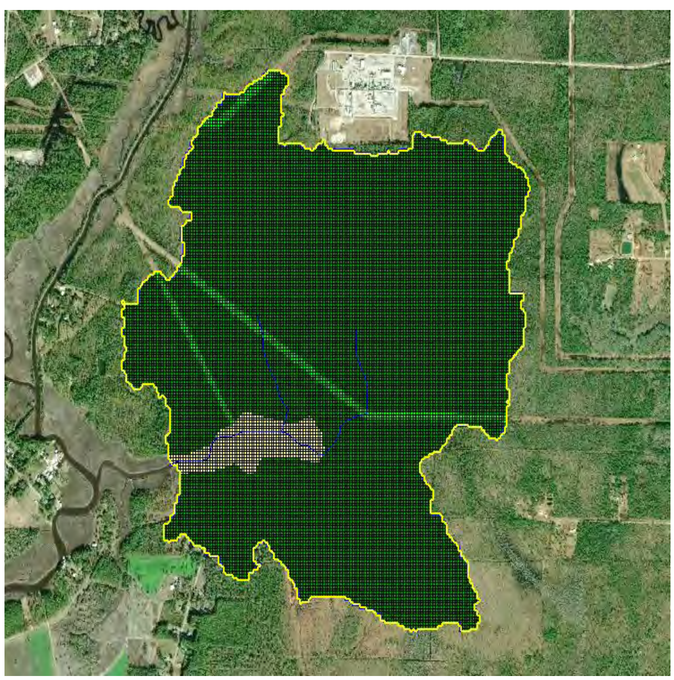


**Figure 3-39**
**Basin 6 – Watershed with Gridded Soil Type Data**

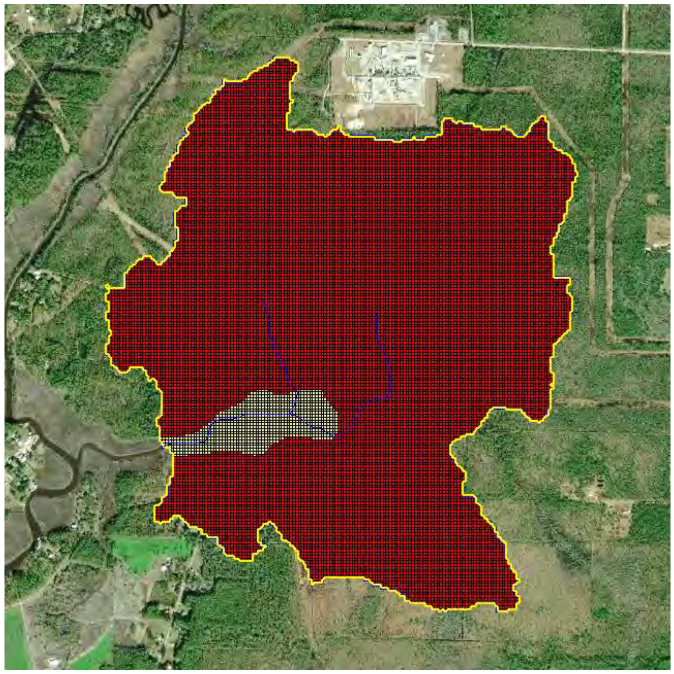


**Figure 3-40**
**Basin 6 – Watershed with Gridded Land Use/Soil Type Data**

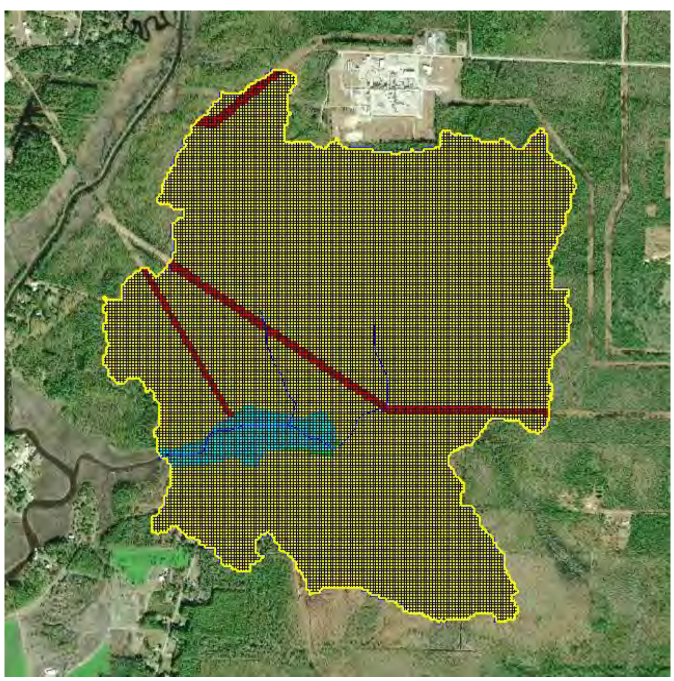


**Figure 3-41**
**Basin 7 – Watershed Boundary**

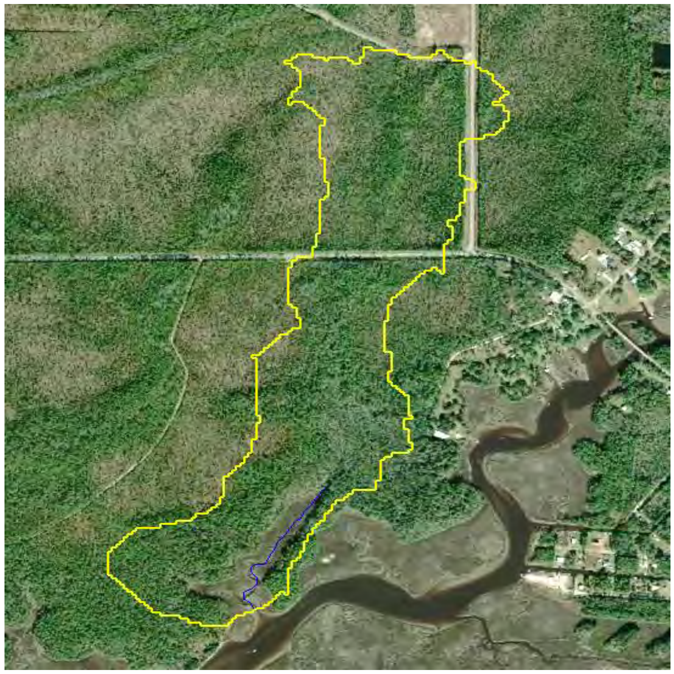


**Figure 3-42**
**Basin 7 – Watershed with Elevation Data**

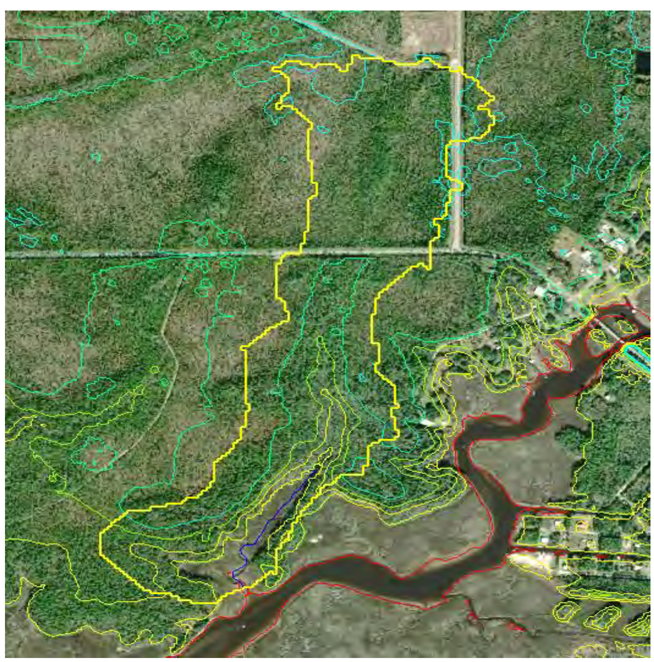


**Figure 3-43**
**Basin 7 – Watershed with Gridded Elevation Data**

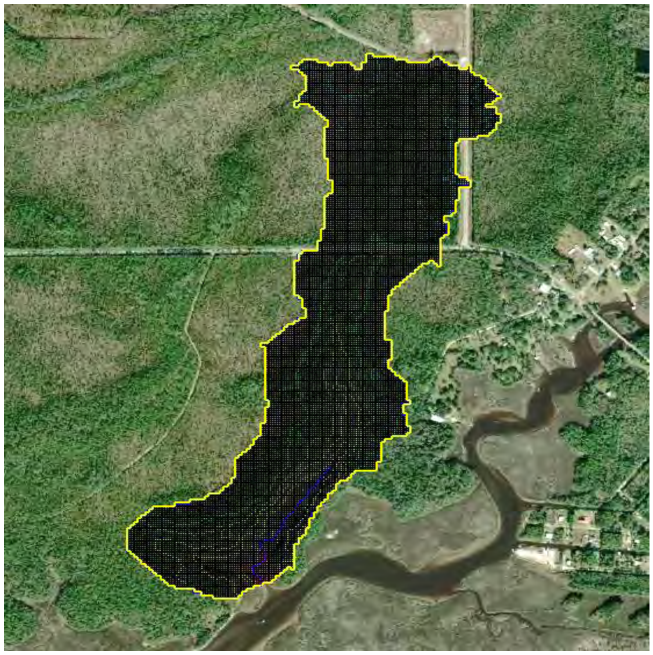


**Figure 3-44**
**Basin 7 – Watershed with Gridded Land Use Data**

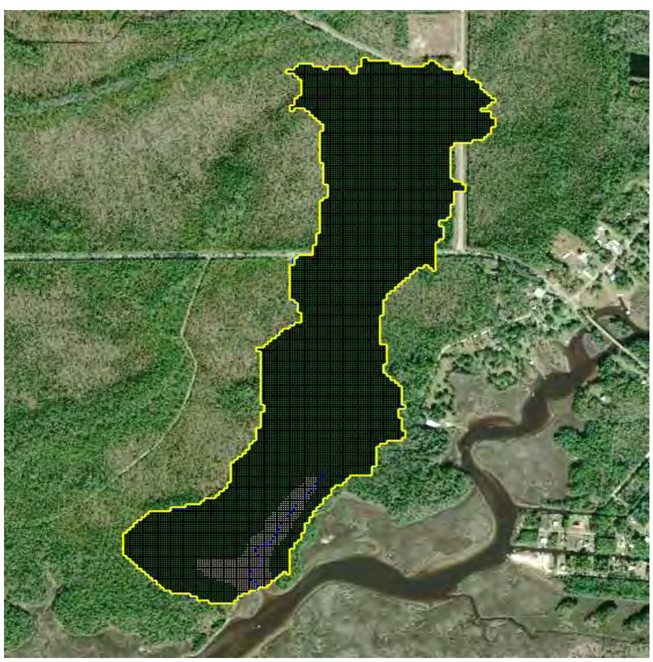


**Figure 3-45**
**Basin 7 – Watershed with Soil Type Data**

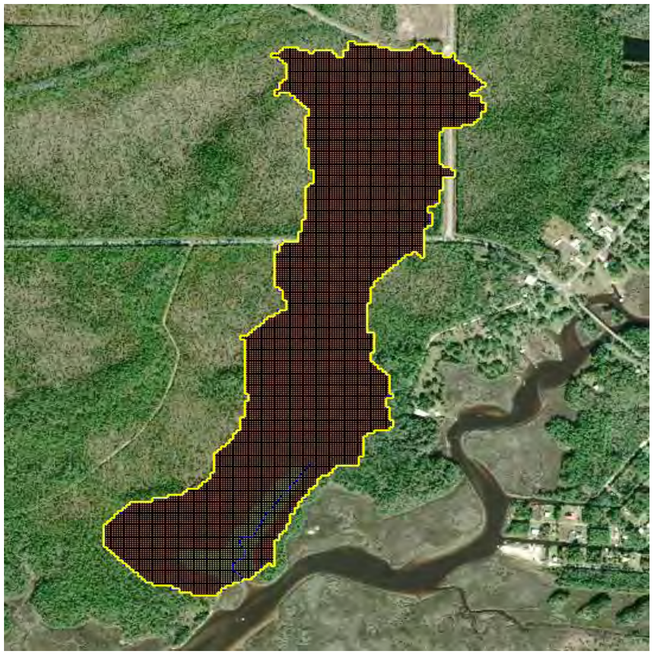


**Figure 3-46**
**Basin 7 – Watershed with Gridded Land Use/Soil Type Data**

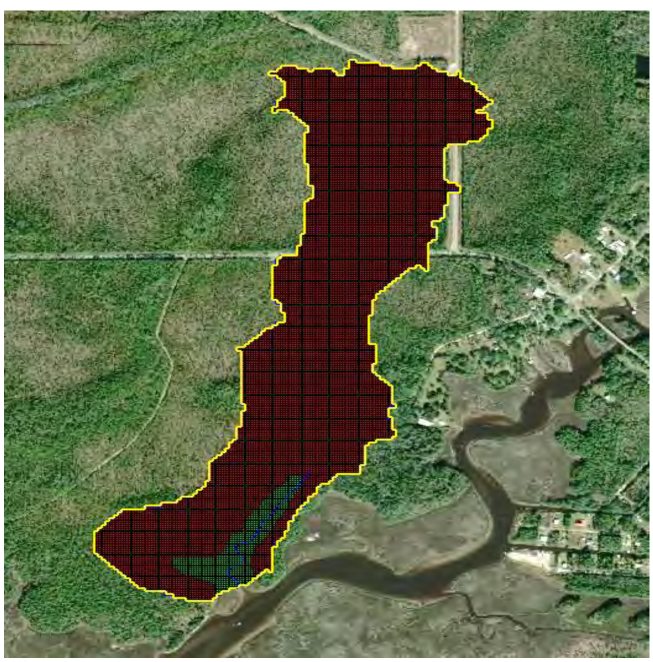


**Figure 3-47**
**Basin 8 – Watershed Boundary**

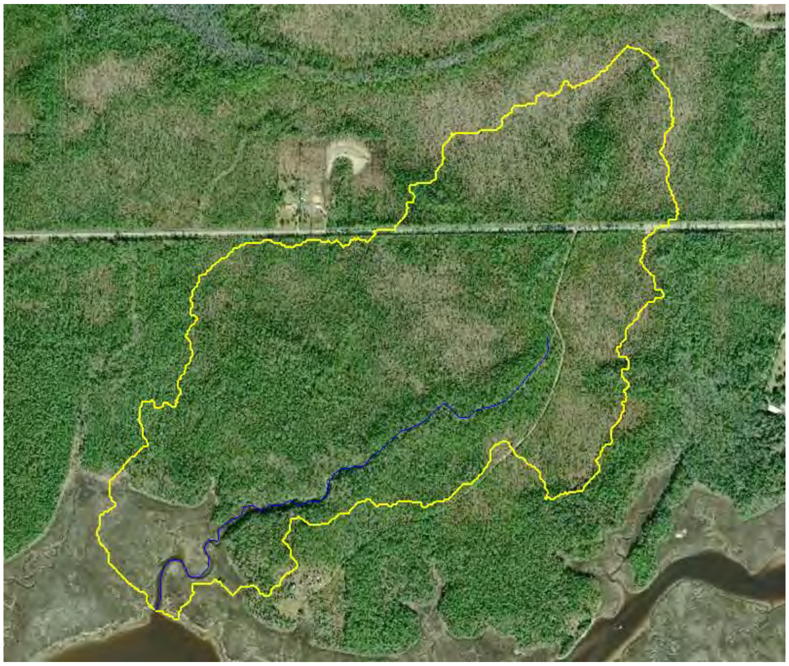


**Figure 3-48**
**Basin 8 – Watershed with Elevation Data**

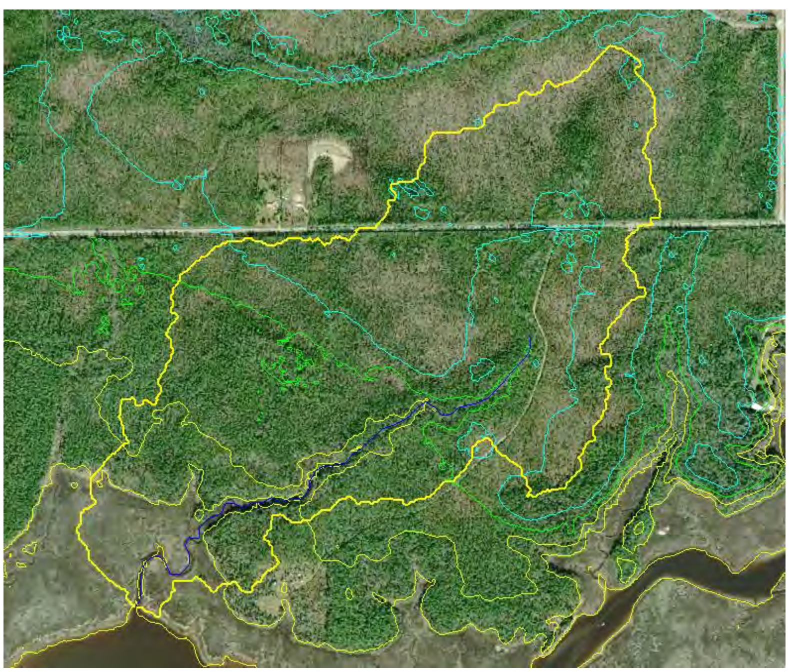


**Figure 3-49**
**Basin 8 – Watershed with Gridded Elevation Data**

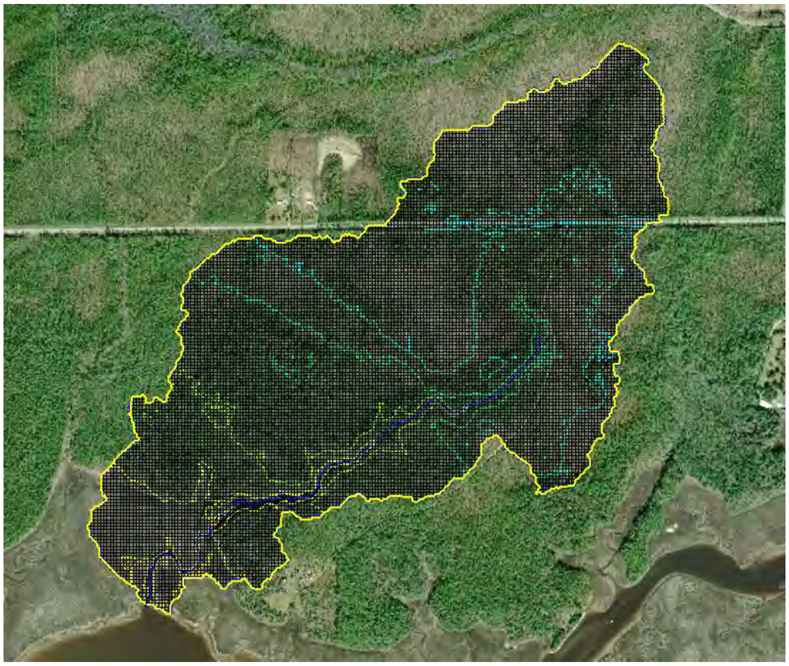


**Figure 3-50**
**Basin 8 – Watershed with Gridded Land Use Data**

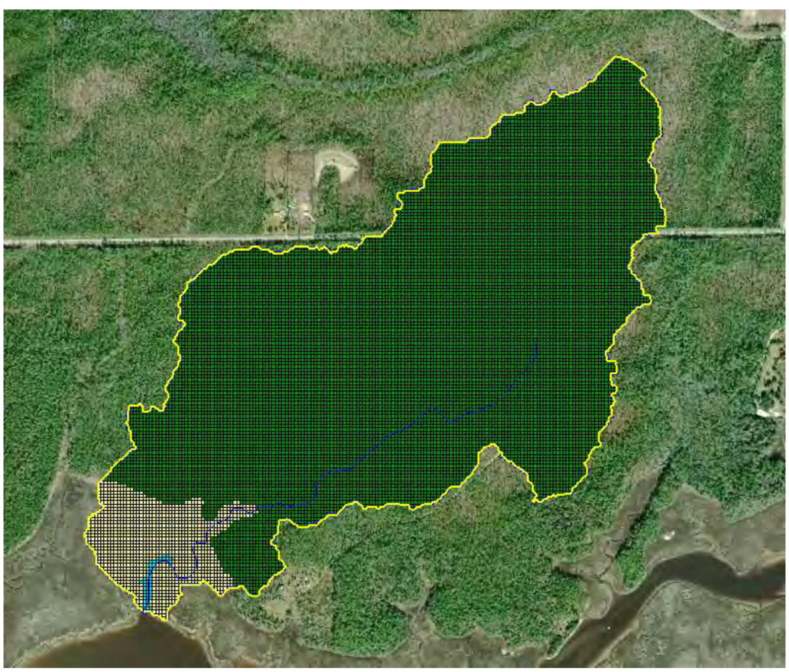


**Figure 3-51**
**Basin 8 – Watershed with Gridded Soil Type Data**

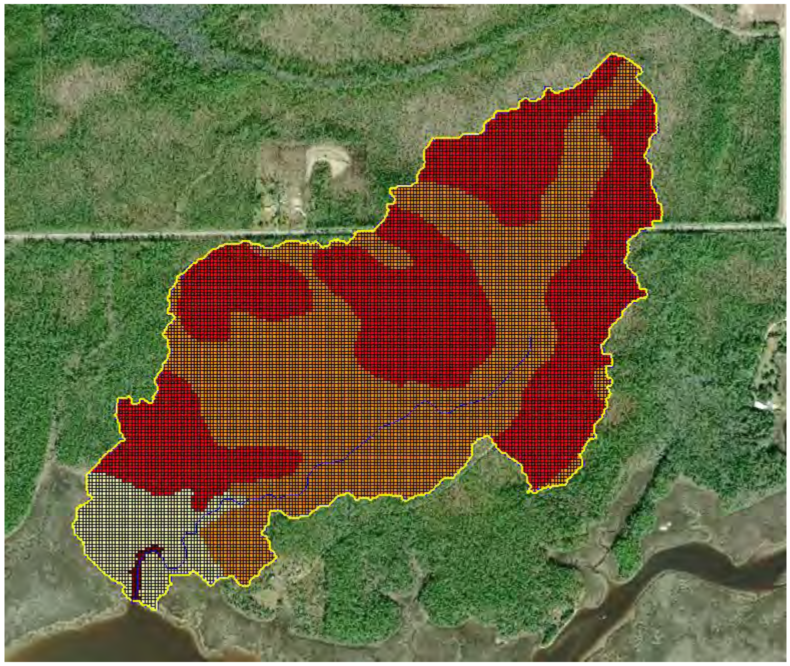
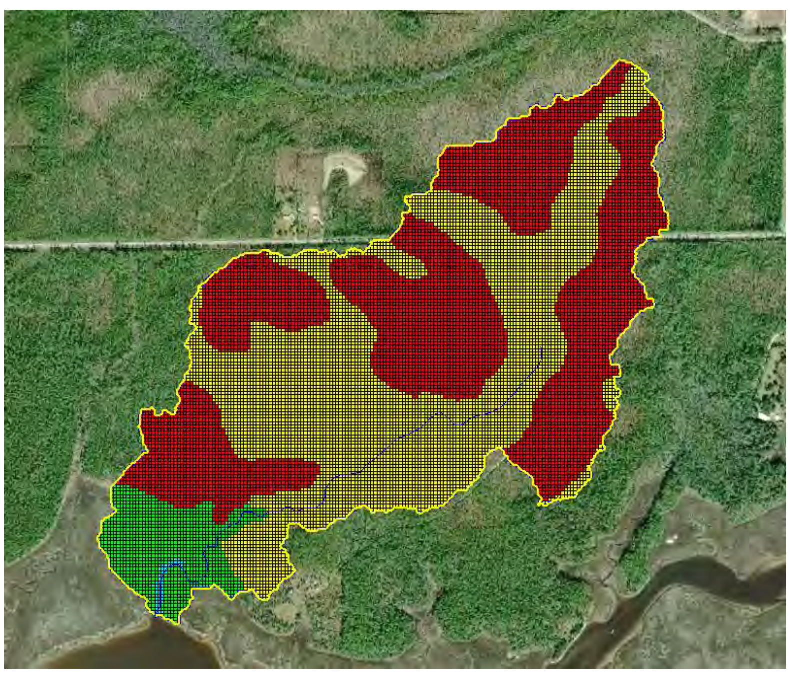


**Figure 3-52**
**Basin 8 – Watershed with Gridded Land Use/Soil Type Data**



# 4. Calibration

## 4.1. Calibration

For a model to be used for forecasting it is best to calibrate to real world storm events. Calibration requires both historic rainfall data distribution and water surface elevations or discharge measurements in a stream during the rain event. With the rainfall distribution being obtained from the installed weather stations, it was necessary to find or install gauges in the watershed to determine stream stages. Telog RU-33 gauges with level logger sensors were used for measuring stream data. These gauges contain a Recording Telemetry Unit (RTU) which forwards data wirelessly to a host computer which can be accessed through the internet. After a rain event, level data can easily be downloaded from the Telog Enterprise website. A site visit was performed in order to determine the best location for installing the monitoring gauges.

In addition to the RU-33 gauges, crest stage gages were also installed either upstream or downstream in order to record another highwater mark. These simple gages were constructed with PVC pipe, a wooden rod, and some crushed cork. During a flooding event, the cork would rise with the water level and then be deposited on the wooden rod. A measurement of the cork marking can be used to determine maximum stage height during the storm. These cork gauge marks were used in conjunction with the RU-33 highwater readings in order to obtain the water surface slope during the flood event.

There were three locations within the watershed that were deemed useful for monitoring (Figure 4-1). These locations were located near existing drainage structures to help with ease of access. Variables that come into consideration for a gauge location are dependent on location in the watershed, backwater effects, and the possibility of the gauge being vandalized. The three gauges were installed and started recording data on June 15, 2018. A list of gauges and locations can be found in Table 4-1. MBNEP 6 was relocated in May 2019 due to the lack of peak discharge information being recorded at the previous location.

**Figure 4-1**
**West Fowl River Watershed with Stream Gauge Locations**

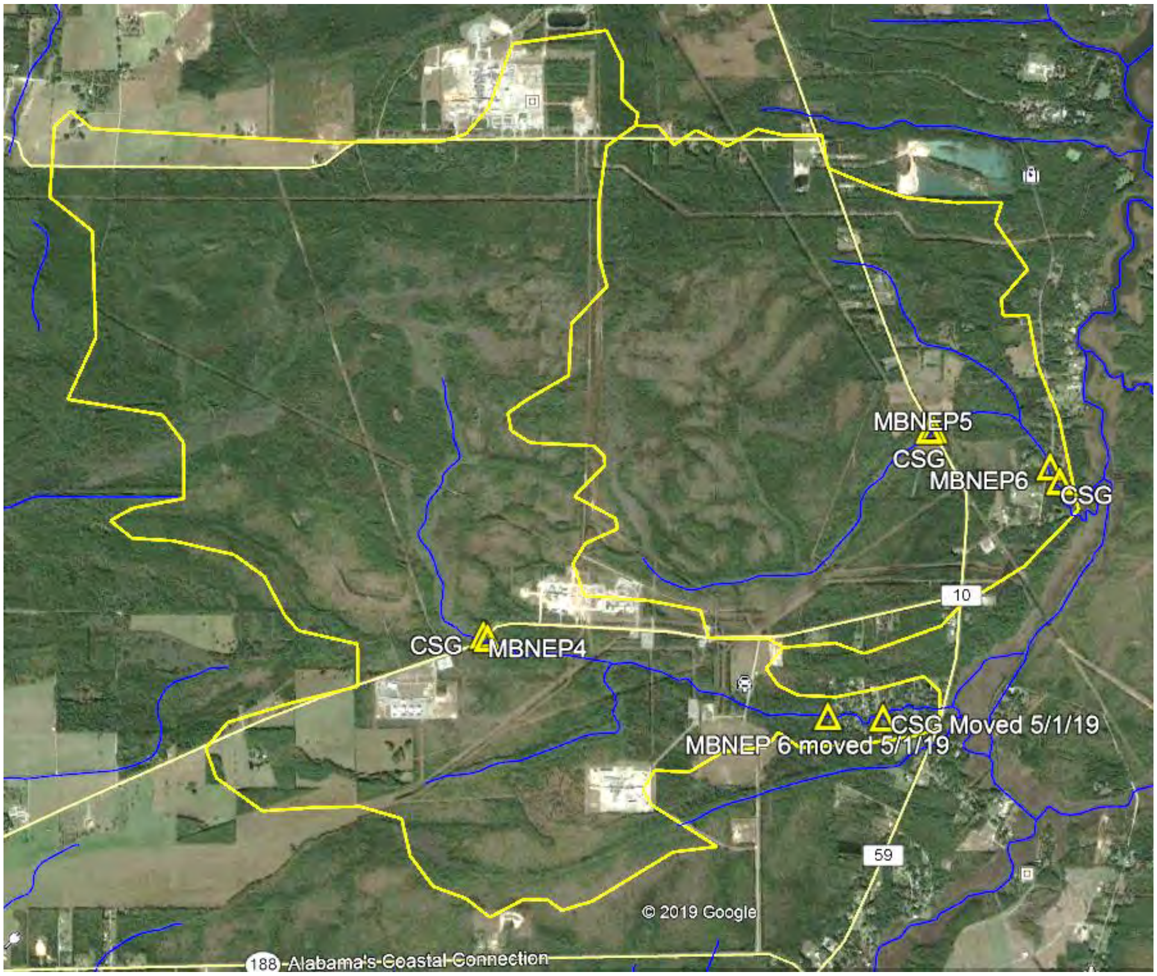


**Table 4-1**
**Stream Gauges and Locations**

| Gauge Name | Stream | Location |
|---|---|---|
| MBNEP 4 | Bayou Jonas | 65’ d.s of Rock Road CL |
| Cork Gage 4 | Bayou Jonas | 50’ u.s. of Rock Road CL |
| | | |
| MBNEP 5 | East Fowl River | 35’ d.s of Bellingrath Road CL |
| Cork Gage 5 | East Fowl River | 50’ u.s. of Bellingrath Road CL |
| | | |
| MBNEP 6 | East Fowl River | 30’ d.s of Rebel Road CL |
| Cork Gage 6 | East Fowl River | 410’ d.s. of Rebel Road CL |
| | | |
| MBNEP 6* | Bayou Jonas | 200’ from end of Bayou Shores Dr |
| Cork Gage 6* | Bayou Jonas | 1375’ d.s. of MBNEP 6 |

* Gage was relocated on 5/1/2019

During the June 2018 to June 2020 evaluation period, there were a couple of storm events that were possible candidates for calibration and validation. From the Telog RU-33 stream gauge data (Figures 4-2 to 4-4), it was determined that a fairly adequate storm event occurred on September 4-5, 2018 due to Tropical Storm Gordon. This event produced approximately 4.5”-5.5” of rain throughout the watershed in approximately 20 hours. Using NOAA Atlas 14 (Figure 4-5) for this rain depth and time period, it was determined that this rain event is equivalent to a 1-year storm. Typically calibrations are not performed using such low storm events as the model variables usually do not translate to larger flooding events (10+ yr). This event was used, however, in order to get an initial understanding of how the watershed reacts.

The second rainfall event that was analyzed was the July 13, 2019 event (Figures 4-2 to 4-4). This event produced on average approximately 3.8” of rain throughout the watershed in approximately 12 hours and 4.6” of rain in 16 hours. Using NOAA Atlas 14 (Figure 4-5) for this rain depth and time period, it was determined that this rain event is less than a 1-year storm event.

The third rainfall event that was analyzed was the August 26, 2019 event (Figures 4-2 to 4-4). This event produced approximately 4.5” of rain throughout the watershed in approximately 6 hours. Using NOAA Atlas 14 (Figure 4-5) for this rain depth and time period, it was determined that this rain event is equivalent to a 2-year storm.

The final rainfall event that was analyzed was the June 7, 2020 event (Figures 4-2 to 4-4). This event produced approximately 4.6” of rain in the northern half of the study area in approximately 12 hours. Using NOAA Atlas 14 (Figure 4-5) for this rain depth and time period, it was determined that this rain event is just above a 1-year storm. The remainder of the watershed experienced 2.9” of rain in the same time period. This equates to less than a 1-year storm event.

In order to compare discharges from the hydrologic model to the discharges in the field, it was necessary to build a hydraulic model of the stream in the location of the stream gauge. Information required for the hydraulic model includes a field surveyed cross-section at the location of the RU-33 gauge, Manning’s ‘n’ values for the channel and floodplain, discharges, and a stream slope. The stream slope was determined from the difference in elevation of the peak stage at the RU-33 gauge and at the crest stage gage divided by the distance between them. A range of discharges were entered into the hydraulic model along with the stream slope in order to develop a rating curve. This curve was plotted in Excel against the discharge output from the hydrologic model. If any additional model cross-sections were necessary for enhancing the hydraulic model, they were cut using the LiDAR data obtained from NOAA.

Calibration of the hydrologic model requires adjustment of the key parameters that affect infiltration, overland flow, and channel routing. The three main variables that are usually examined and adjusted include hydraulic conductivity, overland roughness, and channel roughness. These values were adjusted until the model output best fit the observed data. Other factors that can be considered are interception and retention.

**Figure 4-2**
**MBNEP 4 Gauge Height Readings – June 2018-June 2020**

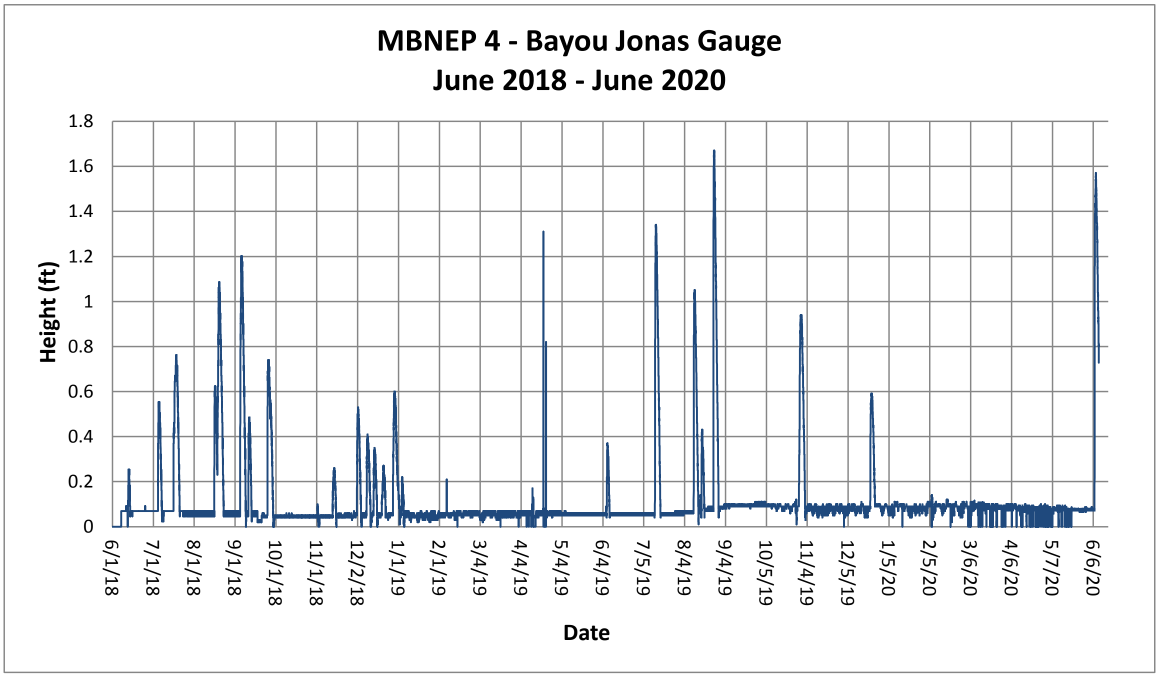



**Figure 4-3**
**MBNEP 5 Gauge Height Readings – June 2018-June 2020**

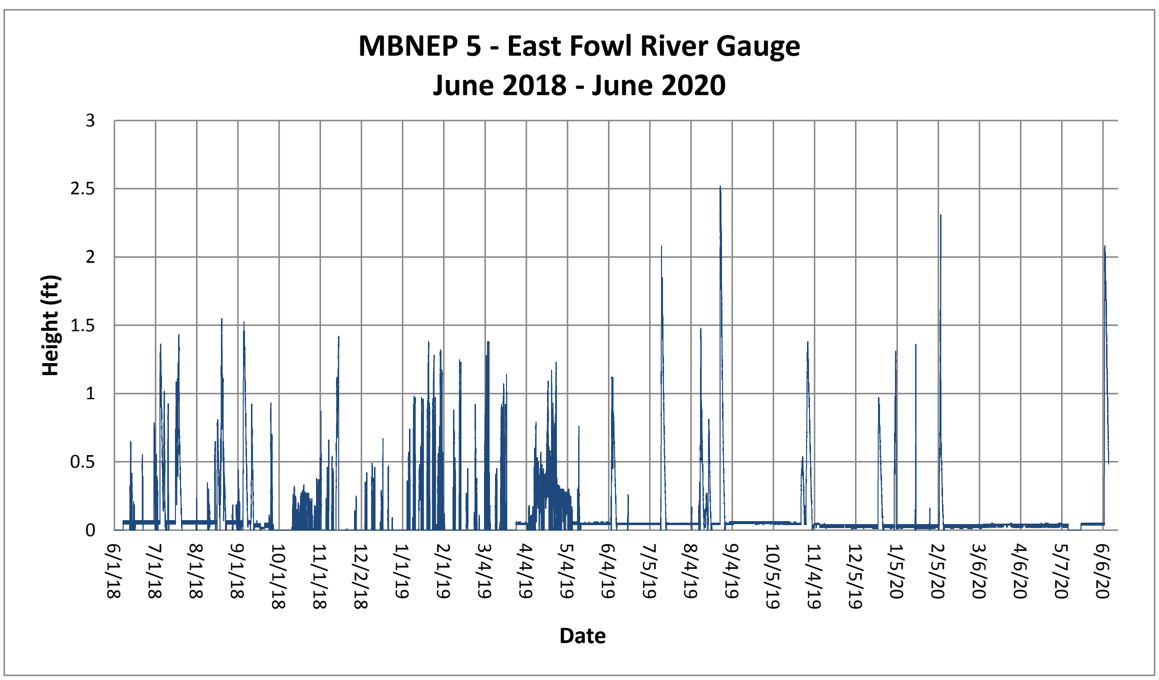


**Figure 4-4**
**MBNEP 6 Gauge Height Readings – June 2018-June 2020**

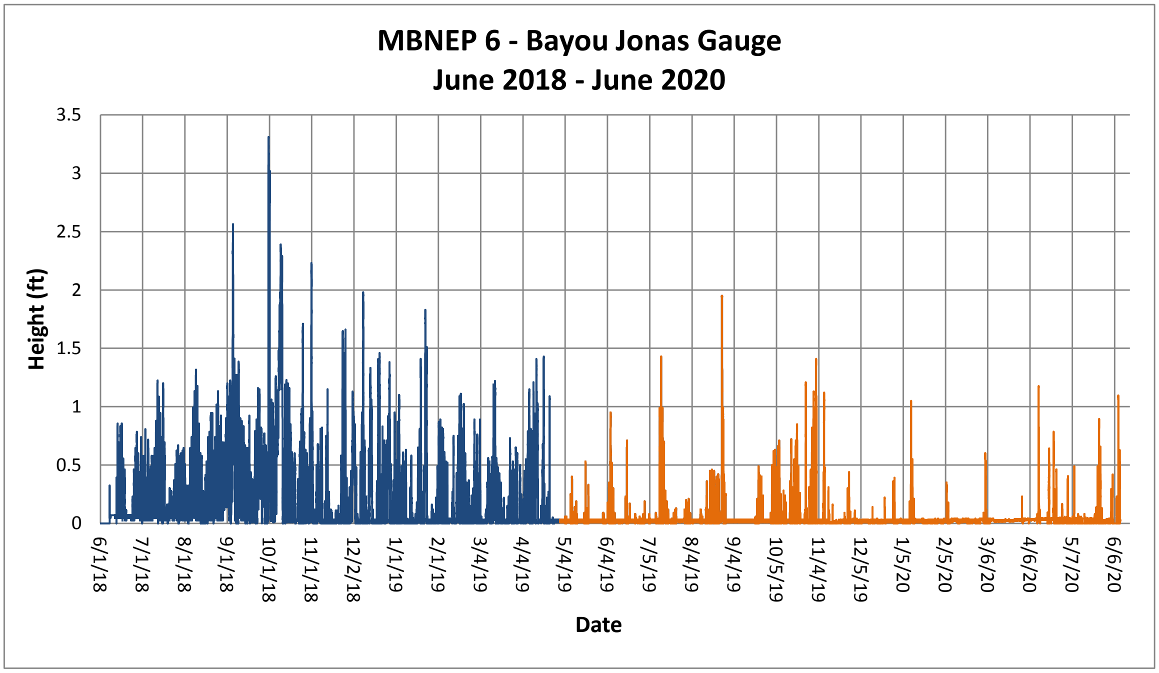


**Figure 4-5**
**Point Precipitation Frequency Estimates**

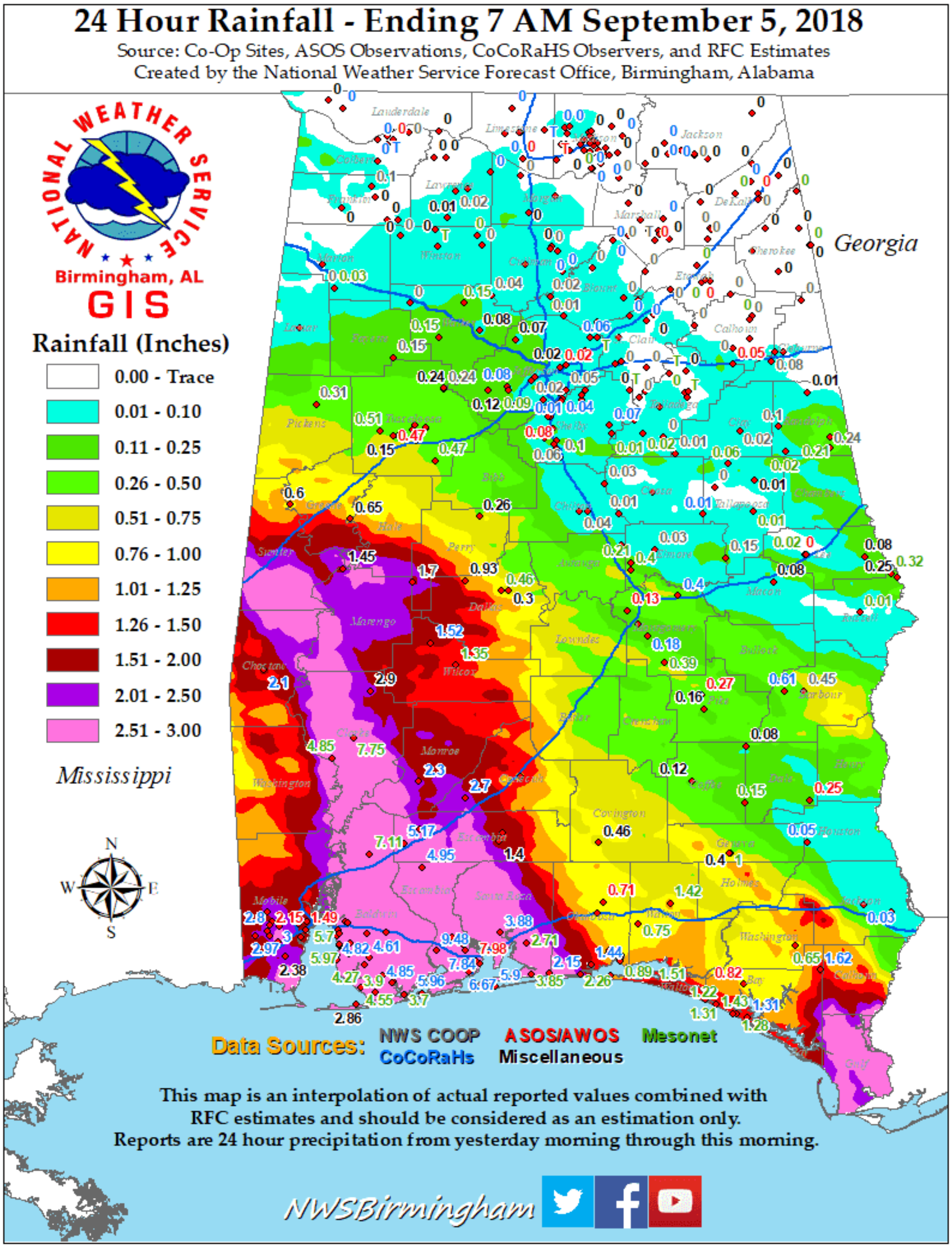
| PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Duration | Average recurrence interval (years) | | | | | | | | | |
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 500 | 1000 |
| 5-min | **0.611** (0.495-0.756) | **0.695** (0.563-0.861) | **0.834** (0.673-1.03) | **0.950** (0.762-1.18) | **1.11** (0.861-1.41) | **1.23** (0.936-1.59) | **1.36** (0.996-1.78) | **1.48** (1.05-1.99) | **1.65** (1.12-2.27) | **1.78** (1.18-2.48) |
| 10-min | **0.895** (0.725-1.11) | **1.02** (0.825-1.26) | **1.22** (0.986-1.52) | **1.39** (1.12-1.73) | **1.62** (1.26-2.07) | **1.81** (1.37-2.33) | **1.99** (1.46-2.61) | **2.17** (1.53-2.92) | **2.42** (1.64-3.32) | **2.61** (1.72-3.63) |
| 15-min | **1.09** (0.885-1.35) | **1.24** (1.01-1.54) | **1.49** (1.20-1.85) | **1.70** (1.36-2.11) | **1.98** (1.54-2.53) | **2.20** (1.67-2.84) | **2.42** (1.78-3.19) | **2.65** (1.87-3.56) | **2.95** (2.00-4.05) | **3.18** (2.10-4.42) |
| 30-min | **1.59** (1.29-1.97) | **1.83** (1.48-2.26) | **2.20** (1.78-2.74) | **2.52** (2.02-3.14) | **2.95** (2.29-3.76) | **3.29** (2.49-4.23) | **3.62** (2.66-4.76) | **3.96** (2.79-5.31) | **4.41** (2.99-6.05) | **4.74** (3.14-6.61) |
| 60-min | **2.15** (1.74-2.66) | **2.45** (1.98-3.03) | **2.96** (2.39-3.67) | **3.39** (2.72-4.22) | **4.00** (3.12-5.13) | **4.49** (3.42-5.81) | **4.99** (3.67-6.58) | **5.52** (3.89-7.43) | **6.23** (4.23-8.57) | **6.78** (4.48-9.44) |
| 2-hr | **2.70** (2.20-3.32) | **3.07** (2.50-3.78) | **3.71** (3.01-4.57) | **4.26** (3.44-5.27) | **5.06** (3.97-6.45) | **5.70** (4.37-7.34) | **6.37** (4.72-8.36) | **7.07** (5.03-9.48) | **8.05** (5.50-11.0) | **8.81** (5.86-12.2) |
| 3-hr | **3.07** (2.51-3.76) | **3.49** (2.85-4.27) | **4.22** (3.43-5.18) | **4.87** (3.94-6.00) | **5.83** (4.60-7.43) | **6.63** (5.10-8.52) | **7.47** (5.56-9.79) | **8.37** (5.98-11.2) | **9.63** (6.62-13.2) | **10.6** (7.11-14.7) |
| 6-hr | **3.71** (3.05-4.51) | **4.24** (3.48-5.16) | **5.20** (4.26-6.34) | **6.08** (4.95-7.44) | **7.42** (5.91-9.44) | **8.55** (6.63-11.0) | **9.76** (7.32-12.8) | **11.1** (7.99-14.8) | **13.0** (8.99-17.7) | **14.5** (9.75-19.9) |
| 12-hr | **4.36** (3.60-5.26) | **5.06** (4.18-6.11) | **6.34** (5.22-7.68) | **7.53** (6.16-9.15) | **9.35** (7.51-11.9) | **10.9** (8.52-13.9) | **12.6** (9.51-16.4) | **14.4** (10.5-19.2) | **17.1** (11.9-23.1) | **19.2** (13.0-26.1) |
| 24-hr | **5.04** (4.19-6.05) | **5.93** (4.93-7.12) | **7.56** (6.26-9.09) | **9.08** (7.47-11.0) | **11.4** (9.21-14.4) | **13.4** (10.5-17.0) | **15.5** (11.8-20.1) | **17.9** (13.1-23.6) | **21.3** (14.9-28.7) | **24.0** (16.4-32.5) |
| 2-day | **5.81** (4.85-6.92) | **6.84** (5.71-8.15) | **8.74** (7.27-10.4) | **10.5** (8.70-12.6) | **13.2** (10.7-16.6) | **15.5** (12.3-19.6) | **18.0** (13.8-23.2) | **20.8** (15.3-27.3) | **24.7** (17.5-33.1) | **28.0** (19.2-37.5) |
| 3-day | **6.32** (5.30-7.49) | **7.38** (6.18-8.76) | **9.34** (7.80-11.1) | **11.2** (9.29-13.3) | **14.0** (11.4-17.5) | **16.4** (13.1-20.7) | **19.1** (14.7-24.4) | **22.0** (16.2-28.7) | **26.1** (18.6-34.9) | **29.6** (20.3-39.5) |
| 4-day | **6.74** (5.67-7.98) | **7.81** (6.56-9.24) | **9.79** (8.19-11.6) | **11.6** (9.69-13.9) | **14.5** (11.9-18.1) | **17.0** (13.5-21.3) | **19.7** (15.2-25.1) | **22.6** (16.8-29.5) | **26.9** (19.2-35.8) | **30.4** (21.0-40.5) |

* This chart was generated from the lat/long point of 30.3963, -88.1619

Source: https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=al

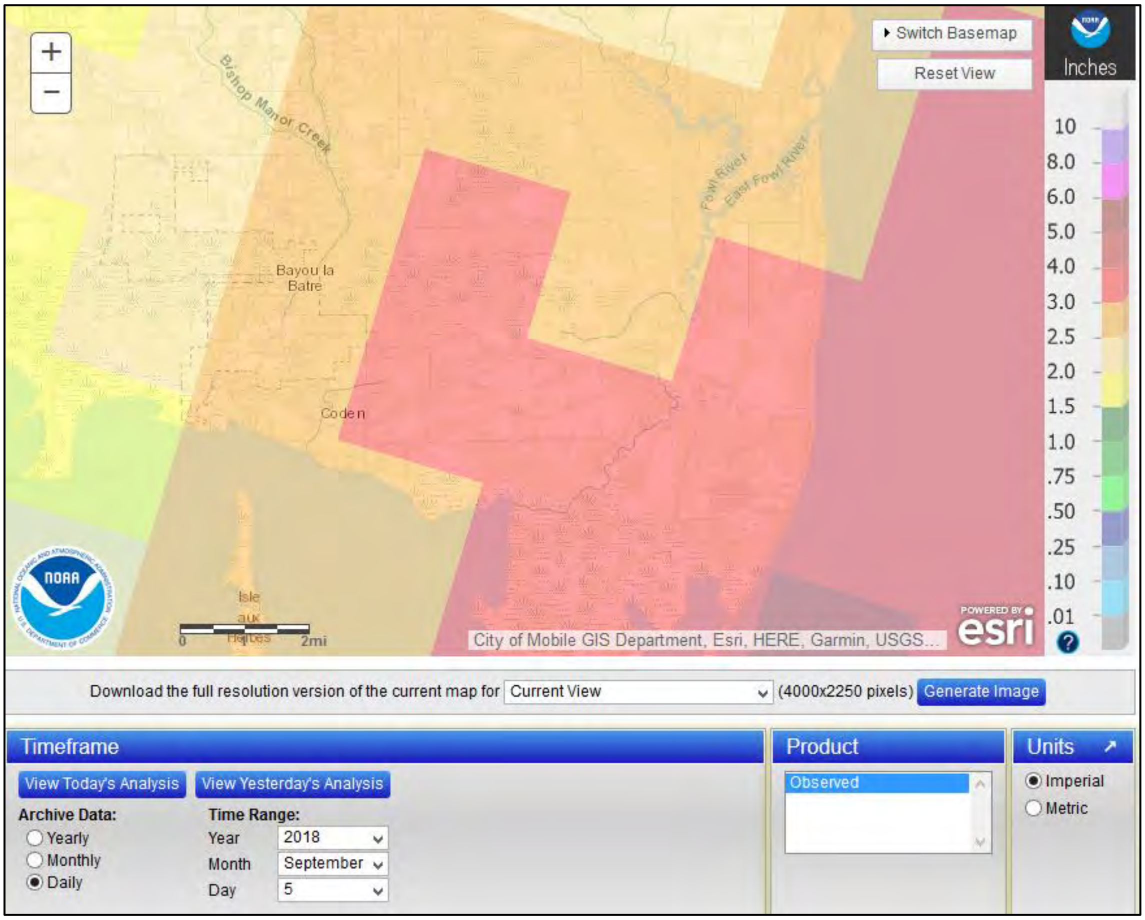
Figures 4-6 and 4-7 indicate the total rainfall maps for the September 4, 2018 rain event generated by the Birmingham NWS Forecast Office and the NWS Advanced Hydrologic Prediction Service. Figures 4-8, 4-9, and 4-10 indicate total rainfall distribution and the calibrated model output.

**Figure 4-6**
**Sept 4-5, 2018 – Total Rainfall Map**




Source: https://www.weather.gov/bmx/rainfallplots

**Figure 4-7**
**Sept 4-5, 2018 – AHPS Total Rainfall Map**




Source: https://water.weather.gov/precip/

**Figure 4-8**
**Sept 4-5, 2018 – Total Rainfall Distribution**

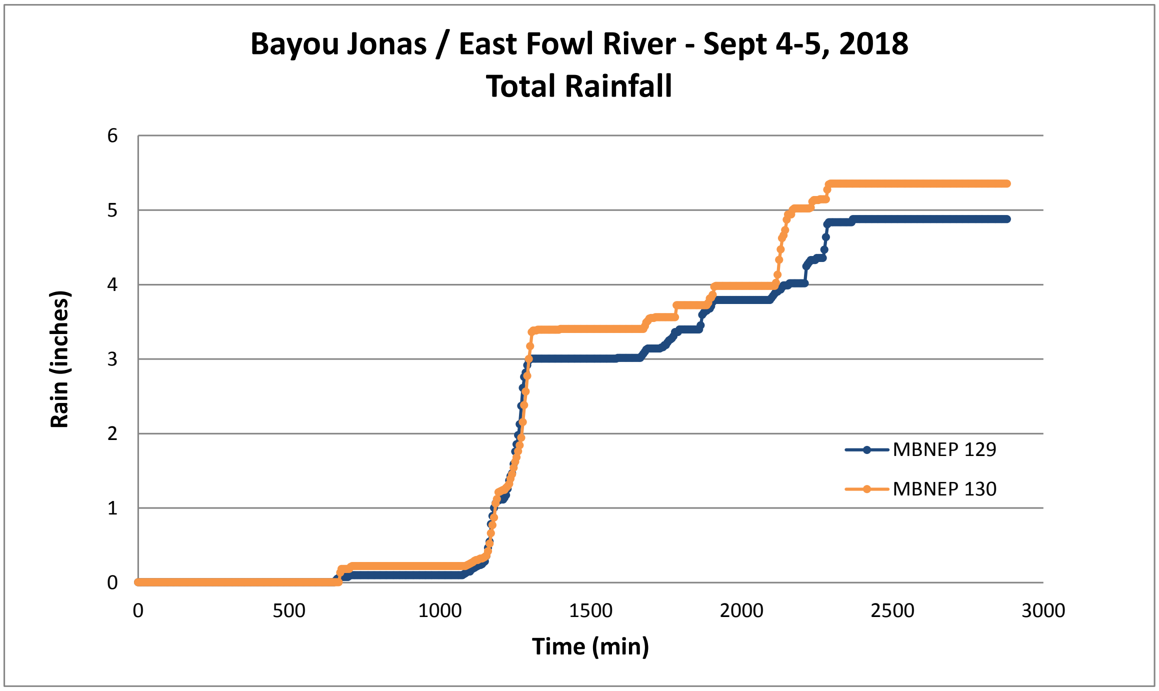



**Figure 4-9**
**Sept 4-5, 2018 – Bayou Jonas Calibration**

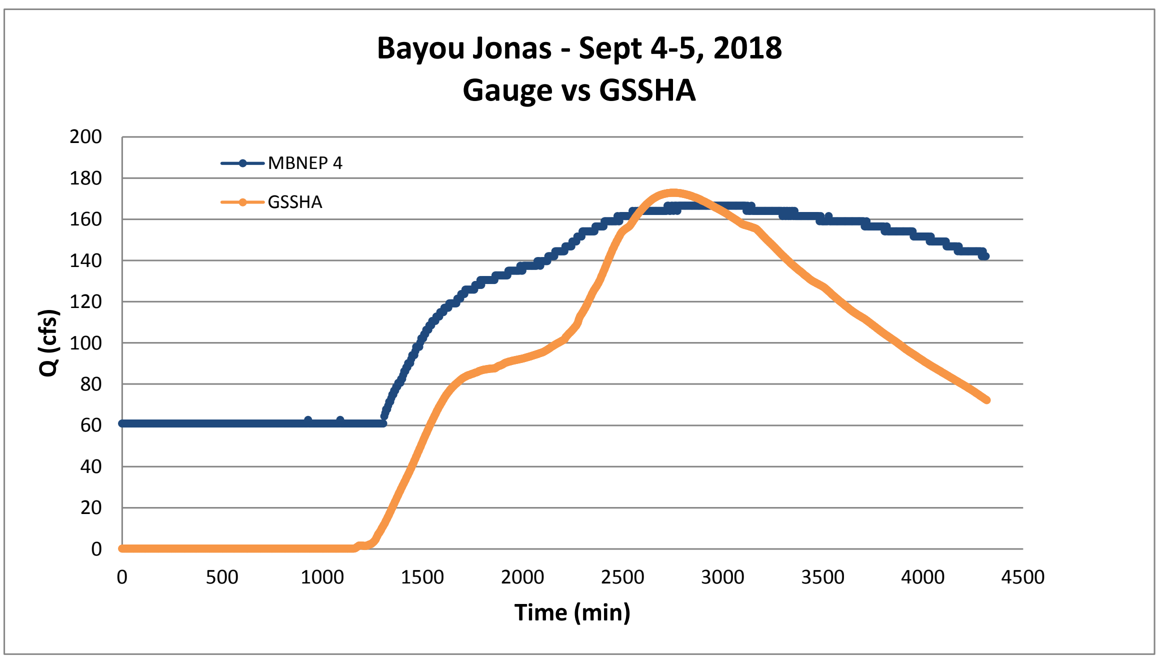
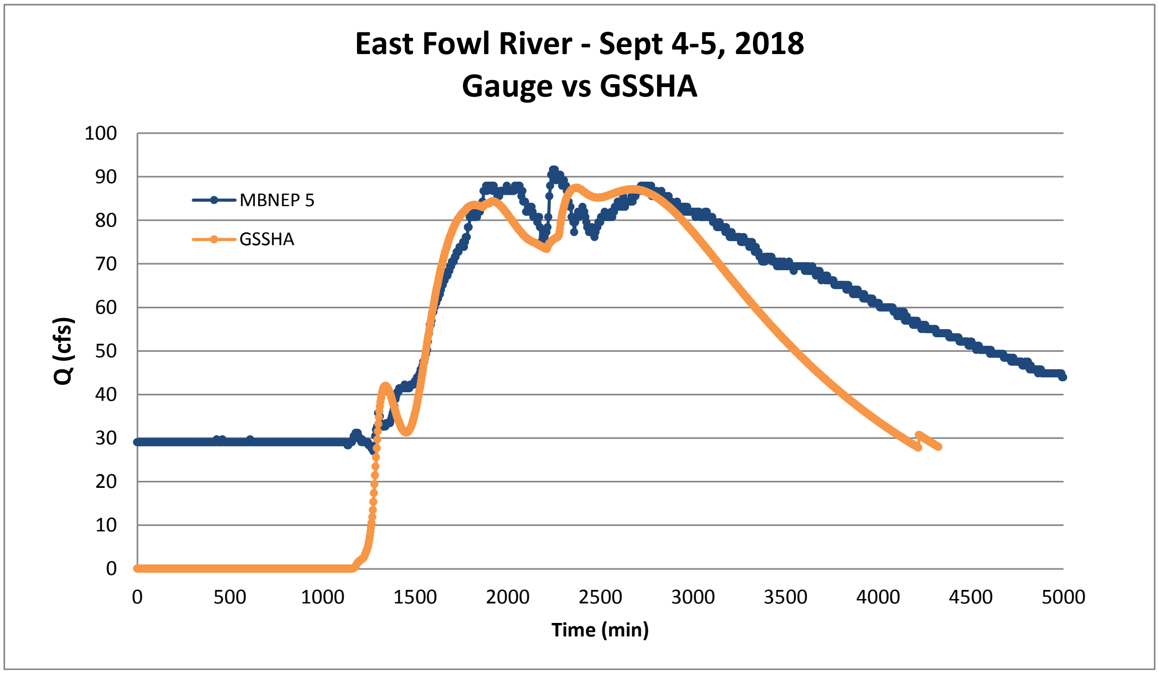


**Figure 4-10**
**Sept 4-5, 2018 – East Fowl River Calibration**




Figures 4-11 and 4-12 indicate the total rainfall maps for the July 13, 2019 rain event generated by the Birmingham NWS Forecast Office and the NWS Advanced Hydrologic Prediction Service. Figures 4-13, 4-14, and 4-15 indicate total rainfall distribution and the calibrated model output.

**Figure 4-11**
**July 13-14, 2019 – Total Rainfall Map**

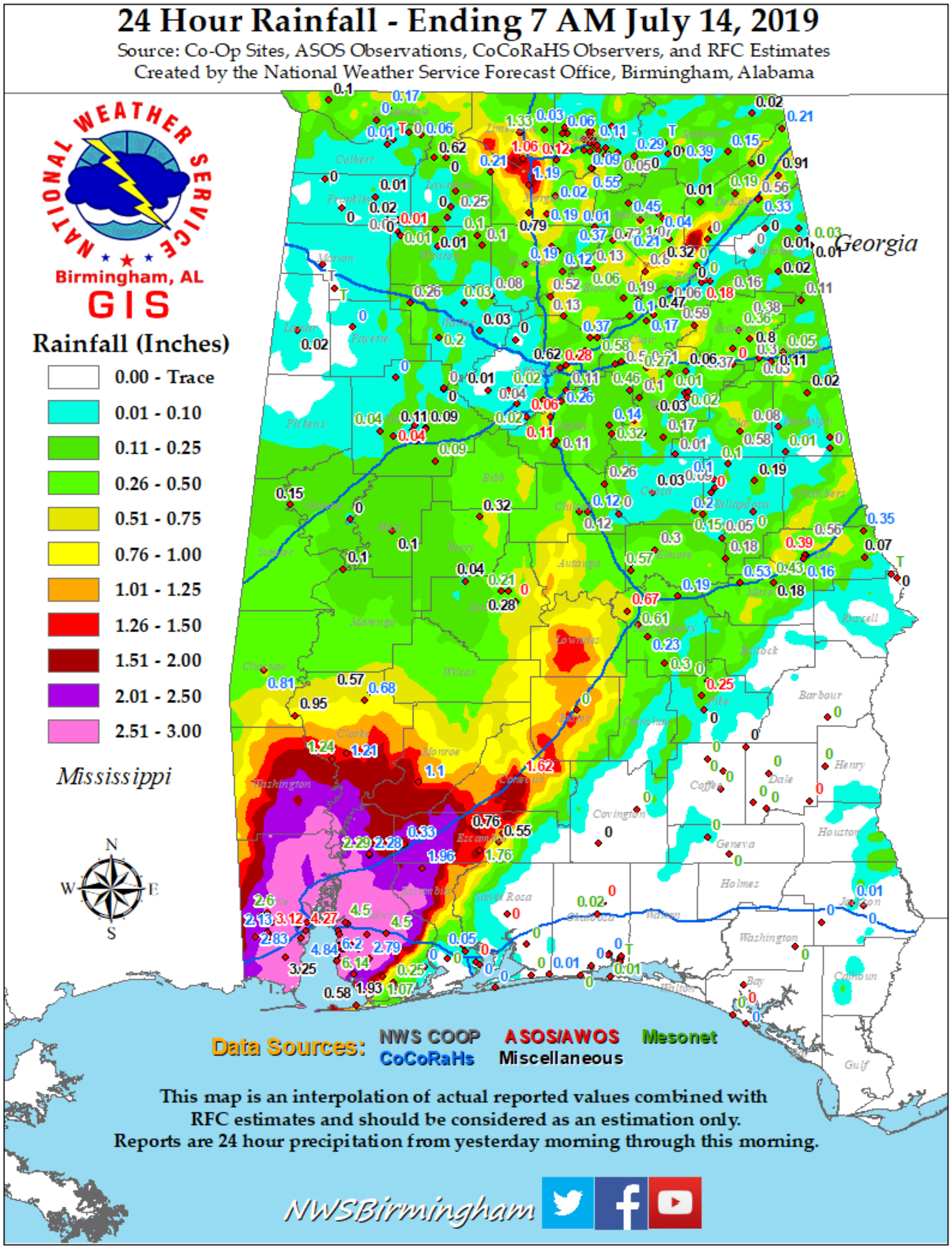


**Figure 4-12**
**July 13-14, 2019 – AHPS Total Rainfall Map**

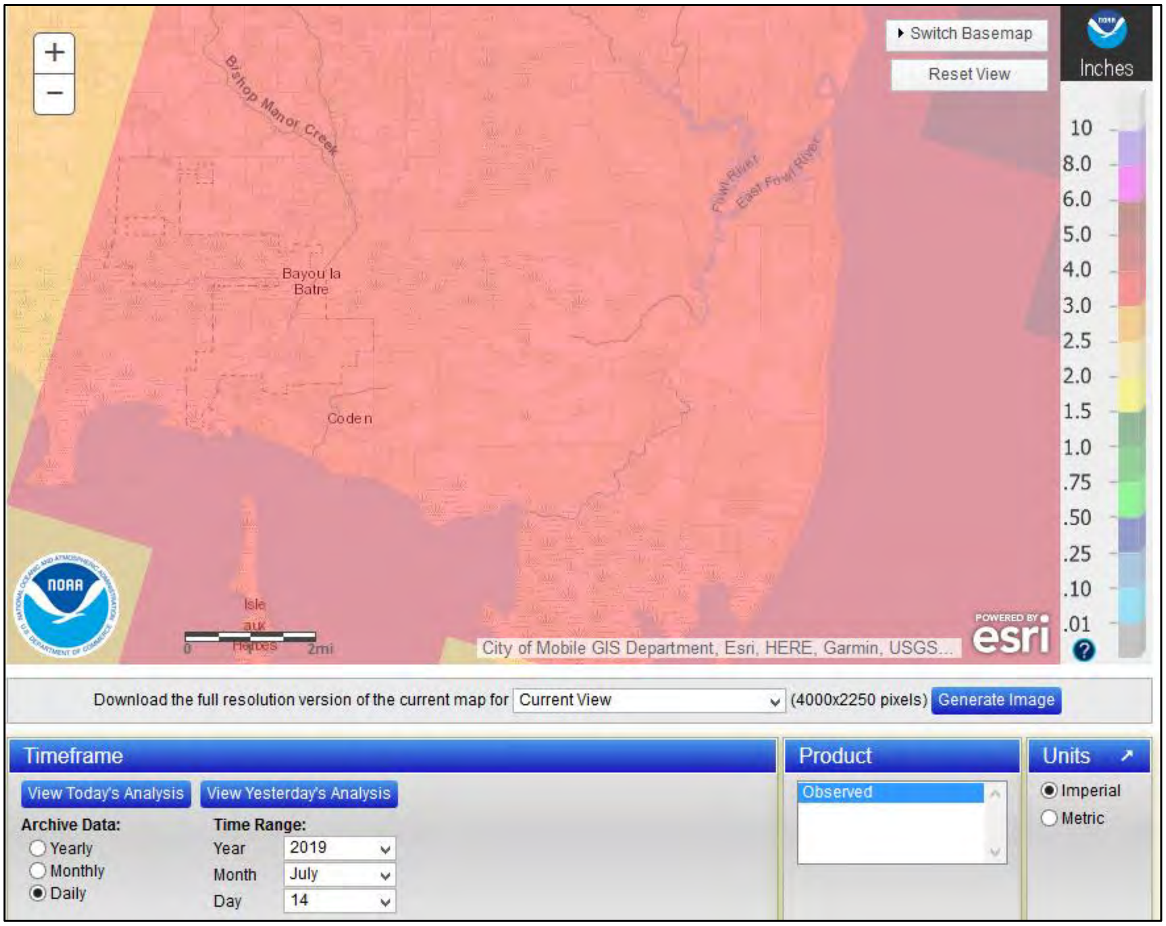


**Figure 4-13**
**July 13, 2019 – Total Rainfall Distribution**

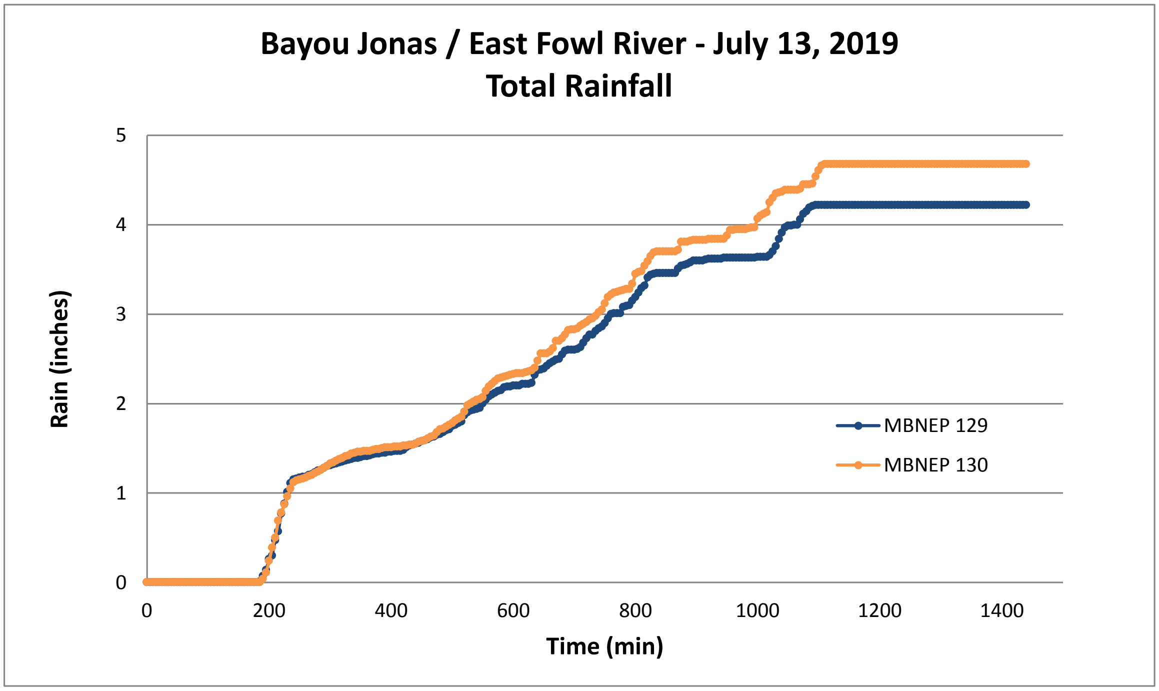



**Figure 4-14**
**July 13-14, 2019 – Bayou Jonas Calibration**

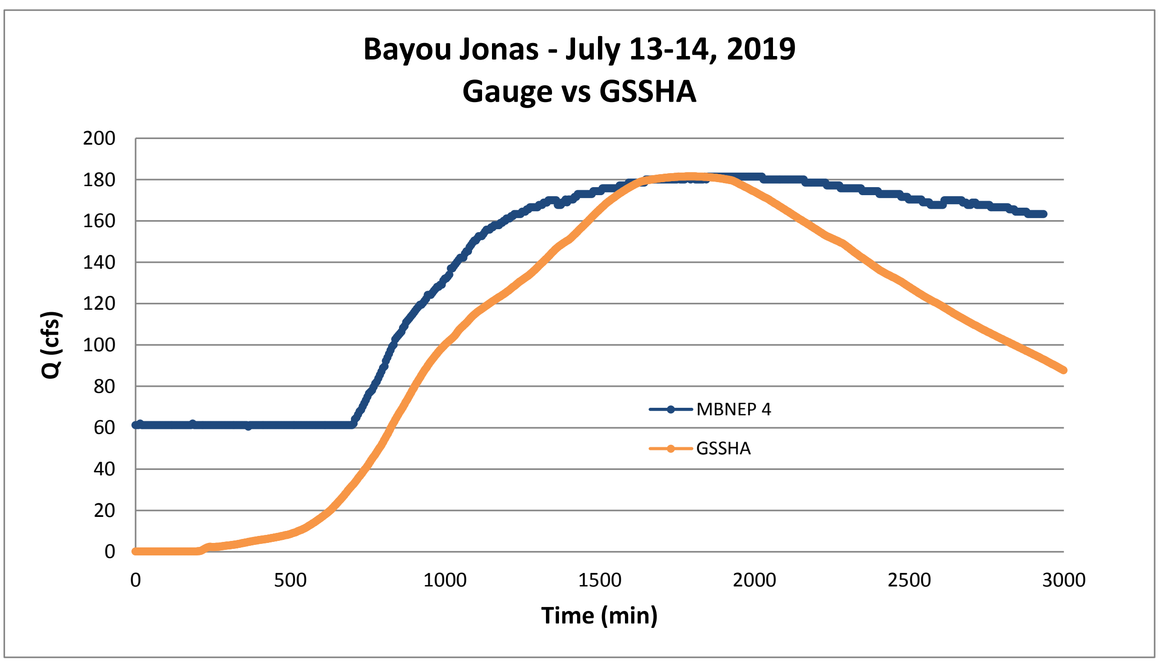
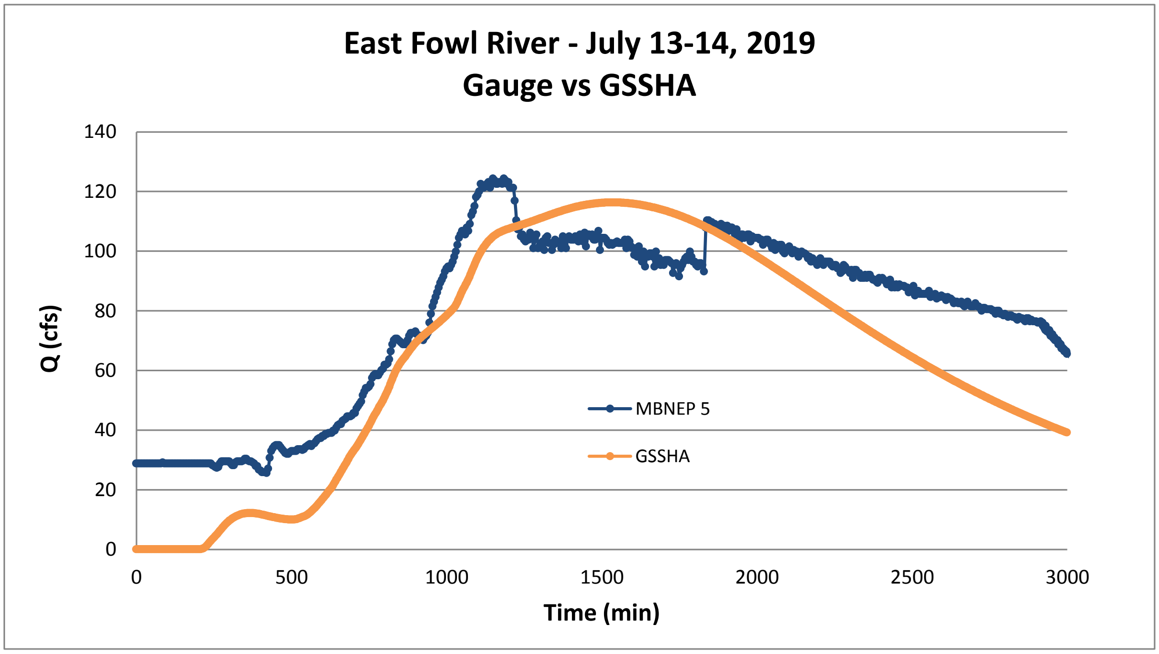


**Figure 4-15**
**July 13-14, 2019 – East Fowl River Calibration**




Figures 4-16 and 4-17 indicate the total rainfall maps for the August 26, 2019 rain event generated by the Birmingham NWS Forecast Office and the NWS Advanced Hydrologic Prediction Service. Figures 4-18, 4-19, 4-20, and 4-21 indicate total rainfall distribution and the calibrated model output.

**Figure 4-16**
**August 26-27, 2019 – Total Rainfall Map**

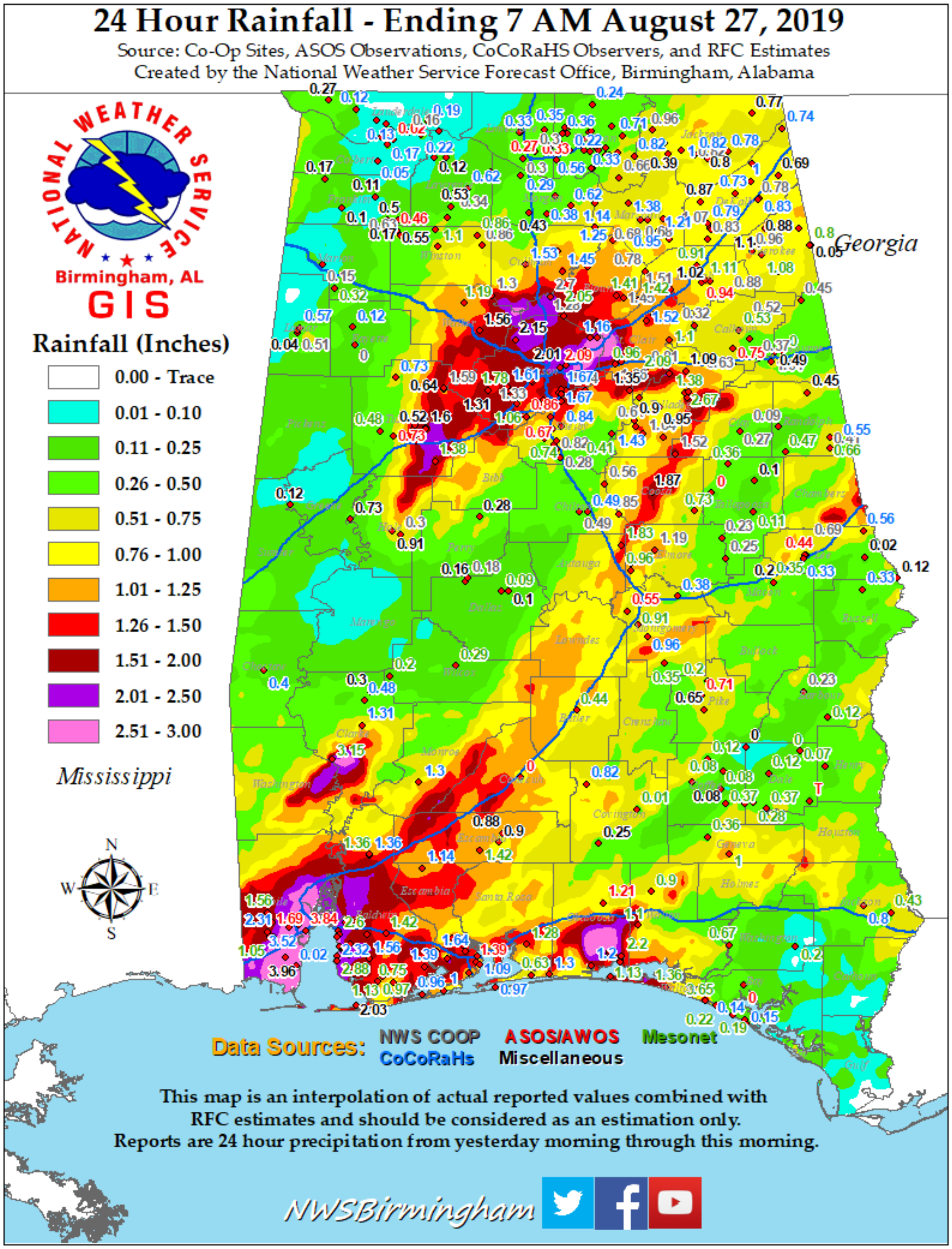


**Figure 4-17**
**August 26-27, 2019 – AHPS Total Rainfall Map**

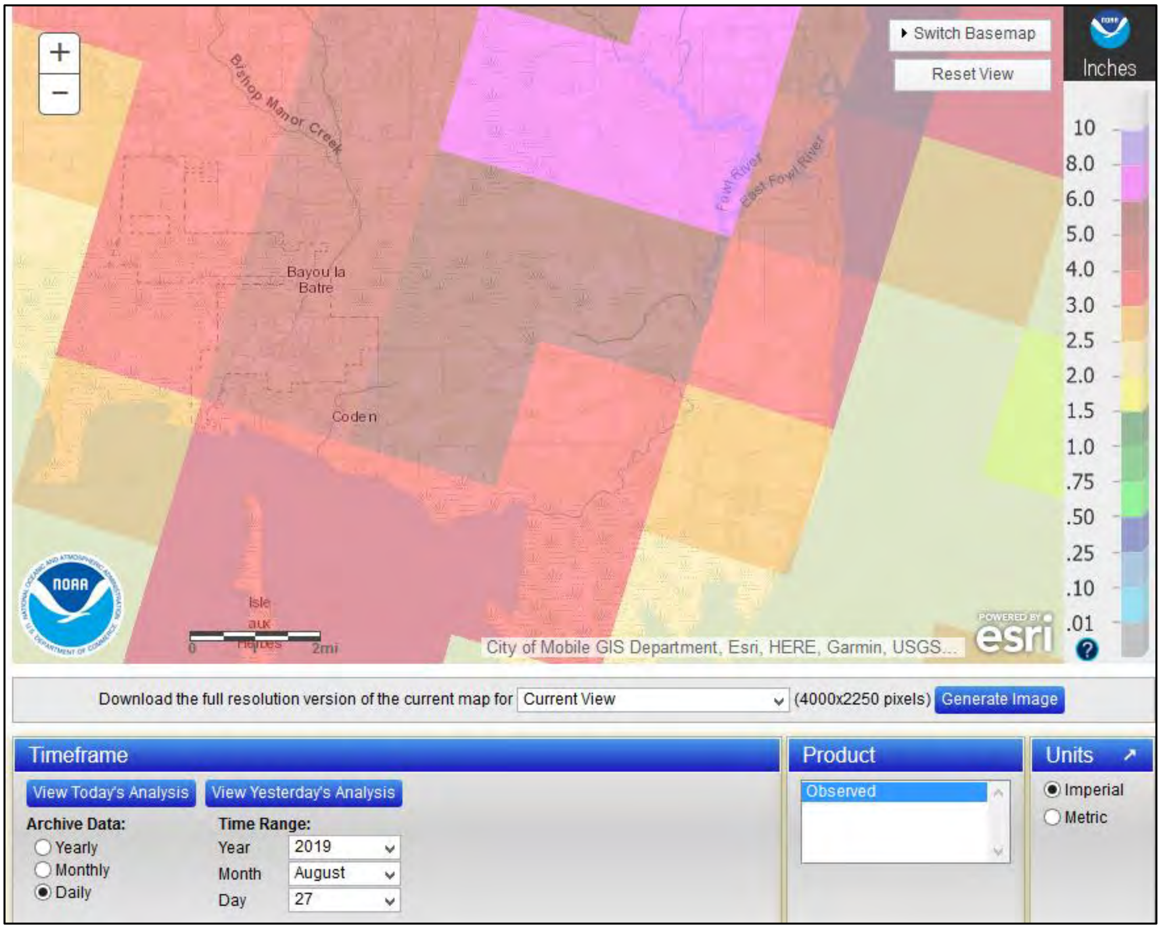


**Figure 4-18**
**August 26, 2019 – Total Rainfall Distribution**

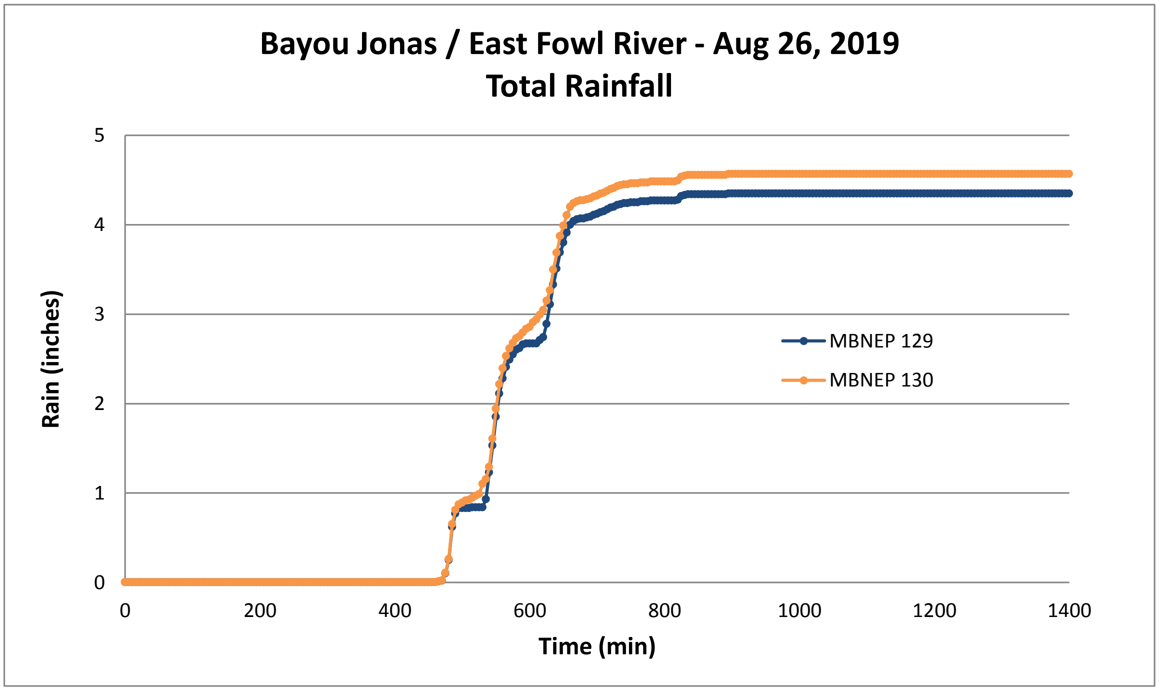



**Figure 4-19**
**August 26-27, 2019 – East Fowl River Calibration**

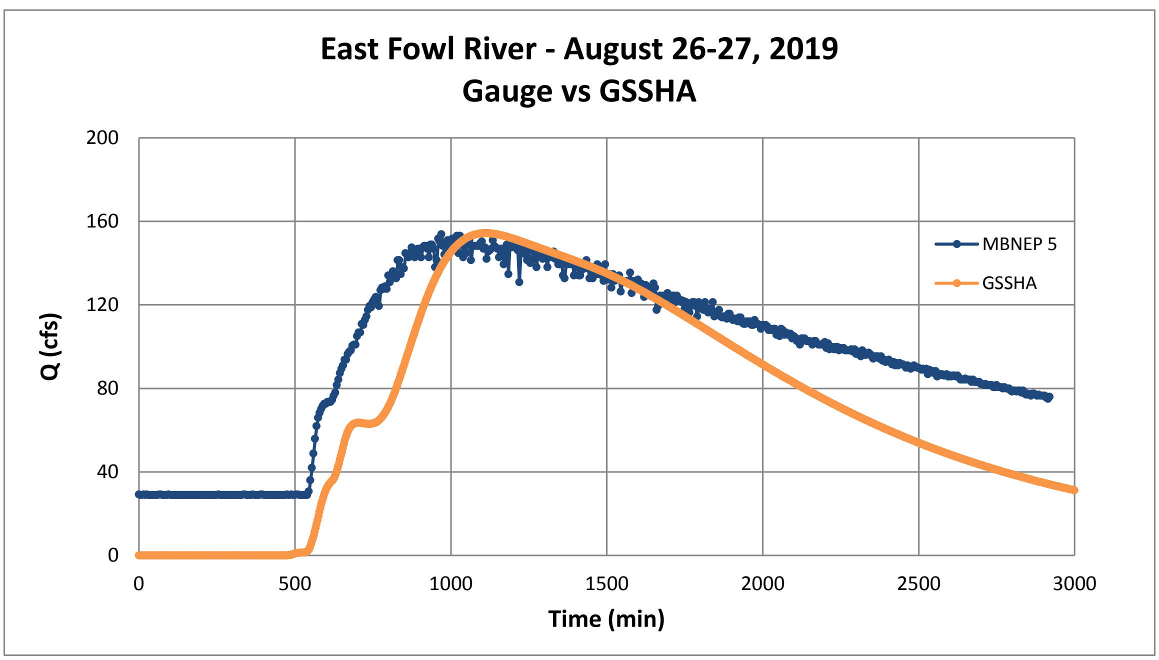


**Figure 4-20**
**August 26-27, 2019 – Bayou Jonas G4 River Calibration**

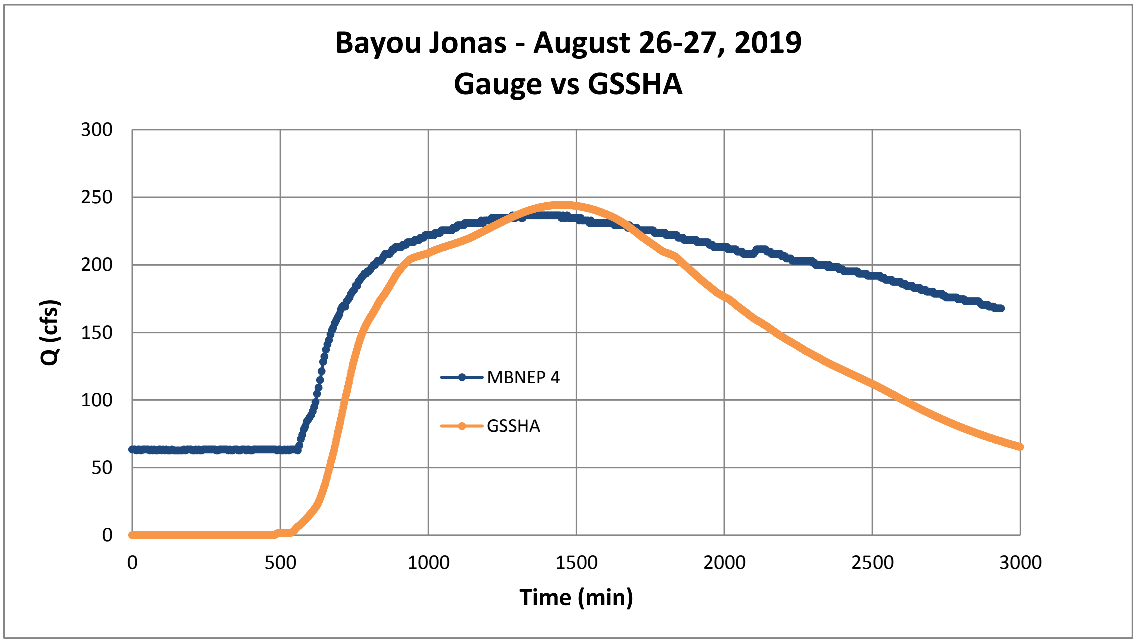
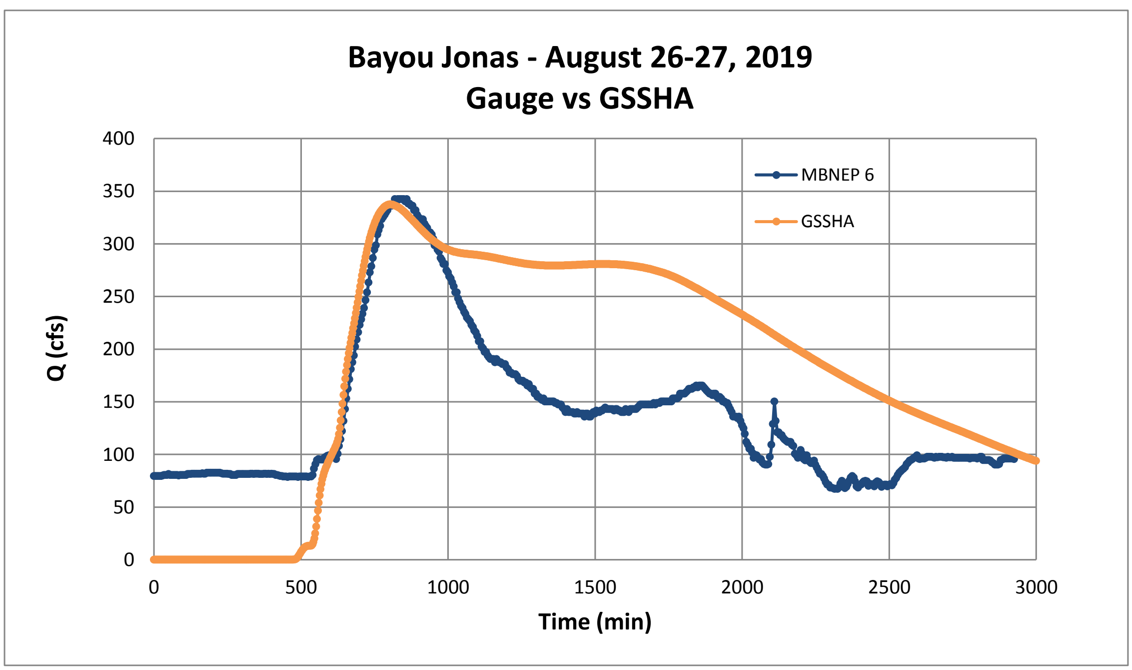



**Figure 4-21**
**August 26-27, 2019 – Bayou Jonas G6 Calibration**



Figures 4-22 and 4-23 indicate the total rainfall maps for the June 7, 2020 rain event generated by the Birmingham NWS Forecast Office and the NWS Advanced Hydrologic Prediction Service. Figures 4-24, 4-25, 4-26, and 4-27 indicate total rainfall distribution and the calibrated model output.

**Figure 4-22**
**June 7-8, 2020 – Total Rainfall Map**

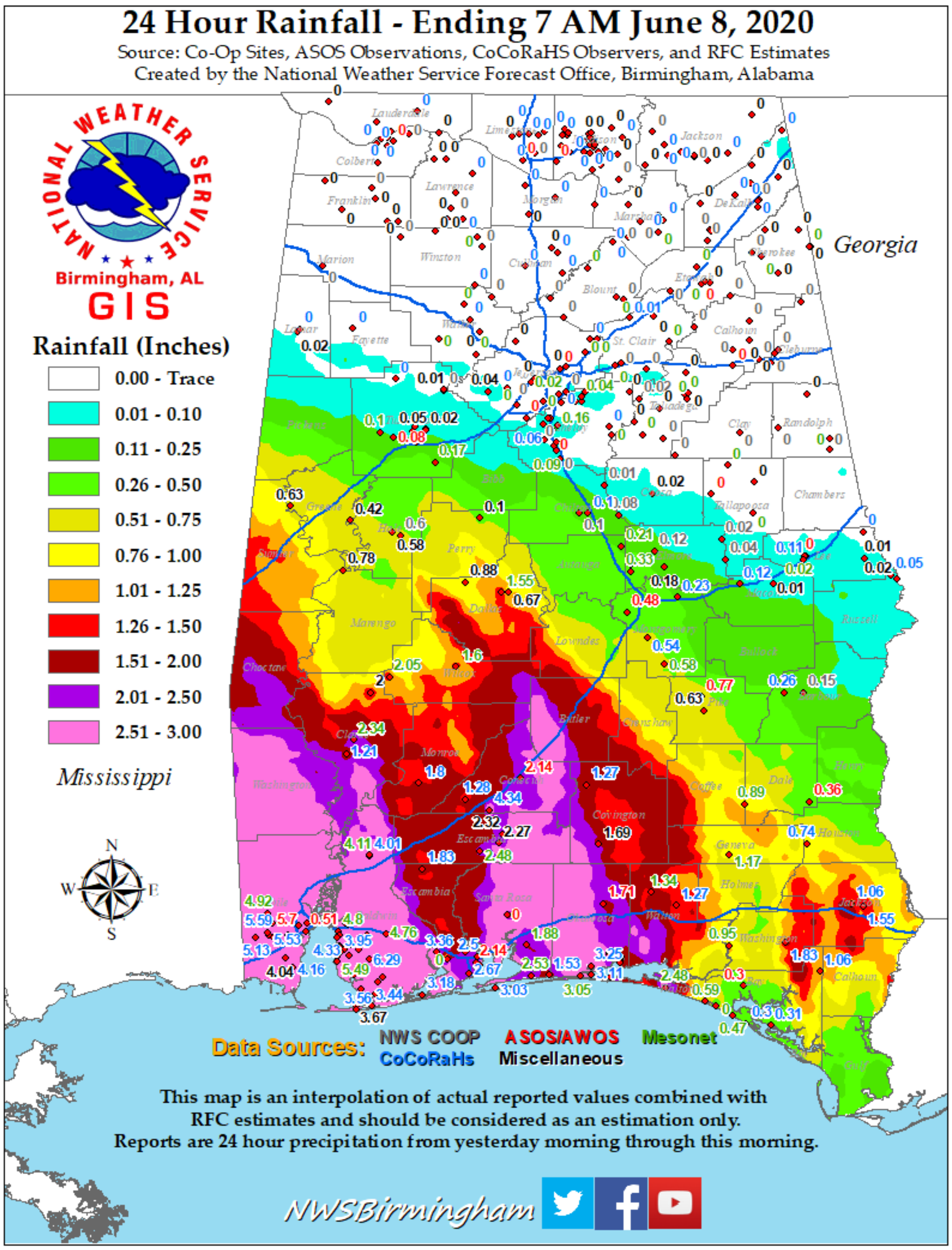


**Figure 4-23**
**June 7-8, 2020 – AHPS Total Rainfall Map**

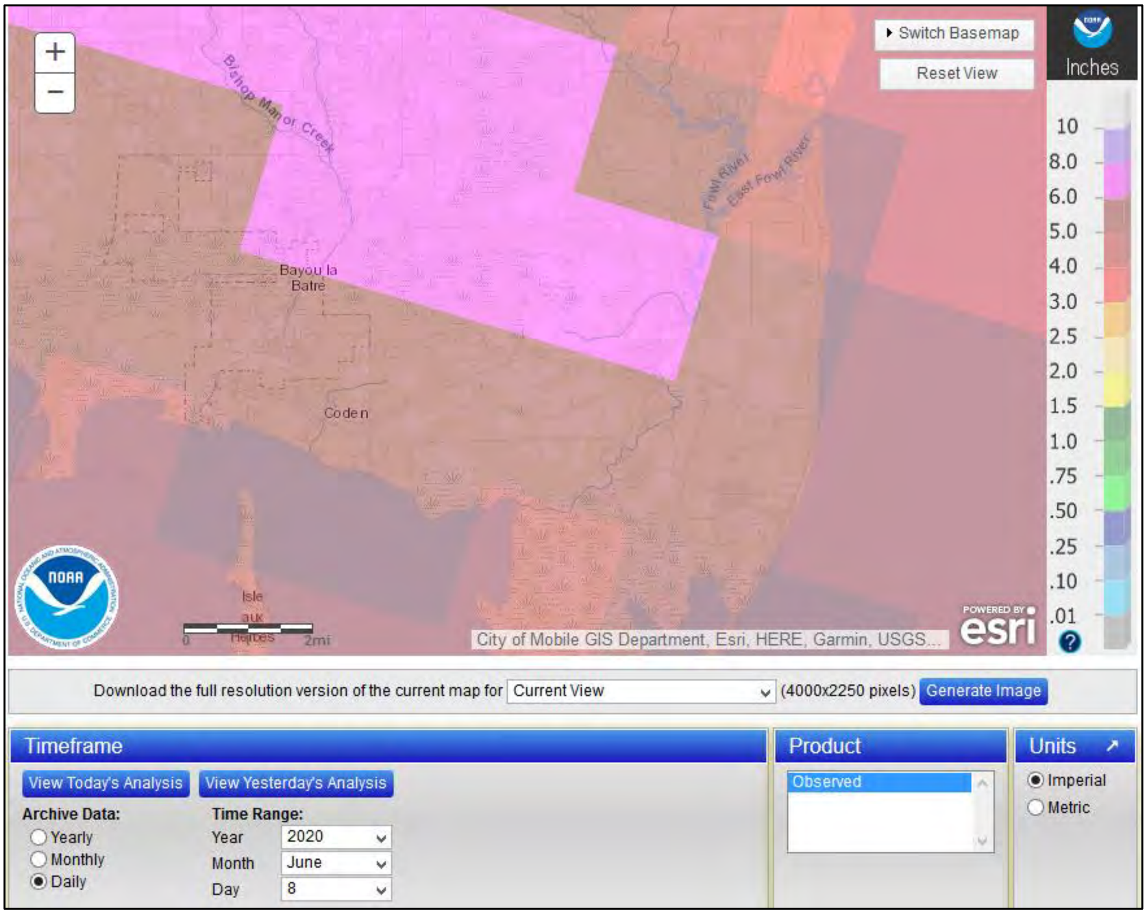


**Figure 4-24**
**June 7-8, 2020 – Total Rainfall Distribution**

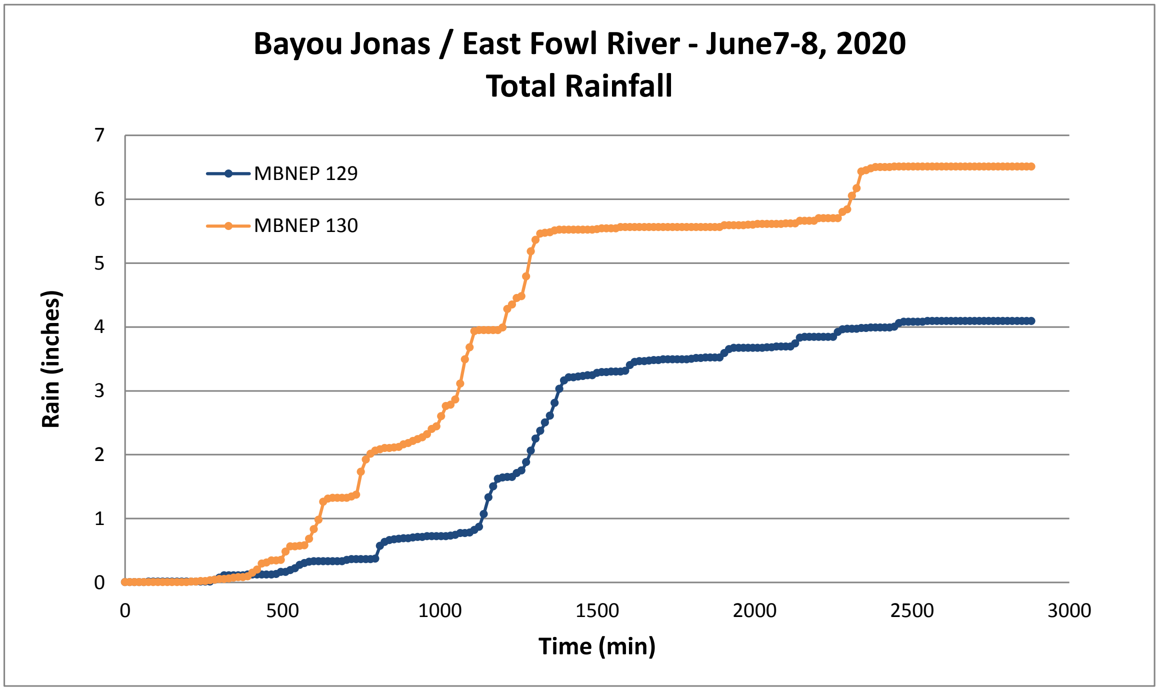



**Figure 4-25**
**June 7-8, 2020 – East Fowl River Calibration**

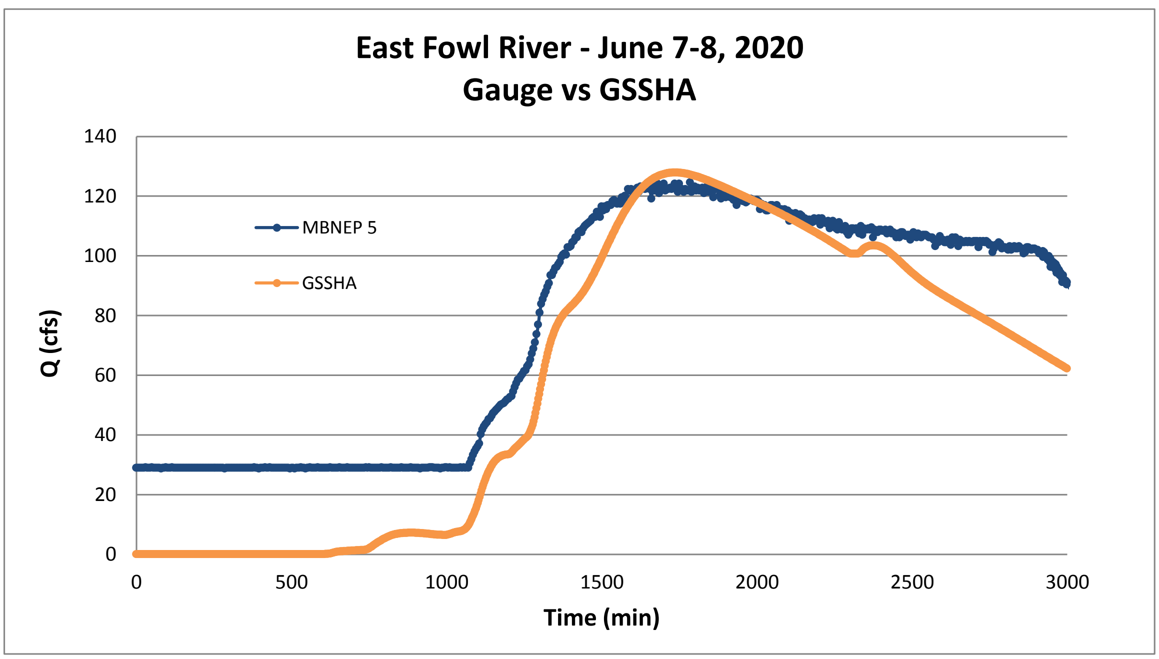
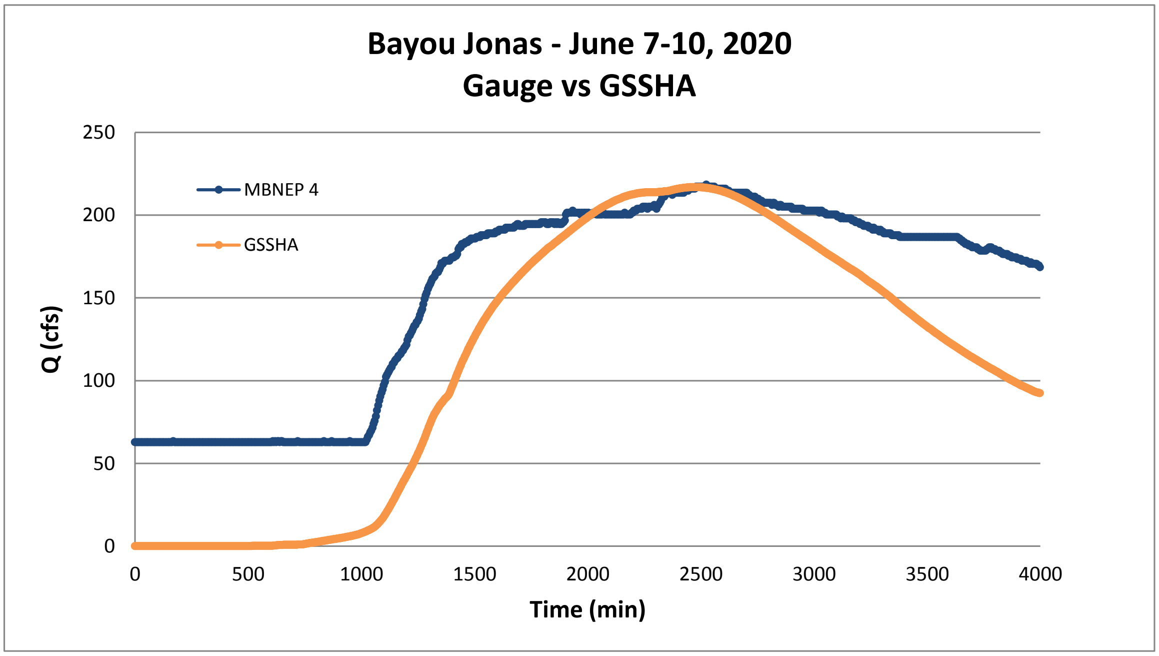


**Figure 4-26**
**June 7-10, 2020 – Bayou Jonas G4 River Calibration**



# 5. Results and Conclusions

## 5.1. Results

During the evaluation period between the middle of June 2018 and June 2020 the West Fowl River watershed experienced multiple small rain storms. These rain storms typically produced less than 2 or 3 inches per event. Using the stream gauge plots found in Figures 4-2, 4-3, and 4-4, the largest events were chosen for model calibration. During this study, the largest event occurred on August 26, 2019. This rainfall event produced approximately 4.6 inches of rain in 6 hours. Using Figure 4-5, it was determined that this is greater than a 2-year recurrence interval. Comparing the calibrated discharges to the discharges determined from the small stream rural regression equations, it can be seen that even though the watersheds experienced an event greater than a 2-year, the discharges are more in line with a 1-year storm for a rural basin.

On September 4, 2018 the watershed experienced 3.1” of rain in 3 hours. Using Figure 4-5, it can be determined that this is equivalent to a 1-year storm. The measured discharges have been determined to be less than that of a 1-year storm. On July 13, 2019 the watershed experienced approximately 3.8” in 12 hours and 4.6” in 16 hours. This equates to a storm event less than a 1-year recurrence interval. The measured discharges for this event are also less than that of a 1-year storm. On June 7, 2020 the northern half of the watersheds experienced approximately 4.6” in 12 hours which equates to a storm event just over a 1-year recurrence interval. The measured discharges for this event have also been determined to be less than that of a 1-year storm for a rural basin.

## 5.2. Conclusions

After analysis of the discharges and rainfall events that occurred between June 2018 and June 2020, it has been determined that 1-year or 2-year rainfall events produce discharges less than that of their equivalent rural discharge recurrence interval. Some of the factors that impact the discharges include the absence of development and the very flat topography. The majority of the watershed is covered with evergreen forest and woody wetlands. This contributes to interception of the rainfall as well as reducing travel time of the overland runoff. The flat topography creates many opportunities for storage which hold and attenuate the flow. While this is the case for the smaller rainfall events, it is uncertain what the extent of the storage routing will be during larger flooding events.

For smaller rain events (< 2-year), the currently calibrated GSSHA model can be used as a management tool for determining bank forming discharges throughout the watershed. Future restoration projects may be able to utilize these discharges for bankfull analysis. For larger discharge events, the model will need to be reevaluated to determine if further calibration is required. This is due to the uncertainty of the amount of impact the storage within the watershed will have on the timing and peak discharges during a large flood event.

# 6. References

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