Compass
Identify, Interpret, Integrate

Toledo Bend Watershed, LA/TX
Base Level Engineering (BLE) Results

Contract #HSFE60-15-D-0003, Task Order #70FA6019F00000035
November 2020

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DOCUMENT HISTORY

DOCUMENT LOCATION

K:/FY2020/20-06-0051S/Hydraulics|Toledo Bend LA| BLE 03

REVISION HISTORY

Version Number	Version Date	Summary Changes	Team/Author
1.0	November 2020	Initial Draft	AECOM

APPROVALS

This document requires the approval of the following persons:

Role	Name	Review Date	Approved Date
Project Manager	Elizabeth Levitz	November 30, 2020	November 30, 2020

CLIENT DISTRIBUTION

Name	Title/Organization	Location
FEMA's MIP	Region VI	See path above
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Executive Summary

FEMA Region VI contracted Compass to complete a Base Level Engineering (BLE) analysis for the Toledo Bend HUC-8 at the Texas/Louisiana border, to support FEMA's Discovery process and validation of effective Zone A Special Flood Hazard Areas (SFHAs). This BLE study will provide significant data for several Texas counties previously lacking modernized flood models.

The BLE process involves using best available data and incorporating automated techniques with traditional model development procedures to produce regulatory-quality flood hazard boundaries for the 1-percent annual chance event as well as estimates of flood hazard boundaries for multiple recurrence intervals.

The source digital terrain data used for surface model development in support of hydrologic and hydraulic analysis as well as mapping activities were leveraged from various local, State, and Federal partners. Details regarding the different datasets used are provided below in Section 1.1.

Flood discharges in Texas for this study were calculated using both the United States Geological Survey (USGS) regression equations and gage analysis, where stream gages with sufficient record exist. Regression equations were obtained from the USGS Scientific Investigations Report (SIR) 2009-5087, *Regression Equations for Estimation of Annual Peak-Streamflow Frequency for Undeveloped Watersheds in Texas Using an L-moment Based, PRESS-Minimized, Residual-Adjusted Approach* (2009). For flood discharges in Louisiana, regression equations were obtained from the USGS Fact Sheet 099-01, *Methods for Estimating Flood Magnitude and Frequency in Rural Areas in Louisiana* (2001).

The Hydrologic Engineering Center's River Analysis System (HEC-RAS) program version 5.0.5 was used to compute water surface elevations on a stream by stream basis. All hydraulic models were computed using 1-D steady state analysis.

The stream mile network that was validated for these watersheds was compiled using FEMA's Community Needs Management Strategy (CNMS) inventory. CNMS is an inventory of flood hazard studies and flood hazard mapping needs for areas where a study is needed. This data is helpful for community officials in analyzing and depicting flood hazards to enhance the understanding of flood risks. Communities may use this information to make informed decisions on their planning and flood mitigation efforts. Table ES-1 lists the Zone A stream miles associated with this validation analysis.

Table ES-1: Summary of Stream Miles

Source	Toledo Bend Stream Miles
CNMS	1,368.4

The full inventory of Zone A studies in the watershed were classified in CNMS. Total miles validated in CNMS are summarized in Table ES-2 and illustrated in Figure ES-1 below.

Table ES-2: Zone A Validation Results

Validation Status	Status Type	Total Miles
VALID	BEING STUDIED	21.9
UNVERIFIED	BEING STUDIED	1,346.4

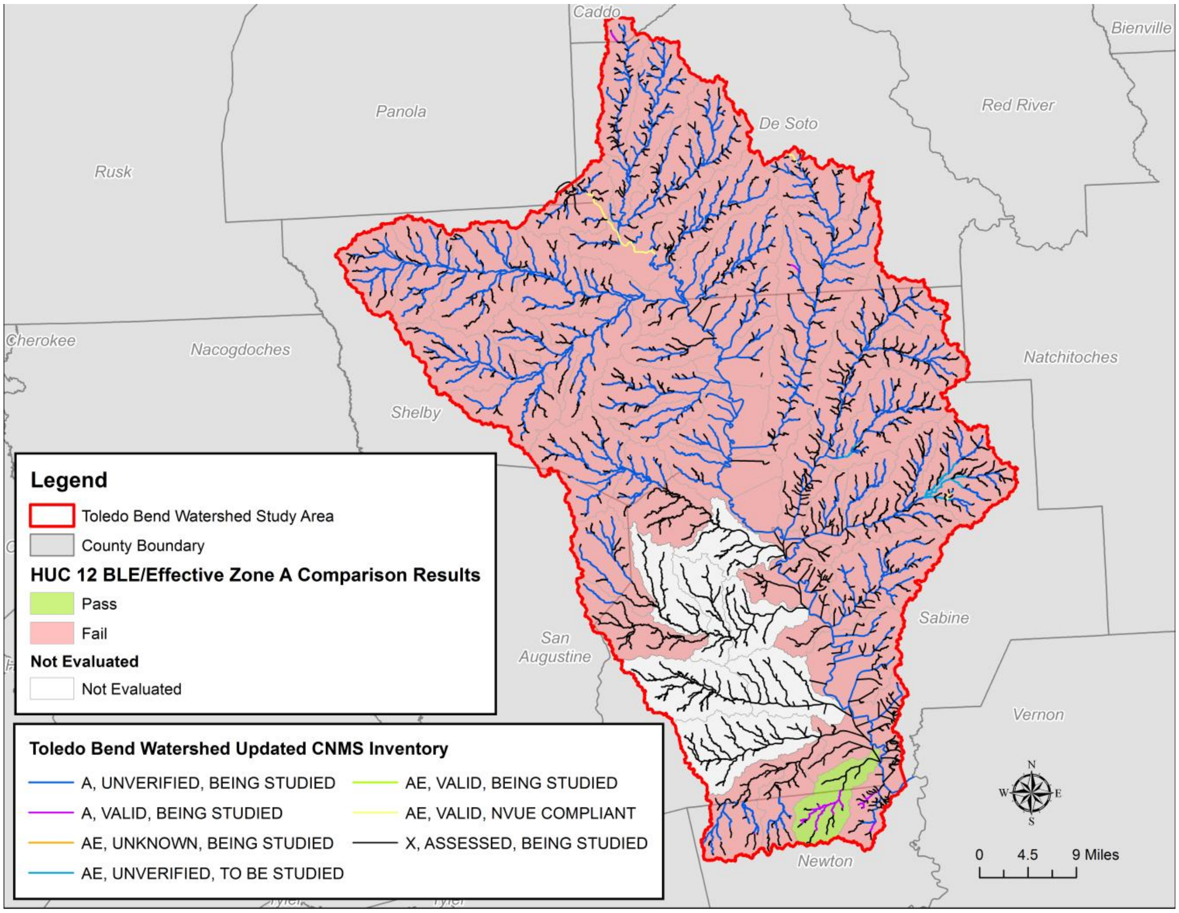

Figure ES-1: Toledo Bend Watershed CNMS Validation Results

An overall risk for each HUC-12 watershed was calculated using the National Flood Risk Percentages Dataset and its proportional area. The weighted risk was multiplied by the percentage of points in the watershed that failed the CNMS comparison to effective to determine the priority score. Figure ES-2 below shows the range of the Toledo Bend HUC-8 priority scores which can be used to initiate discussions during the Discovery phase.

Smith Creek-Flat Fork Creek HUC-12 was determined to have the highest priority score and the most need while Mill Creek-Toledo Bend Reservoir HUC-12 had the lowest scores.

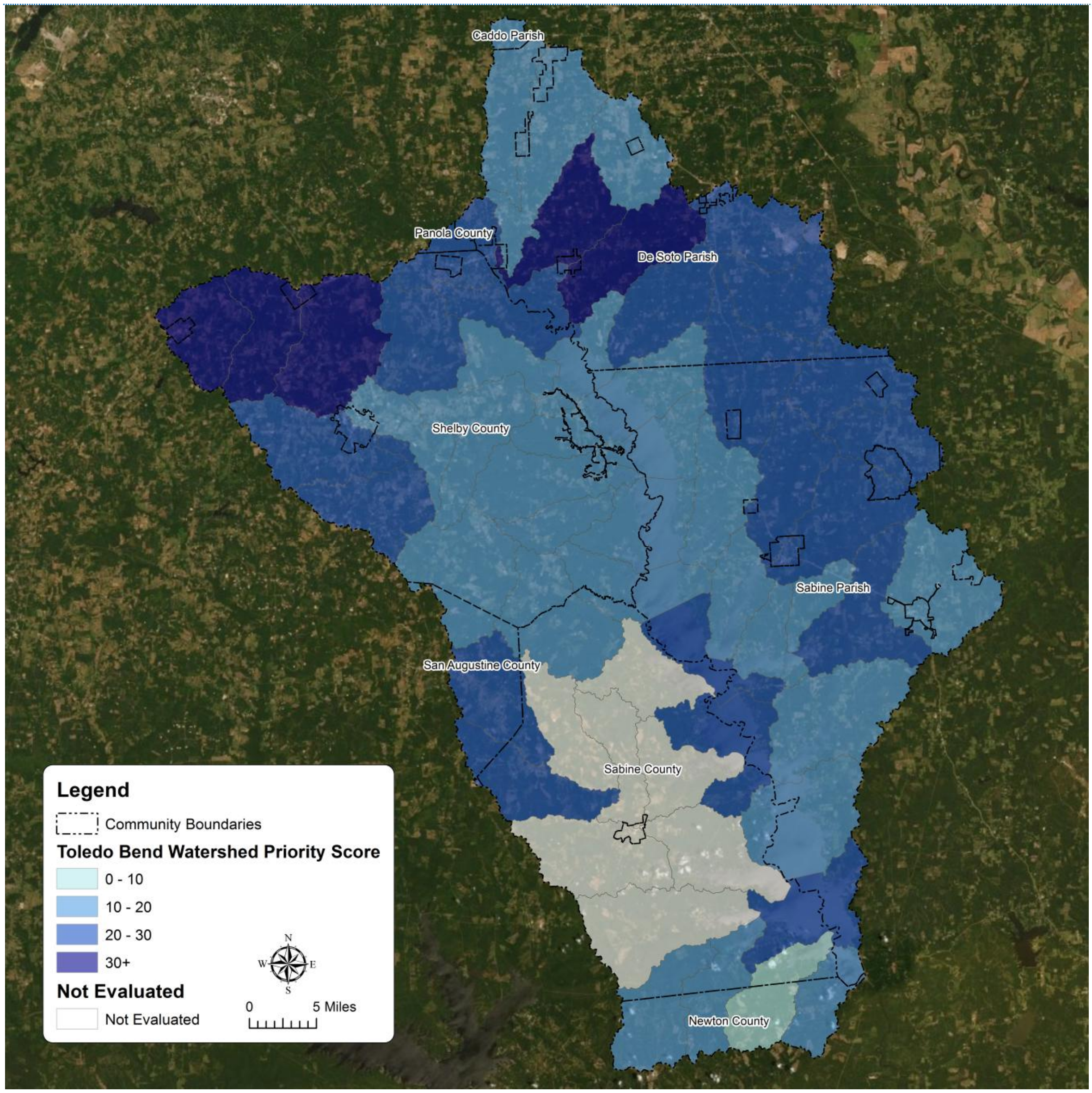

Figure ES-2: Ranking of Toledo Bend Watershed HUC-12s

Base Level Engineering (BLE) Methodology

Recent innovations and efficiencies in floodplain mapping have allowed the U.S. Department of Homeland Security's Federal Emergency Management Agency (FEMA) to develop a process called Base Level Engineering (BLE), which can be used to address current program challenges, including the validation of Zone A studies and the availability of flood risk data in the early stages of a Flood Risk Project. The BLE process involves using best available data and incorporating automated techniques with traditional model development procedures to produce regulatory quality flood hazard boundaries for the 1-percent annual chance event as well as estimates of flood hazard boundaries for multiple recurrence intervals. The cost for developing the data and estimates resulting from the BLE process are lower than standard flood production costs. The BLE results may be used for eventual production of regulatory and non-regulatory products.

As described in Title 42 of the Code of Federal Regulations, Chapter III, Section 4101(e), once every five years, FEMA must evaluate whether the information on Flood Insurance Rate Maps (FIRMs) reflects the current risks in flood-prone areas. FEMA makes this determination of flood hazard data validity by examining flood study attributes and change characteristics, as specified in the Validation Checklist of the Coordinated Needs Management Strategy (CNMS) Technical Reference. The CNMS Validation Checklist provides a series of critical and secondary checks to determine the validity of flood hazard areas studied by detailed methods (e.g., Zone AE, AH, or AO). While the critical and secondary elements in CNMS provide a comprehensive method of evaluating the validity of Zone AE studies, a cost-effective approach for evaluating Zone A studies has been lacking.

In addition to the need for Zone A validation guidance, FEMA standards require flood risk data to be provided in the early stages of a Flood Risk Project. FEMA Program Standard SID #29 requires that during Discovery, data must be identified that illustrates potential changes in flood elevation and mapping that may result from the proposed project scope. If available data does not clearly illustrate the likely changes, an analysis is required that estimates the likely changes. This data and any associated analyses should be shared and results should be discussed with stakeholders.

An important goal of the BLE process is the scalability of the results. Scalability means that the results of a BLE analysis can not only be used for CNMS evaluations of Zone A studies, but can also be leveraged throughout the Risk MAP program. The data resulting from a BLE analysis can be updated as needed and used for the eventual production of regulatory and non-regulatory products, outreach and risk communication, and MT-1 processing. Leveraging this data outside the Risk MAP program may also be valuable to external stakeholders.

FEMA Region VI contracted Compass to complete a BLE analysis for the Toledo Bend Watershed in Eastern Texas and Western Louisiana to support FEMA's Discovery process and validation of effective Zone A Special Flood Hazard Areas (SFHA). The study extents include portions of Caddo, De Soto, Natchitoches, Newton, Panola, Sabine, San Augustine, and Shelby Counties, and include the following communities: the City of Center, Hemphill, Huxley, Joaquin, Town of Keachi, Logansport, Many, Zwolle, Village of Converse, Grand Cane, Longstreet, Noble, Pleasant hill, South Mansfield, and Stanley. The study area consists of eleven HUC-10 basins: Bayou La Nana, Bayou San Patricio, Bayou Siep-Toledo Bend Reservoir, Flat Fork Creek, Grand Cane Bayou-Toledo Bend Reservoir, Housen Bayou-Toledo Bend Reservoir, Palo Gaucho Bayou, Patroon Bayou, San Miguel Bayou, Sixmile Creek-Toledo Bend Bayou, and Tenaha Creek. Figure 1 shows the orientation of the Toledo Bend Watershed HUC-10 basins with respect to the counties.

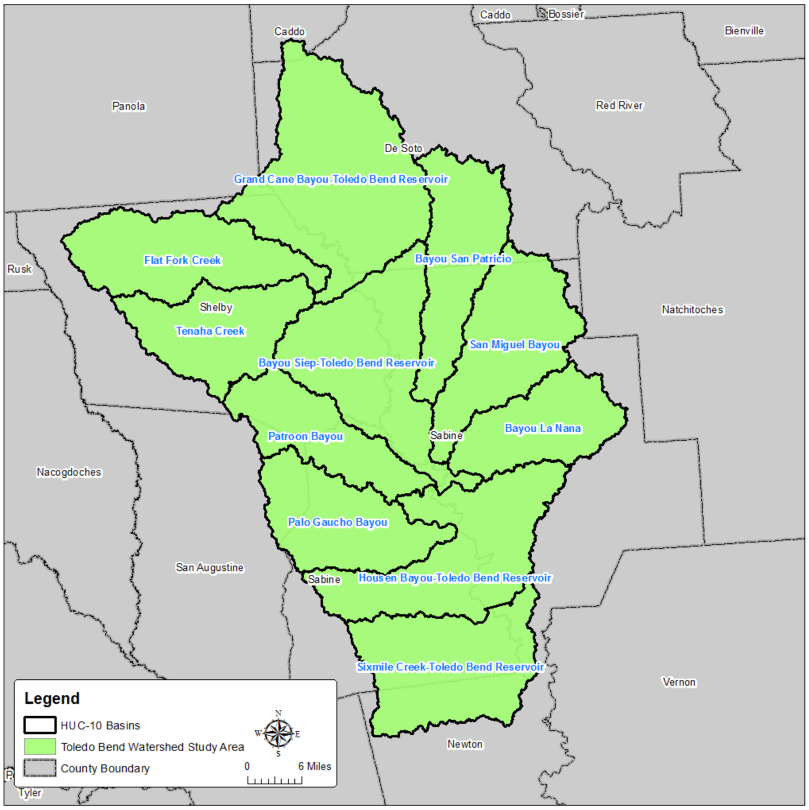

Figure 1: Toledo Bend Watershed HUC-10 Basins

AECOM studied approximately 3,260 miles of stream reaches within the Toledo Bend Watershed with a minimum drainage area tolerance of one square mile outside of population centers and half a square mile inside population centers. The selection and extent of stream reaches studied were based upon the number of stream miles with a minimum drainage area of one square mile and not the number of effective Zone A stream miles. Study reaches were extended above this threshold as appropriate to ensure all effective Zone A flood areas received an updated analysis. Topographic data from multiple sources were used to determine the hydrologic and hydraulic characteristics of the watershed. The following sections summarize the BLE process and discuss the results along with their recommended use.

1.1 Topographic Data

Topographic data from multiple sources were used to determine the hydrologic and hydraulic characteristics of the watershed. Topographic data were obtained from the Texas Natural Resources Information System (TNRIS), and the United States Geological Survey (USGS).

All available metadata, survey reports, and other leverage documentation are available with the source dataset. Figure 2 shows the extents of the source Digital Terrain Model (DTM) data used for the Toledo Bend Watershed.

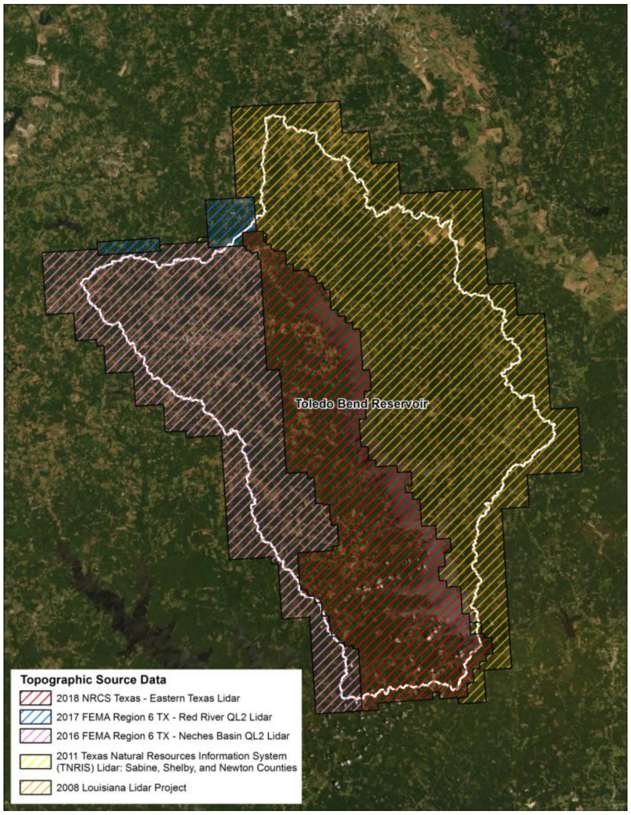

Figure 2: Extent of LiDAR Data for Toledo Bend Watershed

1.1.1 Source Terrain Data

Five topographic datasets were used in the development of the BLE hydraulic models. Details on each dataset are outlined below.

1.1.1.1 2018 NRCS Texas – Easter Texas LiDAR

The 2018 NRCS Texas – Eastern Texas LiDAR was acquired from the United States Geological Survey (USGS). Data was collected and processed by Digital Aerial Solutions (DAS), LLC. The LiDAR data was collected from March 6th to March 21st of 2018. This task order requires LiDAR data to be acquired over approximately 5,577 square miles of LiDAR affecting Leon, Washington, Sabine, San Jacinto, Shelby, Grimes, Lee, Madison, Milam, Trinity and Newton Counties in Texas. The LiDAR was collected at a nominal pulse spacing (NPS) of 0.7 meters. The LiDAR data was acquired and processed in compliance with USGS National Geospatial Program LiDAR Base Specification version 1.2. The Root Mean Square Error (RMSE)z reported for the dataset was 5.1 cm at the 95% confidence level which meets project accuracy specifications of the National Standard for Spatial Data Accuracy (NSSDA).

1.1.1.2 2017 FEMA Region 6 TX – Red River QL2 LiDAR

This USGS LiDAR collection covers portions of Lamar, Red River, Bowie, Franklin, Titus, Morris, Cass, Camp, Wood, Upshur, Marion, Gregg, Smith, Harrison, Rusk, Panola, and Hopkins Counties, Texas. The primary purpose of this project was to develop a consistent and accurate surface elevation dataset derived from high-accuracy LiDAR technology for the Texas Red River FEMA R6 Project Area. The LiDAR data were processed and classified according to project specifications. Detailed breaklines and bare-earth DEMs were produced for the project area. Data was formatted according to tiles with each tile covering an area of 1500m by 1500m. A total of 10,138 tiles were produced for the project encompassing an area of approximately 8,587 sq. miles.

Dewberry served as the prime contractor for the project. In addition to project management, Dewberry was responsible for LAS classification, all LiDAR products, breakline production, DEM production, and quality assurance. Quantum Spatial and Precision Aerial Reconnaissance completed LiDAR data acquisition and data calibration for the project area. Kinetics completed some breakline production in a portion of TX Red River FEMA R6 LiDAR Project. Dewberry was responsible for all QA/QC of the final deliverables. Data acquisition occurred January 20, 2017 through March 1, 2017. The project was funded by FEMA to assist with hydrologic studies and hydraulic analysis to determine the risk of flood hazards.

1.1.1.3 2016 FEMA Region 6 TX – Neches Basin QL2 LiDAR

This USGS LiDAR project was conducted to capture the Neches river basin in East Texas. The project area falls within the Texas counties of Kaufman, Navarro, Freestone, Leon, Madison, Van Zandt, Henderson, Smith, Anderson, Cherokee, Rusk, Shelby, Nacogdoches, Houston, Trinity, Angelina, San Augustine, Sabine, Newton, Jasper, Tyler, Hardin, Polk, Liberty, Jefferson and Orange. The LiDAR data were processed and classified according to project specifications. Detailed breaklines and bare-earth DEMs were produced for the project area. Data was formatted according to tiles with each tile covering an area of 1500m by 1500m. The Texas Neches area of interest covers approximately 14,148 square miles and an additional 89 square miles of Texas Red River was added to the Texas Neches LiDAR project. A total of 16,796 tiles were produced for the project encompassing an area of approximately 14,237 sq. miles.

Dewberry served as the prime contractor for the project. In addition to project management, Dewberry was responsible for LAS classification, all LiDAR products, breakline production, DEM production, and quality assurance. Quantum Spatial, Inc (Quantum Spatial) and Precision Aerial Reconnaissance (PAR) completed LiDAR data acquisition and data calibration for the project area.

The date of the acquisition spanned two years. Collection in 2016 was flown March 3, 2016 through March 5, 2016. Collection in 2017 was flown January 25, 2017 through February 22, 2017. A reflight occurred on October 9, 2017. The LiDAR data was acquired and post-processed by Quantum Spatial and Dewberry. The purpose of this project was to produce high accuracy 3D elevation products for the region which previously did not have any LiDAR data.

1.1.1.4 2011 Texas Natural Resources Information System (TNRIS) LiDAR: Sabine, Shelby, and Newton Counties

This StratMap LiDAR collection covers portions of Sabine, Shelby and Newton Counties in East Texas. Aerial collection took place from January 12 to February 13, 2011 by MJ Harden (now PhotoScience) and Dewberry provided third-party quality assurance and quality control (QA/QC). The project was funded through collaboration between the TNRIS and the Sabine River Authority (SRA). This project was procured through the Council on Competitive Government's High Priority Imagery and Datasets (HPIDS) contract. The area of interest was selected based on statewide prioritization of floodplain mapping needs and in coordination with SRA.

1.1.1.5 2008 Louisiana LiDAR Project

Begun in 2000, Louisiana's statewide LIDAR project was initiated in response to the high per capita and repetitive flood loss rates experienced by the FEMA, National Flood Insurance Program and the private insurance industry in the state. LIDAR derived, high-resolution topographic information has been accepted by FEMA as a low cost means to update inaccurate and out of date flood maps. The state sponsor for the project, thus far, has been the Louisiana Oil Spill Coordinators Office (LOSCO), which has managed the project and arranged for state match through legislative action. Oil spill contingency planning and response issues plague all Louisiana parishes requiring critical high resolution topographic information. The Louisiana Office of Emergency Preparedness (OEP) has recently assumed administrative control of the project, largely because of OEP's direct, official connection with FEMA. The LIDAR systems being used in the Louisiana project are accurate to 15- 30 cm RMSE, depending upon land cover, and will support contours of 1'-2' vertical map accuracy standards. The task areas included in this area fall within 8.81 - 15.94 cm RMSE. These accuracies meet FEMA standards for floodplain reevaluation studies and map modernization programs designed to update the Flood Insurance Rate Maps (FIRM).

1.1.2 Terrain Data Processing

The LiDAR data were processed in Environmental System Research Institute (ESRI) ArcGIS software to create a composite DTM dataset for the project area. The outputs from the processing described below were used during the hydrology, hydraulics, floodplain mapping and CNMS processes and validations.

The Watershed Information System (WISE) software platform was utilized in order to create a digital surface model for the Toledo Bend Reservoir project area. This module allows source data from a variety of sources to be prioritized based on level of accuracy or preference of the user. The 2018 NRCS Texas - Eastern Texas LiDAR dataset was prioritized as the best data source for the Toledo Bend Reservoir Watershed followed by the 2017 FEMA Region 6 TX - Red River QL2 LiDAR, 2016 FEMA Region 6 TX - Neches Basin QL2 LiDAR, 2011 TNRIS LiDAR: Sabine, Shelby, and Newton Counties, and 2008 Louisiana LiDAR Project.

The 10-foot DEMs created from the LiDAR datasets described above were compiled in order of vertical accuracy into a mosaic dataset using ArcMap. The normal pool elevation for the Toledo Bend reservoir was determined to be 171.75 feet. The reservoir is not always constant, so another raster was created for the lake boundaries and given the highest priority in the mosaic dataset in order to override the LiDAR datasets showing various elevations above and below normal pool. From this mosaic, a tile index was created for the project area and the mosaic was clipped into 40,000-foot tiles, converted to asciis and imported into Wise Terrain Analyst (WTA). Visual inspection of the 10-foot DEMs was performed to ensure no voids and/or artifacts were present. The DEM surface model was affirmed to be suitable for hydraulic takeoffs and supporting other hydraulic analyses.

Stream centerlines were manually digitized using the 10-foot DEMs as a source for horizontal alignment and vertical elevation. These stream centerlines are created for use in the hydraulic analysis-and hydro-enforcement of the 50-foot DEMs. Several routines were then used to take localized elevations from the source topographic data and apply them to the streams. This gave the stream vertices elevation information along the Z axis. The resulting elevations ensure that the streams are lower in elevation than any overbank sumps. A separate routine was then used to ensure that the elevations of these vertices descend in height down to an outfall. The final streams file is then "burned" into the 50-foot DEMs to force flow through structures while preventing it from jumping out of the channel banks.

After the DEM was imported, an additional 50-foot DEM was created from the same mosaic and tile index used for the 10-ft DEM. This 50-foot DEM was used for hydro enforcement of the project area. Proprietary software was used to identify natural sinks, peaks and flat areas in the 50-foot DEM surface. Elevations of the cells in the DEM were algorithmically calculated and the best path to route flow was determined without filling sinks in the DEM. Once all calculations were completed, the flow was checked confirming that all drainage flowed downstream correctly and routed to outside of the project area.

In addition to the quantitative assessment of the source digital terrain, a qualitative visual inspection of the composite DEM was performed using a hillshade derived from the 10-foot DEM. The visual inspection indicated no unusual or non-terrestrial features were observed in the composite DEM assuring the surface files used for hydrologic and hydraulic analyses and floodplain mapping activities are sufficient for BLE analysis.

1.2 Hydrology

Flood discharges for this study were calculated using both the USGS regression equations and gage analysis, where stream gages with sufficient record exist. Regression equations obtained from the USGS Scientific Investigations Report (SIR) 2009-5087, *Regression Equations for Estimation of Annual Peak-Streamflow Frequency for Undeveloped Watersheds in Texas Using an L-moment Based, PRESS-Minimized, Residual-Adjusted Approach* (2009) contain the most recent regression equations for Texas. For Louisiana, regression equations were obtained from the USGS Fact Sheet 099-01, *Methods for Estimating Flood Magnitude and Frequency in Rural Areas in Louisiana* (2001). Although some HUC-10 boundaries (Grand Cane Bayou, Bayou Siep, Housen Bayou, and Sixmile Creek) include reaches in both Louisiana and Texas, the respective regression equations were used for the basins and reaches existing in each state. There were no instances of a studied reach utilizing both Texas and Louisiana regression equations due to the Sabine River/Toledo Bend Reservoir flowing along the state boundary. There are differences in the parameters used in the Texas and Louisiana regression equations discussed in the following sections. USGS Peak FQ Version 7.3 was used to perform the Flood Frequency Analysis (FFA) for the twenty gages within the Toledo Bend Watershed (see below for further discussion).

1.2.1 Regression Analysis

The WISE software was used to delineate drainage basins in shapefile format using the 50-foot DEM. WISE was also used to calculate the main-channel slope for each basin. The basin shapefile attribution was automated by WISE with drainage area, main-channel slope, precipitation, and OmegaEM, all inputs for the USGS regression equations.

Table 1 shows the published equations used in this study for Texas. In these equations, Q_i represents peak streamflow for i-recurrence interval (annual chance exceedance (a.c.e.)) in cubic feet per second (cfs), P represents mean annual precipitation in inches, S represents dimensionless main-channel slope, Ω represents the OmegaEM parameter, and A represents cumulative drainage area in square miles.

Table 1: Summary of Regression Equations in Texas (SIR 2009-5087)

Recurrence Interval	Equation
$Q_{10\%}$	$P^{1.203} \times S^{0.403} \times 10^{[0.918\Omega + 13.62 - 11.97A^{\wedge}(-0.0289)]}$
$Q_{4\%}$	$P^{1.140} \times S^{0.446} \times 10^{[0.945\Omega + 11.79 - 9.819A^{\wedge}(-0.0374)]}$
$Q_{2\%}$	$P^{1.105} \times S^{0.476} \times 10^{[0.961\Omega + 11.17 - 8.997A^{\wedge}(-0.0424)]}$
$Q_{1\%}$	$P^{1.071} \times S^{0.507} \times 10^{[0.969\Omega + 10.82 - 8.448A^{\wedge}(-0.0467)]}$
$Q_{0.2\%}$	$P^{0.988} \times S^{0.569} \times 10^{[0.976\Omega + 10.40 - 7.605A^{\wedge}(-0.0554)]}$
Variables: Q_i, peak flow for i recurrence interval (a.c.e.), in cubic feet per second; P, mean annual precipitation, in inches; S, Main-channel slope (dimensionless); Ω, OmegaEM parameter; A, cumulative drainage area, in square miles	

Discharges for the 1-percent plus and 1-percent minus a.c.e. were calculated as well. These values were computed as $Q_{1\%+/-} = Q_{1\%} \pm 10^{1.6*0.30}$, where 0.30 is the mean residual standard error for the $Q_{1\%}$ equation.

The mean annual precipitation values were determined based on a shapefile coverage obtained from the TWDB and is available for download at the following location: https://www.twdb.texas.gov/mapping/gisdata.asp

The annual precipitation values reflect data for the climatological period 1981-2010 as recorded by the Natural Resources Conservation Service (NRCS).

Main-channel slope was calculated in WISE. An automated routine determined the longest flowpath from upstream of a reach to the outlet of the sub-basin of interest. Two points along the channel, one at 0 percent and the other at 100 percent of the channel length, determined the endpoints of the segment used in the main-channel slope calculation. The elevations for those endpoints were based on the 10-foot DEM developed from the LiDAR.

From SIR 2009-5087, the OmegaEM parameter is a generalized terrain and climate index that expresses relative differences in peak-streamflow potential. A shapefile was developed and populated with OmegaEM values based on Figure 2 in SIR 2009-5087. This shapefile was used to determine OmegaEM values on a sub-basin basis. For sub-basins spanning more than one OmegaEM grid, the sub-basin's centroid determined its OmegaEM parameter.

Table 2 shows the published equations used in this study for Louisiana. The study area is within the Pine hills physiographic region. In these equations, Q_i represents peak streamflow for i-recurrence interval (annual chance exceedance (a.c.e.)) in cubic feet per second (cfs), AP represents mean annual precipitation in inches, SLP represents channel slope channel slope measured between two points along the main channel, one at 10% of the channel length and the other at 85% of the channel length, in feet per mile, and DA represents cumulative drainage area in square miles.

Table 2: Summary of Regression Equations in Louisiana (Pine Hills Region) (FS099-01)

Recurrence Interval	Equation
$Q_{10\%}$	$19.5DA^{0.768} \times SLP^{0.392} \times (AP-35)^{0.658}$
$Q_{4\%}$	$28.0DA^{0.778} \times SLP^{0.401} \times (AP-35)^{0.629}$
$Q_{2\%}$	$34.6DA^{0.785} \times SLP^{0.407} \times (AP-35)^{0.616}$
$Q_{1\%}$	$41.2DA^{0.791} \times SLP^{0.412} \times (AP-35)^{0.610}$
$Q_{0.2\%}$	$56.0DA^{0.803} \times SLP^{0.425} \times (AP-35)^{0.608}$
Variables: Q_i, peak flow for i recurrence interval (a.c.e.), in cubic feet per second; DA, cumulative drainage area, in square miles AP, mean annual precipitation, in inches; SLP, channel slope measured between two points along the main channel, one at 10% of the channel length and the other at 85% of the channel length, in feet per mile	

Discharges for the 1-percent plus and 1-percent minus a.c.e. were calculated as well. These values were computed as $Q_{1\%+/-} = Q_{1\%} \pm 10^{1.6*0.30}$, where 0.49 is the standard of error, in percent.

The annual precipitation values reflect data for the climatological period 1981-2010 as recorded by the PRISM Climate group.

Main-channel slope was calculated in WISE. An automated routine determined the longest flowpath from upstream of a reach to the outlet of the sub-basin of interest. Two points along the channel, one at 10 percent and the other at 85 percent of the channel length, determined the endpoints of the segment used in the main-channel slope calculation. The elevations for those endpoints were based on the 10-foot DEM developed from the LiDAR.

Drainage area for each sub-basin was determined based on automated basin delineations performed by WISE. Basin break points were set by the user with a sub-basin target size of one square mile. This criterion was adjusted for the main stem of the Toledo Bend River to avoid excessive and unnecessary discharge breaks. Break points were also set immediately upstream of stream confluences. Cumulative drainage area was determined based on these automated delineations performed by WISE in combination with a stream connectivity routine that defined the stream reach segments with upstream and downstream neighbors.

The sub-basin shapefile was attributed with the computed regression discharges, and those discharges were incorporated into the Hydrologic Engineering Center's River Analysis System (HEC-RAS) models using an automated routine in WISE. Discharges, as well as water surface elevation results, were associated with the hydraulic cross-sections prior to generation of floodplain boundaries and grid mapping. Those results are available in GIS format as part of this BLE submittal package.

1.2.2 Stream Gage Analysis

Figure 3 shows the location of the twenty USGS stream gages on the Toledo Bend River mainstem used to develop weighted discharges for the study (Table 3). FFA were performed for all gages, according to USGS Bulletin 17C guidelines.

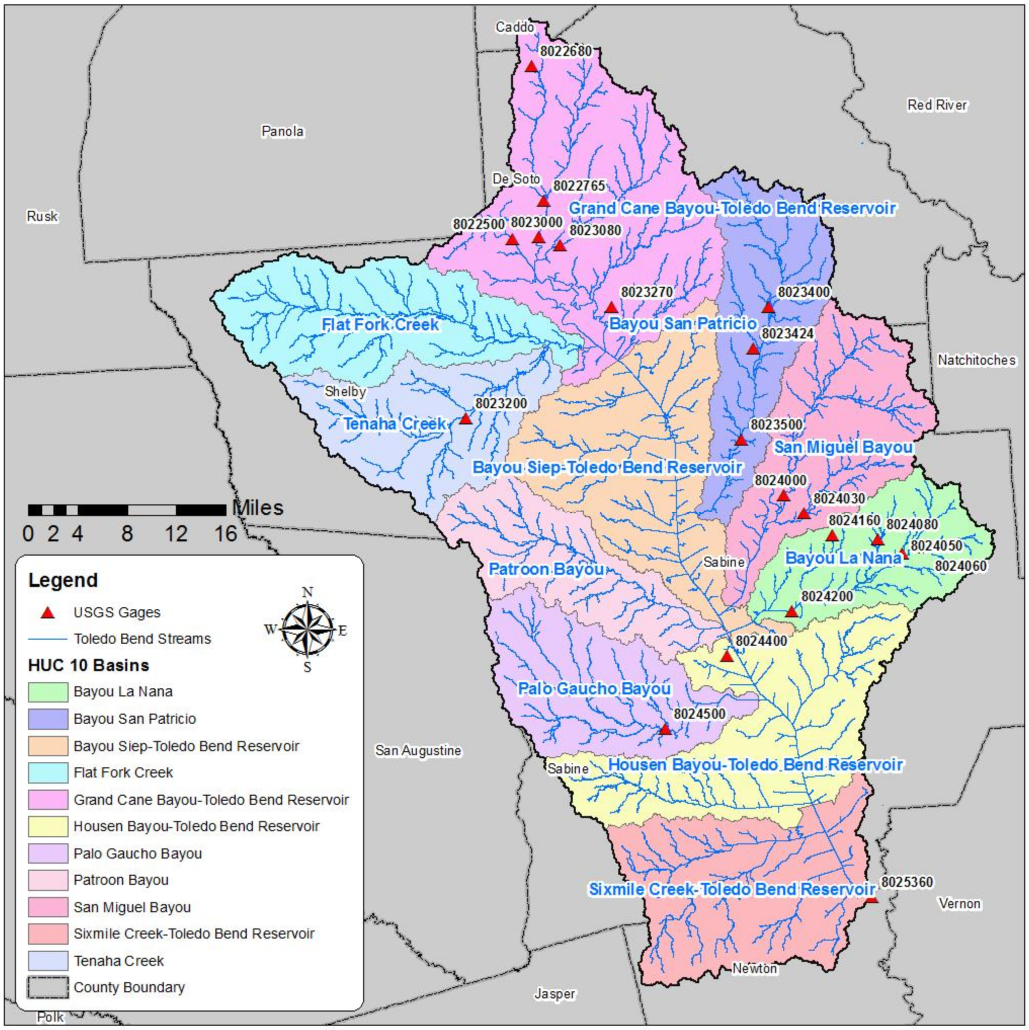

Figure 3: Locations of USGS Gages Utilized in Flood Frequency Analyses

Table 3: USGS Stream Gages in Toledo Bend Watershed

Gage ID	Flooding Source and Location	Computed Drainage Area (mi.^{2})	Published Drainage Area (mi.^{2})	Period of Record
08022765	Bayou Castor nr Funston, LA	90.1	91.5	1972-1986
08023000	Bayou Castor nr Logansport, LA	96.8	96.5	1955-1985
08023080	Bayou Grand Cane nr Stanley, LA	72.0	72.5	1981-2019
08024200	Bayou La Nana nr Zwolle, LA	130.1	130	1956-1966
08024000	Bayou San Miguel nr Zwolle, LA	113.2	111	1949-1967
08023400	Bayou San Patricio nr Benson, LA	80.6	80.2	1954-2019
08023500	Bayou San Patricio nr Noble, LA	154.1	154	1952-1967
08023424	Bayou San Patricio Trib No. 2 nr Converse, LA	1.0	0.9	1967-1981
08024030	Bayou Scie at Zwolle, LA	44.5	49.5	1950-2019
08024060	Blackwell Cr at Many, LA	3.5	3.2	1960-1983
08023270	Bull Bayou nr Hunter, LA	8.2	8.5	1964-1983
08022680	Bushneck Br Trib nr Keatchie, LA	1.0	1.2	1967-1981
08024050	Harpoon Bayou nr Many LA	23.3	22.7	1951-1968
08024160	Hurricane Creek Trib at Loring Lake nr Zwolle, LA	1.1	0.92	1954-1967
08024080	Lewis Creek nr Many, LA	12.8	12.5	1951-1965
08024500	Palo Gaucho Bayou nr Hemphill, TX	122.4	123	1952-1965
08022500	Sabine River at Logansport, LA	4,839	4,839	1884-2019
08025360	Sabine River at Toledo Bd Res nr Burkeville, TX	7,178	7,178	1972-2016
08024400	Sabine River nr Milam, TX	6,508	6,508	1924-1966
08023200	Tenaha Ck nr Shelbyville, TX	96.9	97.8	1952-1981

The flood flow frequency data from these gages were weighted with the regression developed discharges using the procedure described in SIR 2009-5087 and FS099-01. Adjusted discharges were held constant if the adjustment resulted in flows decreasing in the downstream direction.

Gage variances for each storm event were used to develop weighted discharges. These variances are provided in Table 4.

Table 4: Summary of Gage Variances Used

Gage ID	Variance				
	10PCT	4PCT	2PCT	1PCT	0.2PCT
08022765	0.0088	0.0125	0.0159	0.0199	0.0314
08023000	0.0072	0.0109	0.0145	0.0189	0.0321
08023080	0.0043	0.0065	0.0088	0.0116	0.0202
08024200	0.0194	0.0281	0.0360	0.0452	0.0708
08024000	0.0203	0.0298	0.0388	0.0495	0.0806
08023400	0.0042	0.0061	0.0083	0.0110	0.0198
08023500	0.0222	0.0322	0.0417	0.0527	0.0846
08023424	0.0222	0.0312	0.0399	0.0500	0.0789
08024030	0.0055	0.0083	0.0114	0.0153	0.0276
08024060	0.0036	0.0056	0.0074	0.0095	0.0154
08023270	0.0045	0.0065	0.0084	0.0106	0.0172
08022680	0.0178	0.0258	0.0333	0.0420	0.0670
08024050	0.0232	0.0342	0.0446	0.0568	0.0924
08024160	0.0124	0.0174	0.0222	0.0277	0.0436
08024080	0.0172	0.0251	0.0326	0.0412	0.0658
08024500	0.0229	0.0336	0.0436	0.0551	0.0882
08022500	0.0017	0.0022	0.0029	0.0039	0.0071
08025360	0.0061	0.0104	0.0154	0.0218	0.0430
08024400	0.0026	0.0036	0.0047	0.0062	0.109
08023200	0.0114	0.0172	0.0230	0.0299	0.0510

Weighted discharges were adjusted using a gage adjustment factor developed from a comparison between the rural and gage discharges and rounded to determine final discharges. Final discharges estimated by gage analysis adjustment, and used in the final BLE hydraulic models, are presented in Table 5.

Table 5: Final Discharges at USGS Stream Gages in Toledo Bend Watershed

Gage ID	10PCT (cfs)	4PCT (cfs)	2PCT (cfs)	1PCT (cfs)	0.2PCT (cfs)
08022765	5,760	8,020	9,880	11,770	16,850
08023000	5,350	7,750	9,790	11,980	18,070

Gage ID	10PCT (cfs)	4PCT (cfs)	2PCT (cfs)	1PCT (cfs)	0.2PCT (cfs)
08023080	8,390	11,480	14,070	16,980	24,680
08024200	8,620	12,890	16,590	20,600	32,180
08024000	9,870	15,180	19,940	25,700	41,950
08023400	10,380	15,160	19,300	24,050	36,930
08023500	8,950	13,770	18,040	22,980	36,930
08023424	510	760	980	1,230	1,910
08024030	9,410	14,700	19,550	25,460	42,600
08024060	930	1,200	1,410	1,620	2,180
08023270	740	1,020	1,230	1,430	1,980
08022680	220	350	450	560	890
08024050	6,980	10,550	13,840	18,180	30,360
08024160	500	680	830	990	1,410
08024080	2,280	3,360	4,280	5,350	8,300
08024500	9,360	14,600	19,500	25,300	42,800
08022500	39,400	53,500	64,900	77,000	108,000
08025360	75,400	115,000	152,000	195,000	328,000
08024400	50,600	66,700	79,700	93,300	128,000
08023200	10,000	15,800	21,100	27,400	46,800

A review of the stream gages with respect to Hurricane Harvey was performed to determine whether an additional adjustment factor would be appropriate. After the review, it was determined that the Hurricane Harvey event did not warrant an additional watershed adjustment factor. For Sabine River, only one gage had an annual max peak flow as a result of Harvey. The annual max peak flow associated with Harvey on 9/1/17 was 84,900 cfs. This was much less than the largest peak flow, 254,000 cfs, which occurred on 3/11/16. For the tributary gages, 3 stream gages had an annual max peak flow as a result of Harvey. However, all of these peaks were much less than their largest peak flow.

1.3 Hydraulics

The hydraulic approach for this BLE analysis of the Toledo Bend Watershed consisted of using the terrain model described in Section 1.1 in combination with the hydrologic outputs from Section 0 to establish water surface elevations using 1-D steady state analysis. HEC-RAS program version 5.0.5 was chosen as the computer model to compute water surface elevations on a stream by stream basis. The WISE software was used to establish model stream orientation, generate initial hydraulic cross section layout and stationing, assign n-values to cross-sections, and develop all input files for the HEC-RAS program. ESRI's ArcGIS program was used to review and refine cross-section layout orientation.

First pass cross-section layout was performed using an automated routine in WISE that varies cross-section spacing based on the cumulative drainage area at the cross-section location. A first draft model was created based on this initial cross-section layout, and draft boundaries were developed. Next, a second pass inspection for cross-section placement and alignment occurred. Significant refinement occurred during this step. To improve the hydraulic models, additional cross-sections were added as needed to better define the BLE floodplain boundary. Cross-sections were extended in locations where overtopping occurred. Orientation of cross-sections was refined to improve on the perpendicular orientation to flow. Additional cross-sections were added at floodplain constrictions and at downstream portions of tributaries to ensure a proper tie-in with receiving streams. Cross-sections were adjusted to remove sections that intersected hydraulic crossings in the floodplain. For some of the largest studied streams, cross-sections were laid out manually in order to have more reasonable spacing and better capture the constrictions in the floodplain.

Cross-sections were not drawn on top of roadways or railroads but were placed at the upstream and downstream face of major roads and railroads. Ineffective flow stations were placed in the hydraulic models as appropriate to account for flow constrictions and other locations deemed by the engineer to be ineffective at conveying flow downstream.

Cross-sections were drawn on dam crests for dams with well-defined spillways in order to better represent ponded water upstream of the structures. In so doing, it was assumed that the vast majority of the flow during a flood event would pass the spillway and that the hydraulic model would reasonably estimate flow across the spillway as represented in the hydraulic cross-section. The elevations used in the modeling were checked against effective Zone A boundaries, and the results were deemed reasonable.

The relationship between cumulative drainage area and assigned channel geometry is shown in Table 6. These default values for dimensions and spacing were subject to change based on engineering judgment.

Table 6: Cross-Section Default Parameters

Drainage area (upper limit)	XS Spacing	Channel Top Width	Channel Bottom Width	Channel Depth
1	300	6	5	0.8
2	300	7	6	0.8
4	300	10	8	0.8
8	400	12	11	0.8
10	500	13	12	0.8
15	500	18	13	0.8
20	500	19	14	0.8
25	500	20	15	0.8
30	500	21	16	0.8
40	500	25	17	0.8
50	600	28	18	0.8
75	600	30	19	1
100	750	33	20	1
150	750	36	21	1

Drainage area (upper limit)	XS Spacing	Channel Top Width	Channel Bottom Width	Channel Depth
250	1,000	38	22	2
500	1,500	40	23	2
1,000	2,500	100	50	3
2,000	2,500	150	75	3
5,000	2,500	200	100	3

In typical BLE projects, Manning's roughness coefficients (n-values) are determined using the 2016 National Land Cover Data (NLCD) dataset in combination with n-values from Chow (1959) and Calenda et al. (2005). For this watershed, the n-values for the developed areas indicated an underestimation of the roughness coefficients when compared to the aerial imagery and were adjusted accordingly. The association between the n-values and the NLCD Classification is shown in Table 7. Manning's n-value takeoffs are performed by WISE (default values taken from the "Normal" column). N-values within channel banks are constrained by the automated routine to a range of 0.030 to 0.070. Then, overbank and channel n-values are manually adjusted in certain locations based on engineering judgment.

Table 7: Manning's "n" Roughness Based on 2016 NLCD Classification (Moore, 2011)

NLCD Classification	Selected Manning's n	Minimum	Normal	Maximum	Source
Open Water	0.033	0.025	0.03	0.033	Chow 1959
Developed, Open Space	0.04	0.01	0.013	0.016	Calenda et al. 2005
Developed, Low Intensity	0.08	0.038	0.05	0.063	Calenda et al. 2005
Developed, Medium Intensity	0.1	0.056	0.075	0.094	Calenda et al. 2005
Developed, High Intensity	0.15	0.075	0.1	0.125	Calenda et al. 2005
Barren Land	0.025	0.025	0.03	0.035	Chow 1959
Deciduous Forest	0.16	0.1	0.12	0.16	Chow 1959
Evergreen Forest	0.16	0.1	0.12	0.16	Chow 1959
Mixed Forest	0.16	0.1	0.12	0.16	Chow 1959
Scrub/Shrub	0.1	0.035	0.05	0.1	Chow 1959
Grassland/Herbaceous	0.035	0.025	0.03	0.035	Chow 1959
Pasture/Hay	0.03	0.03	0.04	0.05	Chow 1959
Cultivated Crops	0.035	0.025	0.035	0.045	Chow 1959
Woody Wetlands	0.12	0.08	0.1	0.12	Chow 1959
Emergent Herbaceous Wetland	0.07	0.07	0.1	0.15	Chow 1959

The downstream boundary condition used for the majority of the study streams was normal depth with a default value of 0.005 ft/ft. For streams with large drainage areas (generally greater than 8 square miles), the normal depth slope was calculated based on the channel inverts of the downstream cross-sections.

In cases where streams tie in to a lake, a normal depth slope was calculated based on the channel inverts of the downstream cross-sections (typically between 0.0001 and 0.001 ft/ft). Several HUC-

10s within this watershed are located in urban areas with storm drain systems, which are unaccounted for in the BLE models. Implications of these systems may considerably affect risk.

1.4 Quality Control

Following the initial hydraulic model analysis in each watershed, the resulting flood hazard area delineations were reviewed for areas where the results were not ideal.

QC results indicated that some of the models should be extended to cover the scope of effective flood hazard data. Those streams were extended farther upstream to match the extents of the effective SFHA data.

Typical revisions resulting from reasonability checks included adding cross-sections, adjusting orientation of cross-sections, trimming cross-sections and reduction of the default “V” angle of cross-sections. Examples of default “V” angled cross-sections are shown in Figure 4. It is estimated that 75 percent of cross-sections were adjusted in some work areas while other areas did not require as much editing. Other examples of manual editing included the addition of cross-sections at confluence areas (see Figure 5 below), modifications to improve perpendicular orientation at the channel, adjustment of discharge breaks to better represent flow addition points, revisions to cross-sections at dams, additional cross-sections bounding major hydraulic structures, and revisions to n-values.

A major component of the QC process was an automated check that identified locations where the 1-percent a.c.e profile was crossed by any other frequency profile. Significant effort was made to reasonably resolve all of these instances. Another automated check identified locations where there was a drawdown of greater than 0.5 foot on the 1-percent a.c.e. water surface profile. This check is particularly useful for identifying errors in the model such as a channel that is too wide, a poorly placed cross-section, or a need for additional cross-sections. Again, significant effort was made to reasonably resolve these drawdown situations.

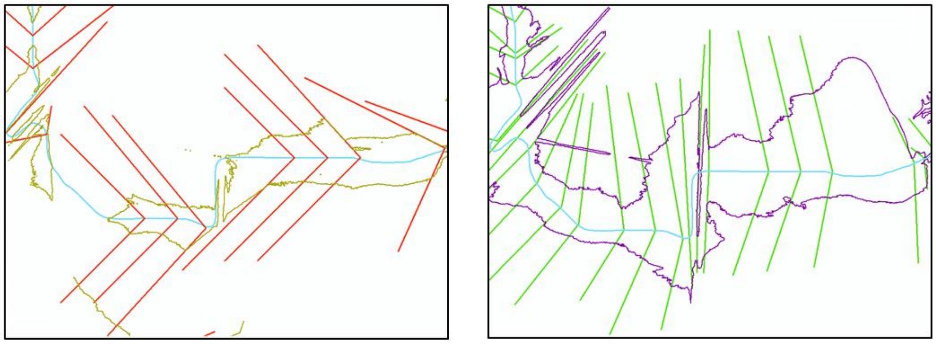

Figure 4: Default "V" angle cross-sections automated by WISE (left). Manually edited cross-sections to more accurately capture terrain (right). Resulting flood boundaries shown in gold (left) or purple (right) for clarity.

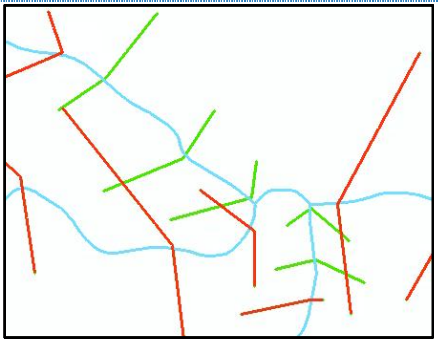

Figure 5: Manually added cross-sections (green) to improve accuracy of tie-ins at confluences.

1.5 One-percent Special Flood Hazard Area Delineation

The 1-percent and 0.2-percent boundaries were mapped using a routine that develops water surface elevation grids based on the 10-foot cell size DEM developed from the LiDAR dataset used for this project (see Section 1.1). This product was converted to a polygon for cleaning. The cleaning routine involved manual inspection of the polygons to identify and remove areas of disconnected flooding. In general, all polygons greater than 5,000 square feet are investigated, but all polygons, including those less than 5,000 square feet that intersect the stream line are included in the final output. This investigation was aided by the ground DEM and aerial imagery. Manual adjustments to the polygons were made to account for spillways on dams which could not be accurately modeled using HEC-RAS as well as disconnected areas along the flooding source that should reasonably be connected.

Following the removal of disconnected flooding areas and other boundary adjustments, the small islands in the floodplain were filled. In general, islands less than 2 acres were inspected and filled.

Once the island filling process was complete, the water surface raster mapping routine was run and set to conform to the polygon boundary. This ensures that the water surface raster and the floodplain boundary are consistent with each other. The depth raster product was created at the end of the process by performing a raster subtraction with the water surface elevation raster and the ground DEM.

Challenges

In Patroon Bayou, there is an overtopping issue on Bull Bay Creek just upstream of where Bull Bay Creek meets Patroon Bayou at station 5468. This is an issue for at 10YR WSELs and becomes more significant at 100YR and 500YR. At approximately station 3483 on Bull Bay Creek, there is a possibility of overtopping into UNT 058 in PCW to the north. This is a more minor overtopping issue and is only possible for 500YR flows.

In Bayou San Patricio, there were two streams with overtopping concern. At station 8026 on UNT 056 in BSP, overtopping is possible to the south into Bayou San Patricio with 10YR flows. On UNT 031 in BSP, overtopping is possible for 100YR and 500YR along State Route 513 to Bayou San Patricio. In several locations, obtaining precise flow values was difficult due to the shared floodplain of many of the streams along the Bayou San Patricio. This can be observed around station 135649 on Bayou San Patricio, where a XS crosses Bayou San Patricio, UNT 044 in BSP, Green Cane Bayou, and Stinkfinger Creek.

In Bayou Siep, there are several areas where new roads/new development has occurred since the LiDAR was flown. These areas occur at stations 18846 along Big Branch and 21450 along UNT 29 in BSP_LA.

In Tenaha Creek, there were several areas where obtaining precise flow/stage values was difficult due to shared floodplains of many streams. These areas were manually interpolated using in-house tools. These areas included Morrison Creek (station 3599), Porter Creek (station 4763), Tenaha Creek (station 104595), Town Creek (station 26379) and UNT 027 in TCW (station 9048).

In Palo Gaucho, there is a split flow near the confluence of Maddox Creek with Palo Gaucho Bayou. Further detailed analysis is suggested in this area to better understand the flooding impacts in this area

In Bayou La Nana, there was some difficulty with the tie in at Edmonson Creek and Bayou La Nana where the constrained raster editor had to be used. There is also a shared floodplain issue with Bayou La Nana and UNT 028 in Bayou La Nana where the main channel flow overtops into UNT 028 ahead of the junction.

In Housen Bayou, along Carrice Creek cross-sections were extended past the low lying area running parallel to the channel, this lead to a split in mapping suggesting a need for detailed study. Moreover, due to substantially high water surface elevations along Bayou Negreet, UNT 054 in HBW couldn't tie in, so detailed study is recommended. Right upstream of the confluence between Yocum Creek and UNT 040 in HBW, there is a small ditch/channel that connects the two streams. There is a significant difference in water surface elevations on both sides of the ditch; to further access flooding along this area detailed study is suggested.

In Grand Cane Bayou, cross-sections were clipped at basin extent for UNT 069 in GCBW due to overtopping, so detailed study is recommended.

In Flat Fork Creek Watershed, the confluence of Flat Fork Creek and Chicken Bayou may need further study as split area is located. Similarly, the area between UNT039 and UNT040 also has split overflow, thus further study is recommended.

In Six Mile Creek Watershed, Sixmile Creek stream may require further study as multiple cross-sections are overtopped. Cross-sections were clipped at the basin extent and further study is required.

In San Miguel Bayou Watershed, Little Bayou Scie and Bayou Scie may require further study as multiple cross-sections are overtopped. Cross-sections were clipped at the basin extent and further study is required.

Results and Recommendations

The BLE results for this study produced an SFHA that conforms to the existing topography and compares favorably with the effective SFHA. These boundaries provide an approximate SFHA in areas that have not been previously studied and therefore do not currently have an SFHA mapped. These results provide context for flood risk communication as part of the Discovery process, and should be verified through community work map meetings before being applied to a regulatory product.

A map showing the BLE results is included as Appendix A.

3.1 CNMS Validation of Effective Zone A SFHA

The inventory of Zone A studies (1,368.4 miles) in the Toledo Bend Watershed were classified in CNMS with validation status of "UNVERIFIED" (1,346.4 miles) or "VALID" (21.9 miles), and with status type of "BEING STUDIED." The following is a summary of the results of the CNMS validation assessment for the effective Zone A studies in the study area. Initial Assessment checks A1-A3 were evaluated for the CNMS inventory of Zone A studies.

INITIAL ASSESSMENT A1 – SIGNIFICANT TOPOGRAPHY UPDATE CHECK

This check involves determining whether a topographic data source is available that is significantly better than what was used for the effective Zone A modeling and mapping. For the study area in the Toledo Bend Watershed, the effective Zone A topographic data leveraged is old and likely consisted of USGS topographic maps for the majority of the watershed. The LiDAR sources discussed in section 1.1 are a significant improvement from the effective Zone A topographic source for most of the study area. Therefore, most reaches failed this check. The studies in Newton County, TX and Caddo Parish, LA utilized LiDAR in their effective studies though and, therefore, the reaches in these areas passed this check.

INITIAL ASSESSMENT A2 – CHECK FOR SIGNIFICANT HYDROLOGY CHANGES

This check involves first determining if regression equations were used for the effective study. Next, it must be determined whether new regression equations have become available from the USGS since the date of the effective Zone A study. If newer regression equations exist for the area of interest, then an engineer must determine whether these regression equations would significantly affect the 1-percent annual chance flow.

The hydrologic methods for the majority of Zone A study areas located in the Toledo Bend watershed are unknown and, therefore, pass this assessment check. The reaches in Newton County, TX and Caddo Parish, LA did use regression equations in their effective studies. In both instances, the newest equations available were used in those studies. For this reason, these reaches also PASS this check.

INITIAL ASSESSMENT A3 – CHECK FOR SIGNIFICANT DEVELOPMENT

This check involves using the National Urban Change Indicator (NUCI) dataset to assess increased urbanization in the watershed of the Zone A study. If the percentage of urban area within the HUC-12 watershed containing the effective Zone A study is 15% or more, and has increased by 50% or more since the effective analysis, the study would fail this check. Although the NUCI data provide year-to-year changes in urbanization, the NLCD also is needed to establish a baseline of urban land cover for this analysis. The check for significant development in this watershed was completed by evaluating percentage of urban change at the HUC-12 level. The entire study area, except for reaches in Newton County, TX, is still classified as rural. The reaches in Newton County, TX are iHUC-12 watersheds that meet the urban threshold but they have not experienced a significant increase in urban area since the effective analysis was completed. Therefore, all reaches within the study area PASS this check. All of the initial assessment results are shown in Table 8.

Table 8: Zone A Initial Assessment Results

Assessment Check	Pass / Fail	Notes
A1 – Topography	Pass/Fail	LiDAR was used in the effective study/LiDAR sources available are a significant improvement from effective topography
A2 – Hydrology	Pass	Regression equations not known to be used in effective study OR No new equations have been published
A3 – Development	Pass	HUC-12 watershed does not meet urban threshold OR There has not been a significant increase in urban area

VALIDATION CHECK A4 – CHECK OF STUDIES BACKED BY TECHNICAL DATA

Zone A studies that pass all initial assessment checks described above may be categorized as "Valid" in the CNMS Inventory only if the effective Zone A study is supported by modeling or sound engineering judgment and all regulatory products are in agreement. If the effective Zone A study passes all initial assessment checks, but is not supported by modeling, or if the original engineering method used is unsupported or undocumented, a comparison of the BLE results and effective Zone A's is performed. Zone A studies in Newton County, TX and Caddo Parish, LA are model-backed studies and PASS this check. . All other Zone A studies within the Toledo Bend Watershed are not model-backed studies and FAIL this check.

VALIDATION CHECK A5 – COMPARISON OF BLE AND EFFECTIVE ZONE A

The BLE /effective Zone A comparison method leverages the existing Floodplain Boundary Standard (FBS) certification procedures described in FEMA SID 113, but with a slight modification. This modified FBS comparison approach uses the 1-percent plus and 1-percent minus flood profiles and horizontal and vertical tolerances described in FEMA's Automated Engineering guidance document dated May 2016. For the comparison of BLE and effective Zone A in the Toledo Bend study area, the following vertical and horizontal tolerances were used to conduct the modified FBS procedure. One point was placed every 200 feet along the floodplain boundaries for comparison.

- Vertical Tolerance: +/- 10 feet (one-half contour interval of assumed effective topographic source).
- Horizontal Tolerance: +/- 75 feet (standard horizontal tolerance for BLE comparison testing).

Comparison results for these streams were grouped at the HUC-12 level and are summarized in Table 9 to better understand the general health of the HUC-12 watershed, but the validation check was performed at the stream level. Streams where the percentage of passing FBS sample points is greater than or equal to 85% are marked as "Pass", otherwise they are marked as "Fail".

Table 9: BLE Comparison Results

HUC-12 Watershed		Total FBS points	Fail	Pass	%Pass	BLE Comparison Pass? (>85%)	Priority Score
Watershed Name	Watershed Number						
Toledo Bend Watershed	All Streams	76,891	32,254	44,637	58%	FAIL	
Ayers Branch-Toledo Bend Reservoir	120100040807	1,403	800	603	43%	FAIL	13.6
Bayou Siep	120100040803	1,545	715	830	54%	FAIL	25.0
Bear Creek-Bayou San Patricio	120100040403	1,955	1,022	933	48%	FAIL	14.9
Beauchamp Creek-Tenaha Creek	120100040104	1,588	823	765	48%	FAIL	24.4
Big Sandy Creek	120100041101	1,230	347	883	72%	FAIL	35.1
Blue Bayou	120100040802	817	385	432	53%	FAIL	15.9
Bull Bay Creek-Patroon Bayou	120100040702	914	421	493	54%	FAIL	32.3
Bushneck Bayou	120100040302	2,402	737	1,665	69%	FAIL	21.3
Canadian Bayou-Grand Cane	120100040305	2,249	1,003	1,246	55%	FAIL	19.4
Caney Branch-Flat Fork Creek	120100040205	1,103	481	622	56%	FAIL	14.3
Carrice Creek-Toledo Bend Reservoir	120100041002	1,618	912	706	44%	FAIL	19.9
Castor Bayou	120100040303	3,125	951	2,174	70%	FAIL	25.1
Chatman Bayou-Bayou San Patricio	120100040401	1,436	655	781	54%	FAIL	23.3
Chicken Bayou-Flat Fork Creek	120100040203	2,195	1,012	1,183	54%	FAIL	17.6
Choctaw Branch-San Miguel	120100040505	1,834	612	1,222	67%	FAIL	21.4
Clement Creek	120100040306	2,265	1,125	1,140	50%	FAIL	17.6
Cow Bayou	120100040308	2,007	854	1,153	57%	FAIL	23.6
Derby Branch-Bayou San	120100040404	1,944	868	1,076	55%	FAIL	24.8
Grannies Creek-Toledo Bend	120100040801	1,749	719	1,030	59%	FAIL	13.9
Harpoon Bayou	120100040601	1,157	447	710	61%	FAIL	11.7
Horsehead Creek-San Miguel	120100040504	1,641	823	818	50%	FAIL	16.4
Huana Creek	120100040101	1,975	822	1,153	58%	FAIL	4.7
Hurricane Creek	120100040602	708	249	459	65%	FAIL	13.6
Lewis Creek-Bayou La Nana	120100040603	1,760	755	1,005	57%	FAIL	25.0
Lick Creek-Patroon Bayou	120100040701	1,760	910	850	48%	FAIL	14.9
Lost Bayou-San Miguel Bayou	120100040502	1,404	664	740	53%	FAIL	24.4
Lows Creek-Toledo Bend Reservoir	120100041105	1,395	782	613	44%	FAIL	35.1
Martinez Bayou-Toledo Bend Reservoir	120100040806	1,339	520	819	61%	FAIL	15.9
McDonald Bayou-Toledo Bend Reservoir	120100040804	671	175	496	74%	FAIL	32.3
McGrue Creek-Toledo Bend Reservoir	120100040805	1,145	467	678	59%	FAIL	21.3
Mill Creek-Toledo Bend Reservoir	120100041104	1,038	60	978	94%	PASS	19.4

Morris Creek-Toledo Bend Reservoir	120100040301	1,128	500	628	56%	FAIL	22.9
Negreet Creek	120100041001	3,155	1,054	2,101	67%	FAIL	18.5
Pen Bayou-Toledo Bend Reservoir	120100040309	896	387	509	57%	FAIL	14.9
Plum Creek-Flat Fork Creek	120100040204	1,603	799	804	50%	FAIL	28.2
Porter Creek	120100040102	1,095	573	522	48%	FAIL	25.9
Prairie Creek-Tenaha Creek	120100040103	1,006	439	567	56%	FAIL	20.0
Ramsey Creek-Flat Fork Creek	120100040201	1,278	518	760	59%	FAIL	30.5
San Miguel Creek	120100040501	1,263	601	662	52%	FAIL	23.8
Scie Bayou	120100040503	1,857	878	979	53%	FAIL	22.6
Smith Creek-Flat Fork Creek	120100040202	1,436	681	755	53%	FAIL	38.2
South Prong Creek-Toledo Bend Reservoir	120100041102	507	156	351	69%	FAIL	17.4
South Prong Indian Creek-Toledo Bend Reservoir	120100041106	1,633	362	1,271	78%	FAIL	17.6
Spring Branch-Bayou La Nana	120100040604	2,265	657	1,608	71%	FAIL	12.6
Styles Creek-Toledo Bend	120100040307	1,290	774	516	40%	FAIL	27.0
Tebo Creek	120100040902	135	60	75	56%	FAIL	22.2
Tenmile Bayou-Bayou San	120100040402	1,713	770	943	55%	FAIL	22.5
Tiger Creek-Palo Gaucho Bayou	120100040901	1,212	566	646	53%	FAIL	23.3
Wallace Creek-Grand Cane	120100040304	1,472	403	1,069	73%	FAIL	15.0
Yocum Creek-Toledo Bend	120100041005	2,575	960	1,615	63%	FAIL	18.3

VALIDATION RESULTS

Based on the validation assessments and BLE comparison results described above, the CNMS inventory of Zone A studies in the Toledo Bend Watershed has been updated as summarized in Table 10 and illustrated in Figure 6 below.

Table 10: Zone A Validation Results

Validation Status	Status Type	Total Miles
VALID	BEING STUDIED	21.9
UNVERIFIED	BEING STUDIED	1,346.4

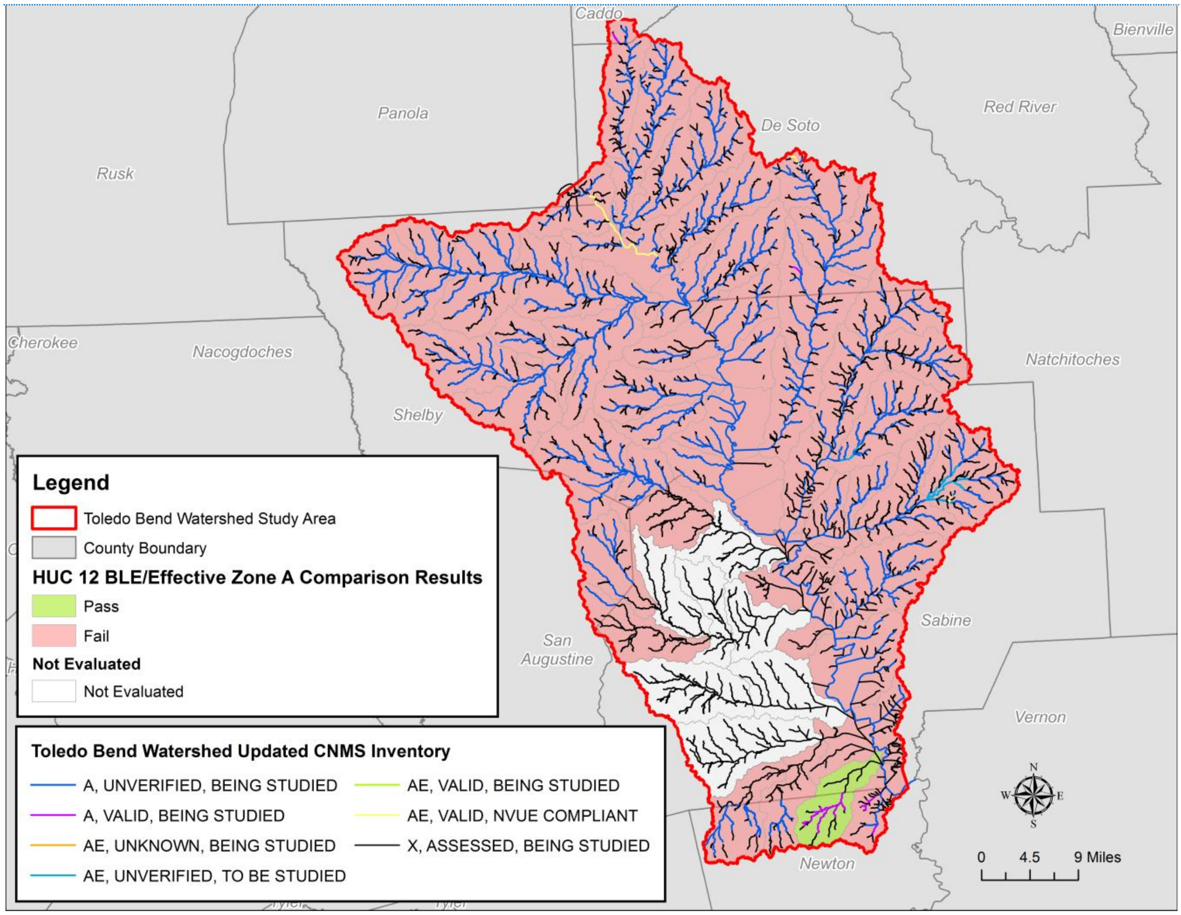

Figure 6: Toledo Bend Watershed CNMS Validation Results

An overall risk for each HUC-12 watershed was calculated using the National Flood Risk Percentages Dataset and its proportional area. The weighted risk was multiplied by the percentage of points in the watershed that failed the CNMS comparison to effective to determine the priority score. Figure 7 below shows the range of the HUC-12 priority scores which can be used to initiate discussions during the Discovery phase.

Smith Creek-Flat Fork Creek HUC-12 was determined to have the highest priority score and the most need while Mill Creek-Toledo Bend Reservoir HUC-12 had the lowest scores.

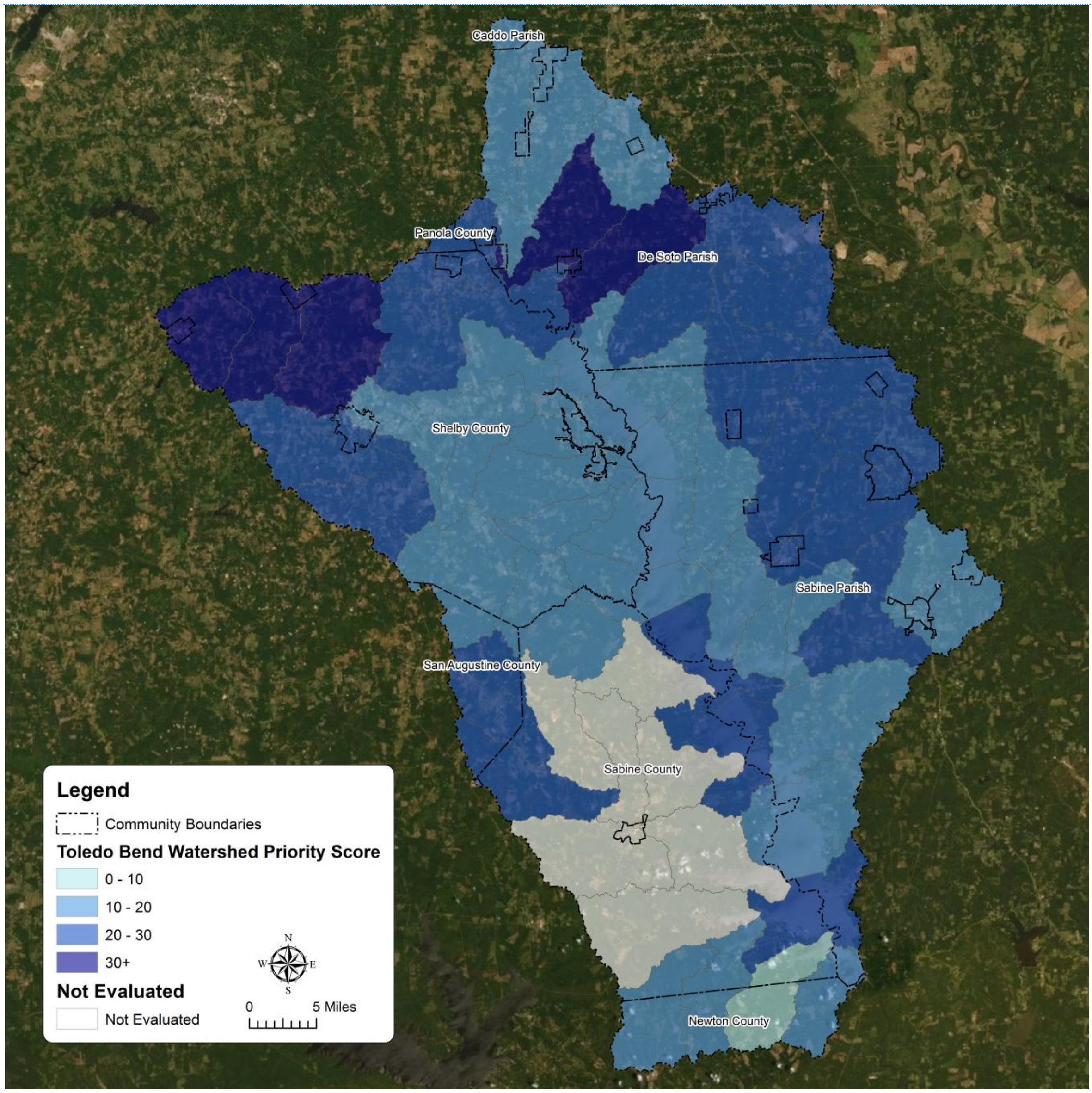

Figure 7: Ranking of Toledo Bend Watershed HUC-12s

3.2 Flood Risk Analysis

An advanced flood risk analysis was performed using the updated 1-percent-annual-chance grid (known as ‘refined base level engineering grid”) created for this project. The loss analysis uses 2010 census data and the subsequent results are stored in the L_RA_Results table.

Hazus version 4.2 was used for the loss analysis.

The losses are reported via census blocks. It is important to note that Hazus version 4.2 uses dasymetric census blocks. Dasymetric mapping removes undeveloped areas (such as areas covered by other bodies of water, wetlands, or forests) from the Census blocks, changing their shape and reducing their size in these areas. For more information on dasymetric data visit FEMA’s Media Library for the Hazus-MH Data Inventories: Dasymetric vs. Homogenous, or Hazus 3.0 Dasymetric Data Overview.

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Appendix A BLE Map