Update and Calibration of the Hydrologic Engineering Center River Analysis System (HEC-RAS) Model

Econfina Creek System

Draft

Northwest Florida Water Management District
80 Water Management Drive
Havana, Florida 32333
(850) 539-5999
www.nwfwater.com

January 2025

NORTHWEST FLORIDA WATER MANAGEMENT DISTRICT

DISTRICT OFFICES
Havana (Headquarters)
DeFuniak Springs
Youngstown
Milton

For Additional Information, write or call:
Northwest Florida Water Management District
81 Water Management Drive
Havana, Florida 32333
850-539-5999
www.nwfwater.com

Table of Contents

List of Figures

List of Tables

List of Acronyms

ATM	Applied Technology and Management, Inc.
XS	Cross Section or Transect
cfs	Cubic Feet per Second
CR	County Road
DEM	Digital elevation model
ET	Evapotranspiration
FEMA	Federal Emergency Management Agency
ft.	Feet
GIS	Geographic Information System
HEC-RAS	Hydrologic Engineering Center River Analysis System
LiDAR	Light Detection and Ranging
MSE	Mean Square Error
MFL	Minimum Flow and Level
NAVD	North American Vertical Datum
NGVD	National Geodetic Vertical Datum
NWFID	Northwest Florida Identification Number
NWFWMD (District)	Northwest Florida Water Management District
P or PF	Percentile Flow
RS	River Station
SR	State Road
USF	University of South Florida
USGS	United States Geological Survey
WRV	Water Resource Value
WS	Water Surface Elevation

Acknowledgements

The authors would like to recognize Bob Burleson (Geosyntec Consultants, Inc.) for his continued technical assistance and model development during this project.

1 Introduction and Model Domain

The study area for the Gainer Spring Group, Williford Spring, and Sylvan Spring Minimum Flows and Level (MFL) encompasses the 11.8-mile portion of Econfina Creek between Williford Spring and Deer Point Lake at the confluence of Econfina Creek and Bear Creek as well as all spring runs associated with these spring groups (Figure 1-1). This report documents the development and calibration of the Hydrologic Engineering Centers River Analysis System (HEC-RAS) model of the Econfina Creek system to support Minimum Flows and Levels (MFL) development for Gainer Spring Group, Williford Spring Group, and Sylvan Spring Group. An existing HEC-RAS model, developed in 2006 for performing Federal Emergency Management Agency (FEMA) flood evaluations along Econfina Creek, was considered in the development of the model described in this report for MFL development.

The model domain extends from immediately north of Williford Spring to the northern portion of Deer Point Lake at the confluence of Econfina Creek and Bear Creek, encompassing all spring groups and runs considered for MFL evaluation. The model was extended just above Williford Spring to allow for Williford springflow to be included as an independent flow input from upstream flows. The model was extended from just below County Road (CR) 388 to Deer Point Lake to allow for adequate representation of a downstream model boundary condition (Figures 1-2a, 1-2b, 1-2c).

Development of this HEC-RAS model was conducted by Northwest Florida Water Management District (District) staff with support from Applied Technology and Management, a Geosyntec Company (ATM). The following tasks were performed to develop and calibrate a HEC-RAS model suitable for MFL development for Gainer Spring Group, Williford Spring Group, and Sylvan Spring Group:

- Review existing model developed in 2006 for performing FEMA flood evaluations along Econfina Creek.
- Review available data for use in developing HEC-RAS model for MFL development including bathymetric data, hydrologic data, and available light detection and ranging (LiDAR).
- Determine additional data needs and perform a field reconnaissance of the study area.
- Develop model geometry using best available bathymetric and LiDAR data.
- Develop input flow files and boundary conditions using best available hydrologic monitoring data from District and U.S. Geological Survey (USGS) stations.
- Determine appropriate flow mode, calibration, and simulation period.
- Perform model testing and calibration.

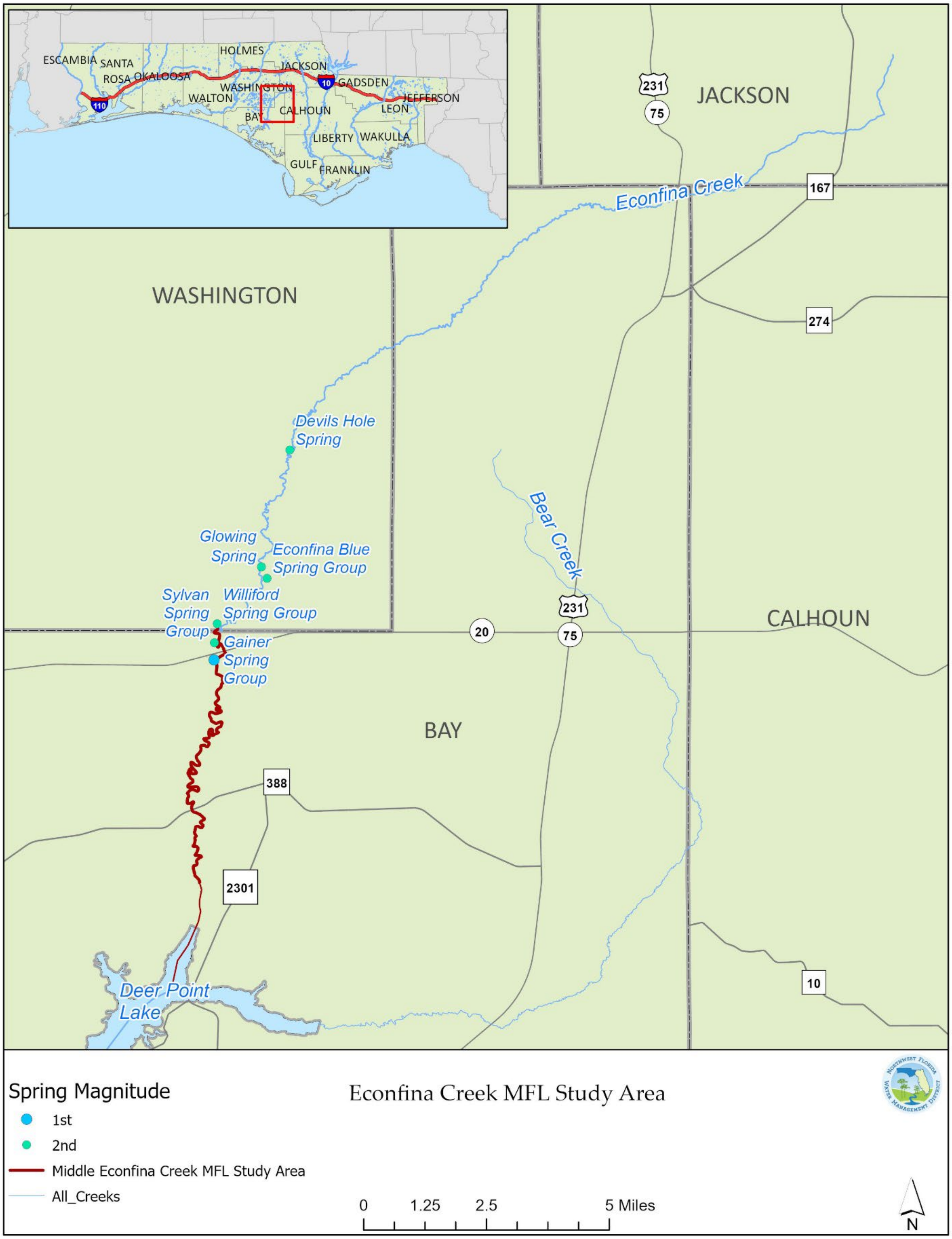


Figure 1-1. Econfina Creek and Springs MFL Study Area

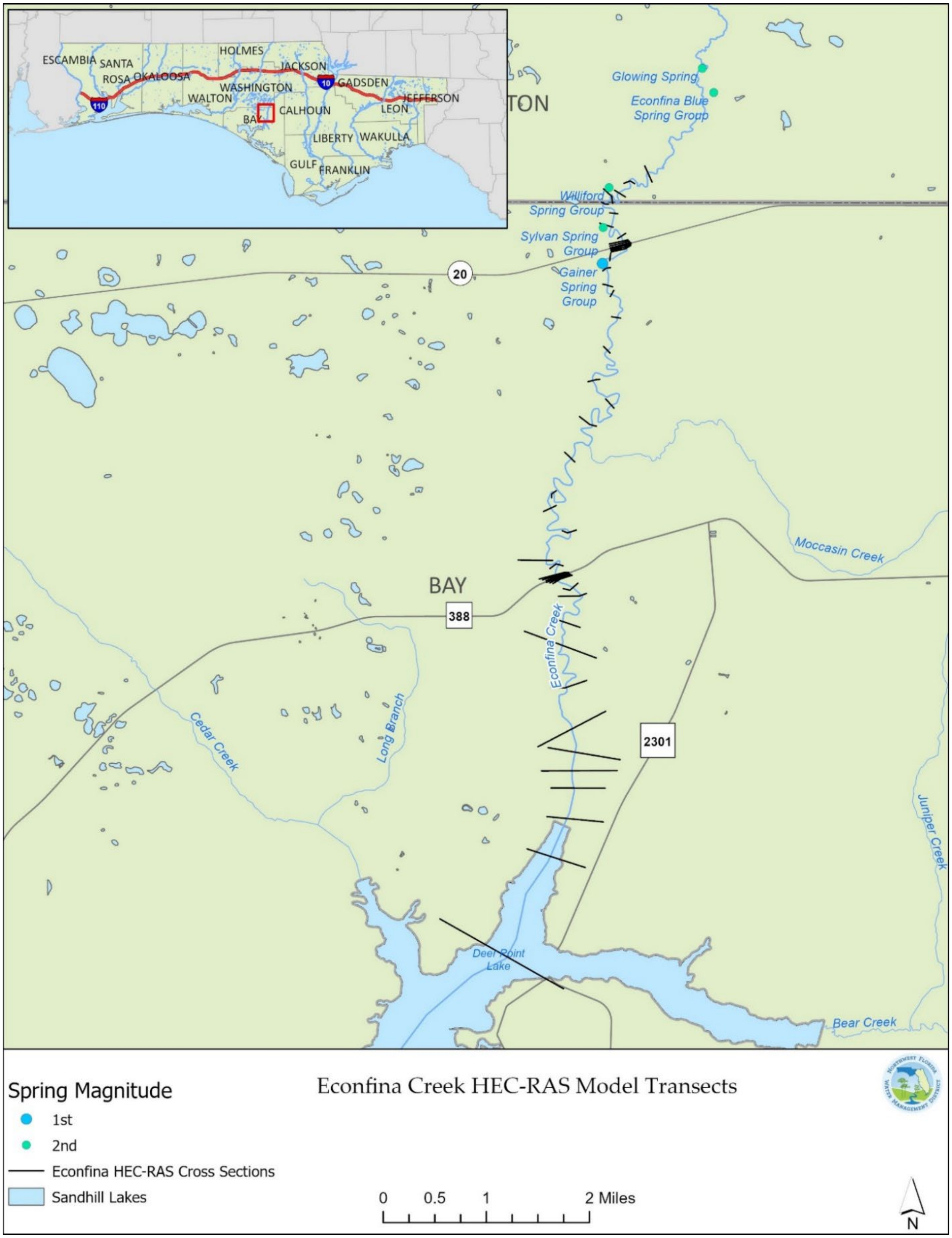


Figure 1-2a. Econfina Creek and Springs MFL HEC-RAS Model Extent

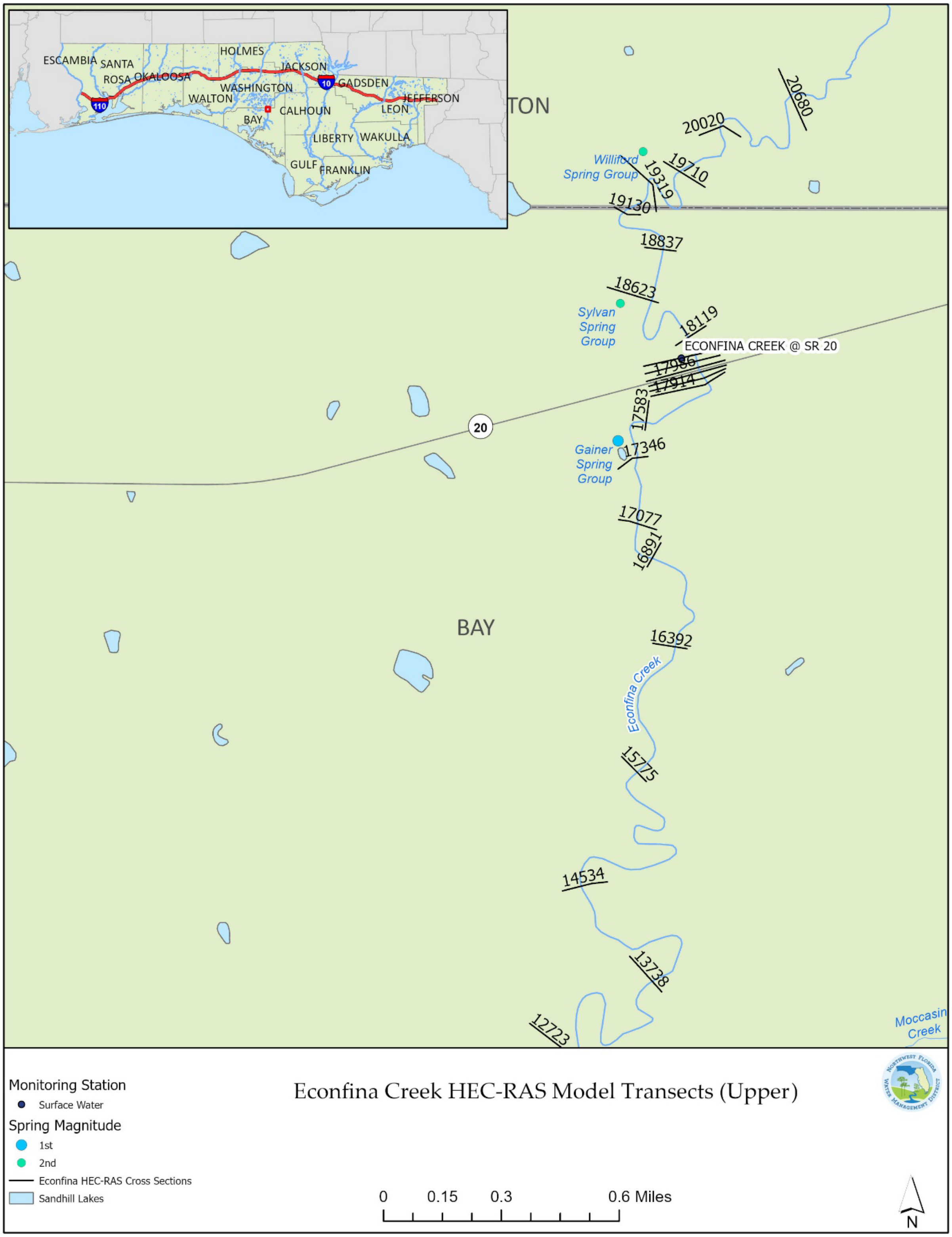


Figure 1-3b. Econfina Creek and Springs MFL HEC-RAS Model Extent– Upper Creek

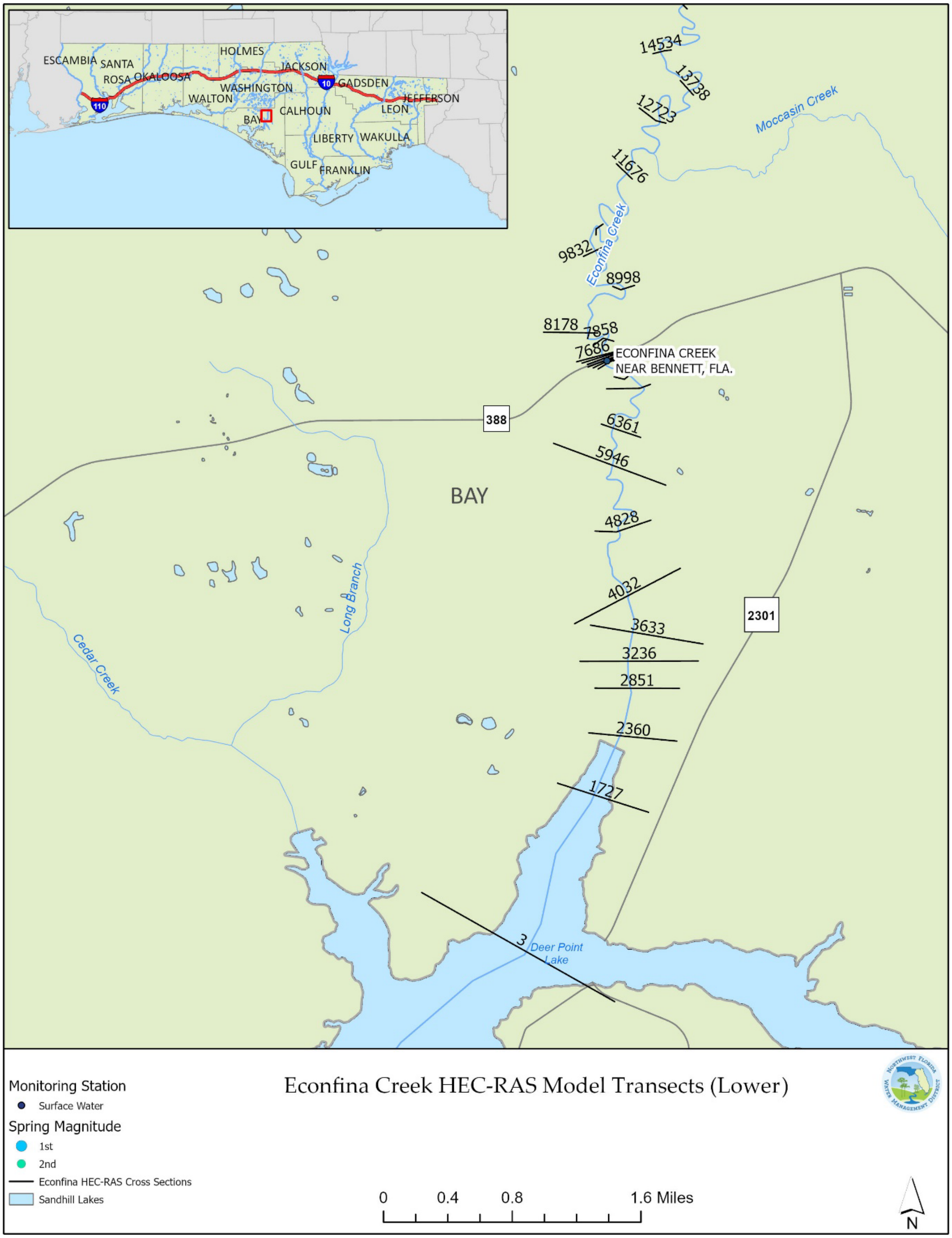


Figure 1-4c. Econfina Creek and Springs MFL HEC-RAS Model Extent – Lower Creek

2 HEC-RAS Model Development

A steady-state HEC-RAS (HEC-RAS Version 6.3.1) model of the middle (between Williford Spring Group and CR 388 bridge) and lower (below CR 388 bridge) portion of Econfina Creek was developed by District staff with support from ATM in support of MFL development for Gainer Spring Group, Williford Spring Group, and Sylvan Spring Group. The model was constructed with the best available data, including high resolution Digital Elevation Model (DEM), recent cross sectional survey data throughout the model domain, and hydrologic data from all available stations along Econfina Creek. Although a HEC-RAS model had previously been developed in 2006 for the middle and lower portion of Econfina Creek for performing FEMA flood evaluations, a new model was constructed for purposes of MFL evaluation due to the required model resolution at low flows as well as newly available DEM, survey, and hydrologic data along with significant changes to the system resulting from Hurricane Michael impacts. Surveyed bridge dimensions for the SR 20 and CR 388 Econfina Creek bridge crossings obtained from Florida Department of Transportation, as well as dimensions contained in the existing FEMA model, were utilized for the updated MFL HEC-RAS model. For details regarding impacts to Econfina Creek hydrology from Hurricane Michael, please refer to Section 2.8 of the Econfina Creek MFL Technical Assessment.

2.1 Geoprocessing, Projection System, and Digital Elevation Model

HEC-RAS 6.3.1 requires a consistent spatial reference system to be utilized for all geospatial data utilized in model development. The horizontal coordinate system used for this project was NAD_1983_2011_StatePlane_Florida_North_FIPS_0903_ft_US. The vertical datum used for this project was North American Vertical Datum 1988 (NAVD88). All elevation survey data utilized within this model development was obtained and provided in NAVD88. Horizontal survey positions were provided using the North American Datum 1983 (NAD83), 2011 adjustment, State Plane Florida- Zone:North horizontal datum. A geographic information system (GIS) layer of provided survey coordinates and elevations was generated using ArcMap v. 10.8.1 and was imported into HEC-RAS and reprojected to be consistent with the project's horizontal datum. All District station river stage data used within this model development was available in NAVD88. The river stages measured at USGS station 02359500 Econfina Creek Near Bennett, FL (Econfina Creek @ CR 388) required a shift of +0.61ft to convert from the National Geodetic Vertical Datum of 1929 (NGVD29) to NAVD88.

High resolution post Hurricane Michael LiDAR was received by the District in August 2022 which consisted of raster files with 0.76 meter grid cell resolution and 1 meter vertical resolution for the majority of the District, including the study area in the vicinity of Econfina Creek. Post Hurricane Michael LiDAR for this area was flown between December 2019 and October 2020. The horizontal datum of this data was NAD83, 2011 adjustment, State Plane Florida- Zone:North. A mosaic DEM was generated from provided raster files and reprojected to be consistent with the project's horizontal datum. The resulting DEM was clipped to the Econfina Creek watershed boundary, to reduce processing time for the purposes of this project (Figure 2-1).

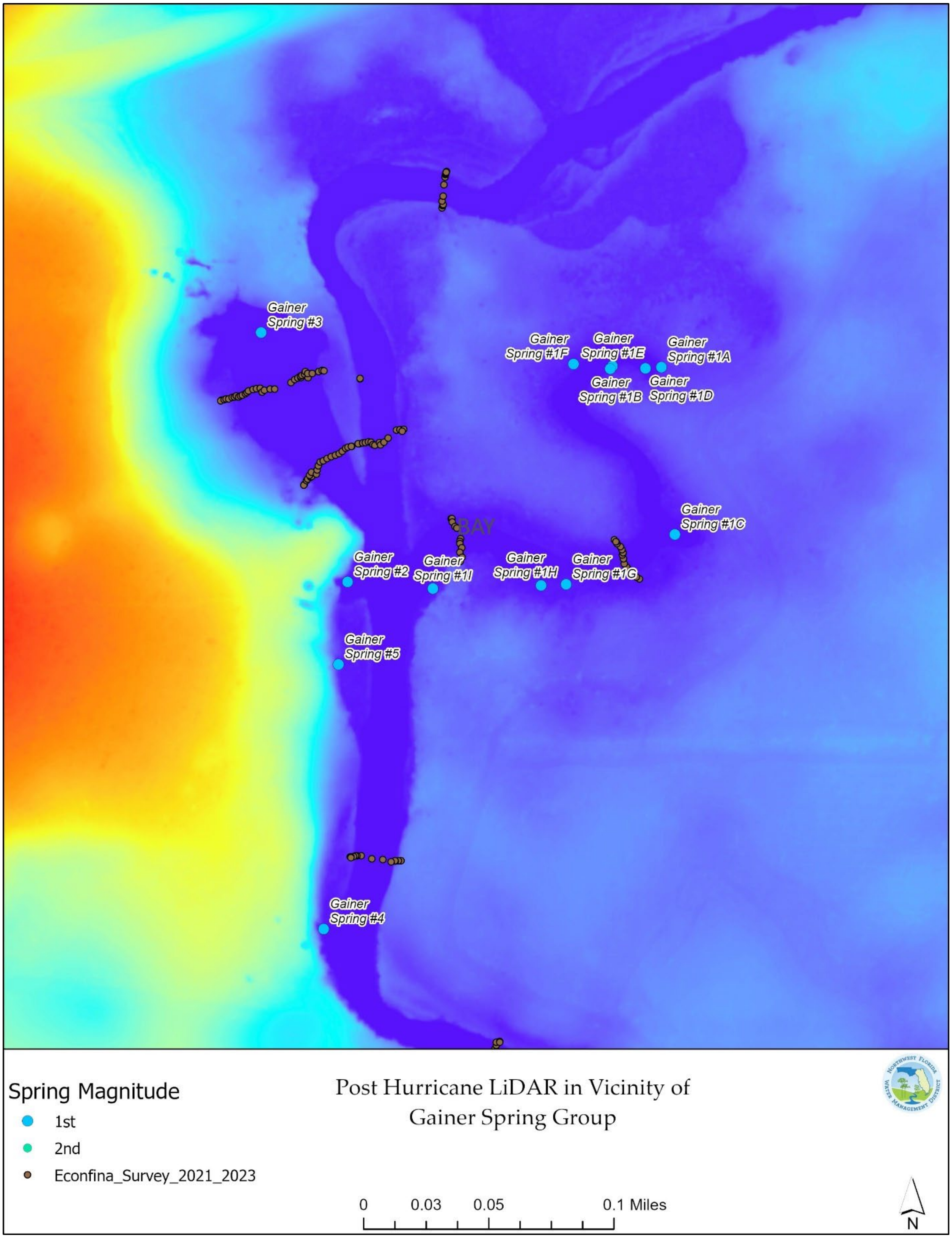


Figure 2-1. Post Hurricane Michael LiDAR in Vicinity of Gainer Spring Group

2.2 Model initialization and digitization

Model initialization was performed within the RAS Mapper feature of HEC-RAS 6.3.1. The coordinate reference system was set to NAD_1983_2011_StatePlane_Florida_North_FIPS_0903_ft_US and the clipped DEM was input into RAS Mapper and converted into a Terrain Layer (Figure 2-2). The river centerline was digitized primarily using the generated Terrain Layer within RAS Mapper. The high-resolution generated terrain allowed for accurate depiction of Econfina Creek within the model domain. Aerial imagery, post Michael LiDAR, and the National Hydrography dataset (NHD) (McKay et al. 2012) were also utilized as supporting information to aid in digitizing. Riverbanks and flow paths were also digitized in a similar manner. Econfina Creek was represented as a single reach within the model.

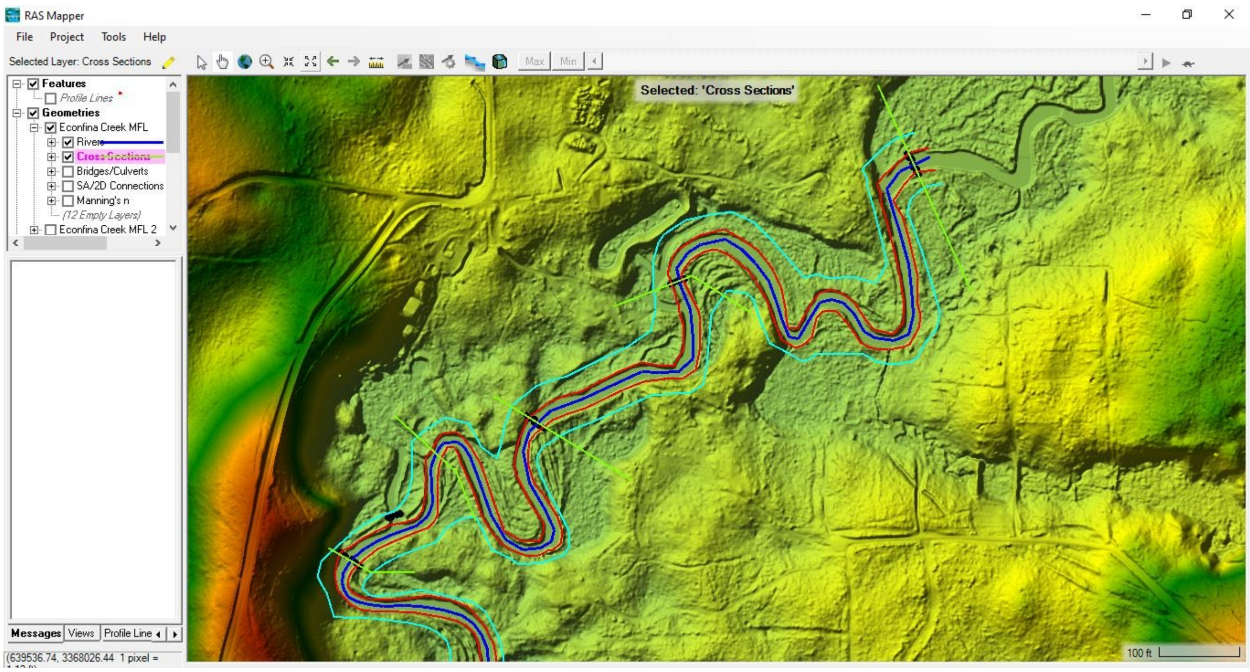


Figure 2-2. Model Digitization in RAS-Mapper

2.3 Elevation Survey and Cross Section Channel Geometry

Based on an initial review of the previous Econfina Creek FEMA model, District staff in conjunction with ATM determined that all existing transect locations would need to be resurveyed to ensure the channel was represented with appropriate precision to accurately represent low flow conditions. Additionally, Econfina Creek had undergone extensive scouring and deposition as a result of Hurricane Michael, which needed to be reflected by more recent channel bathymetry. Additional survey transect locations were also needed to better represent Econfina Creek in the vicinity of the springs and spring runs, extend the model domain north to Williford Spring and south to Deer Point Lake, capture river bathymetry in areas with sparse representation, and better represent bridge crossings within the model. District staff, along with ATM and Janicki Environmental, Inc. conducted a field reconnaissance on June 15, 2021 to identify potential additional survey transect locations (Figure 2-3). A total of 20 additional locations were identified between Williford Spring and the CR 388 bridge crossing based on the above criteria (ATM 2021).

In 2021, Southeastern Surveying and Mapping, Corporation (Southeastern) performed 37 cross section elevation surveys extending from 5 feet upland of top of bank on either side of the channel between Williford Spring and CR 388 bridge (Southeastern 2021a, Southeastern 2021b). This included some surveys along spring runs in case it became necessary to represent the spring runs within the model. Initially, model transects below CR 388 were taken from the existing FEMA model. After initial model testing had begun, it became apparent that updated survey of these transects would significantly improve model accuracy in the lower reach of the model domain. In 2023, Southeastern was contracted to perform an additional 12 cross section elevation surveys below CR 388 extending to the end of the model domain in Deer Point Lake (Southeastern 2023).

Figure 2-3. Econfina Creek Field Reconnaissance June 2021

A total of 40 cross sections were digitized within RAS Mapper extending sufficiently into the floodplain to accommodate high flow scenarios. Cross sections were digitized to coincide with survey locations as well as locations of transects from the FEMA model where applicable. Elevations for all transects were initially determined based on the terrain generated from the post Michael DEM. Elevation survey points were utilized to replace the terrain derived elevations within the channel for all cross sections where survey was available (Figure 2-4, Figure 2-5). Channel geometry for remaining cross sections was interpolated based on the adjacent upstream and downstream transect. For all cross sections, terrain generated elevations were used for overbank (floodplain) areas. After cross sections were defined in RAS Mapper, each cross section was reviewed in the geometry editor within HEC-RAS. A few minor modifications were made to the generated elevations from RAS mapper to be consistent with survey elevations.

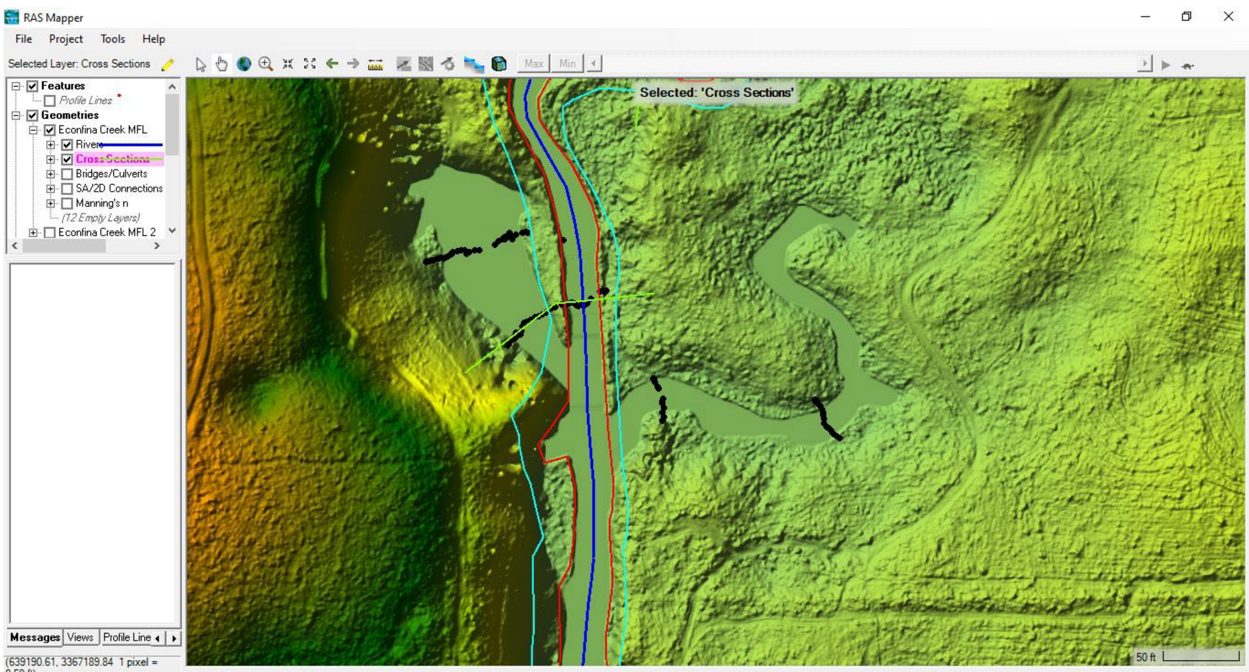


Figure 2-4. Digitization of Cross Sections overlaying survey points in RAS Mapper

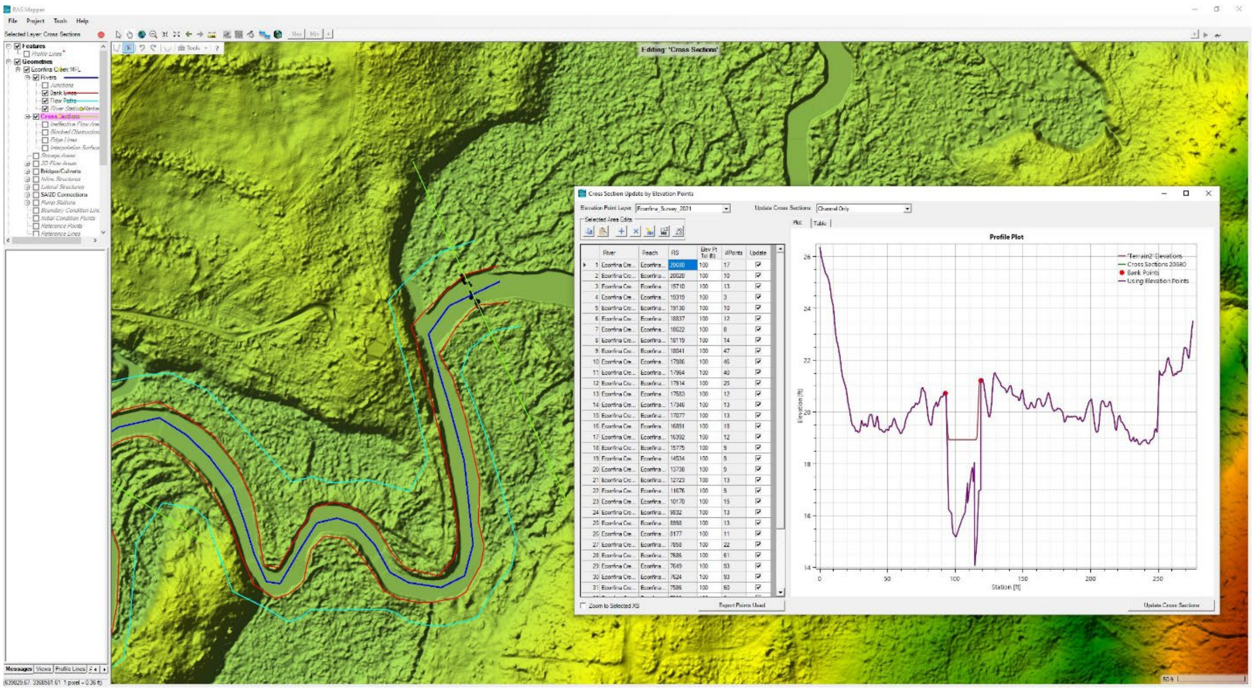


Figure 2-5. Updating Channel Portion of Cross Sections with Survey Points in RAS Mapper

2.4 Flow mode and Modeling Scenarios

A steady flow model was determined to be an appropriate flow mode the purposes of developing a suitable HEC-RAS model to assess potential impacts from springflow reduction to applicable water resource value metrics and develop MFLs for Gainer Spring Group, Williford Spring Group, and Sylvan Spring Group. Per guidance from the HEC-RAS User's Manual (USACE 2020), a transient model should be used instead of a steady flow model in the following situations:

- The river is tidally influenced, and the tide has a significant effect on the water surface elevations for the area of interest.
- The events being modeled are very dynamic with respect to time (i.e., dam break flood waves; flash floods; river systems in which the peak flow comes up very quickly, stays high for a very short time, and then recedes quickly).
- Complex flow networks and/or flow reversals occur during the event.
- Dynamic events such as levee overtopping and breaching occur during the event.
- Extremely flat river systems, where gravity, hydrostatic pressure, and friction are not necessarily the only significant force acting on the flow (i.e., local and convective acceleration forces).
- Systems with Pump stations that move a significant amount of water.
- Systems with structures that have complex gate operations based on stages and flows in the system.

Based on these criteria, a steady state model was justified as the study area is not affected by any of the above complexities. In addition, Econfina Creek is primarily spring fed, with relatively low flow variance since baseflow represents the majority of total streamflow. As described in detail in Chapter 3 of the Econfina Creek MFL Technical Assessment Report, stage-discharge relationships have been relatively consistent throughout the available period of record, except from October 2018 – March 2019 when stage-discharge relationships were affected by large amounts of debris which fell into Econfina Creek from Hurricane Michael. Upon completion of debris removal efforts in March 2019, the stage-discharge relationship returned to conditions similar to historical, although stages remain slightly elevated for a given flow, likely due to remaining debris upstream and/or in the floodplain.

Modeling scenarios for purposes of model development consisted of one model plan for each flow percentile, based on period of record flows for all model inputs. Therefore, a total of 99 steady state model scenarios were run. This allows for determination of precise critical flow percentiles associated with a given water resource value (WRV) metric. The downstream boundary was kept constant for all scenarios. Additional details are provided in section 2.5.5.

2.5 Boundary Conditions

Flow inputs for the Econfina Creek HEC-RAS model consist of Econfina Creek flow immediately upstream of Williford Spring, springflow contributions from Gainer Spring Group, Williford Spring Group, and Sylvan Spring Group, and lateral inflow pickup between Gainer Spring Group and the CR 388 bridge (Figure 2-6). The Deer Point Lake water surface elevation was utilized as the downstream stage boundary condition. Consideration was given to adjust flow inputs based on potential changes to flow frequencies caused by Hurricane Michael. These inputs were derived based on surface water monitoring stations along Econfina Creek maintained by the District and USGS including:

- USGS 02359500 Econfina Creek Near Bennet, FL (Econfina Creek @ CR 388)
- NWFWMD 8548 Econfina Creek @ SR 20
- NWFWMD 8099 Econfina Ceek Above Gainer Spring
- NWFWMD 8100 Econfina Creek Below Gainer Spring
- NWFWMD 8544 Deer Point Lake Near Dam

Figure 2-6. Econfina Creek Monitoring Stations Utilized to Develop Model Boundary Conditions

2.5.1 Comparison of Flow Frequencies Pre and Post Hurricane Michael

Flow frequency curves were developed for the Econfina Creek @ CR 388 station to determine the extent and nature of flow frequencies post Hurricane Michael as compared to the historical record prior to the hurricane (Figure 2-7). This analysis was conducted to determine the extent to which physical alterations from Hurricane Michael, such as reduced forest land cover and associated evapotranspiration (ET) reductions, may have contributed to changes in total streamflow and baseflow of Econfina Creek.

Figure 2-7 shows flows have been higher across all flow percentiles post hurricane Michael (post 10/10/2018) as compared to the historical period of record. Flow increases are on the order of 50-100 cfs for most flow percentiles. This is consistent with the analysis presented in Section 3 of the Econfina Creek MFL Technical Assessment, indicating that flows have increased from 2013 to present due to above average rainfall and elevated groundwater levels.

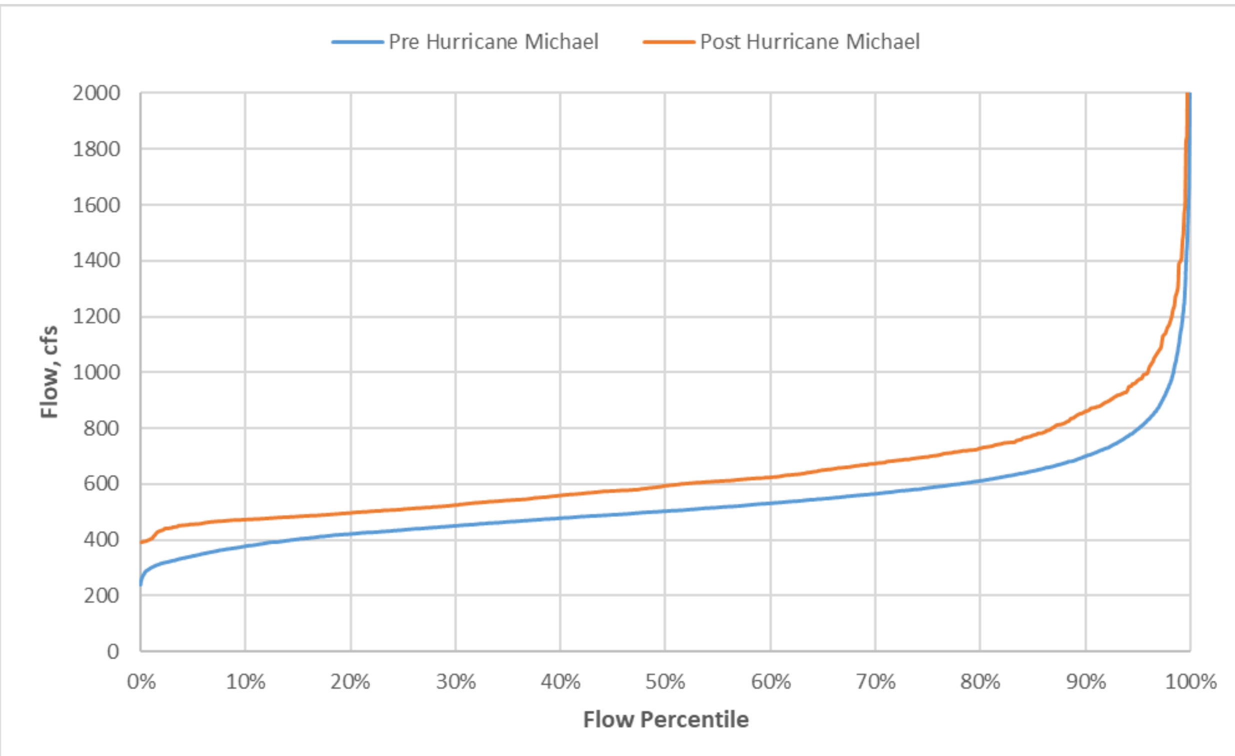


Figure 2-7. Flow Frequency Curve for the USGS station 2359500 Econfina Creek Near Bennett, FL (Econfina Creek @ CR 388)

To further investigate the nature of observed flow increases post hurricane Michael, flow frequencies for the surface water component of total flow were determined. Flow for Econfina Creek can be divided into two components, baseflow derived primarily from spring discharge and surface water runoff. Surface water runoff was determined as the difference between daily average streamflow and estimated baseflow from the University of South Florida (USF) 61 methodology described in Chapter 3 of the Econfina Creek MFL Technical Assessment. As shown in Figure 2-8, flow frequencies for surface water inputs along Econfina Creek are similar pre and post Hurricane Michael, indicating that increased baseflow is the primary contributor of increased flows post Hurricane Michael. This indicates that observed increased flows post Hurricane Michael are largely due to climatic factors. Similar results were also determined for analysis of flow frequencies pre and post Hurricane Michael at the Econfina Creek @ SR 20 gauge. Based on this evaluation, it was determined that utilization of the period of available record flows for both Econfina Creek @ CR 388 an Econfina Creek @ SR 20 to establish flow inputs within the model was appropriate since physical alterations resulting from Hurricane Michael did not appear to significantly affect flow frequencies along Econfina Creek.

For more details, please refer to Section 3 of the Econfina Creek MFL Technical Assessment which presents a detailed hydrologic evaluation of observed trends in flow and stage from USGS Station 2359500 Econfina Creek Near Bennett, FL (Econfina Creek @ CR 388) and Econfina Creek @ SR 20.

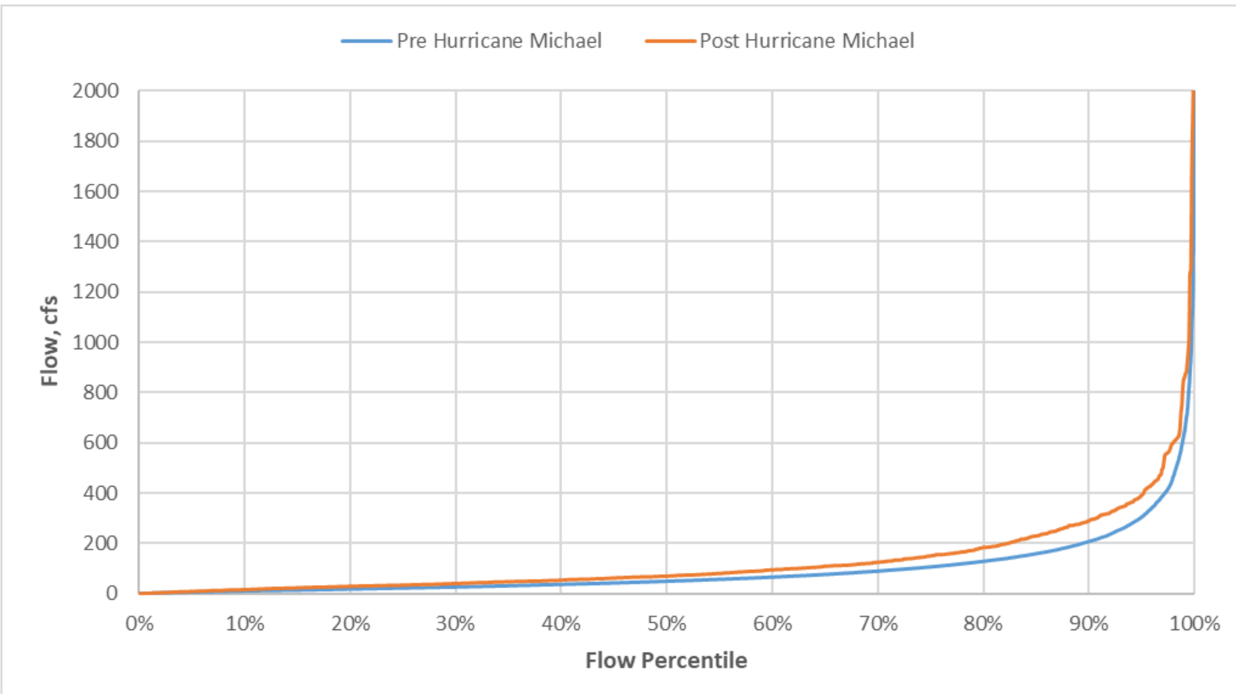


Figure 2-8. Flow Frequency Curve for Surface Water Inputs for the USGS station 2359500 Econfina Creek Near Bennett, FL (Econfina Creek @ CR 388)

2.5.2 Flow Inputs Above SR 20

The upstream boundary flow, immediately upstream of the Williford Spring run was determined as:

Upstream boundary percentile flow= Econfina Creek @SR 20 percentile flow- (Williford Spring Group median flow +Sylvan Spring Group median flow).

Table 2-1 shows flow inputs above SR 20 for the 5th and 95th percentile as well as every 10th percentile for summary purposes. All flow percentiles (1-99) were included as model scenarios. Median flows were used for Williford and Sylvan Spring Group since the number of total measurements was insufficient to develop flow percentiles at these locations. Since the spring runs are within close proximity to the SR 20 gauge, and no notable surface inflows are present in this portion of Econfina Creek, no additional lateral inflows were estimated in this portion of the model domain. Pitt spring, a 3rd magnitude spring between Sylvan

Spring Group and SR 20 was not included as a separate inflow location since few measurements have been taken at this location. Williford Spring Group and Sylvan Spring Group flows were added at transects immediately downstream of their respective spring runs. The full period of record flow timeseries was used to determine Econfina Creek @ SR 20 flow percentiles.

Table 2-1. Flow inputs above SR 20 (cfs)

Flow Percentile	Econfina Creek @SR 20	Model input flow (above Williford)	Williford Spring Group median flow	Sylvan Spring Group median flow
5%	160	100	42	18
10%	174	114	42	18
20%	194	134	42	18
30%	216	156	42	18
40%	242	182	42	18
50%	264	204	42	18
60%	284	224	42	18
70%	308	248	42	18
80%	345	285	42	18
90%	416	356	42	18
95%	493	433	42	18

2.5.3 Flow Inputs Below SR 20

Much of the flow in the portion of Econfina Creek between SR 20 and CR 388 is derived from the Gainer Spring group with the remaining flow being derived from surface water inputs from intermittent streams located north of CR 388. The Gainer Spring Group Composite percentile flow, derived from period of record discharge measurements at station NWFID 10128 (Gainer Spring Group Composite), was entered at the model transect immediately below the Gainer Spring Group. Remaining flow inputs for this portion of the model domain were determined as:

Remaining difference for lateral pickup = (Econfina Creek @CR 388 percentile flow – Econfina Creek @SR 20 percentile flow) – Gainer Spring Group Composite percentile flow.

Table 2-2 shows flow inputs below SR 20 for the 5th and 95th percentile as well as every 10th percentile for summary purposes. All flow percentiles (1-99) were included as model scenarios. Uniform lateral pickup was assumed for the remaining flow inputs. A portion of total lateral pickup was entered at five flow change transect locations proportional to river distance between Gainer Spring Group and the CR 388 bridge. The full period of record flow timeseries was used to determine Econfina Creek @ CR 388, Econfina Creek @ SR 20, and Gainer Spring Group composite flow percentiles.

Table 2-2. Flow inputs above SR 20 (cfs)

Flow Percentile	Econfina Creek @CR 388 – Econfina Creek @SR 20	Gainer Spring Group Composite	Remaining difference for lateral pickup
5%	185	120	65
10%	206	126	80
20%	232	135	97
30%	238	152	86
40%	240	159	81
50%	242	167	75
60%	252	176	76
70%	262	186	76
80%	273	193	80
90%	291	203	88
95%	313	208	105

2.5.4 Steady Flow File

Based on the calculated flow inputs above SR 20 and between SR 20 and CR 388, the steady flow file was developed as shown in Table 2-3. Flow inputs for the 5th and 95th percentile as well as every 10th percentile for displayed summary purposes. All flow percentiles (1-99) were included as model scenarios. River station (RS) 20680 represents the upstream boundary just above Williford Spring. RS 19130 represents the location of Williford Spring Group inflow, located just below the spring run. RS 18119 represents the location of Sylvan Spring Group inflow, located just below the spring run. RS 17077 represents the location of Gainer Spring Group inflow, located just below the spring runs and all spring vents associated with the Gainer Spring Group. The remaining flow change locations represent the remaining lateral pickup between Gainer Spring Group and CR 388, proportional to river distance between Gainer Spring Group and the CR 388 bridge.

Table 2-3. Steady Flow File for Econfina Creek MFLs HEC-RAS Model Development

RS	PF 5	PF 10	PF 20	PF 30	PF 40	PF 50	PF 60	PF 70	PF 80	PF 90	PF 95
20680	100	114	134	156	182	204	224	248	285	356	433
19130	142	156	176	198	224	246	266	290	327	398	475
18119	160	174	194	216	242	264	284	308	345	416	493
17077	280	300	329	368	401	431	460	494	538	619	701
16392	285	307	337	375	408	437	466	501	545	627	710
14534	300	325	359	395	427	455	484	518	563	647	734
12723	315	343	381	414	445	471	501	535	581	667	758
10170	336	368	412	442	470	495	525	559	606	694	791
8998	345	380	426	454	482	506	536	570	618	707	806

2.5.5 Downstream Stage Boundary Condition

The Deer Point Lake water surface elevation was utilized as the downstream stage boundary condition. The water surface elevation of Deer Point Lake is controlled by the Bay County Water Division and was typically held constant between 4.8 and 5.0 ft., NAVD88 prior to July 2015 (Figure 2-9). Since August 2015, lake levels have remained between 4.4 and 4.6 ft., with only brief excursions below or above that range. The County commonly drops the lake several feet every winter to facilitate clearing of near-shore submerged vegetation by exposing it to freezing temperatures. Aside from the controlled drawdown events, Deer Point Lake elevations remain constant. To reflect recent operations, a known water surface of 4.5 ft. reflective of normal lake levels since August 2015, was utilized for all percentile flow scenarios.

Lake levels from District station 8544 (Deer Point Lake Near Dam) were compared with Econfina Creek stage at USGS Station 2359500 Econfina Creek Near Bennett, FL (Econfina Creek @ CR 388), located several miles upstream of Deer Point Lake to determine the extent of backwater effects (Figure 2-5). Visual examination of Figure 2-9 suggests no noticeable effect of lake level fluctuations on Econfina Creek stage @ CR 388. This is particularly noticeable during scheduled lake winter drawdowns where lake levels drop by several feet for several months while stages along Econfina Creek remain stable. This suggests that Econfina Creek stages at CR 388 are controlled predominantly by flow inputs upstream rather than backwater effects caused by Deer Point Lake Reservoir.

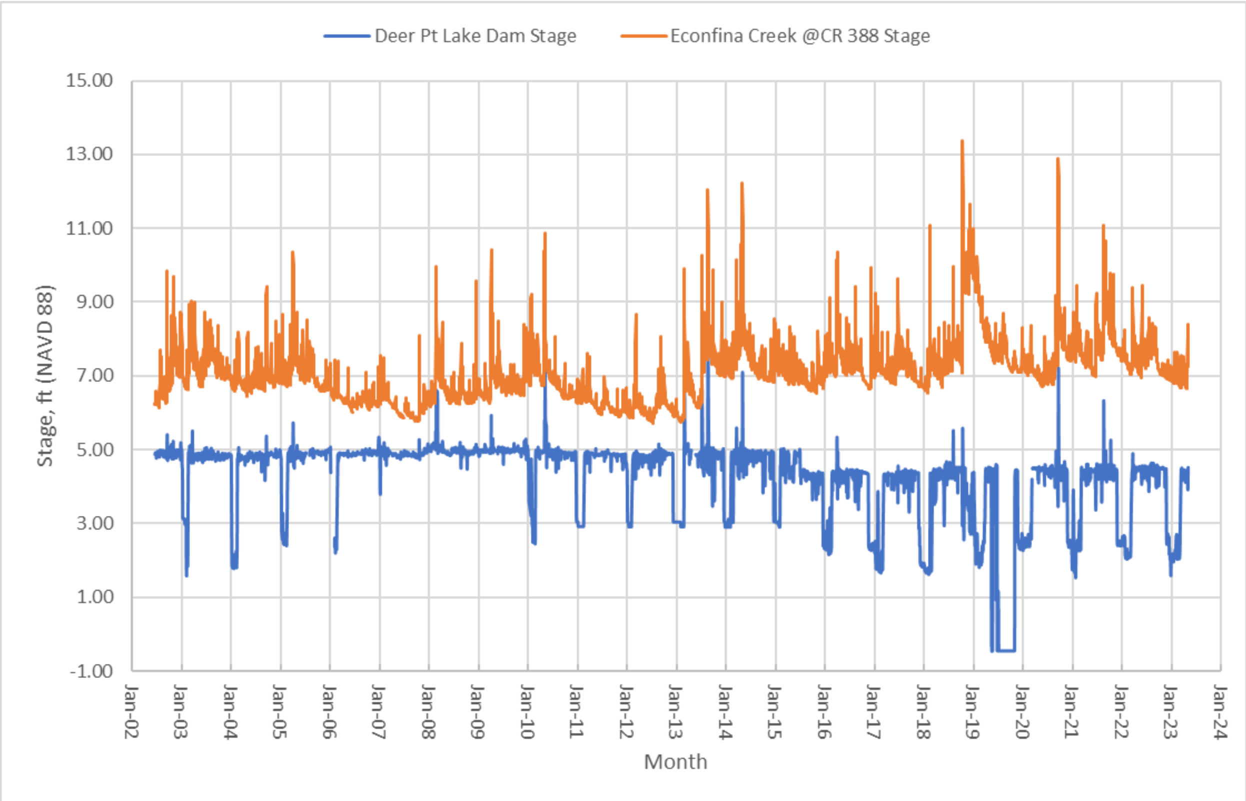


Figure 2-9. Comparison of Deer Point Lake levels with Econfina Creek Stage

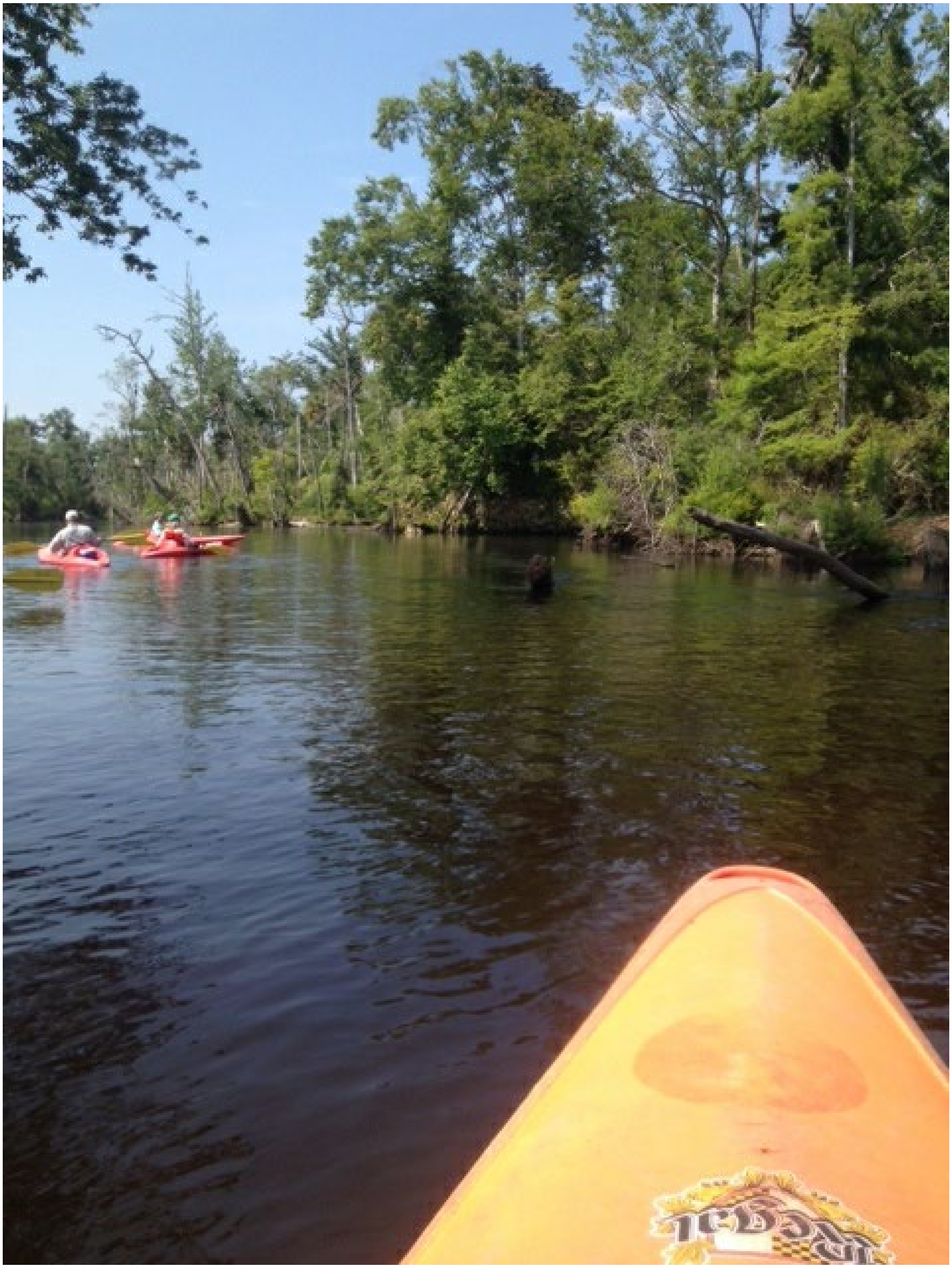
2.6 Manning's n

Initial values for Manning's n (model roughness coefficients) were based on field reconnaissance trips on June 2021 and January 2023 of the study area (Figure 2-10a, Figure 2-10b). Following Hurricane Michael, the channel was relatively clear due to debris removal in the study area. The floodplain had sparse trees due to hurricane damage, with increasing vegetation cover in some areas. Based on observed conditions from these reconnaissance trips, manning's n values utilized for similar systems in Florida, and guidance contained in the HEC-RAS Hydraulic Reference Manual (USACE 2020), appropriate Manning's n values were selected as initial values for all transects. For the main channel, transects were either assigned n=0.03 (clean, straight, no rifts or deep pools) or n=0.04 (clean, winding, some pools and shoals) based on whether or not the segment surrounding the transect was straight or meandered (Table 2-4). For the floodplain, n=0.1 was selected to represent medium to dense brush, in summer. Similar conditions were observed during the second visit in the winter (January 2023). Therefore, seasonal n values were not required.

Table 2-4. Initial assignment of Manning's n values

River Station	n #1	n #2	n #3
20680	0.1	0.04	0.1
20020	0.1	0.04	0.1
19710	0.1	0.04	0.1
19319	0.1	0.04	0.1
19130	0.1	0.04	0.1
18837	0.1	0.03	0.1
18623	0.1	0.03	0.1
18119	0.1	0.04	0.1
18040	0.1	0.04	0.1
18013	0.1	0.04	0.1
17986	0.1	0.04	0.1
17975		*bridge*	
17965	0.1	0.04	0.1
17937	0.1	0.04	0.1
17914	0.1	0.04	0.1
17583	0.1	0.03	0.1
17346	0.1	0.03	0.1
17077	0.1	0.03	0.1
16891	0.1	0.03	0.1
16392	0.1	0.03	0.1
15775	0.1	0.04	0.1
14534	0.1	0.04	0.1
13738	0.1	0.04	0.1
12723	0.1	0.04	0.1
11676	0.1	0.03	0.1

River Station	n #1	n #2	n #3
10170	0.1	0.04	0.1
9832	0.1	0.04	0.1
8998	0.1	0.04	0.1
8178	0.1	0.04	0.1
7858	0.1	0.04	0.1
7686	0.1	0.04	0.1
7669	0.1	0.04	0.1
7649	0.1	0.04	0.1
7636		*bridge*	
7624	0.1	0.04	0.1
7608	0.1	0.04	0.1
7586	0.1	0.04	0.1
7322	0.1	0.04	0.1
7137	0.1	0.04	0.1
6361	0.1	0.03	0.1
5946	0.1	0.03	0.1
4828	0.1	0.03	0.1
4032	0.1	0.03	0.1
3633	0.1	0.03	0.1
3236	0.1	0.03	0.1
2851	0.1	0.03	0.1
2360	0.1	0.03	0.1
1727	0.1	0.03	0.1
3	0.1	0.03	0.1

A) 

B) 

Figure 2-10. A) Econfina Creek, July 2021 **B)** Econfina Creek, January 2023

2.7 Ineffective Flow Areas

Ineffective flow areas allow the user to define areas of the cross section that will contain water that is not actively being conveyed. Ineffective flow areas are often used to describe portions of a cross section in which water will pond and the velocity of that water, in the downstream direction, is close to zero. This water is included in the storage calculations and other wetted cross section parameters but is not included as part of the active flow area. When using ineffective flow areas, no additional wetted perimeter is added to the active flow area (USACE 2020).

In order to determine the necessity for including ineffective flow areas, preliminary steady state model simulations were run for all flow percentiles and resulting water surface elevations were reviewed in RAS Mapper at each transect location. For each transect, the area surrounding the left and right bank were examined to determine if portions of the water surface profile were not part of the active flow area at certain percentile flows. In other words, were any areas acting as storage as opposed to actively connected to the main channel flow. An example evaluation for RS 19319 is described below. Figure 2-11 and Figure 2-12 shows water surface profile (inundation) for the 90^{th} and 99^{th} percentile flows respectively at RS 19319 (purple line). For the 90^{th} percentile flow scenario, the area east of the left bank is inundated with water. However, review of the terrain in the vicinity suggests no noticeable connection to the main channel, indicating this area is likely not contributing to the active flow area under this scenario. However, at the 99th percentile flow, the inundated area east of the left bank is connected with the main channel in the vicinity transect suggesting it is contributing to the active flow area under this scenario. Based on this assessment, an ineffective flow area was put on the left bank at the p99 water surface elevation, as depicted in Figure 2-13.

This process was performed for all transects in the model domain, incorporating ineffective flow areas where appropriate. Additionally, ineffective flow areas were placed on both banks immediately above and below both bridge crossings. Ineffective flow areas were added for 18 out of 47 transects in the model domain.

Figure 2-11. RS 19319, 90th percentile flows

Figure 2-12. RS 19319, 99th percentile flows

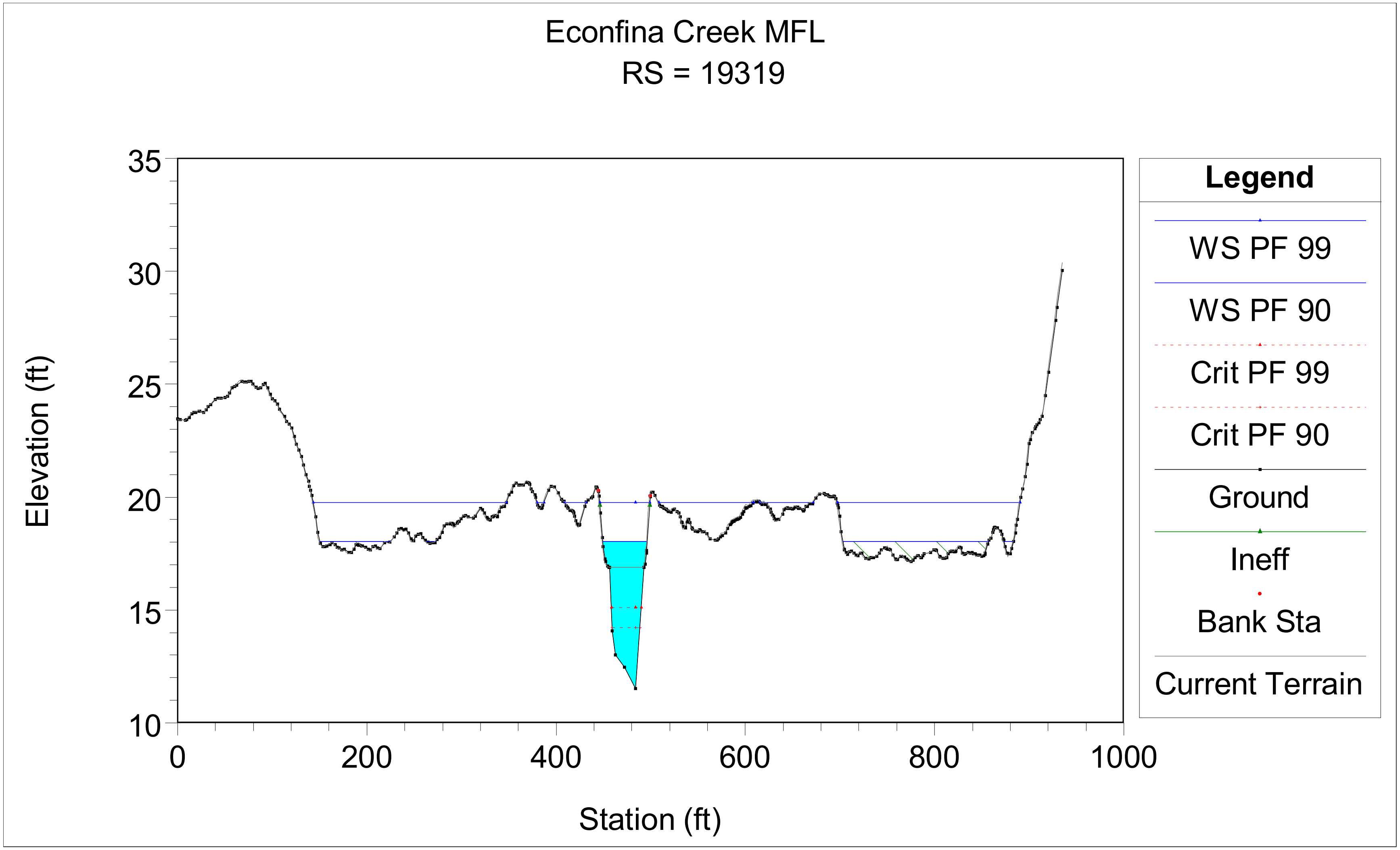


Figure 2-13. RS 19710 water surface profiles for 90th and 99th percentile flows

3 HEC-RAS Model Testing and Calibration

The steady state HEC-RAS model was calibrated by adjusting model parameters to observed stages and flows at three locations with sufficient data along Econfina Creek. The primary model parameters adjusted were channel and floodplain roughness coefficients (Manning's n). Other adjustments included addition of interpolated cross sections to improve model stability near bridge crossings, adjustments to ineffective flow areas, and modifications to channel cross section geometry. The impact of Hurricane Michael as well as post hurricane debris cleanup was considered when selecting an appropriate calibration period of record to represent current riverine hydrology.

3.1 Evaluation of Stage- Discharge Relationships for Econfina Creek and Selection of Period of Record for Calibration

An evaluation of potential changes to Econfina Creek stage-discharge relationships over time was conducted to determine an appropriate period of calibration which reflects current riverine hydrodynamics and expected future conditions to ensure model results and simulations are protective of the system. In particular, changes caused as a result of downed trees in the channel and floodplain from Hurricane Michael and subsequent debris removal were evaluated. Large amounts of debris fell into Econfina Creek and surrounding floodplain areas from Hurricane Michael, causing changes to the hydrology of Econfina Creek. Downed trees in the channel and floodplain resulted in less conveyance area, resulting in slower water velocities and increased river stage for a given flow. In hopes of restoring the Econfina Creek to pre-hurricane conditions, debris was removed from portions of the main channels of Econfina Creek, including upstream of the Econfina Creek @ CR 388 station. No debris removal was known to be conducted in the floodplains.

Analysis of stage- discharge relationships was conducted for three periods for the Econfina Creek @ CR 388 station, shown in Figure 3-1:

- Pre hurricane conditions (pre 10/10/2018)
- Post hurricane conditions prior to completion of debris clearing (10/10/2018- 3/31/2019)
- Post hurricane conditions after completion of debris clearing (4/1/2019- present)

Review of Figure 3-1 shows substantial increases in stage for a given flow following Hurricane Michael as compared to historical conditions pre hurricane. However, upon completion of debris removal in the Econfina Creek channel, the stage-discharge relationship returned to conditions similar to historical, although stages remain slightly elevated for a given flow, likely due to remaining debris in the floodplain. An analogous assessment of stage-discharge relationships for Econfina Creek @ SR 20 yielded similar results, indicating the stage-discharge relationship upon completion of debris removal in the Econfina Creek channel similar to historical, although stages remain slightly elevated, likely due to remaining debris in the floodplain (Figure 3-2). See Chapter 3 of the Econfina Creek MFL Technical Assessment for more details.

Based on this evaluation, a calibration period of April 1, 2019 – September 18, 2023 was selected as the period of available record at the time of model calibration which represents the current stage-discharge relationship for Econfina Creek. This period is reflective of debris removal completion and recovery of the system to a stable rating from the impact of Hurricane Michael. Fluctuations in stage-discharge relationships will continue to be monitored for this system as it continues to recover from Hurricane Michael impacts and floodplain and instream communities continue to recuperate.

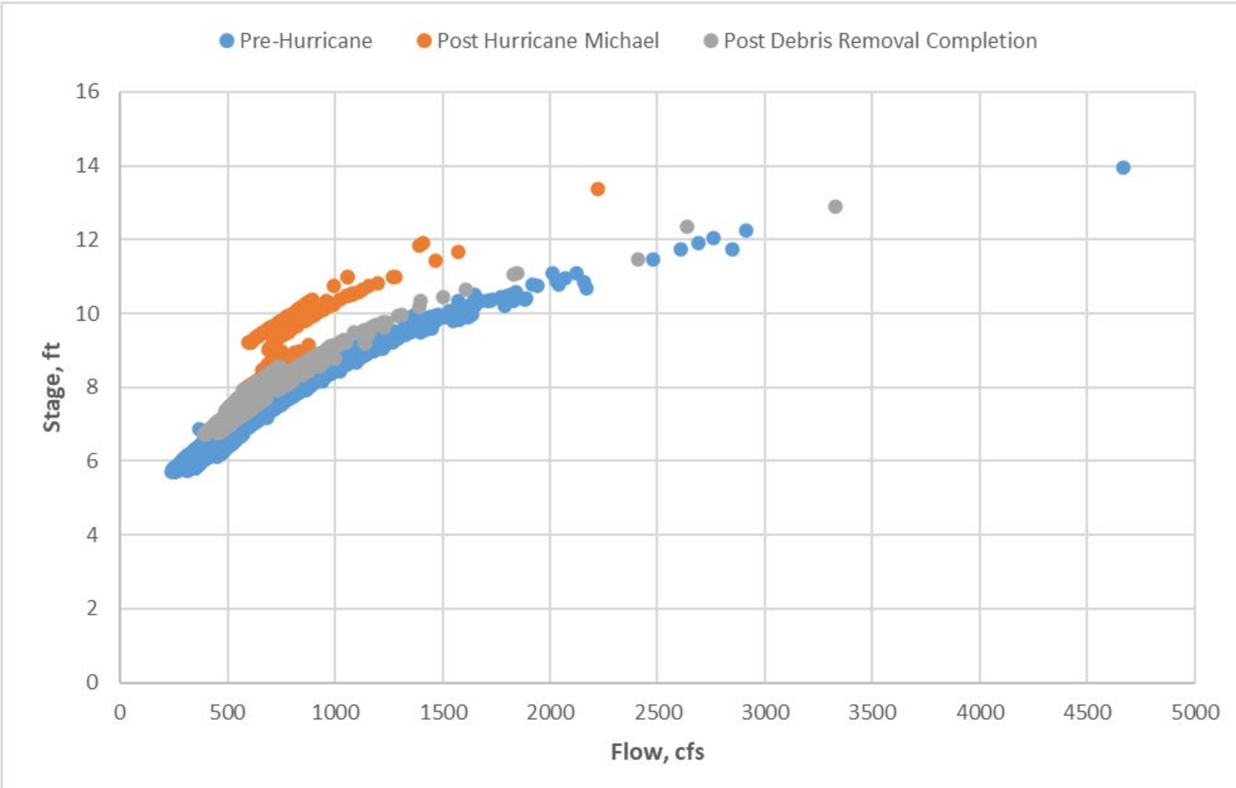


Figure 3-1. Comparison of stage-discharge relationships for the USGS station 2359500 Econfina Creek Near Bennett, FL (Econfina Creek @ CR 388)

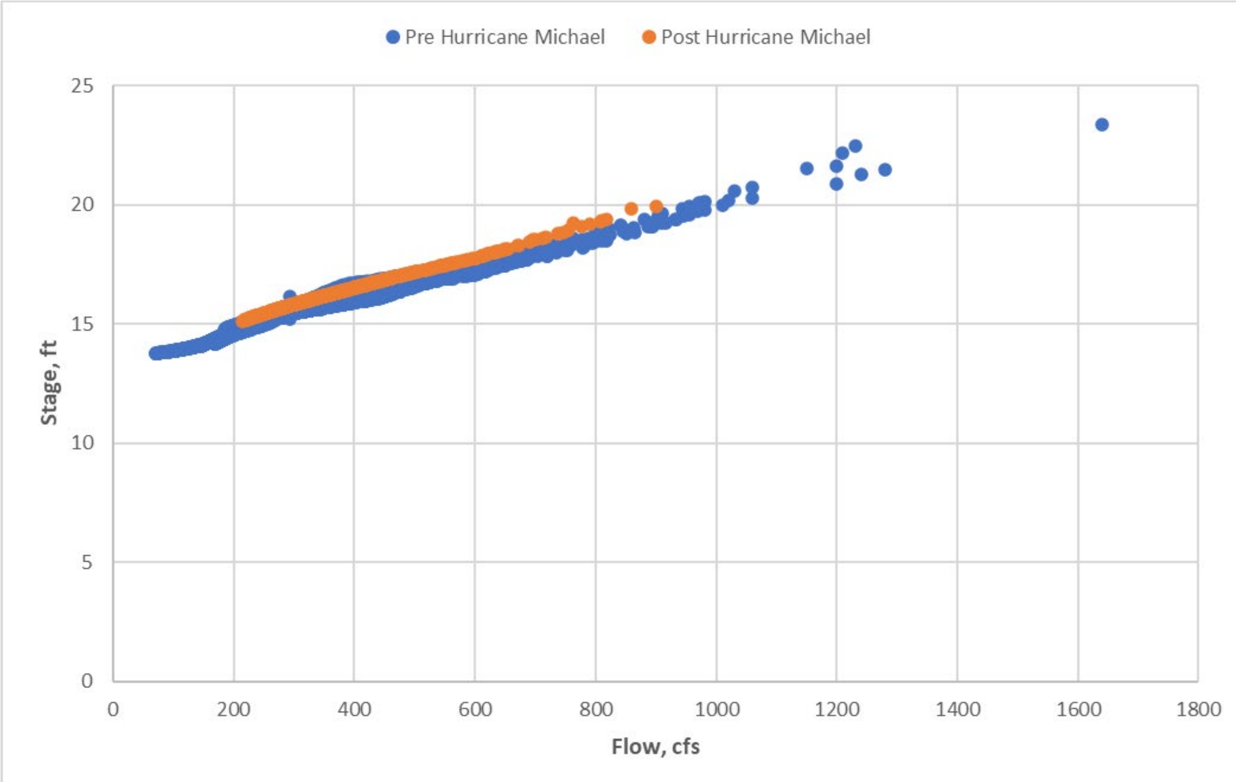


Figure 3-2. Comparison of stage-discharge relationships for the NWFWMD station 8458 Econfina Creek @ SR 20

3.2 Model calibration locations and targets

The performance of Econfina Creek MFLs HEC-RAS model was evaluated by comparing model predicted stage-discharge rating to observed stage-discharge rating for all available data from April 1, 2019 – September 18, 2023 for all three stations listed in Table 3-1. (The locations of these stations are shown in Figure 2-6). The Gainer Spring group composite had a data gap during the calibration period from September 10, 2020 – June 9, 2021. Suitable data was available at all three locations to allow for comparison of rating across a wide range of flow conditions, allowing for suitable calibration target datasets.

Table 3-1. Surface water stations and available period of record for calibration of the Econfina Creek MFLs HEC-RAS model

Station Number	Site Name	Period of Record Available for Stage-Discharge Rating Calibration
USGS 02359500	Econfina Creek Near Bennett, FL (Econfina Creek @ CR 388)	April 1, 2019- present
NWFWMD 8548	Econfina Creek @ SR 20	April 1, 2019- present
NWFWMD 8100	Econfina Creek Below Gainer Spring	October 28, 2019- September 9, 2020; June 10, 2021- present

3.3 Initial model simulation

An initial steady state simulation was performed with the parameterization presented previously in Section 2. A comparison of simulated to observed rating curves at XS 17965 (nearest to Econfina Creek @ SR 20), XS 17077 (nearest to Gainer Spring Group Composite), and XS 7624 (nearest to Econfina Creek @ CR 388) is shown in Figures 3-3, 3-4, and 3-5. Graphical comparisons of simulated stage-discharge rating curves with observed rating curves indicated the model overestimated stage by approximately 0.5 ft to 1.0 ft at all three locations although the overall shape of the rating curves matched reasonably well with observed data. This indicated that the initial Manning's n values were likely too high and/or additional conveyance needed to be added by removing ineffective flow areas at transects that contribute to conveyance. Also, model geometry at all transects needed to be reviewed to ensure accuracy and consistency.

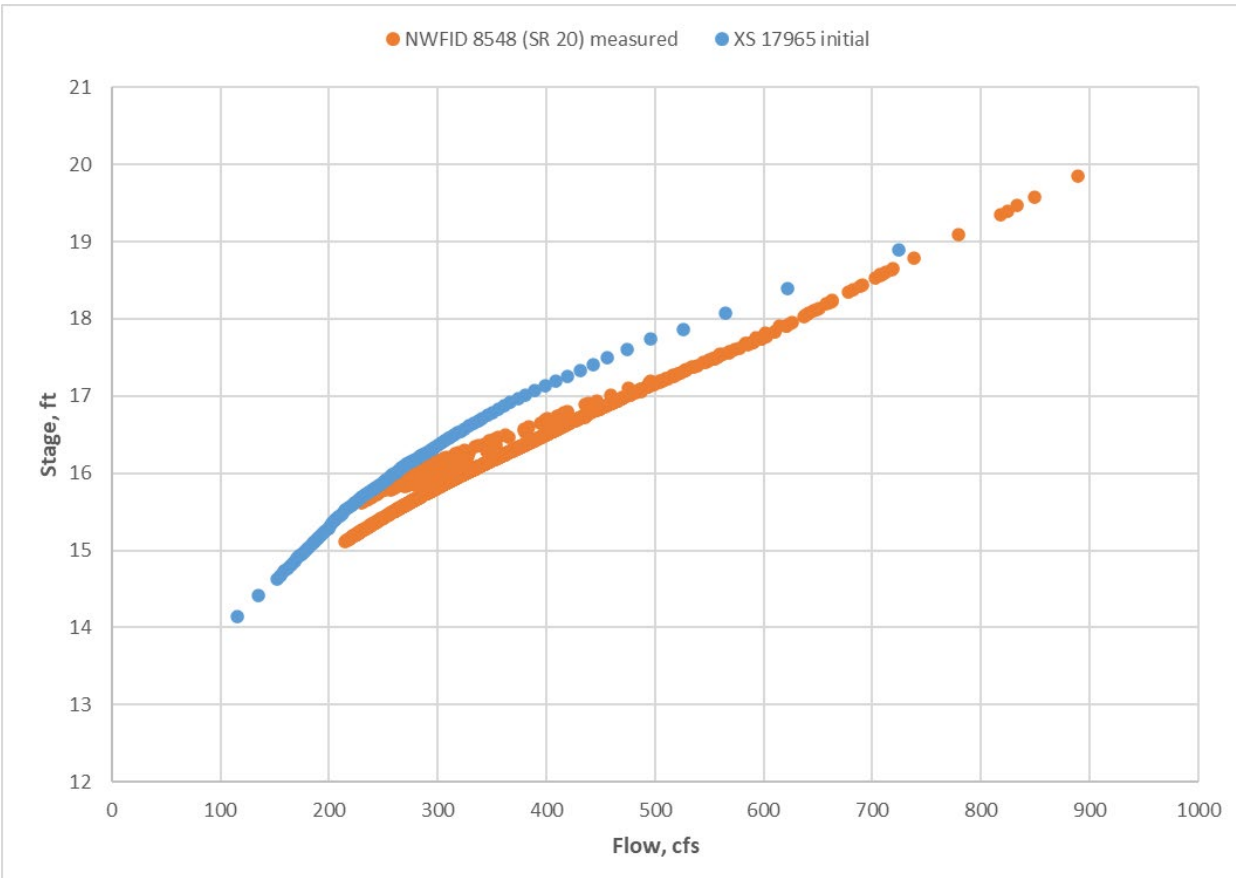


Figure 3-3. Comparison of measured stage-discharge rating at NWFWMD 8548 (Econfina Creek @ SR 20 with Initial simulated stage-discharge rating at XS 17965 (nearest XS to Econfina Creek @ SR 20 station)

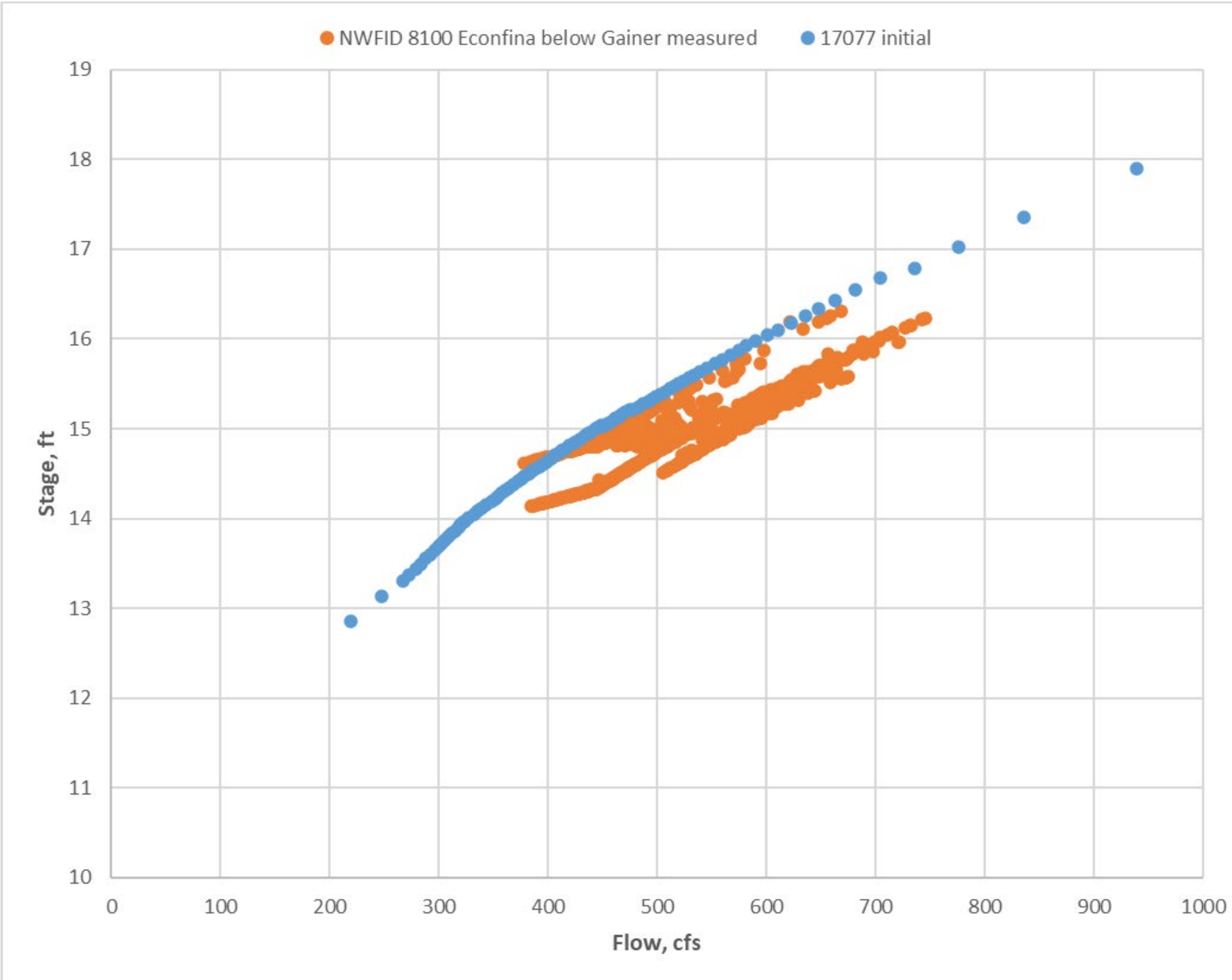


Figure 3-4. Comparison of measured stage-discharge rating at NWFWMD 8100 (Econfina Creek Below Gainer Spring Group) with initial simulated stage-discharge rating at XS 17077 (nearest XS to Econfina Creek Below Gainer Spring Group)

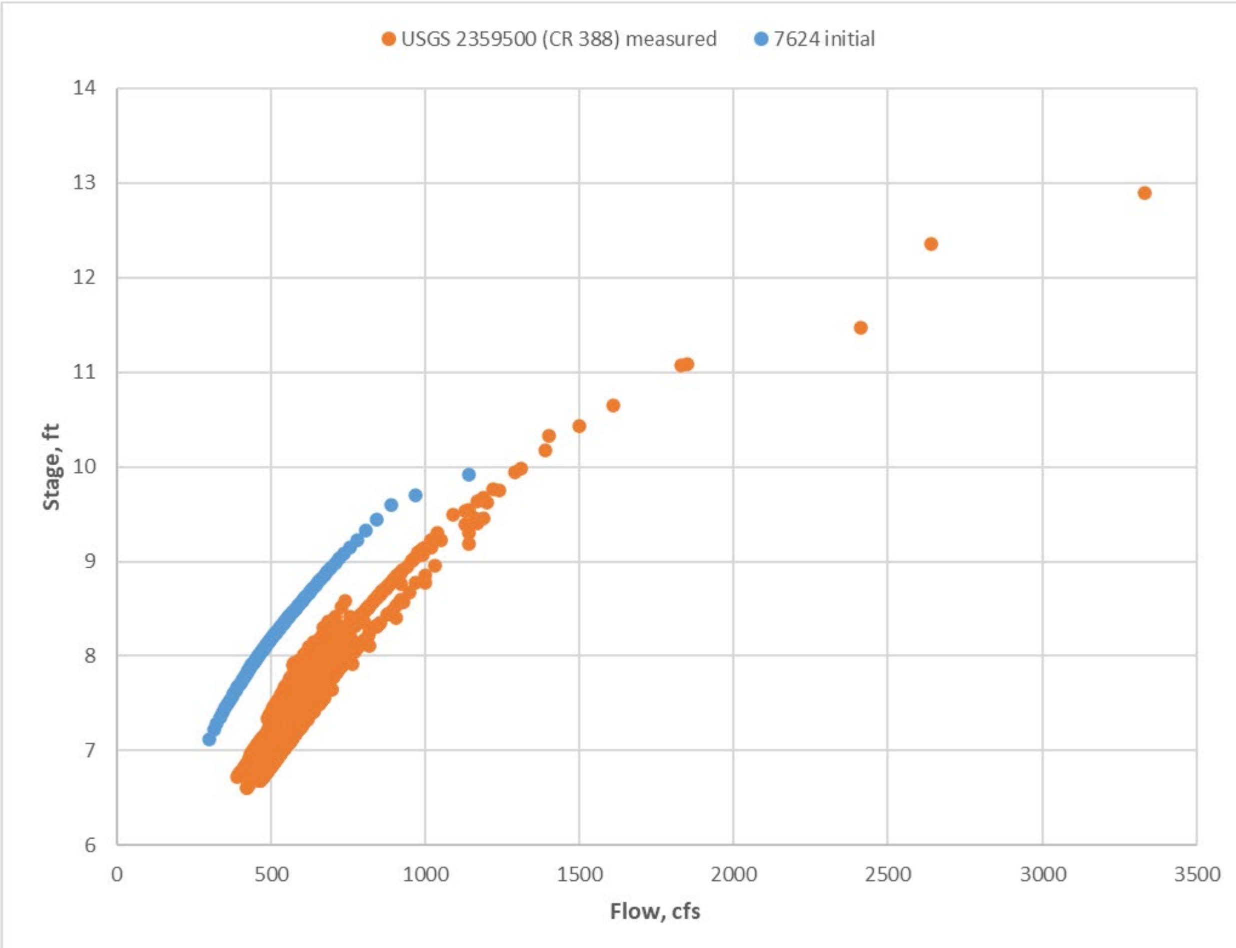


Figure 3-5. Comparison of measured stage-discharge rating at USGS 2359500 (Econfina Creek @ CR 388) with Initial simulated stage-discharge rating at XS 7624 (nearest XS to Econfina Creek @ CR 388 station)

3.4 Calibration Parameter Adjustments and Model Performance

The steady state HEC-RAS model was calibrated by adjusting model parameters to observed stages and flows at three locations with sufficient data along Econfina Creek. The primary model parameters adjusted were channel and floodplain roughness coefficients (Manning's n). Other adjustments included addition of interpolated cross sections to improve model stability near bridge crossings, adjustments to ineffective flow areas, and modifications to channel cross section geometry.

Review of initial error warnings suggested considering additional interpolated cross sections to improve model stability. Test simulations with added interpolated transects at 1,000 ft. and 500 ft. intervals resulted in minimal change to the overall water surface profile, except in the vicinity of the bridges, which appeared to stabilize the water surface profile in these areas. Therefore, interpolated transects immediately before and after both bridges were included in the final model. All other tested interpolated transects were removed.

Next, the sensitivity of ineffective flow areas was tested by performing several test runs removing select ineffective flow areas included in the initial run. Overall, the removal and/or modification of ineffective flow areas resulted in minimal changes to the resultant water profiles except at very high flows. All ineffective flow areas input into the initial run were maintained in the final run to depict the physical system as accurately as possible, although test runs revealed the model was not sensitive to these features, except at high flow.

After careful review of channel cross section geometry and ground profile, two modifications were made to deepen the channel at the CR 388 bridge as well at XS 3236, in the lower portion of the model where Econfina Creek begins to widen and transition into Deer Point Lake. The resultant ground elevation profile comparing the initial model simulation to the final calibrated model simulation (for 50th flow percentile) is shown in Figure 3-6. The initial profile suggests two shoals at the CR 388 bridge and at XS 3236, although field investigation did not identify shoals in these areas indicating the actual channel was likely deeper at these locations. Both locations were deepened to be consistent with nearby transects.

The primary model parameters adjusted to calibrate the Econfina Creek MFL HEC-RAS model were channel and floodplain roughness coefficients (Manning's n). Manning's n values for the main channel were constrained within the range of [0.03, 0.07] to represent natural channels, top width at flood stage <30m, as defined in Mays 1999. Several examples of streams utilizing a channel roughness of 0.05 +/- 0.005 are presented in Barnes 1987. Additionally, channel roughness was reduced in the deepest portions of select transects below CR 388, to reflect reduced friction in deep waters. Manning's n values for the floodplain were constrained within the range of [0.1, 0.25] to reflect medium to dense brush and remaining downed trees in the floodplain in the vicinity of Econfina Creek (Chow 1959).

Manning's n values were adjusted in an iterative process to replicate post debris removal measured stage discharge relationships at all three calibration locations. Goodness of fit was determined by graphical comparison of simulated to measured rating curves (Figures 3-7, 3-8, and 3-9). Graphical comparisons indicate the simulated rating curves replicate measured rating curves sufficiently at all three calibration locations. The simulated ratings are contained within the range of the measured ratings for all simulated percentile flows that could be compared. As described previously, the flow regime during the calibration period (April 1, 2019 – September 18, 2023) was higher than historical conditions due to increased precipitation and groundwater levels. Therefore, simulated historical conditions could not be compared under low flow conditions to measured data during the calibration period, although the majority of the flow regime coincides.

Computation of statistical model performance metrics including: mean squared error (MSE), correlation coefficient, R-squared, and Nash-Sutcliffe efficiency was determined for the Econfina Creek @ SR 20 and Econfina Creek below Gainer stations by defining a base rating curve for each station, defined to be the current rating curve associated with normal hydrologic conditions for a riverine system (Table 3-2).

Continuous discharges for both NWFWMD 8100 Econfina Creek @ SR 20 and NWFWMD 8100 Econfina Creek Below Gainer Spring Group were calculated using a stage-discharge rating curve. A stage-discharge rating curve is the relationship between the water level (stage) at a particular point in a stream and a corresponding streamflow (discharge). The curve is created by collecting concurrent streamflow/water level measurements across the range of hydrologic conditions for a given system. The synchronized points are then plotted. The initial plot forms the base rating curve. The stage-discharge relationship depends on the shape, size, slope, and roughness of the channel. Natural stream channels are rarely static. Periodically, shifts in the bottom substrate slightly alter the riverine hydrodynamics which changes the stage-discharge relationship. Changes to the channel will result in changes in the relationship between the stage and discharge. Shifts to the rating curve accommodate these changes. Shifts generally move around the axis of the base curve. Shifts (i.e. changes to the system) can be abrupt or gradual. They can be temporary, eventually returning to the base curve, or they can accumulate over time to create a new base rating curve. When shifts become relatively stable and no longer fluctuate around the base curve but instead fluctuate around a series of shifts, this indicates a longer-term change has occurred and a new base rating is created from the stabilized shift(s).

To evaluate a stage-discharge rating, regular stage/discharge measurements are made throughout the year to confirm the stage- discharge rating is still valid. When a measurement plots away from the current rating, the precipitation and stage from the data logger at the gauge is evaluated. If the data indicates a change in channel geometry and/or if the following stage/discharge measurement also shows a similar shift, the change is confirmed, and a shift is made to the rating. To implement a shift, a positive or negative adjustment to the stage is made based on the departure from the base rating. A positive shift indicates scour or the clearing of debris or vegetation from the channel either by floods or humans. A negative shift indicates deposition in the channel, debris jams or accumulation, or vegetative growth. If the changes to the system occur gradually, the shifts are prorated.

Econfina Creek is comprised primarily of sandy substrate and experiences periodic changes to stage-discharge relationships. NWFWMD 8548- Econfina Creek @ SR 20 has a total of 8 rating curves since the gauge's installation in 1992. Rating Curve 8 is applicable beginning March 2019 after the Hurricane Michael stream debris cleanup was completed, and is the base rating used to compute model performance metrics for this station. There are 3 shifts to date: November 2022 (-0.14 ft.), April 2023 (-0.36 ft.), and January 2024 (-0.14 ft.). All shifts plot above the base rating.

NWFWMD 8100- Econfina Creek above Gainer Spring Group has only one rating curve, established in March 2019 after the Hurricane Michael stream debris cleanup, and is the base rating used to compute model performance metrics for this station. There are 4 shifts to date: January 2022 (0.24 ft.), May 2022 (0.27 ft.), March 2023 (-0.50 ft.), and October 2023 (-0.40 ft.). Negative shifts plot above the rating. Positive shifts plot below the rating.

For Econfina Creek @ CR 388, only the current rating information is available from the USGS. Therefore, a base rating curve could not be determined and performance metrics were not computed for the model fit to this station.

Final Manning's n values for each transect are shown in Table 3-3. Compared to the initial run, Main channel Manning's n values for each transect were reduced as initial model simulations produced a water surface profile 0.5 ft. to 1.0 ft. too high. This is reasonable since little to no debris remained in the channel post debris cleanup. Floodplain Manning's n values were increased in some portions of the model domain, particularly in the lower portion where heavy debris remains in the floodplain.

A comparison of the final calibrated water surface profile with the initial simulated water surface profile is shown in Figure 3-6 (for the PF 50 simulation). The water surface was lowered 0.5 ft. to 1 ft. throughout most of the model domain, with the furthest departures occurring in the middle portion of the model domain. The water surface profile toward the end of the model domain remained relatively unchanged as Econfina Creek widens into Deer Point Lake. Energy losses through both bridges were minimal.

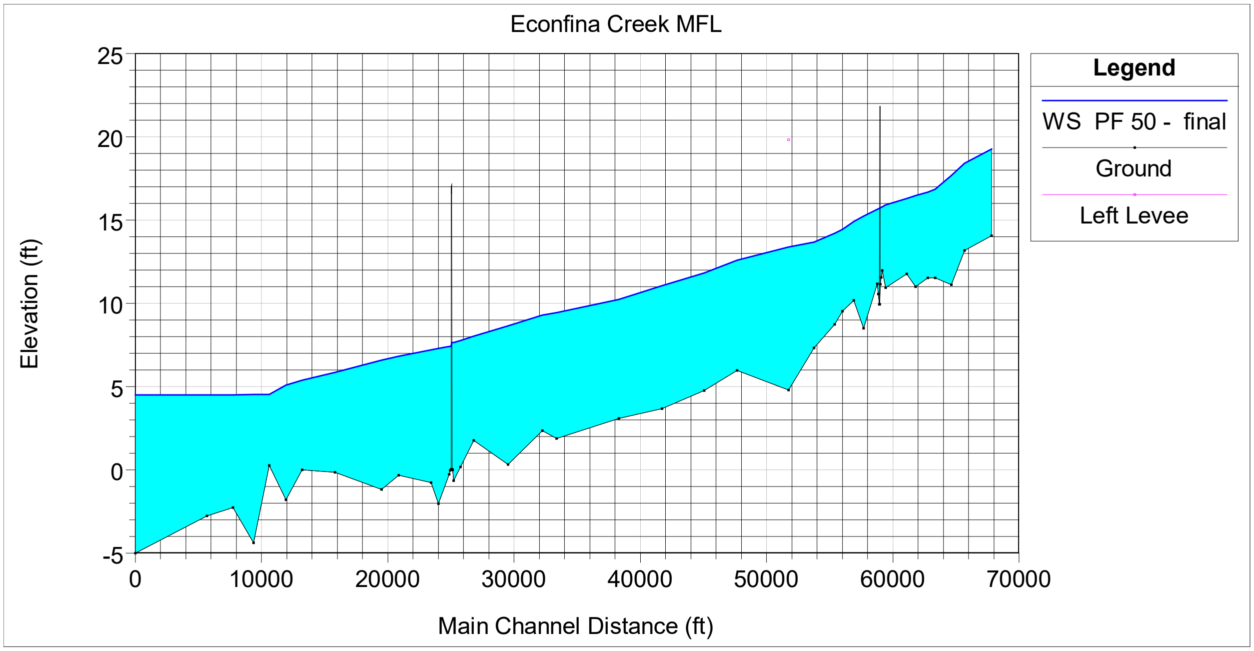


Figure 3-6. Final calibrated water surface profile

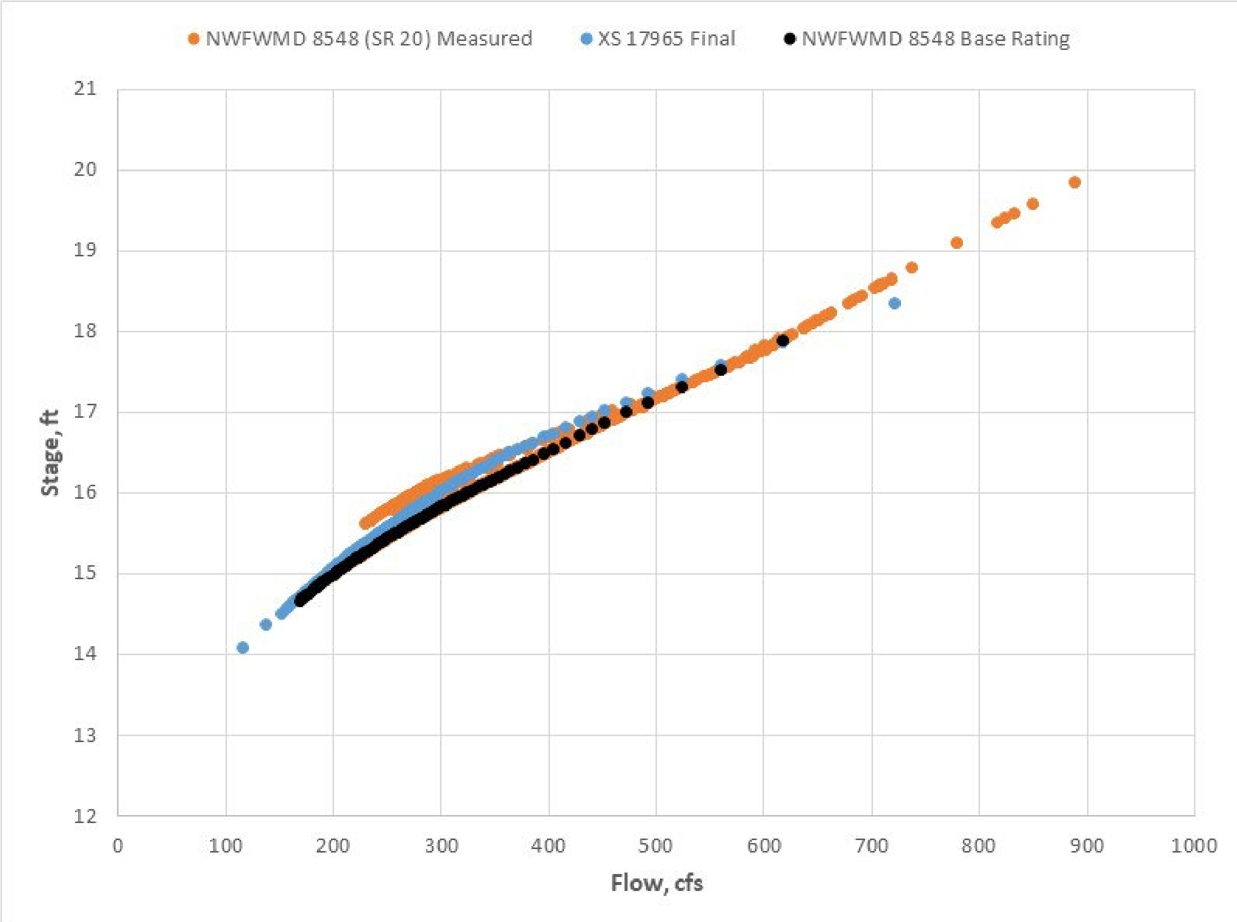


Figure 3-7. Comparison of measured stage-discharge rating at NWFWMD 8548 (Econfina Creek @ SR 20 with final simulated stage-discharge rating at XS 17965 (nearest XS to Econfina Creek @ SR 20 station)

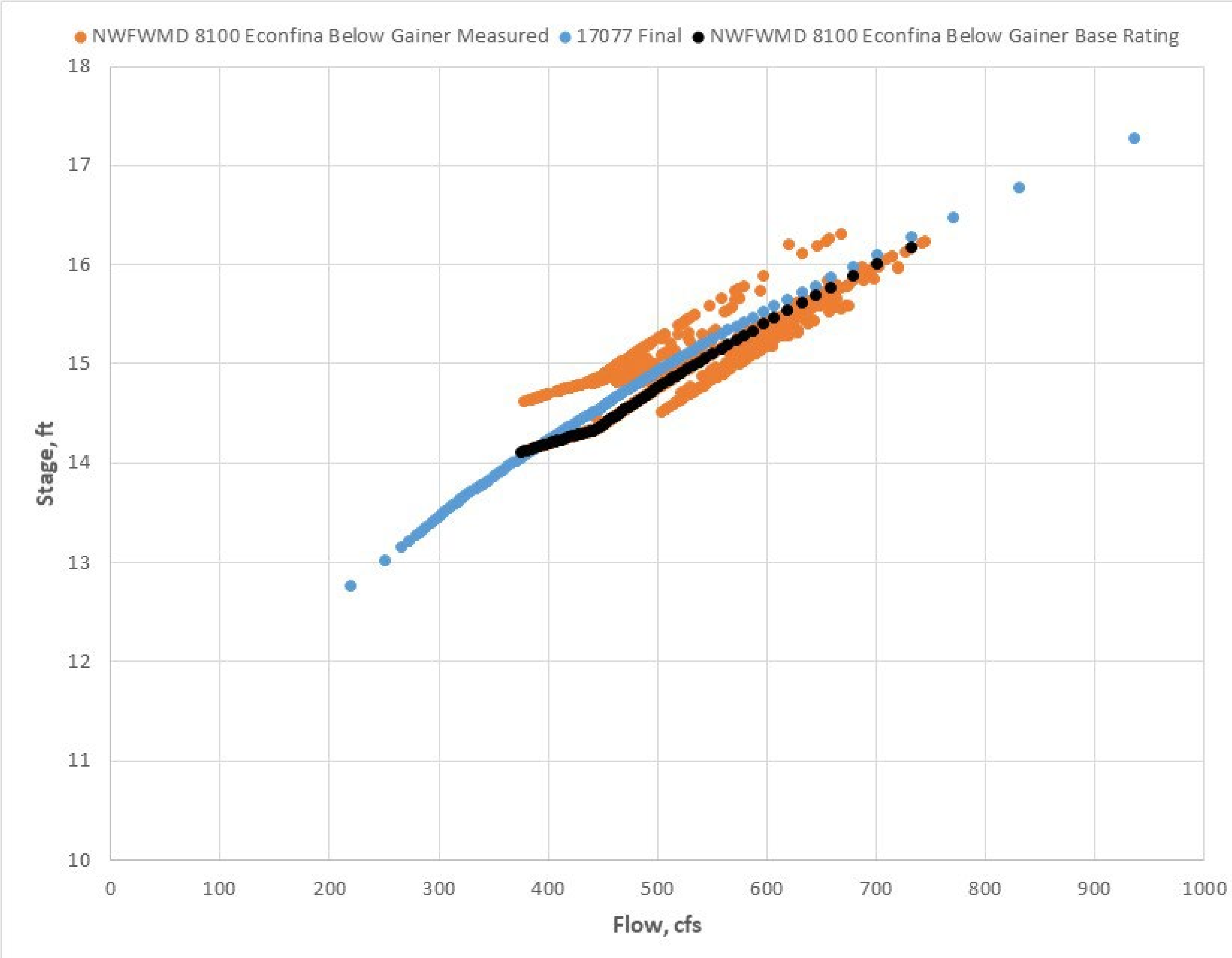


Figure 3-8. Comparison of measured stage-discharge rating at NWFWMD 8100 (Econfina Creek Below Gainer Spring Group) with final simulated stage-discharge rating at XS 17077 (nearest XS to Econfina Creek Below Gainer Spring Group)

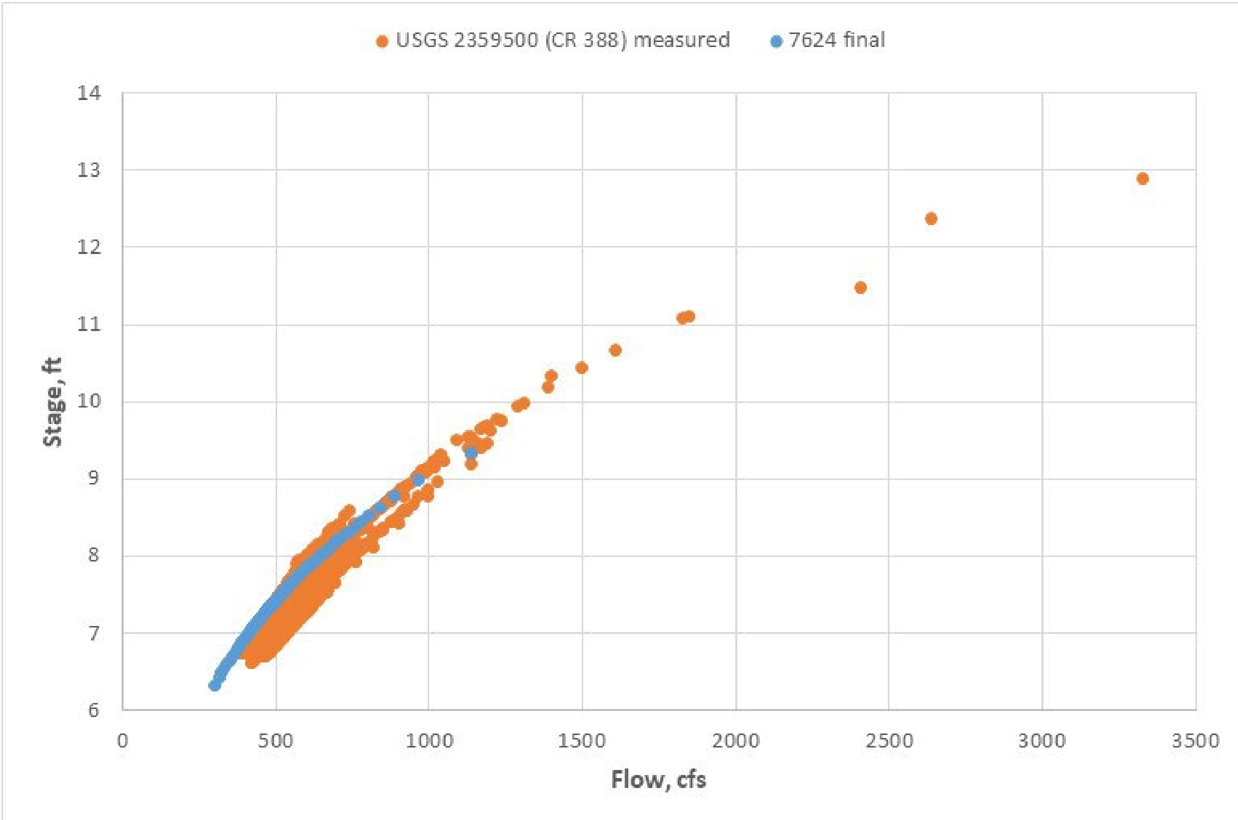


Figure 3-9. Comparison of measured stage-discharge rating at USGS 2359500 (Econfina Creek @ CR 388) with final simulated stage-discharge rating at XS 7624 (nearest XS to Econfina Creek @ CR 388 station)

Table 3-2. Model Calibration Performance Metrics

Model Performance Metric	NWFID 8548 (Econfina Creek @ SR 20)	NWFID 8100 (Econfina Creek Below Gainer Spring Group
MSE	0.0239	0.0195
Correlation Coefficient	0.9973	0.9932
R-squared	0.9947	0.9863
Nash- Sutcliffe	0.9474	0.9301

Table 3-3. Final assignment of Manning's n values

River Station	n #1	n #2	n #3	n #4	n #5	n #6	n #7
20680	0.25	0.055	0.25				
20020	0.25	0.055	0.25				
19710	0.25	0.055	0.25				
19319	0.25	0.055	0.25				
19130	0.25	0.055	0.25				
18837	0.25	0.055	0.25				
18623	0.25	0.055	0.25				

18119	0.25	0.055	0.25				
18040	0.25	0.055	0.25				
18013	0.25	0.055	0.25				
17986	0.25	0.055	0.25				
17975	*bridge*						
17965	0.25	0.055	0.25				
17937	0.25	0.055	0.25				
17914	0.25	0.065	0.25				
17583	0.25	0.065	0.25				
17346	0.2	0.065	0.2				
17077	0.2	0.065	0.2				
16891	0.2	0.065	0.2				
16392	0.2	0.065	0.2				
15775	0.2	0.065	0.2				
14534	0.2	0.065	0.2				
13738	0.2	0.065	0.2				
12723	0.2	0.065	0.2				
11676	0.2	0.065	0.2				
10170	0.2	0.060	0.2				
9832	0.2	0.060	0.2				
8998	0.2	0.060	0.2				
8178	0.2	0.060	0.2				
7858	0.2	0.060	0.2				
7686	0.2	0.060	0.2				
7669	0.2	0.050	0.2				
7649	0.2	0.050	0.2				
7636	*bridge*						
7624	0.25	0.050	0.25				
7608	0.25	0.050	0.25				
7586	0.25	0.050	0.03	0.05	0.25		
7322	0.25	0.052	0.03	0.05	0.25		
7137	0.25	0.052	0.25				
6361	0.25	0.052	0.25				
5946	0.25	0.052	0.03	0.05	0.25		
4828	0.25	0.052	0.03	0.05	0.25		
4032	0.25	0.052	0.25				
3633	0.25	0.052	0.03	0.05	0.25		
3236	0.25	0.052	0.03	0.05	0.03	0.05	0.25
2851	0.25	0.052	0.03	0.05	0.25		
2360	0.25	0.052	0.03	0.05	0.25		
1727	0.25	0.052	0.03	0.05	0.03	0.05	0.25
3	0.25	0.050	0.03	0.05	0.25		

4 References

Applied Technology and Management, Inc. 2021. Econfina Creek Reconnaissance: Summary of Observations and Recommendations. Final Technical Memorandum.

Barnes, Jr., H.H. 1987. Roughness Characteristics for Natural Channels. USGS Water Supply Paper 1849, Washington, D.C.

Chow, V.T. 1959. Open-channel hydraulics: New York, McGraw-Hill Book Co. 680 p.

Mays, L.W. 1999. Hydraulic Design Handbook. McGraw Hill, New York.

McKay, L., Bondelid, T., Dewald, T., Johnston, J., Moore, R., and Rea, A., “NHDPlus Version 2: User Guide”, 2012.

Southeastern Surveying and Mapping Inc. 2021a. Specific Purpose Survey- Econfina Creek Transects and Staff Gauges. Final Report.

Southeastern Surveying and Mapping Inc. 2021b. Specific Purpose Survey- Additional Econfina Creek Transects. Final Report.

Southeastern Surveying and Mapping Inc. 2023. Specific Purpose Survey- Lower Econfina Creek Transects. Final Report.

US Army Corps of Engineers. 2020. HEC-RAS River Analysis System User’s Manual. Version 6.0. HEC-RAS User's Manual (army.mil)