

Modeling Report

Lake Talquin – Including Ochlockonee River and Little River
Nutrients

November 6, 2014

Revision 3



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Watershed Description

Lake Talquin is located west of Tallahassee, Florida approximately 15 miles south of the Florida-Georgia state line. The Lake Talquin Watershed encompasses over 1,700 square miles and includes portions of the following counties in Georgia: Worth, Mitchell, Colquitt, Decatur, Grady and Thomas, along with Gadsden and Leon Counties in Florida (Figure 1). Lake Talquin receives water from both the Little River and the Ochlockonee River. The following creeks drain to Little River: Quincy Creek, Willacoochee Creek, Attapulugus Creek, and Swamp Creek, along with several smaller and/or unnamed tributaries. The following creeks drain to Ochlockonee River: Turkey Creek, Lees Creek, Barnett's Creek (both east and west branches), Lost Creek, Big Creek, Little Creek, and Bridge Creek, along with several smaller and/or unnamed tributaries. See Figure 2 for an aerial view of the delineated watershed.

Approximately 41% of the watershed is forested or clear-cut and 16% of the watershed is wetlands. Agricultural land uses (crop and pasture) comprise 33% with a greater percentage located in Georgia. About 6% of the watershed is urban land uses (Figure 3).



Figure 1 Location of the Lake Talquin Watershed

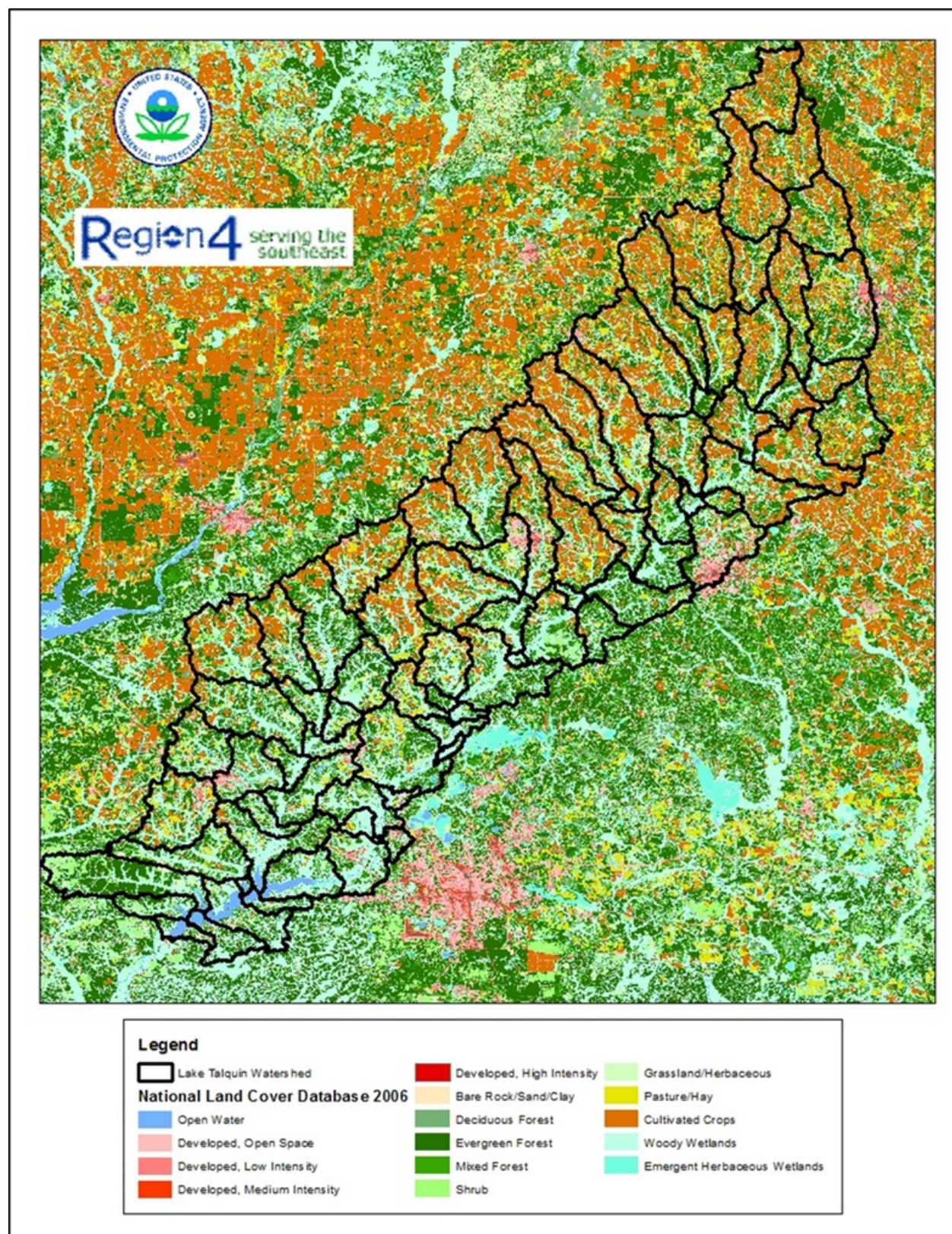


Figure 2 Lake Talquin Watershed Landuse Data

Modeling Approach

The modeling approach that was used for the development of the nutrient model for Lake Talquin (including Little River and Ochlockonee River) considers 17 years of meteorological and flow conditions. The selection of a longer term continuous simulation insures that average, wet and dry conditions are included in the model. The modeling approach uses a dynamic watershed model that predicts surface runoff of pollutants (nitrogen, phosphorus and BOD) and flow as function of landuse and meteorological information. The 17 year simulation of watershed loadings and flow are fed forward to a water quality model that predicts the impacts of the loadings and flow on water quality in the waterbody. The water quality model predicts: dissolved oxygen, nitrogen (ammonia, nitrate, and organic nitrogen), phosphorus (orthophosphate, organic phosphorus), chlorophyll a, biochemical oxygen demand as a function of loads and flows provided by the watershed model.

LSPC Watershed Model

The Loading Simulation Program C++ (LSPC) is the watershed model. LSPC is the Loading Simulation Program in C++, a watershed modeling system that includes streamlined Hydrologic Simulation Program Fortran (HSPF) algorithms for simulating hydrology, sediment, and general water quality on land as well as a simplified stream fate and transport model. LSPC is derived from the Mining Data Analysis System (MDAS), which was originally developed by EPA Region 3 (under contract with Tetra Tech) and has been widely used for TMDLs. In 2003, U.S. Environmental Protection Agency (EPA) Region 4 contracted with Tetra Tech to refine, streamline, and produce user documentation for the model for public distribution. LSPC was developed to serve as the primary watershed model for the EPA TMDL Modeling Toolbox.

WASP Water Quality Model

Water Quality Analysis Simulation Program (WASP 7.52) (USEPA, 2014) is a generalized framework for modeling contaminant fate and transport in surface waters. Its flexible, compartmental approach allows it to address problems in one, two, or three dimensions. It is designed to allow easy substitution of user-written routines into the program structure. WASP has been used to answer questions regarding biochemical oxygen demand, dissolved oxygen dynamics, nutrients and eutrophication, bacterial contamination, and organic chemical and heavy metal contamination. The Advanced Eutrophication Module of WASP was used for Lake Talquin. Figure 3 provides a schematic of the state variables considered by the module.

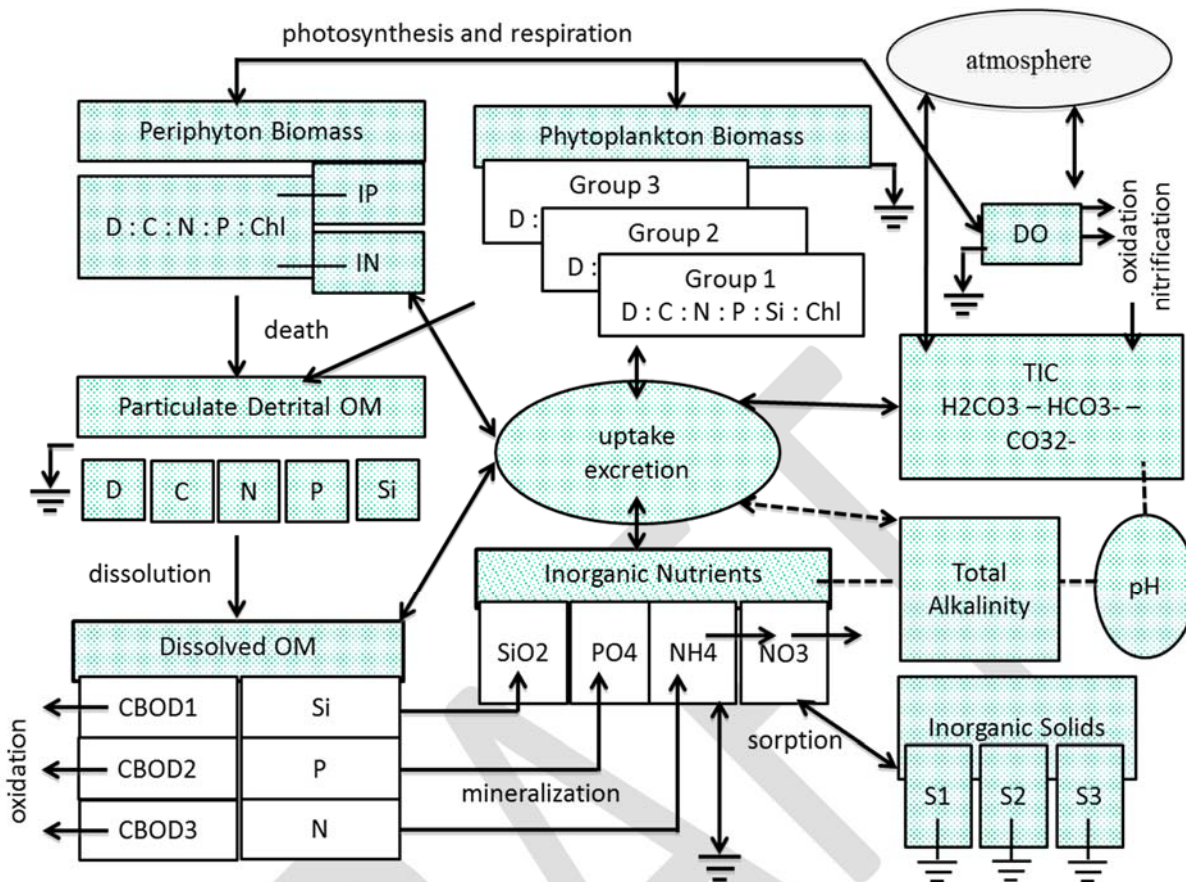


Figure 3 WASP 7.52 Advanced Eutrophication State Variables

The WASP model integrates the predicted flows and loads from the LSPC model to simulate water quality responses in: nitrogen, phosphorus, chlorophyll a and dissolved oxygen. Both LSPC and WASP will be calibrated to current conditions. For this application, WASP is the receiving water quality model for both Lake Talquin and its tributaries. For the Lake Talquin application, the sediment oxygen demand used by WASP is dynamically calculated by a sediment digenesis submodel (see User's Manual in WASP Document Directory).

EFDC Hydrodynamic Model

The Environmental Fluid Dynamics Code (EFDC Hydro) is a state-of-the-art hydrodynamic model that can be used to simulate aquatic systems in one, two, and three dimensions. For this application, a three dimensional EFDC grid was developed for Lake Talquin to provide necessary hydrodynamic inputs to WASP, the advanced receiving water quality model. EFDC uses stretched or sigma vertical coordinates and Cartesian or curvilinear, orthogonal horizontal coordinates to represent the physical characteristics of a waterbody. It solves three-dimensional, vertically hydrostatic, free surface, turbulent averaged equations of motion for a variable-density fluid. Dynamically-coupled transport equations for turbulent kinetic energy, turbulent length scale, salinity and temperature are also solved.

Model Domains

Because of the size and complexity of the watershed and the TMDL/nutrient criteria decision that will be made a set of nested models were developed. Figure 4 depicts the model network for the five models. The green polygons define the areas that were simulated for the Ochlockonee River watershed. Results, both flows and loads are used by all the other models. The red line segments represents the WASP water quality model for the Ochlockonee River. This model incorporates the flows and loads from the watershed model plus the 5 NPDES dischargers for fate and transport to Lake Talquin. The pink line segments represents the WASP water quality model for the Attapulgis River (Georgia)/Little River (Florida). This model incorporates the flows and loads from the watershed model plus the 2 NPDES dischargers for fate and transport to Lake Talquin. The yellow grid represents the hydrodynamic and water quality model for Lake Talquin. The hydrodynamic and water quality model receives flows and loads from the mainstem river WASP models (Ochlockonee and Attapulgis/Little River) and the surrounding watershed model.

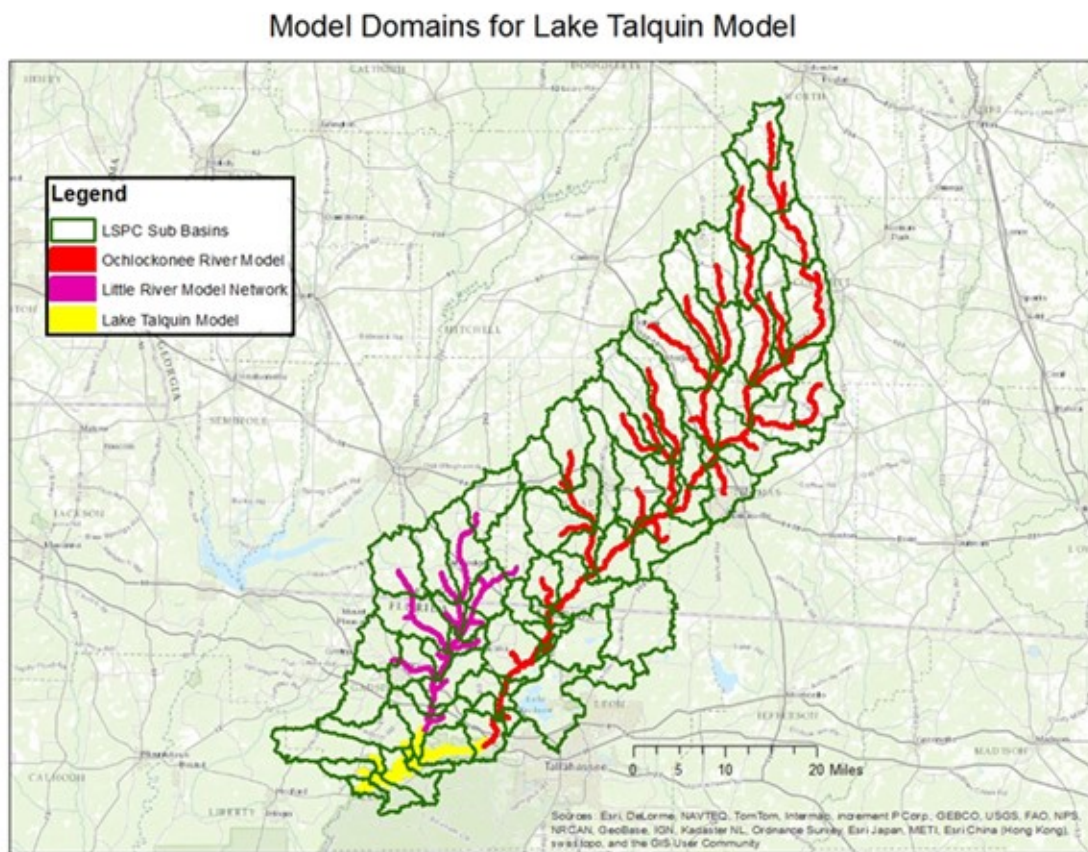


Figure 4 LPSC Watersheds and WASP Segments

Watershed Model Application

The watershed model was applied to the Lake Talquin watershed for the simulation period of 1996 through 2012. The 1996 year was used to equilibrate the initial conditions in the watershed model (soil moisture, buildup and washoff), from 1997 through 2012 was used to predict flows and loads under current conditions that will be passed onto the water quality model.

Watershed Delineation and Landuse

The upstream sections of the watershed that drain ultimately to Lake Talquin, including Little River and Ochlockonee River, were included in the LSPC watershed model. The watershed was delineated into 85 sub basins (Figure 5). Sixteen sub basins drained to the Little River, 57 sub basins drained to Ochlockonee River, and 12 sub basins drained directly to Lake Talquin (Figure 5). The LSPC model predicts flow and loads coming from each of these sub basins into Little River, Ochlockonee River, and eventually into Lake Talquin.

The initial model setup and parameterization for Lake Talquin watershed model was based on EPA's LSPC model used for the purposes of nutrient criteria development and from the Apalachee basin model developed by Tetra-Tech for the State of Georgia (Tetra-Tech, 2011); the initial model was further refined and calibrated to all local data and gages that were available in the watershed.

The watershed model uses land use data as the basis for representing hydrology and nonpoint source loadings. The Georgia Land Use Trends (GLUT), FDEP Level III Florida Land Use, and the National Landuse Coverage Dataset (NLCD) were used to develop the watershed land use representations. The GLUT 2008 was used as the primary coverage in the Georgia portion of the watershed and FDEP and NLCD 2006 data was used complete the land use coverage in Florida where there was no GLUT 2008 data. The coverages utilized a variety of land use classes, and the FDEP coverages were grouped and reclassified into 18 land use categories: beaches/dune/mud, open water, utility swaths, developed open space, developed low intensity, developed medium intensity, developed high intensity, clear-cut/sparse, quarries/strip mines, deciduous forest, evergreen forest, mixed forest, golf courses, pasture, row crop, forested wetland, non-forested wetland (salt/brackish), and non-forested wetland (freshwater). The GLUT and NLCD datasets were then reclassified into the same land use categories. For the LSPC simulation, similar land use classes were grouped together into reduced into 15 modeling categories, i.e., deciduous forest, evergreen forest and mixed forest were grouped together into a unit named forest.

The LSPC model requires division of land uses in each sub-watershed into separate pervious and impervious land units. The GLUT impervious cover was intersected with the GLUT land use-land cover. Any impervious areas associated with utility swaths, developed open space, and developed low intensity, were grouped together and placed into a new category of low intensity developed impervious cover. Impervious areas associated with medium intensity development and high intensity development, were kept separate and placed into two categories of medium intensity

The map displays the Lake Talquin Watershed, which is divided into 100 sub-watersheds. Each sub-watershed is outlined in red and labeled with a unique ID number. The watershed is situated in a hilly, forested area. In the top left corner, there is a logo for the U.S. Environmental Protection Agency (EPA) and a text box that reads "Region 4 serving the Southeast". A legend in the bottom right corner identifies the red outline as the "Lake Talquin Watershed".

Figure 5 Lake Talquin Watershed Delineation

Meteorological Information

Non-point source loadings and hydrological conditions are dependent on weather conditions. Hourly data from weather stations within the boundaries of, or in close proximity to the sub-watersheds were applied to the watershed model. An ASCII file (*.air) was generated for each meteorological and precipitation station used for the hydrologic evaluations in LSPC. Each meteorological and precipitation station file contains atmospheric data used for modeling of the hydrologic processes. These data include precipitation, air temperature, dew point temperature, wind speed, cloud cover, evaporation, and solar radiation. These data are used directly, or calculated from the observed data.

Figure 6 depicts the hourly rainfall for the Tallahassee WSO AP (WBAN 088758) meteorological station. The period of record being simulated during this TMDL development contains average, wet and dry years.

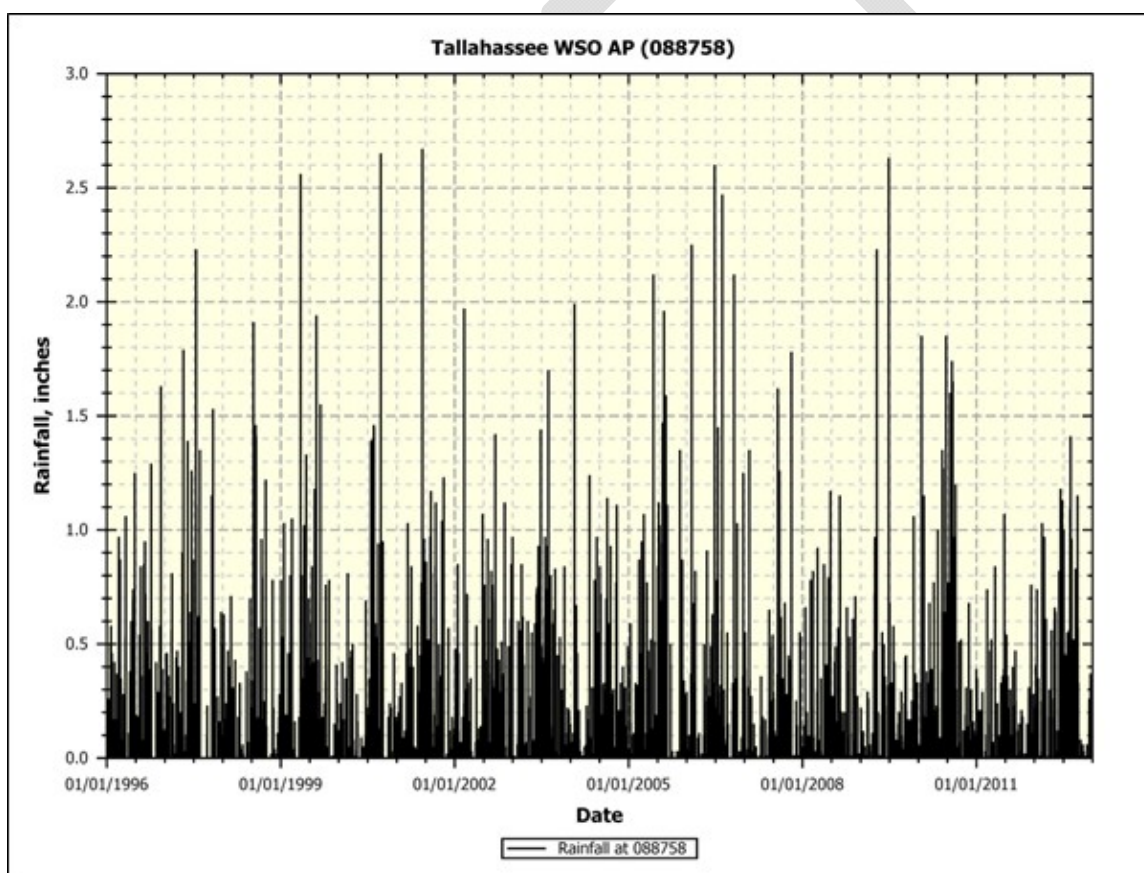


Figure 6 Hourly Rainfall Station 0088758

Table 1 provides the annual rainfall for each of the simulation years.

Table 1 Annual Rainfall for Simulation Period

Year	Quincy (in)	Tallahassee (in)	Bainbridge (in)	Camilla (in)	Moultrie (in)	Cairo (in)	Thomasville (in)
1996	56	53	54	50	49	55	54
1997	74	60	61	56	56	61	69
1998	37	55	57	55	53	51	60
1999	43	48	43	32	35	35	44
2000	45	44	40	41	46	40	55
2001	53	63	46	49	44	55	48
2002	63	55	57	53	59	53	59
2003	57	65	54	64	51	56	58
2004	80	56	51	51	58	57	58
2005	79	68	68	54	65	67	65
2006	46	50	36	47	38	46	45
2007	40	36	34	37	37	37	32
2008	66	51	69	62	53	60	63
2009	63	48	52	58	52	47	50
2010	51	59	43	43	39	44	46
2011	38	35	37	34	38	38	40
2012	45	56	48	35	40	42	44

Figure 7 provides the location of the meteorological stations used in the watershed model.

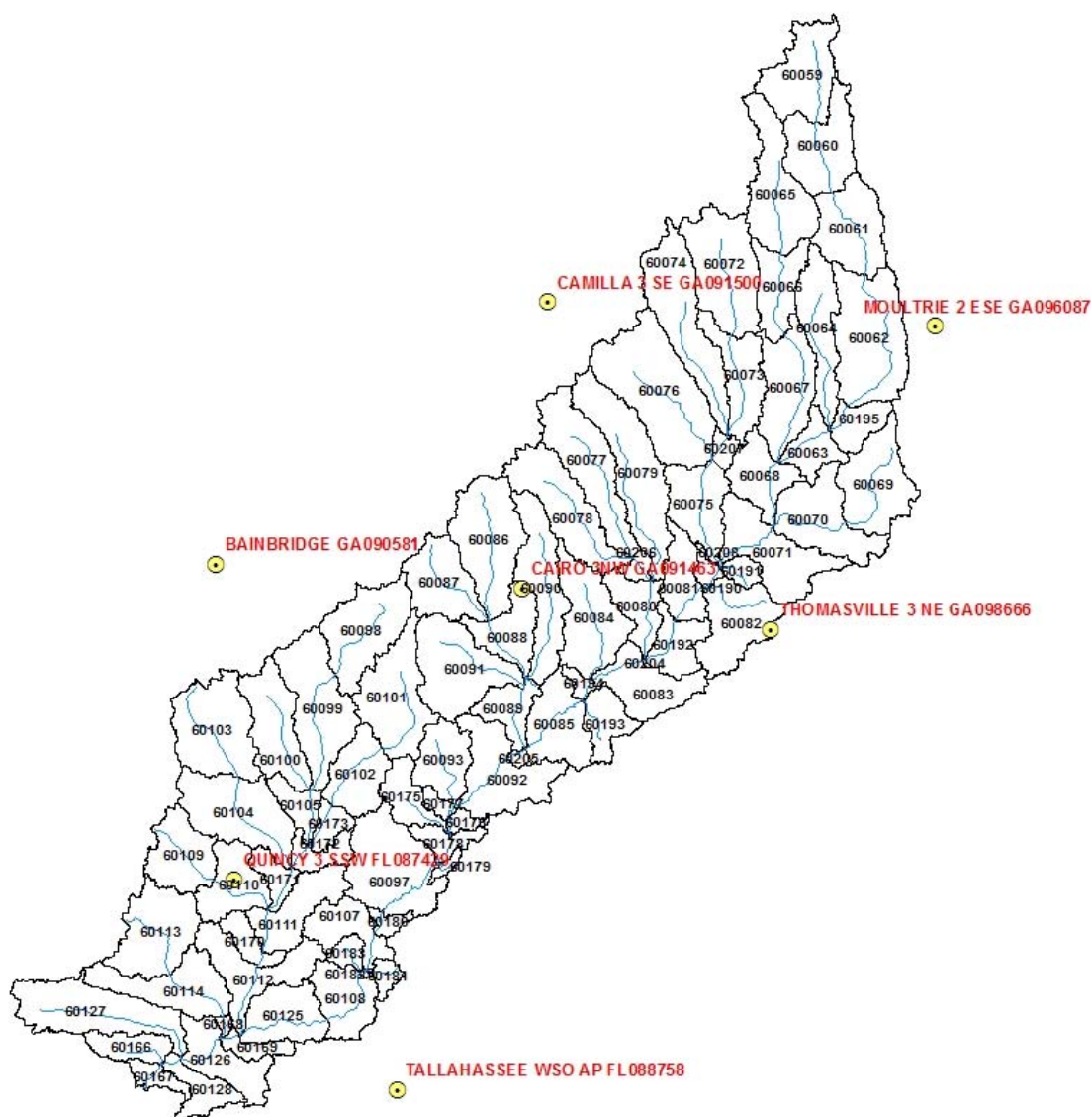


Figure 7 Meteorological Station Locations

Hydraulic Calibration

The watershed and water quality model were calibrated for flow by comparing the predicted flows to several USGS gages located within the watershed. Figure 8 through Figure 10 illustrate both a quantitative and qualitative comparison of the model flow predictions directly compared to measurements at the USGS gages.

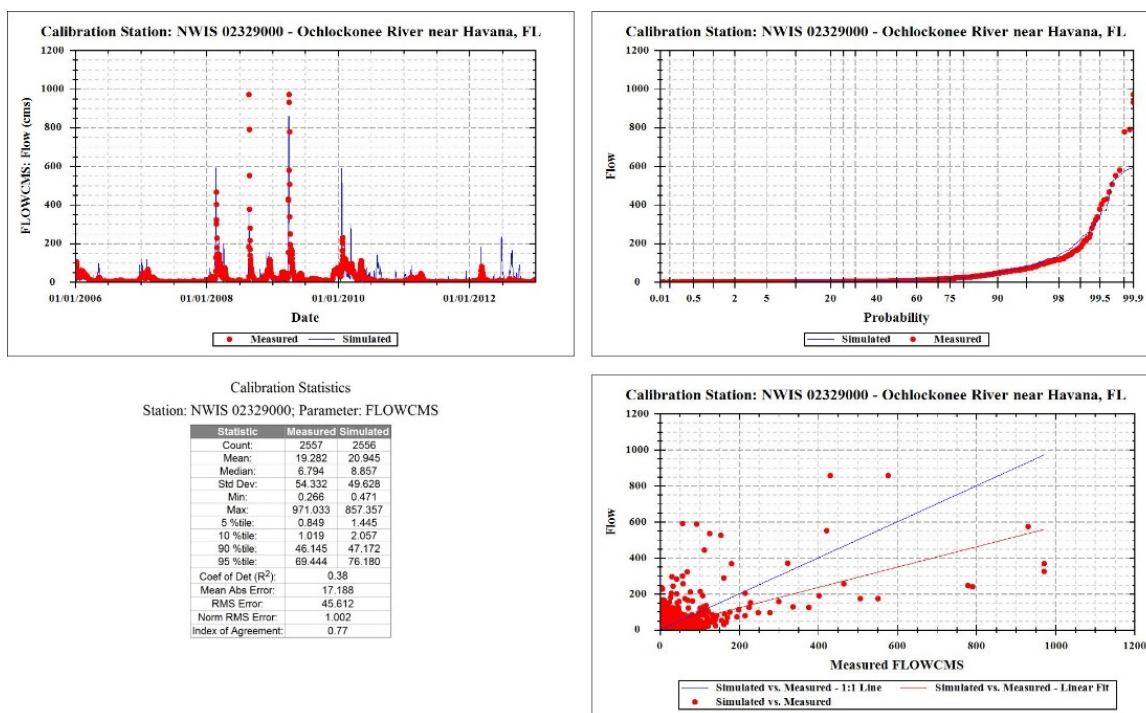


Figure 8 Flow Calibration for Ochlockonee River USGS Gage 02329000

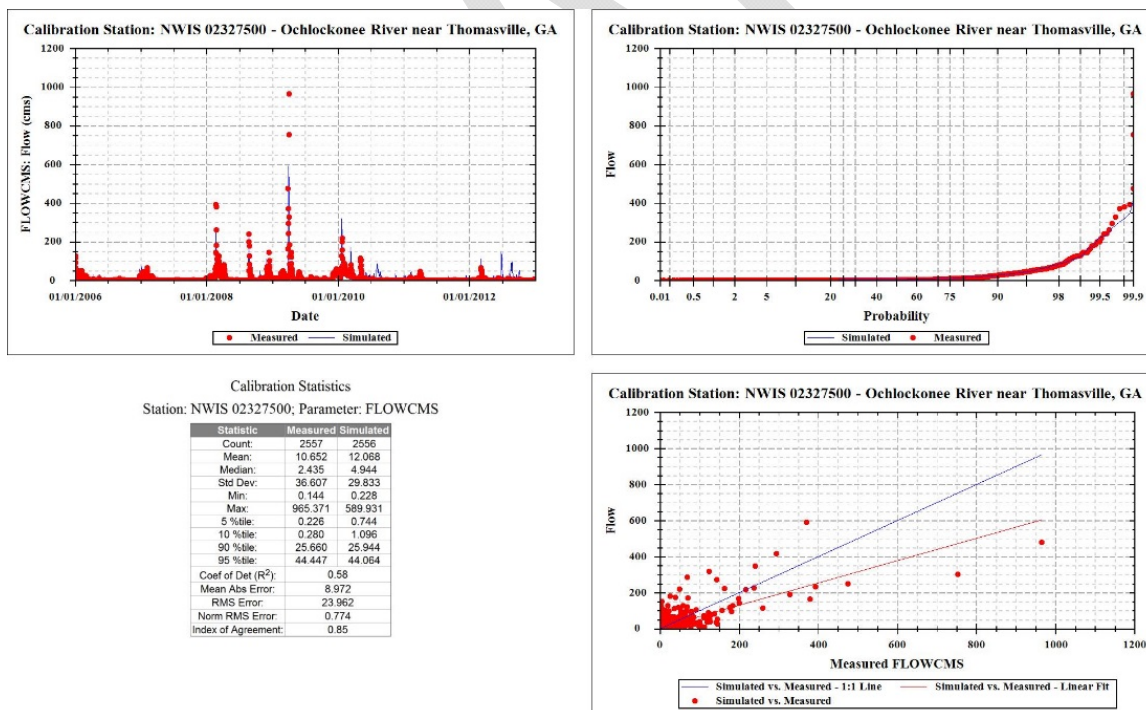


Figure 9 Flow Calibration for Ochlockonee River USGS Gage 02327500

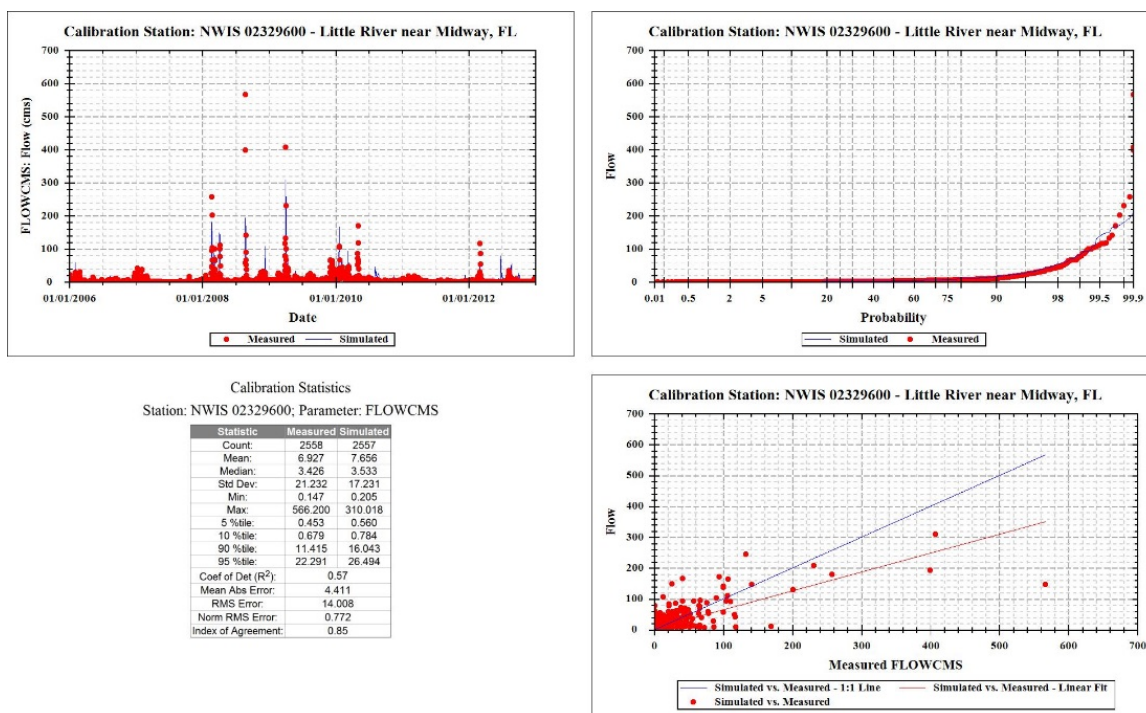


Figure 10 Flow Calibration for Little River USGS Gage 02329600

Nutrient Loadings

Watershed loadings were generated using event mean concentrations for total nitrogen, total phosphorus and BOD (Table 2Table 1). The initial EMC values were derived for each landuse type from a study by Harper and Baker (2007) and then calibrated to all data available for the watershed. Wetland EMCs were derived from the study of Reiss et.al (2009). The study summarizes the available literature on nutrient concentrations and hydrology for wetlands in Florida.

Table 2 Event Mean Concentration (mg/l) for Landuse Classifications

Landuse	TN (mg/L)	TP (mg/L)	BOD ₅ (mg/L)
Beach	2.07	0.41	1.93
Water	1.50	0.10	1.93
LowIntDev-Pervious	2.07	0.41	7.86
LowIntDev-Impervious	1.18	0.19	7.60
MedIntDev-Pervious	2.07	0.41	7.86
MedIntDev-Impervious	2.07	0.41	7.86
HighIntDev-Pervious	2.32	0.52	11.28
HighIntDev-Impervious	2.40	0.35	11.30

Barren	2.07	0.41	1.35
Forest	1.15	0.11	1.35
Golf	3.47	0.62	5.62
Pasture	3.47	0.62	8.24
Crop	2.65	0.85	5.62
WetLand	2.88	0.68	1.93
All Other Impervious	2.07	0.41	7.27

Harper H. H. and D. M. Baker, 2007. *Evaluation of Current Stormwater Design Criteria within the State of Florida*. Final Report submitted to Florida Department of Environmental Protection. Environmental Research & Design, Inc. Orlando, FL.

Reiss, K.C., Evans, J., and M. Brown, 2009. *Summary of Available Literature on Nutrient Concentrations and Hydrology for Florida Isolated Wetlands*. Final Report submitted to Florida Department of Environmental Protection, Tallahassee, FL.

Hydrodynamic Model Application

The Environmental Fluids Dynamic Code (EFDC) was applied to Lake Talquin to predict transport in the lake as a function of watershed flows and meteorological conditions. The Tallahassee Airport station was used to parameterize the meteorological conditions for the lake. The lake was divided up into 212 horizontal segments and consists of two layers (Figure 11).

Hydrodynamic and Water Quality Grid for Lake Talquin

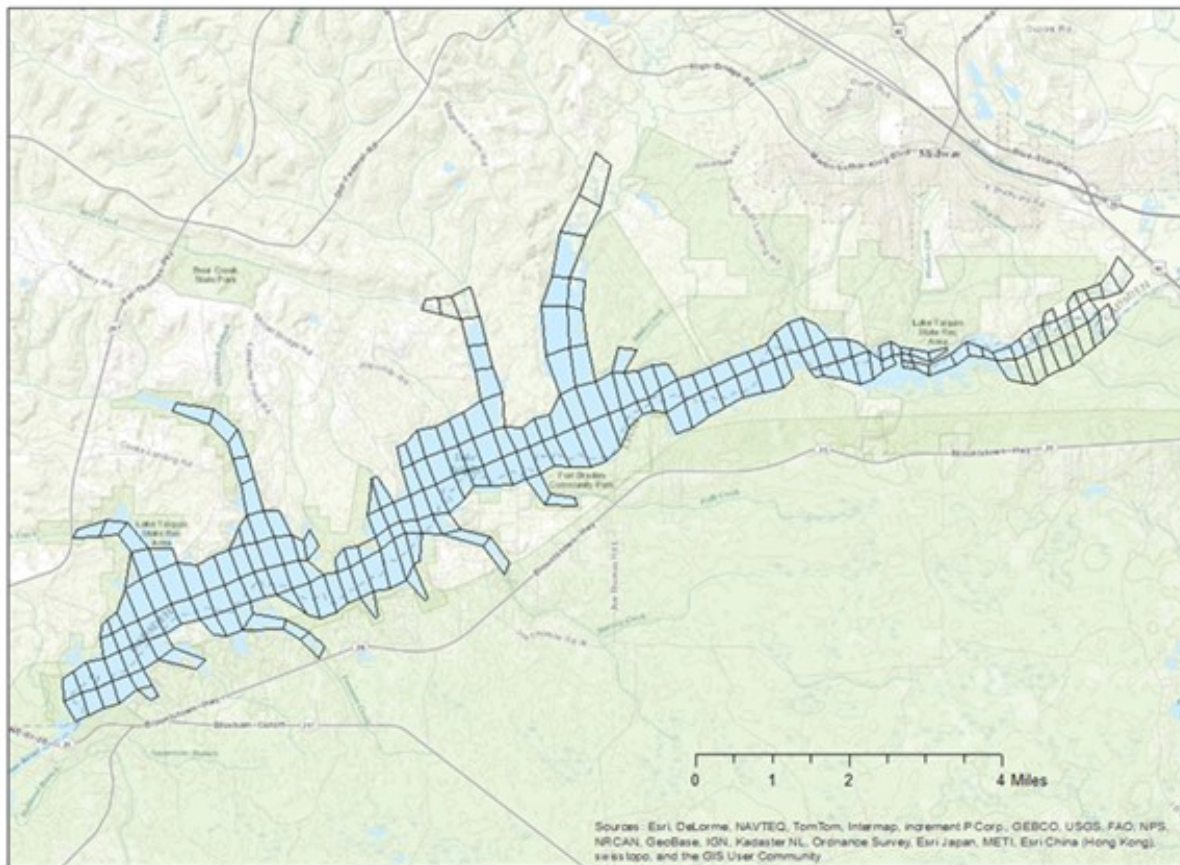


Figure 11 Lake Talquin EFDC Grid

Lake depths were estimated based upon a map that was developed by Gadsden and Leon County from 2007 (Figure 12). Depths were interpolated to the EFDC grid to account for change in depth in the lake.

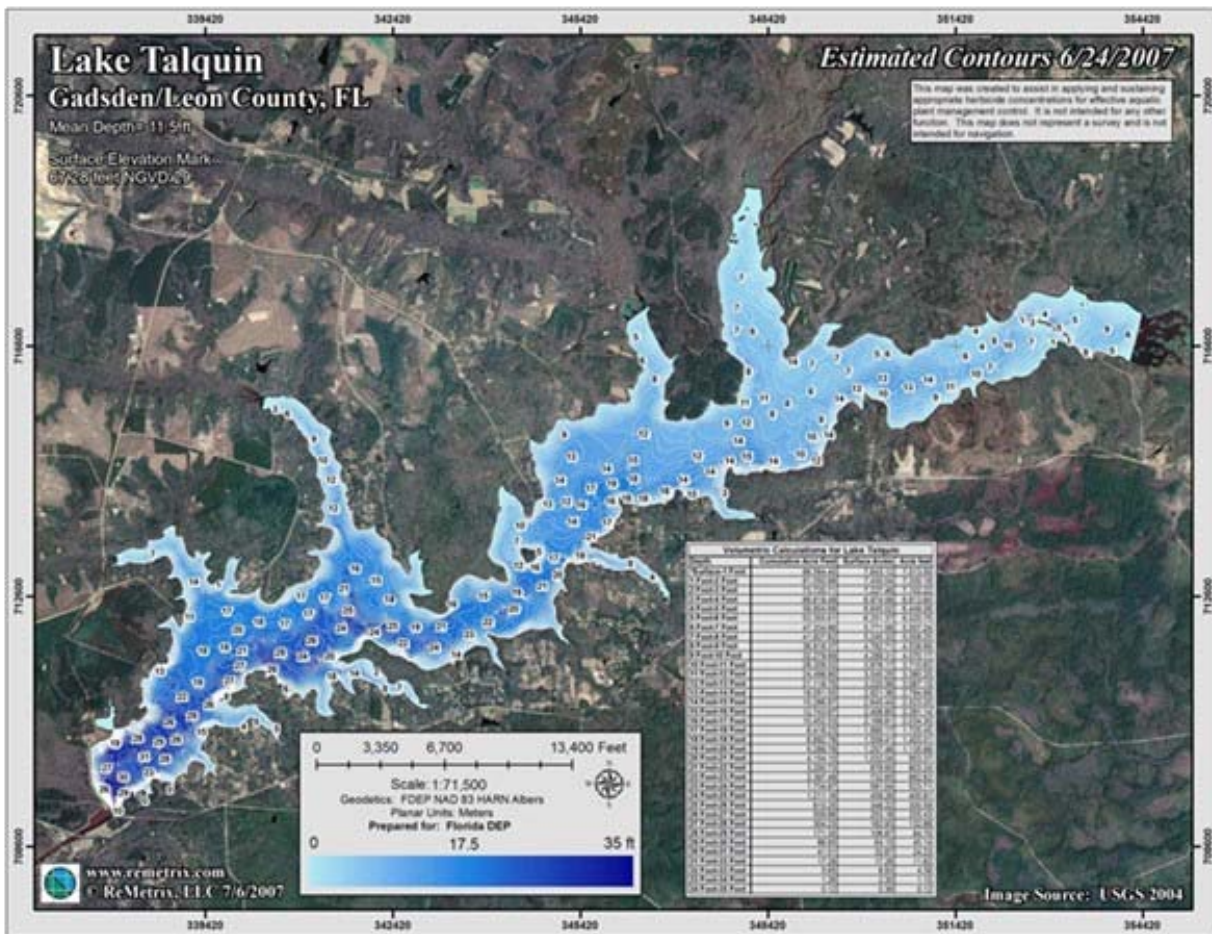


Figure 12 Lake Talquin Depth Profiles

Figure 13 illustrates the calibration of water surface elevation. While the watershed model was executed for 1997 through 2012, the hydrodynamic and water quality model for the lake was executed 2007 through 2012 because of the available water surface elevation data. This data is critical to determine whether the flows are well calibrated.

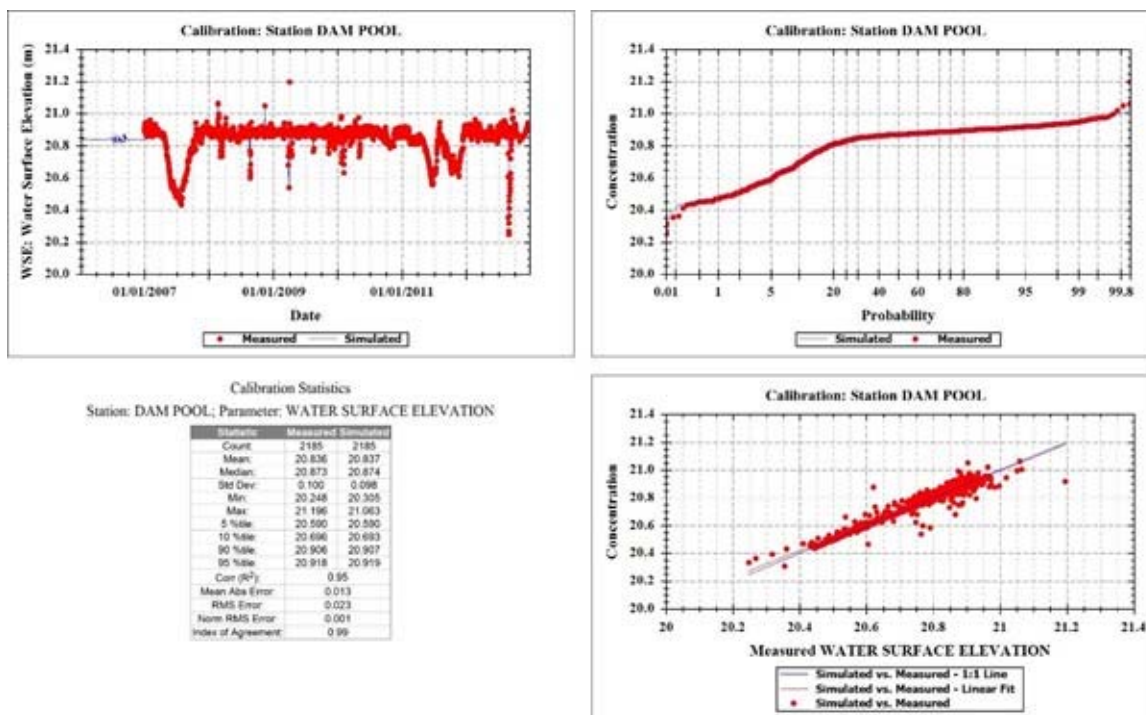


Figure 13 Water Surface Elevation Calibration

The following figures illustrate the temperature calibration for Lake Talquin. For all calibration plots for both the hydrodynamic and water quality model will use the same monitoring stations as depicted in Figure 27. For the lake model, all results shown are for the surface layer of the model. Figure 14 through Figure 22 provide a comparison of the model predicted temperature to the measured data.

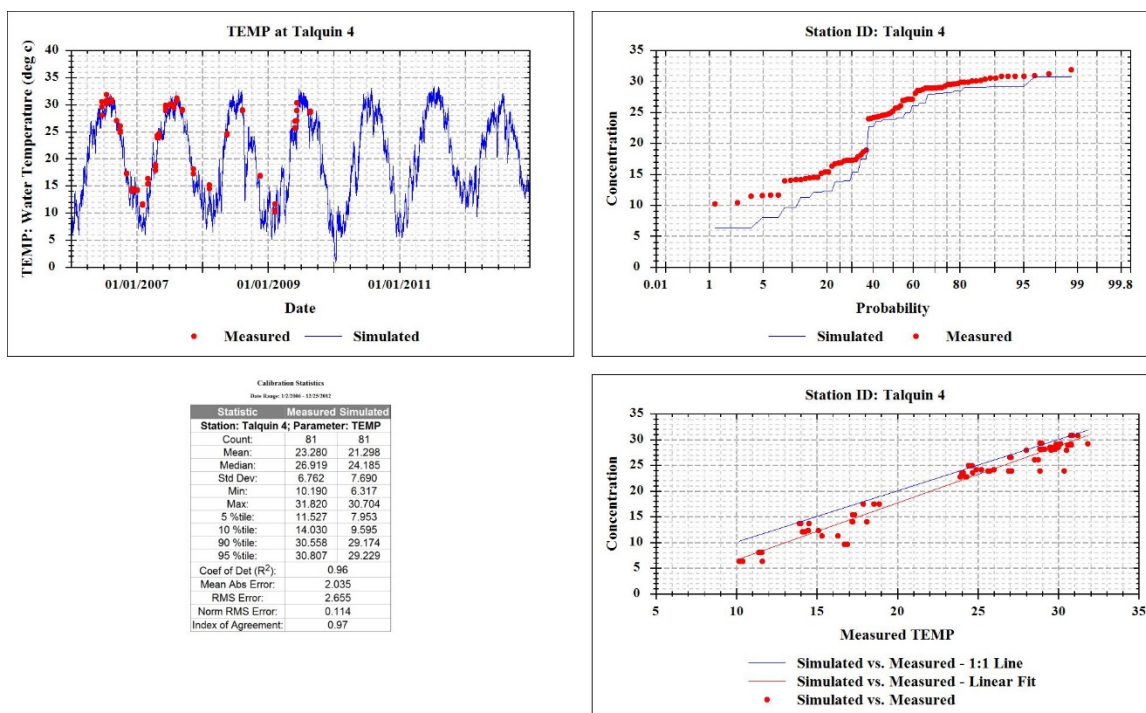


Figure 14 21FLLEONLCT0C3045884492: Talquin 4 for Water Temperature

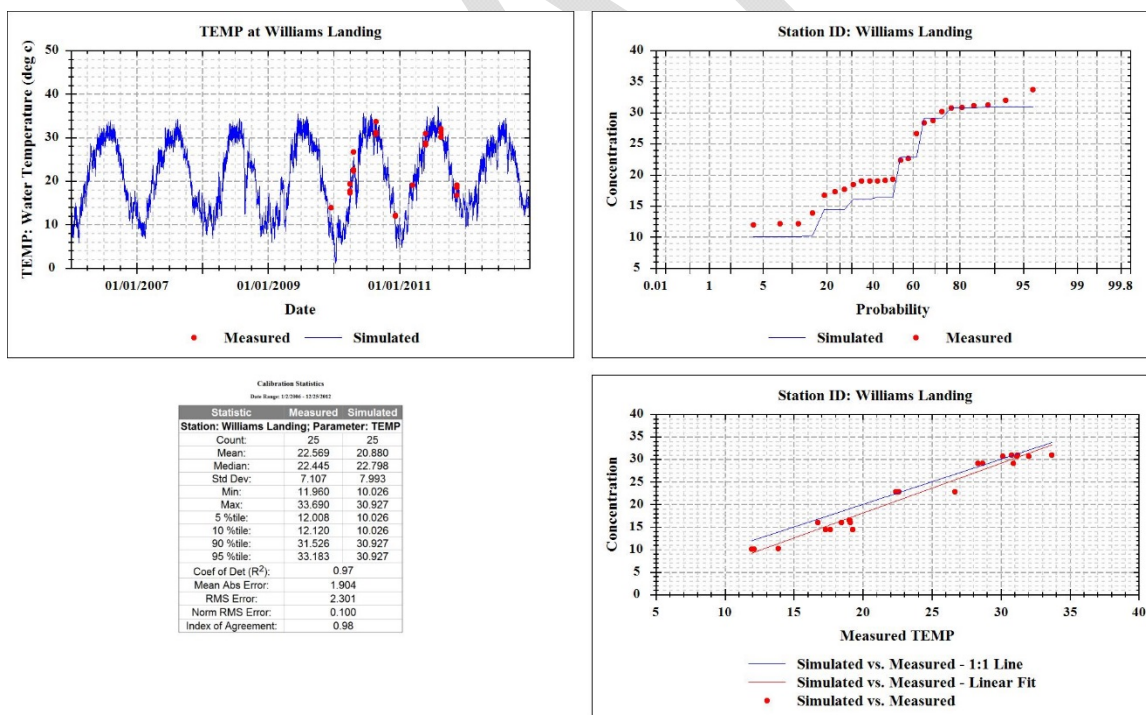


Figure 15 21FLLEONLCT03045184523: Lake Talquin near Williams Landing for Water Temperature

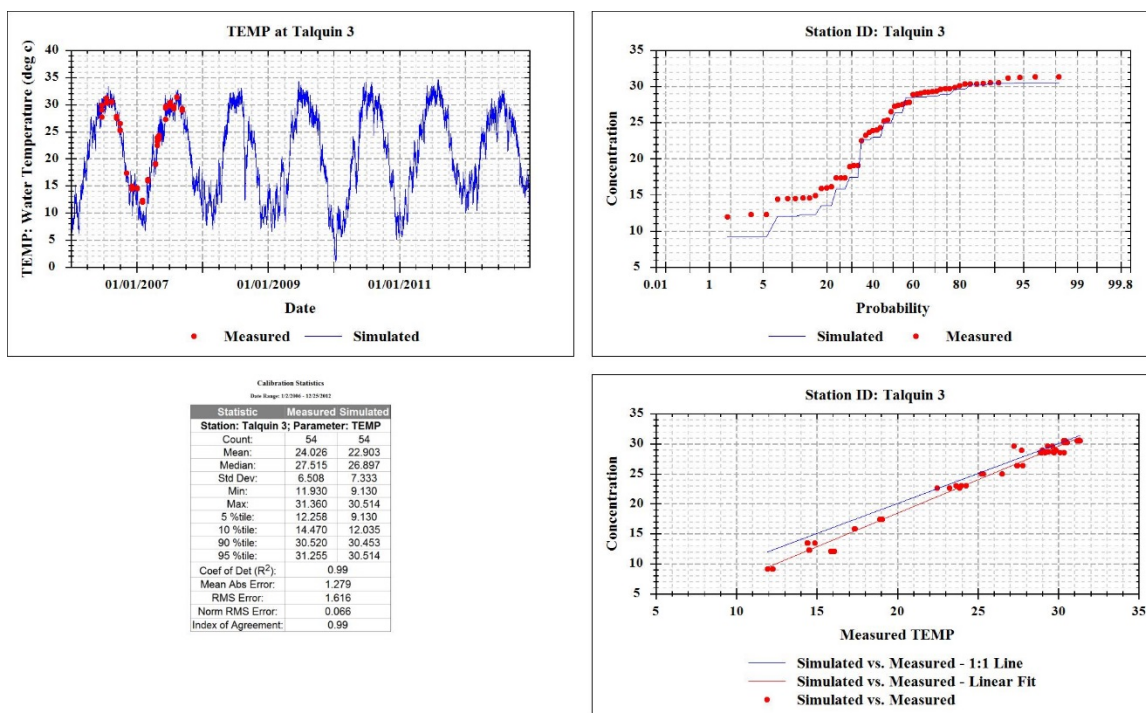


Figure 16 21FLLEONLCT0W3045084521: Talquin 3 for Water Temperature

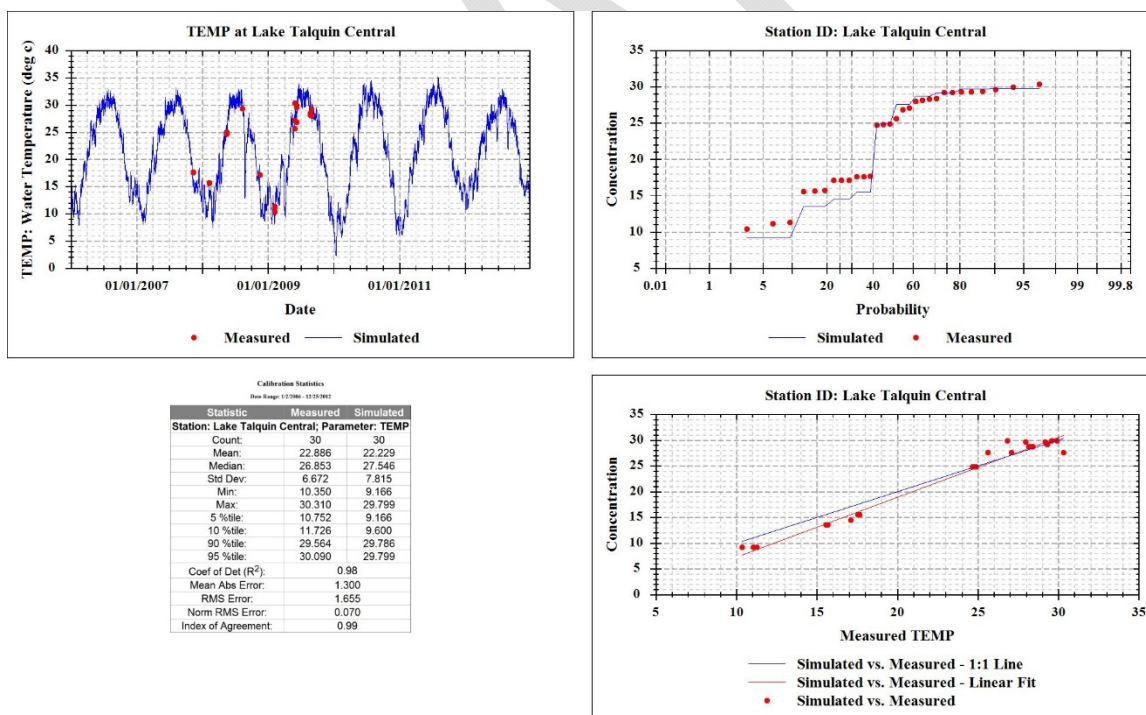


Figure 17 21FLLEONT0E3044084556: Lake Talquin Central for Water Temperature

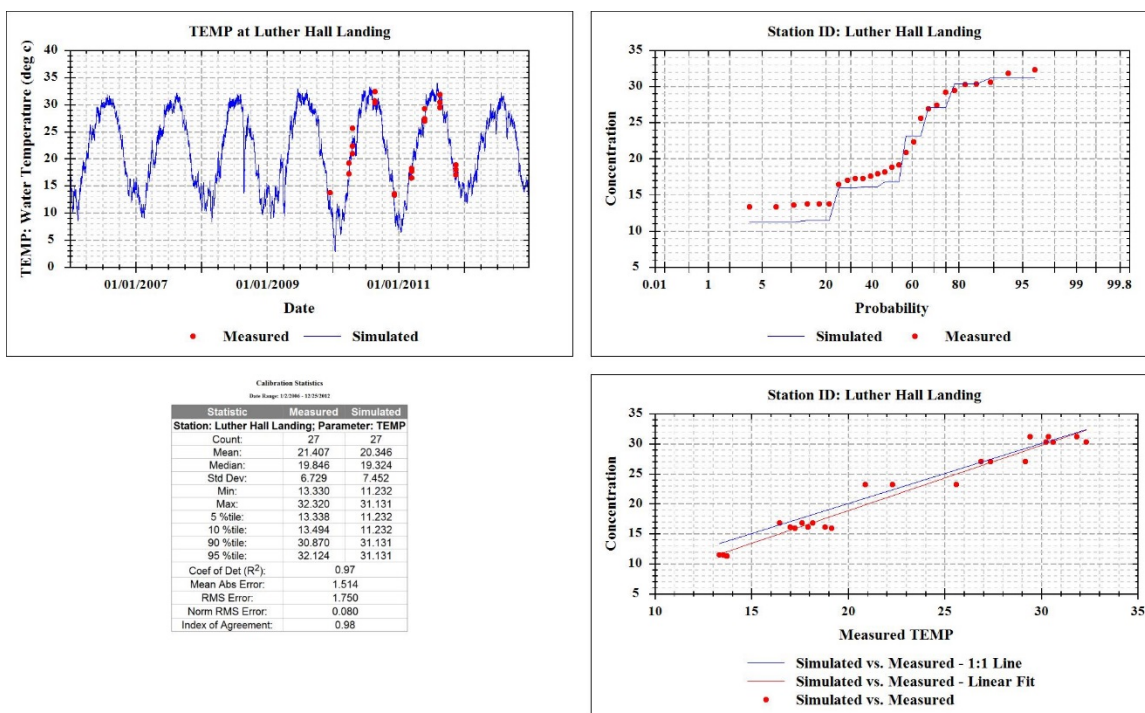


Figure 18 21FLLEONLCT03042384172: Lake Talquin near Luther Hall Landing for Water Temperature

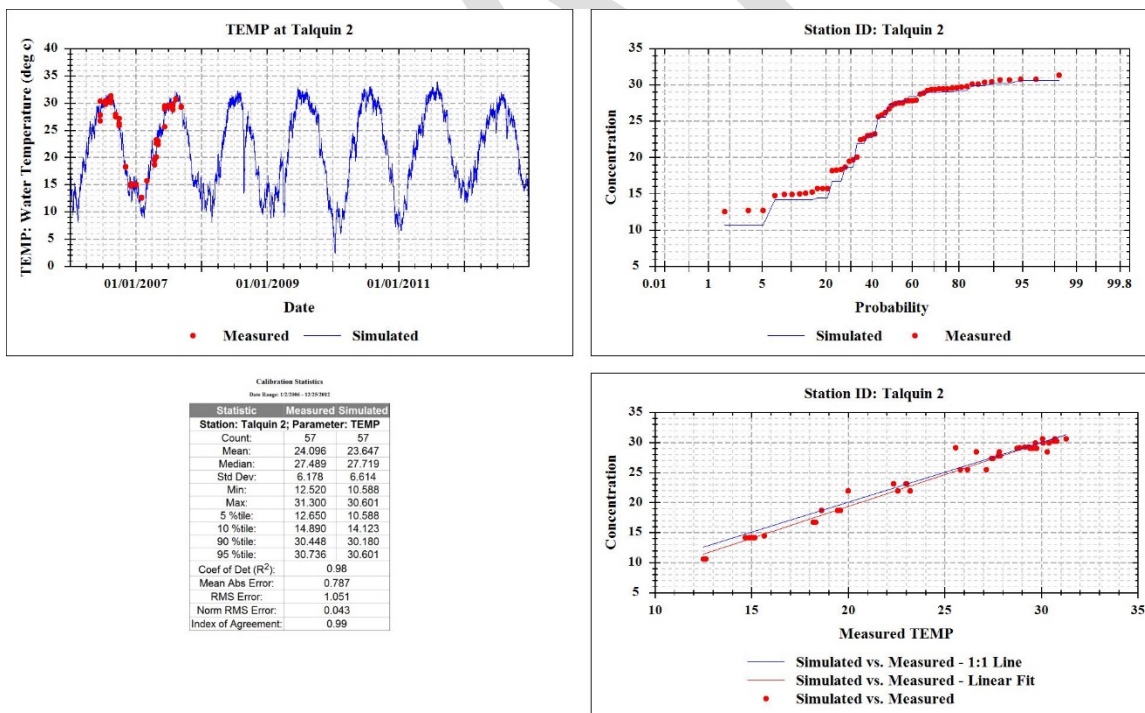


Figure 19 21FLLEONLCT0L3042284573: Talquin 2 for Water Temperature

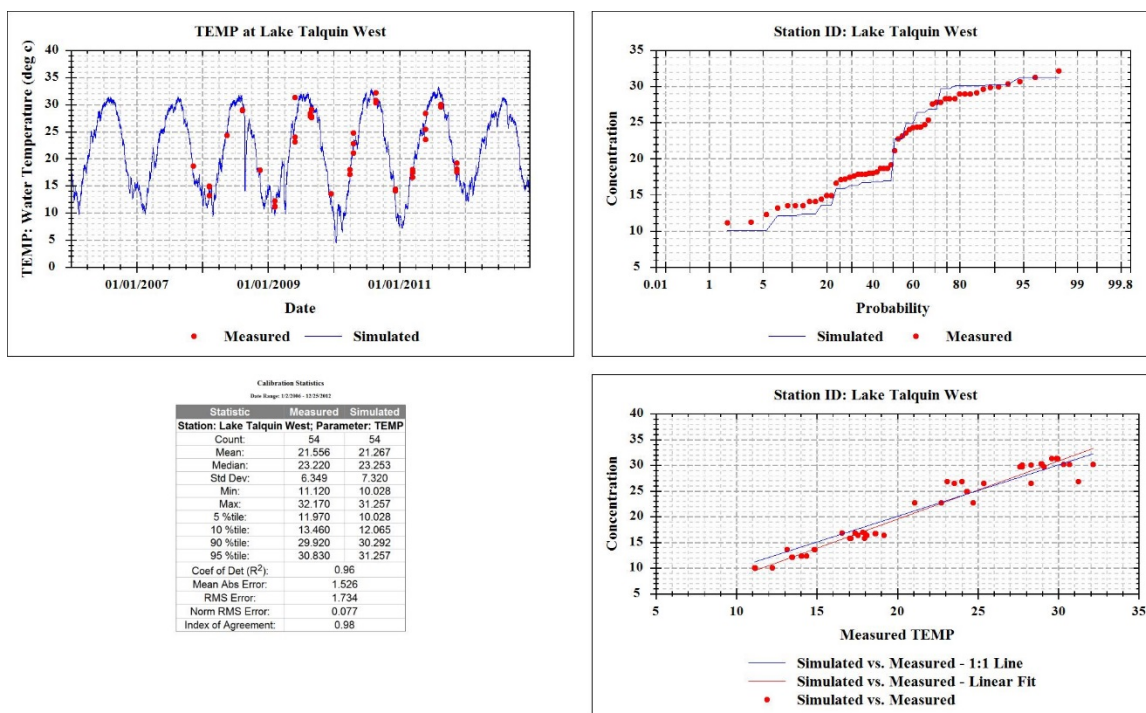


Figure 20 21FLLEONT0D3041488461: Lake Talquin West for Water Temperature

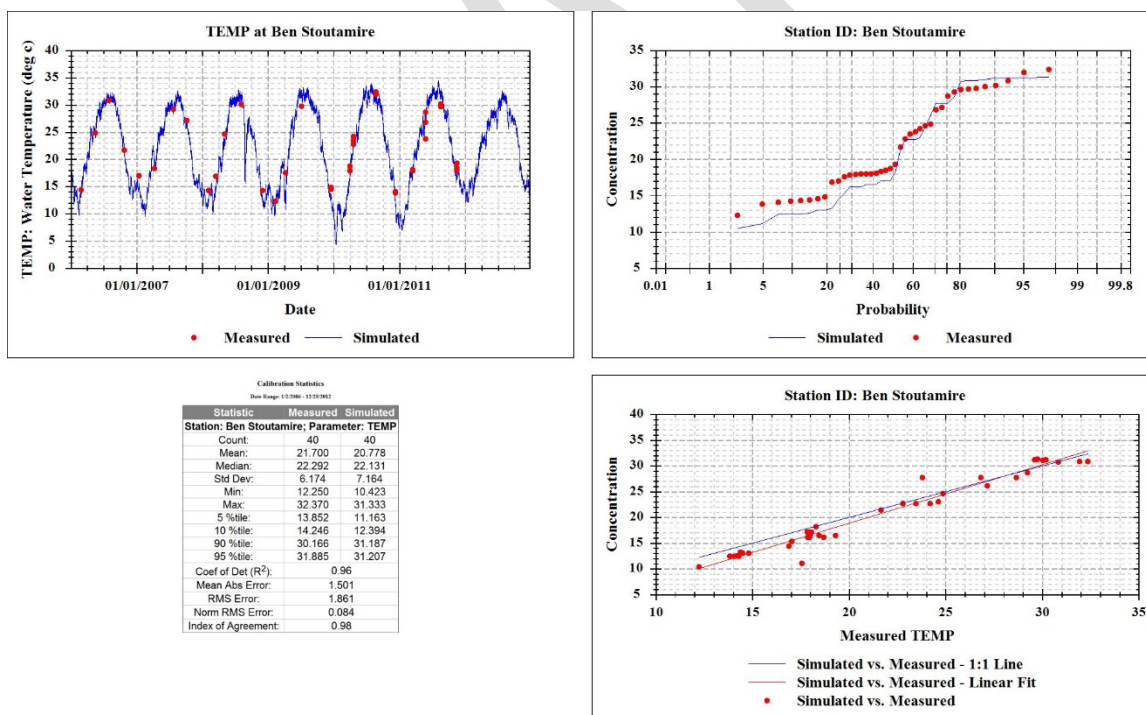


Figure 21 21FLLEONLCOC3040784610: Lake Talquin (Ben Stoutamire Boat Landing) for Water Temperature

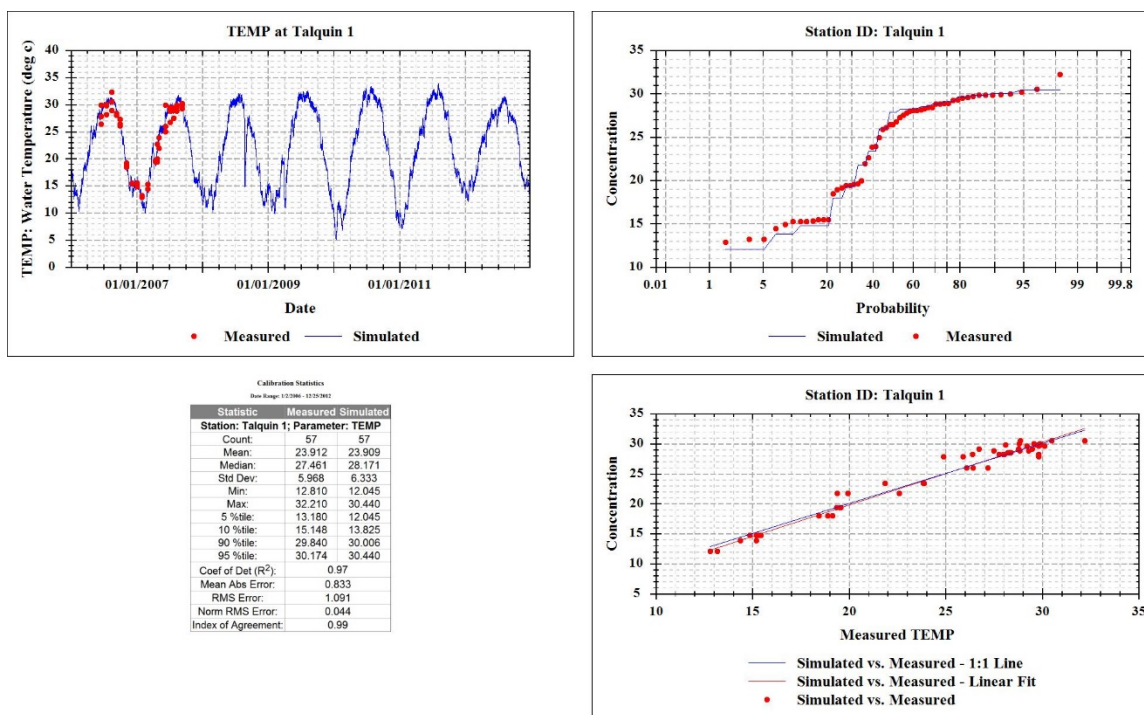


Figure 22 21FLLEONLCT0B3040284630: Talquin 1 for Water Temperature

Water Quality Model Application

The WASP water quality model uses the kinematic wave equation to simulate flow and velocity in Lake Talquin's tributaries, and the advanced eutrophication module to predict dissolved oxygen and Chlorophyll-a responses to BOD, total nitrogen and total phosphorus loadings. The watershed tributary geometry was determined from NHDPlus coverages of the free flowing stream sections.

Model Network

The Lake Talquin WASP model is comprised of 3 separate WASP water quality models, Little River, Ochlockonee River, and Lake Talquin. The output parameters for both Little River and Ochlockonee River tributaries are loaded into the Lake Talquin WASP model. The model segmentation for both of the river models was done based upon the NHDPlus coverage taking into account travel time, pore points for the watershed model and IWR monitoring stations.

Figure 23 illustrates 132 water quality model segments that are simulated for the Little River. The 18 subwatershed LSPC model flows and loads enter the water quality model at 18 different WASP segments. Figure 23 illustrates the 183 water quality model segments that are simulated for the Ochlockonee River. The LSPC model flows and loads enter the water quality model at 55 separate WASP segments.

Little River WASP Segmentation

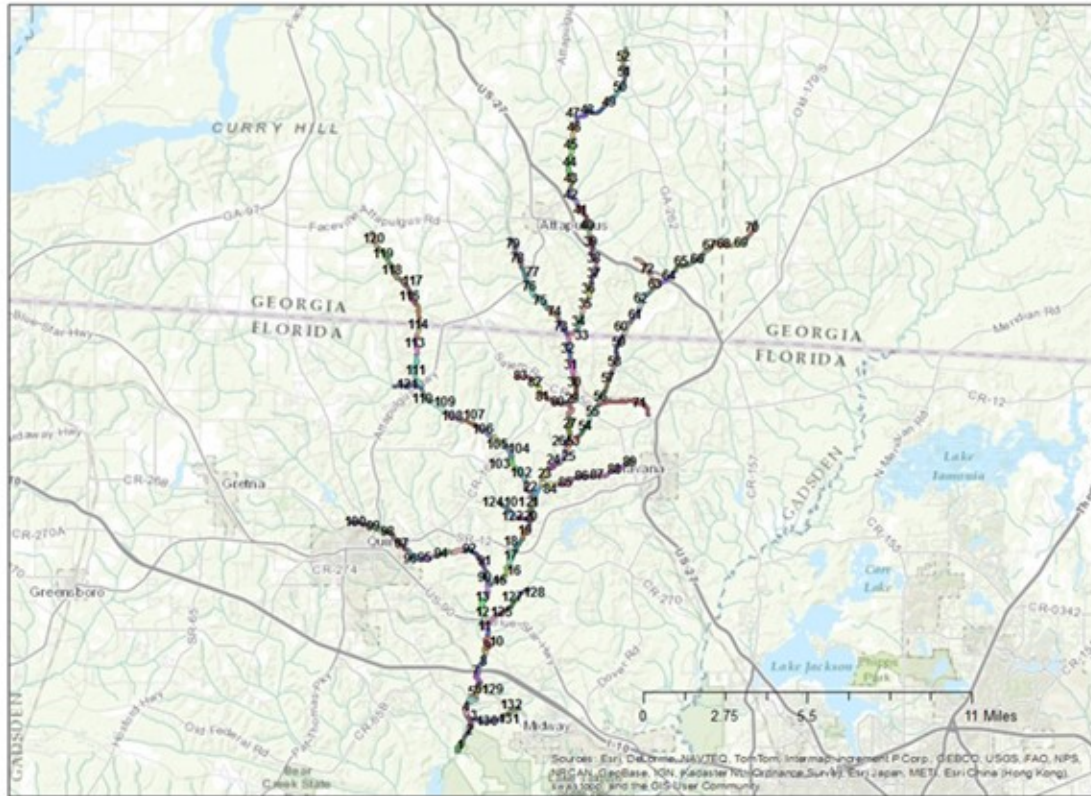


Figure 23 WASP Model Segmentation for Little River

Ochlockonee River WASP Segmentation

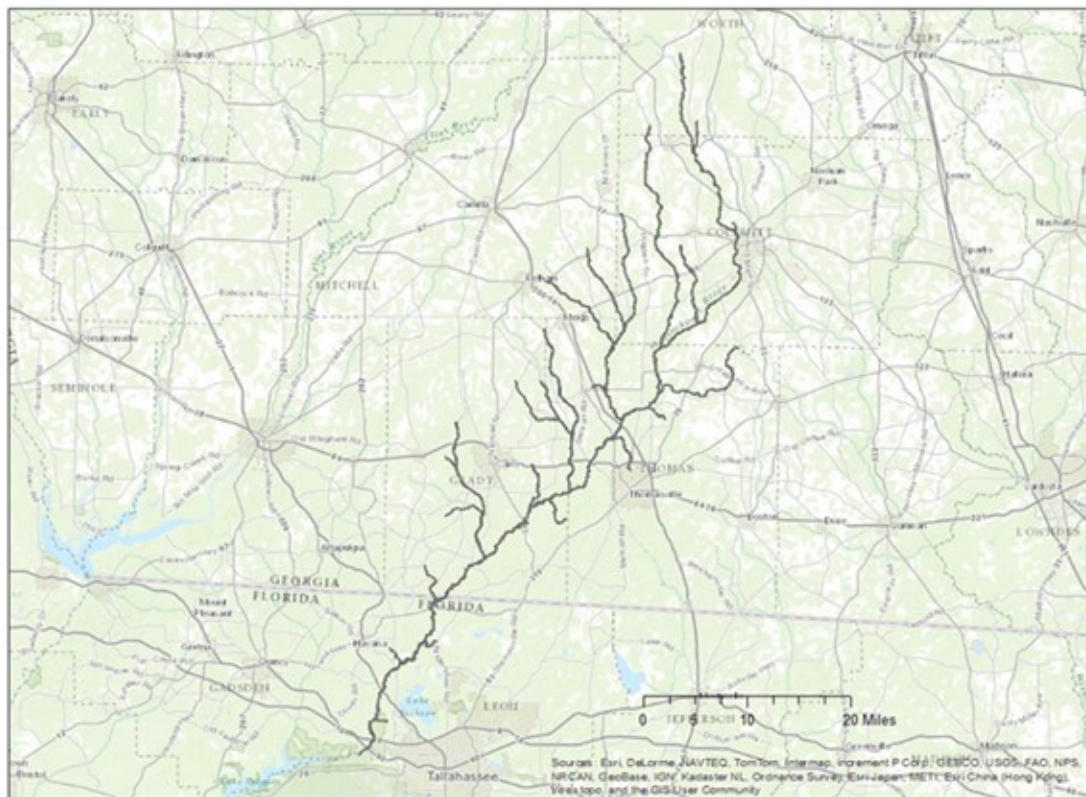


Figure 24 WASP Model Segmentation for Ochlockonee River

An EFDC grid was developed for Lake Talquin which consists of 212 horizontal cells with 2 layers. The model grid includes all the major and minor tributaries to the lake. EFDC and WASP are linked 1 to 1 in space. EFDC supplies updated hydrodynamic information to WASP every 60 EFDC time steps (Figure 11).

Water Quality Model Calibration

The water quality models were calibrated to available data. The fine tuning of the calibration of the models utilized the monitoring station(s) located at the lower end that contained the most monitoring data. For the lake calibration, all model results and measured data are representing the surface layer of the WASP model.

Table 3 - Table 5 list monitoring stations used to calibrate the three WASP models developed for Lake Talquin Watershed. All stations that had nutrient, BOD, dissolved oxygen and chlorophyll-a measurements were used in the calibration process. The stations highlighted in yellow provided the most critical monitoring data and were therefore provided the most influence to the water quality calibration.

Table 3 Monitoring Stations used in Little River Water Quality Model Calibration

WASP Segment	State	Station ID	Station Name
4	FL	21FLBRA 424-A	424 - Little River - far dwnstrm from bridge on SR 268
4	FL	21FLPNS 303043908431244	Little River at SR 268
29	FL	21FLPNS 303946808427477	Attapulcus Creek at SR 159
29	FL	21FLWQA 303946808427477	Attapulcus Creek at SR 159
55	FL	21FLBRA 427-A	427 - Swamp Creek - Calem Rd Crossing
55	FL	21FLWQA 303919608427079	Swamp Creek at SR 159
64	GA	21 GAEPD_WQX_10020001	Swamp Creek at US 27 nr Attapulgas
64	GA	21 GAEPD_WQX_1003020501	Swamp Creek at US 27 nr Attapulgas



Figure 25 Little River WASP Water Quality Calibration Segments

Table 4 Monitoring Stations used in Ochlockonee River Water Quality Model Calibration

WASP Segment	State	Station ID	Station Name
25	GA	21GAEPD_WQX-1003010102	Ochlockonee River @ Hadley Ferry Rd, nr Calvary, Ga.

51	GA	21GAEPD_WQX-1002030102	Ochlockonee River at SR 188 near Coolidge, GA
53	GA	21GAEPD_WQX-10005001	Bridge Creek at County Road 222 near Coolidge,GA
53	GA	21GAEPD_WQX-1002030101	Bridge Creek at County Road 222 near Coolidge, GA
60	GA	21GAEPD_WQX-10003001	Ochlockonee River - FAS 1205 near Moultrie
60	GA	21GAEPD_WQX-1002010401	Ochlockonee River - FAS 1205 near Moultrie
161	GA	21GAEPD_WQX-1002080401	Tired Creek at County Road 151 near Reno, GA
108	GA	21GAEPD_WQX-10008901	Big Creek at State Road 111 near Meigs, GA
108	GA	21GAEPD_WQX-1002040401	Big Creek at State Road 111 near Meigs, GA
32	GA	21GAEPD_WQX-1002070301	Ochlockonee River - SR 93 near Cairo, GA
8	FL	112WRD 02329000	OCHLOCKONEE RIVER NR HAVANA, FLA.
8	FL	21FLGW S468	OCHLOCKONEE R. NR HAVANA
8	FL	21FLWQA 303314308423028	Ochlockonee River at US 27
11	FL	21FLWQA 303507108421337	Ochlockonee River at SR 157
11	FL	21FLPNS T03	Ochlockonee River @ Old Banbridge Road - L(also 21FMCGL)
11	FL	21FLBRA 1297E-B	1297E - Ochlockonee River - At SR-153
20	FL	21FLGW 3540	Ochlockonee river at SR 12

Ochlockonee River Calibration Stations

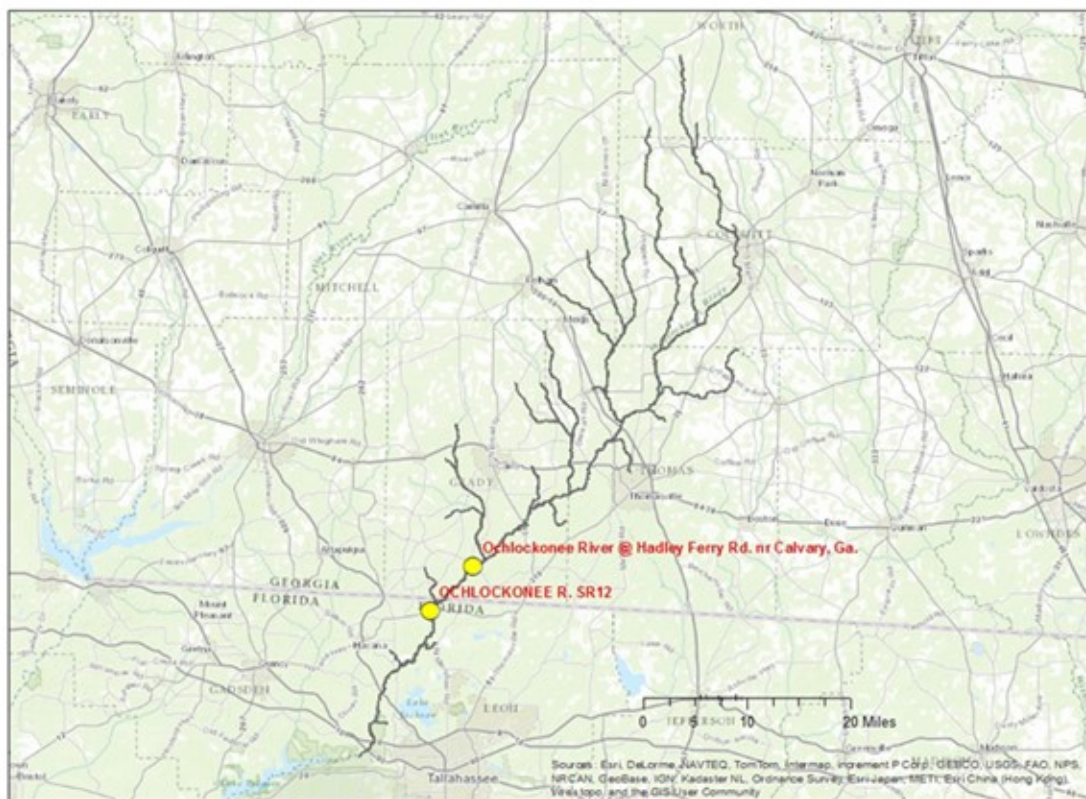


Figure 26 Ochlockonee WASP Water Quality Calibration Segments

Table 5 Monitoring Stations used in Lake Talquin Water Quality Model Calibration

Station	Station Name
21FLLEONLCOC3040784610	Lake Talquin (Ben Stoutamire Boat Landing)
21FLLEONLCT03042384172	Lake Talquin near Luther Hall Landing
21FLLEONLCT03045184523	Lake Talquin near Williams Landing
21FLLEONLCT0B3040284630	Talquin 1
21FLLEONLCT0C3045884492	Talquin 4
21FLLEONLCT0L3042284573	Talquin 2
21FLLEONLCT0W3045084521	Talquin 3
21FLLEONT0D3041488461	Lake Talquin West
21FLLEONT0E3044084556	Lake Talquin Central

Station location

Figure 27 illustrates the location of the water quality stations that were used in the calibration. All of these stations are maintained by Leon County, FL. These stations were chosen because they represent the most complete and long term record of data for Lake Talquin.

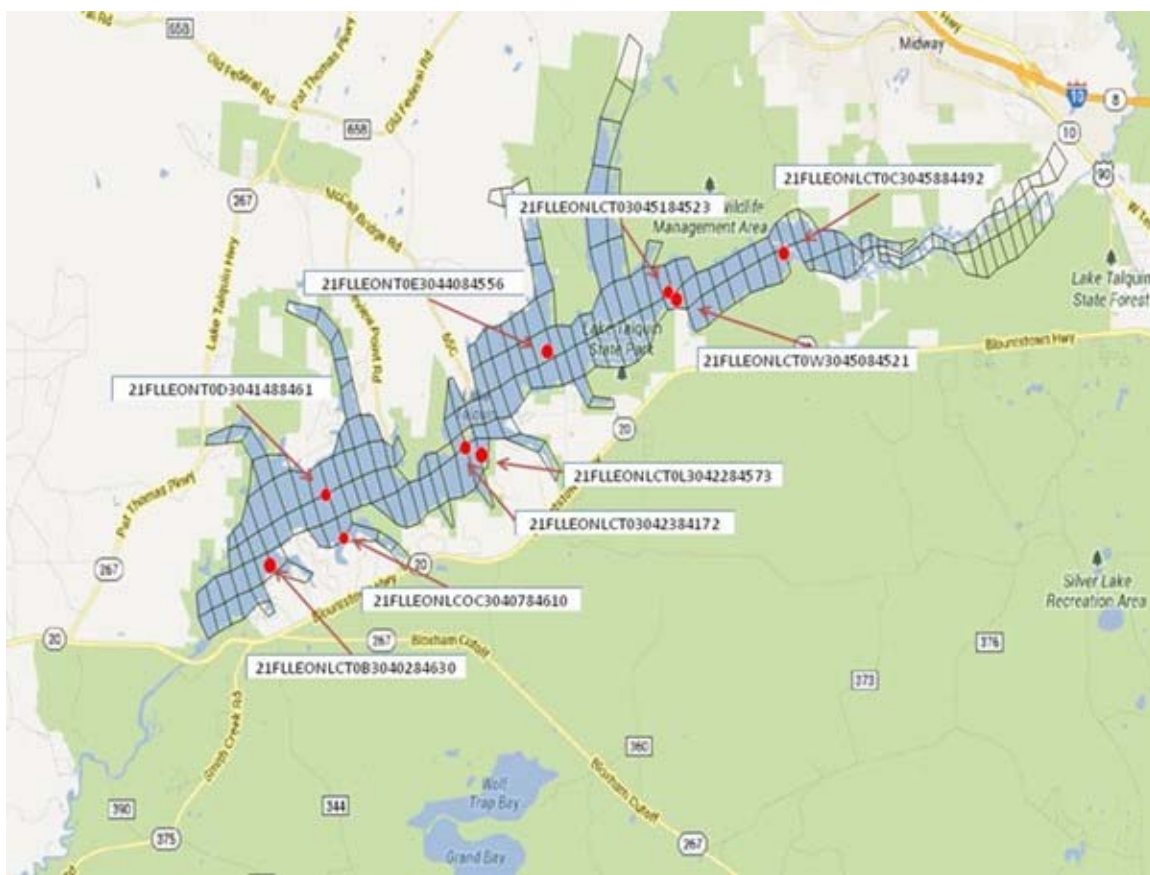


Figure 27 Lake Talquin Calibration Station Location

Little River/Ochlockonee River Water Quality Calibration

Both the Ochlockonee and Little River Models were calibrated against available ambient monitoring data. Stations with the most complete dataset were used. The model calibration focused on getting the loads to Lake Talquin correct.

Water Temperature

The riverine models were configured to simulation water temperature. This step was important because it provides daily water temperatures that are used to influence the degradation of BOD, kinetic transformation (mineralization, dissolution), and algal growth/death rates.

Figure 28 - illustrate both a quantitative and qualitative comparisons of simulated water temperature to direct field measurements.

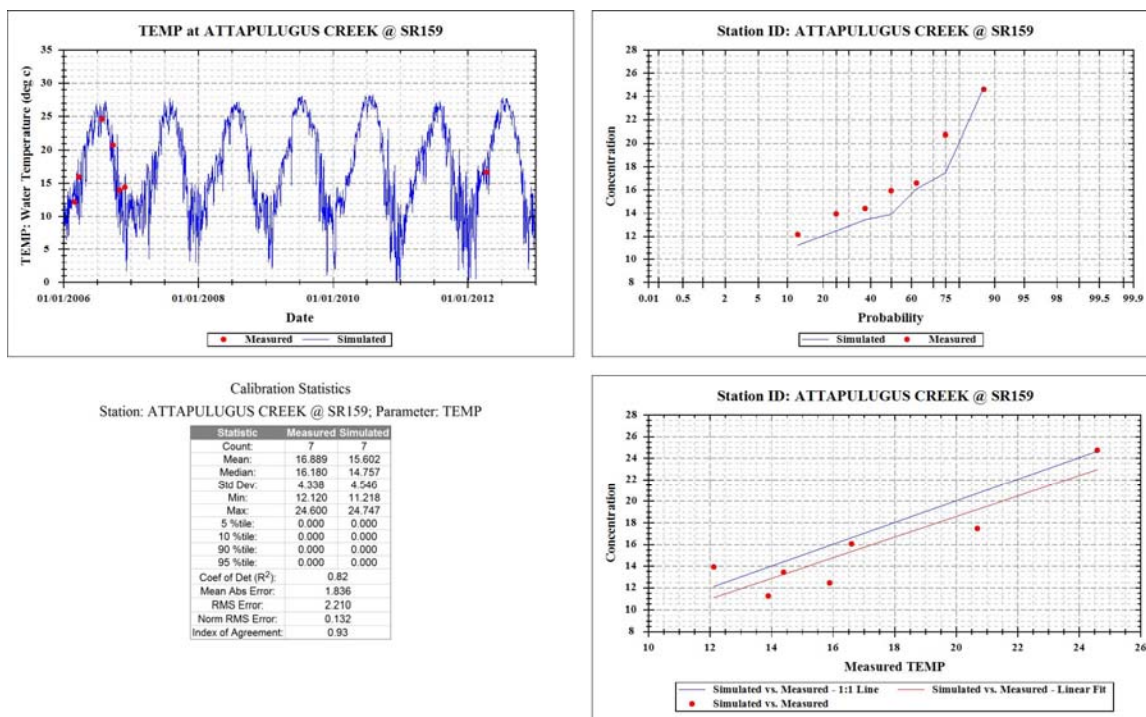


Figure 28 Water Temperature Calibration Attapulugus Creek at SR 159

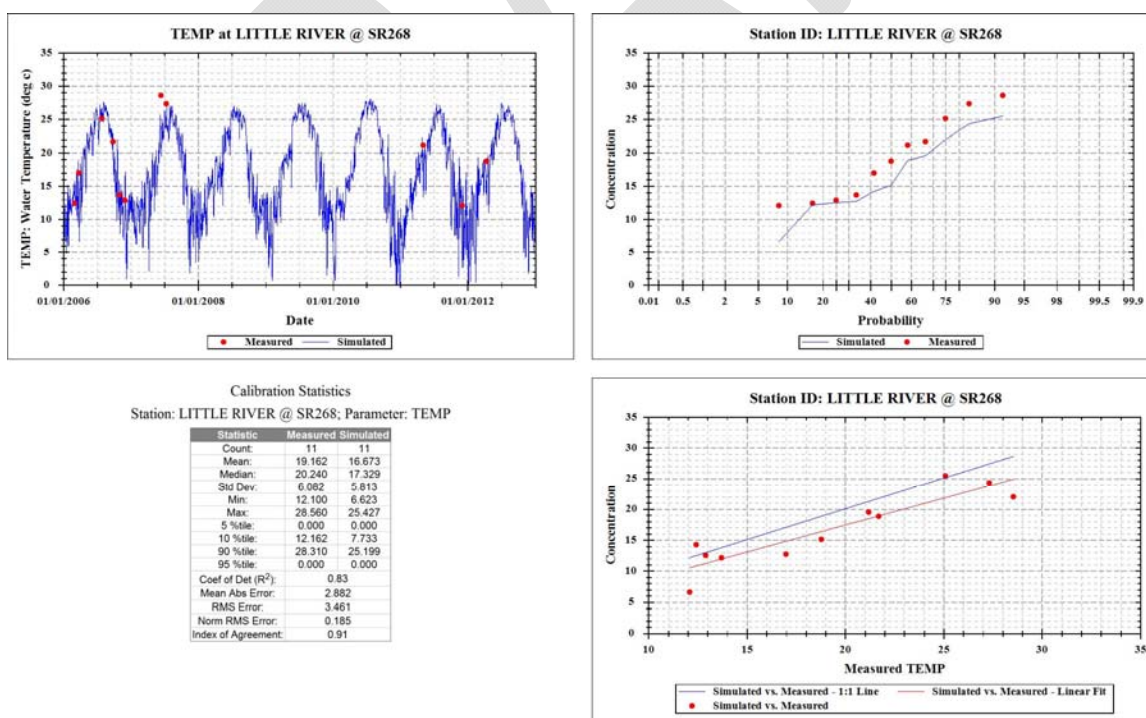


Figure 29 Water Temperature Calibration Little River at SR 268

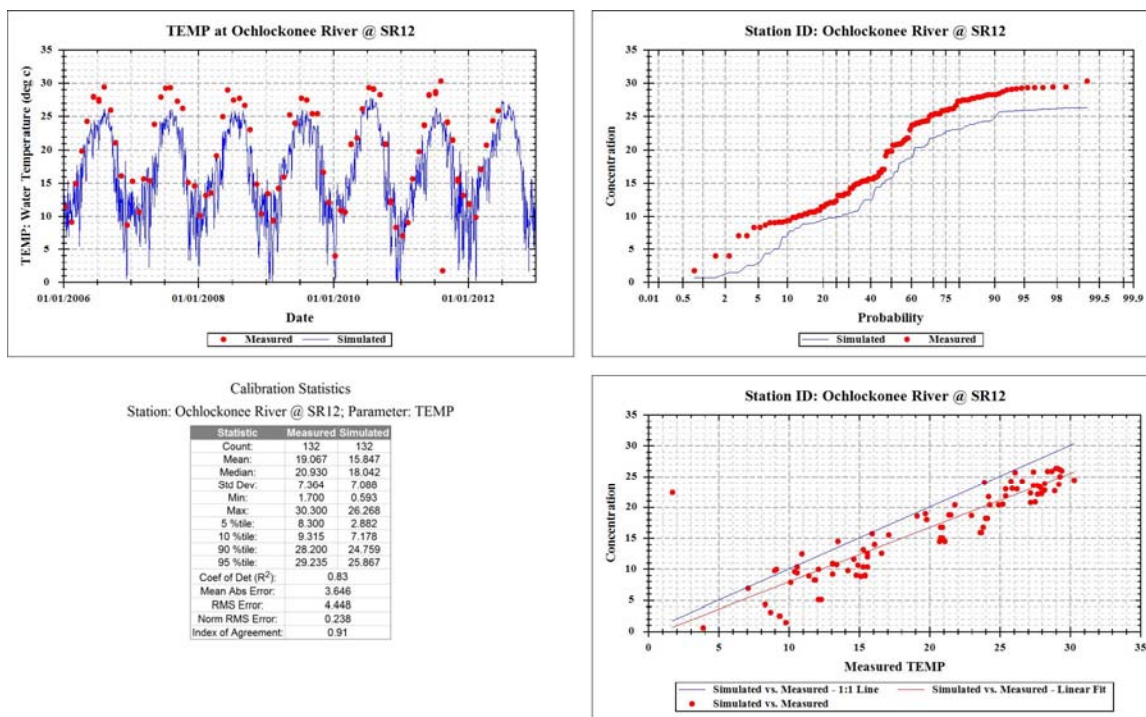


Figure 30 Water Temperature Calibration Ochlockonee River at SR 12

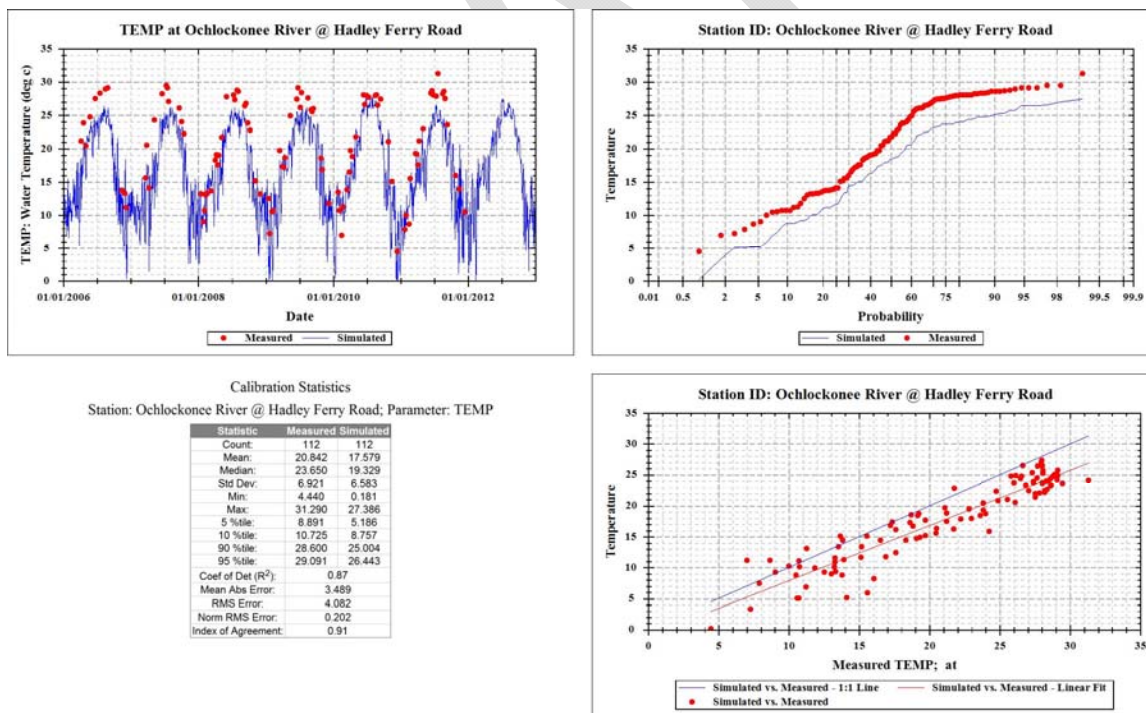


Figure 31 Water Temperature Calibration Ochlockonee River at Hadley Road

Dissolved Oxygen

Figure 32 through Figure 44 illustrates both a quantitative and qualitative comparison of the predicted dissolved oxygen concentrations compared to the direct measurements.

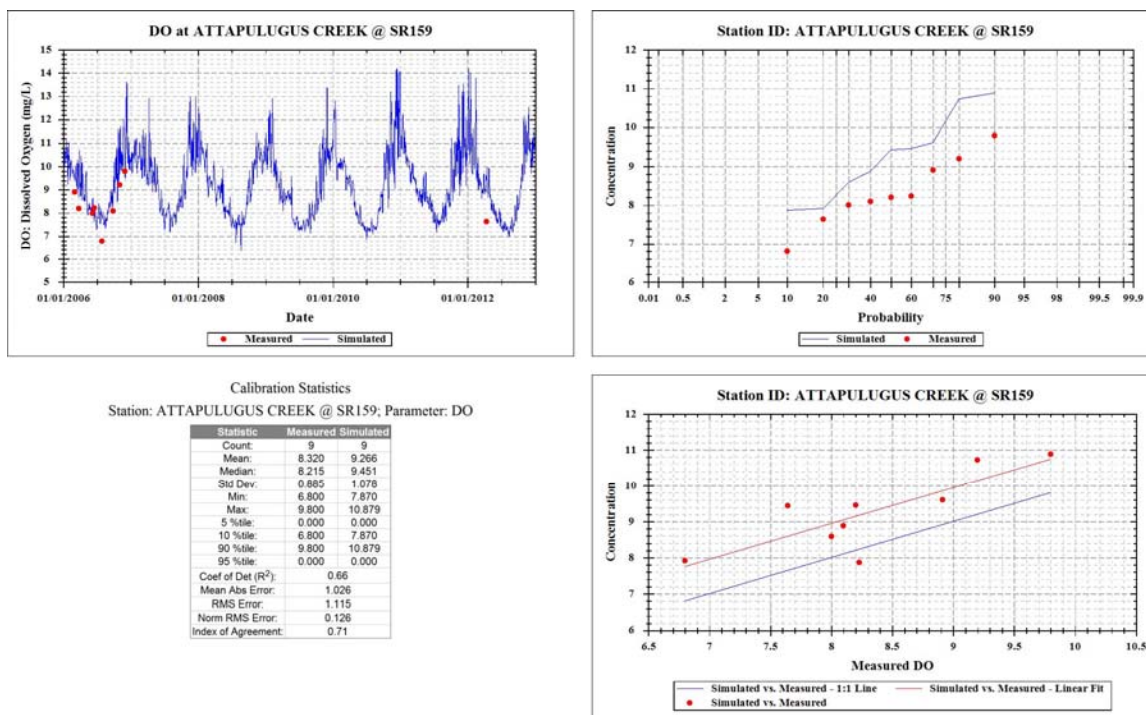


Figure 32 Dissolved Oxygen Calibration Attapulugus Creek at SR 159

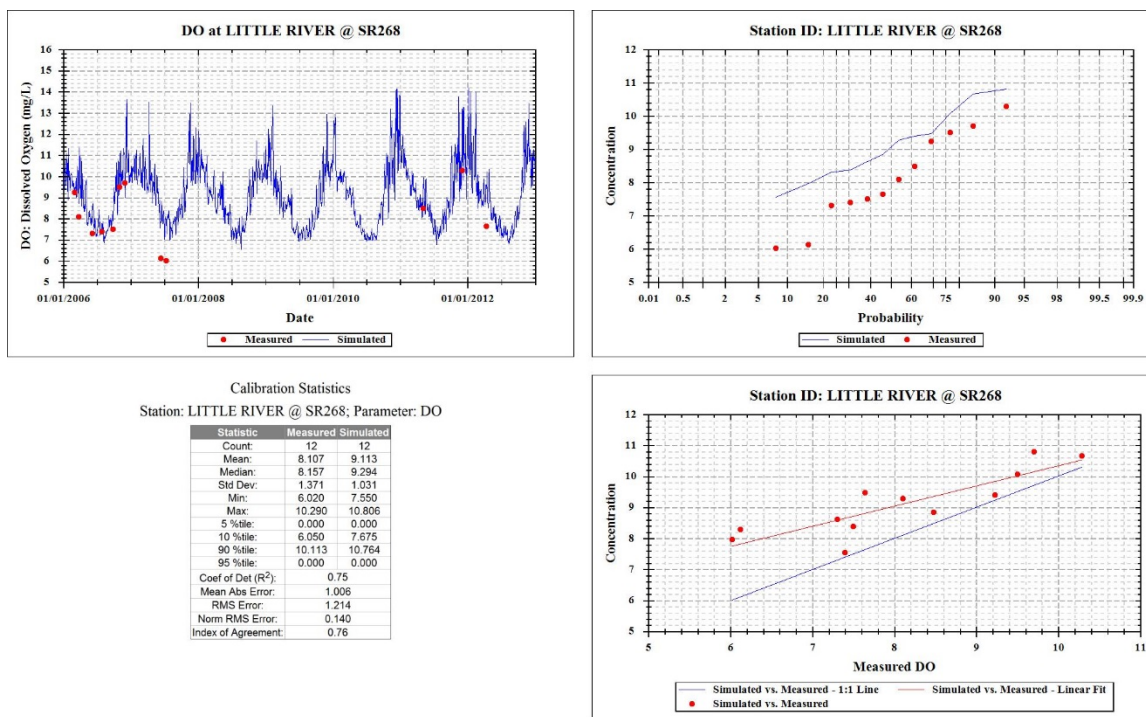


Figure 33 Dissolved Oxygen Calibration Little River at SR 268

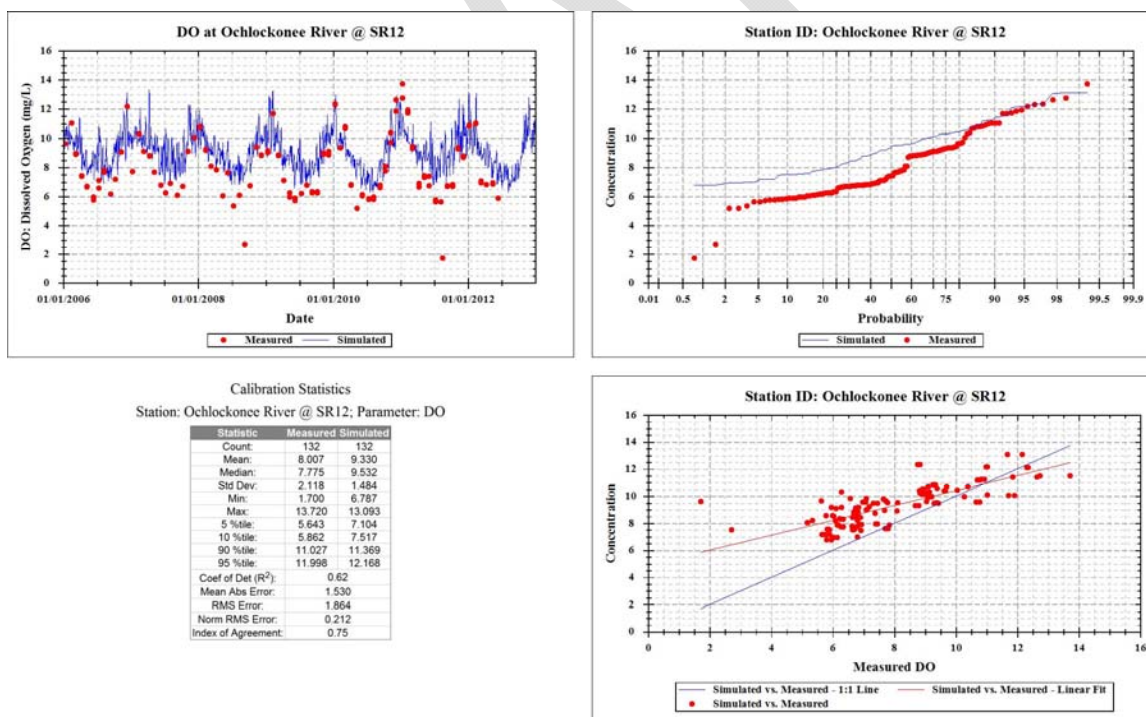


Figure 34 Dissolved Oxygen Calibration Ochlockonee River at SR 12

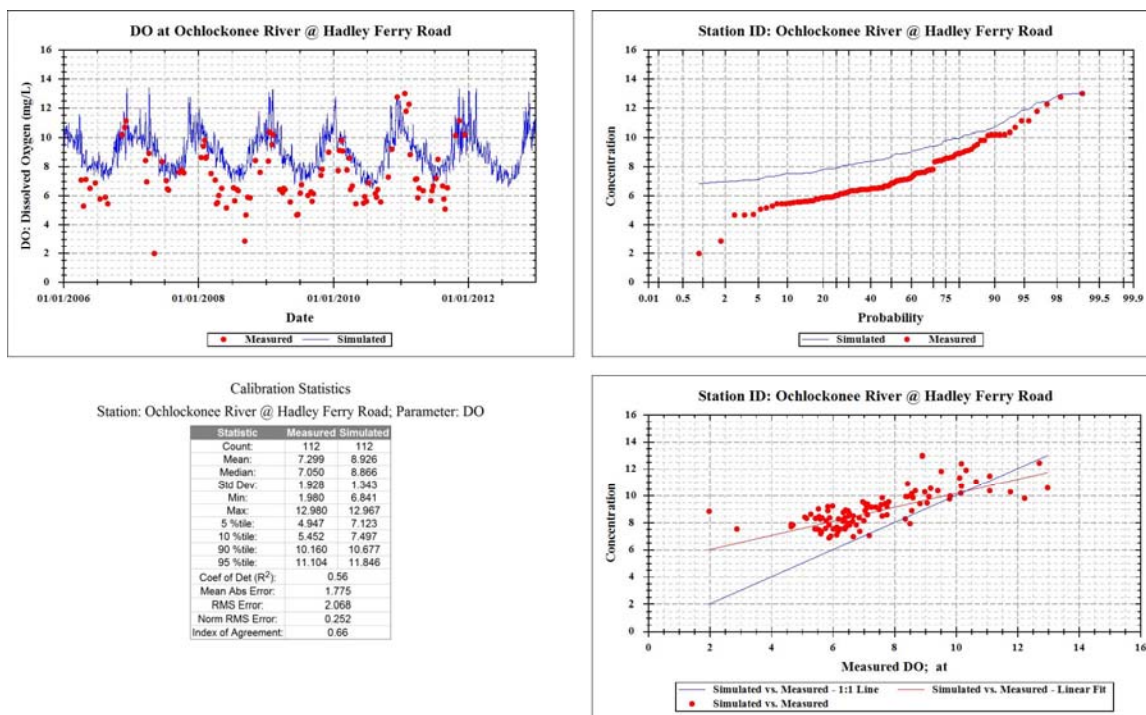


Figure 35 Dissolved Oxygen Calibration Ochlockonee River at Hadley Road

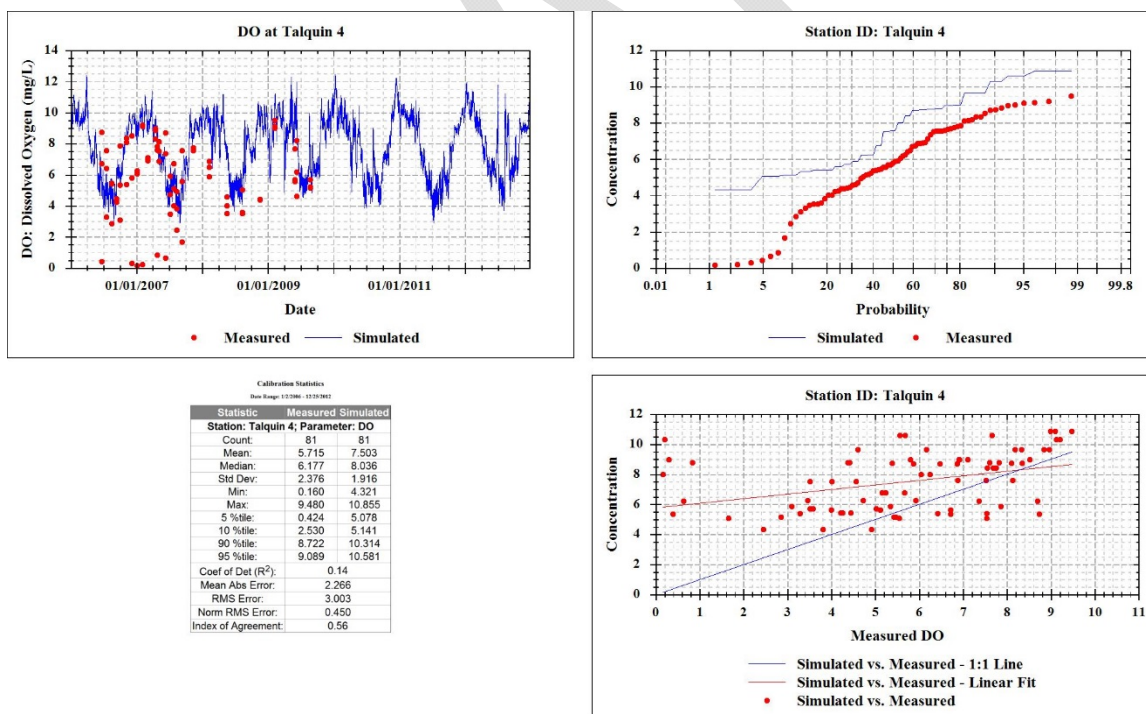


Figure 36 21FLLEONLCT0C3045884492: Talquin 4 for Dissolved Oxygen

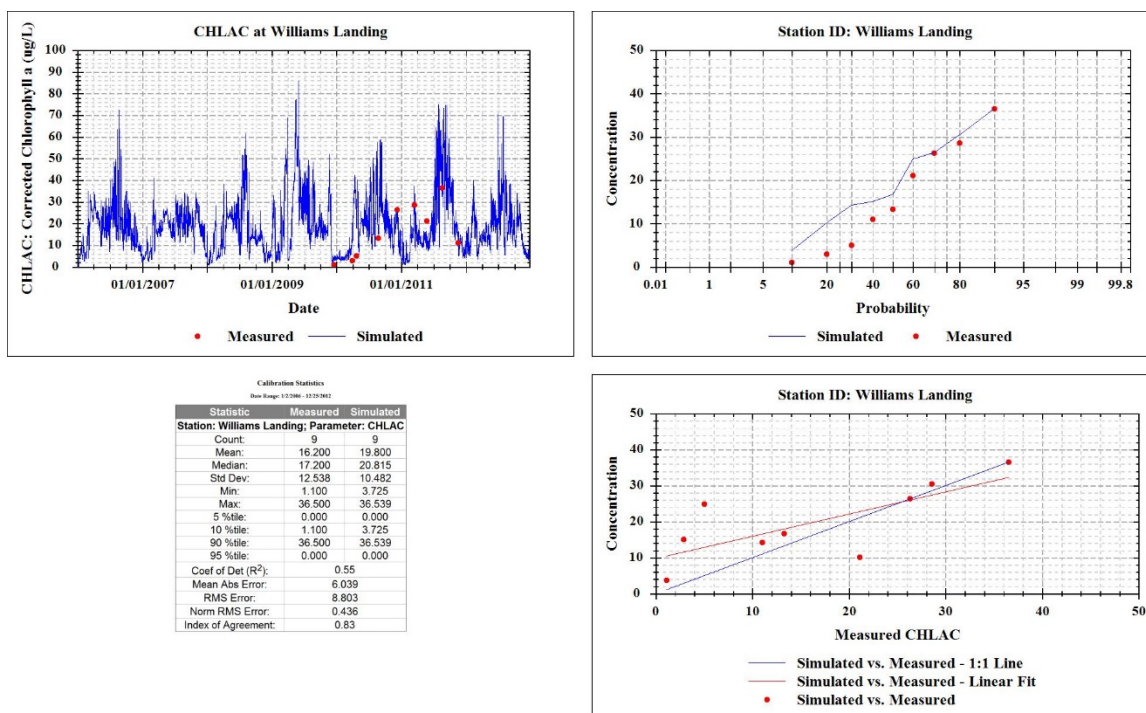


Figure 37 21FLLEONLCT03045184523: Lake Talquin near Williams Landing for Dissolved Oxygen

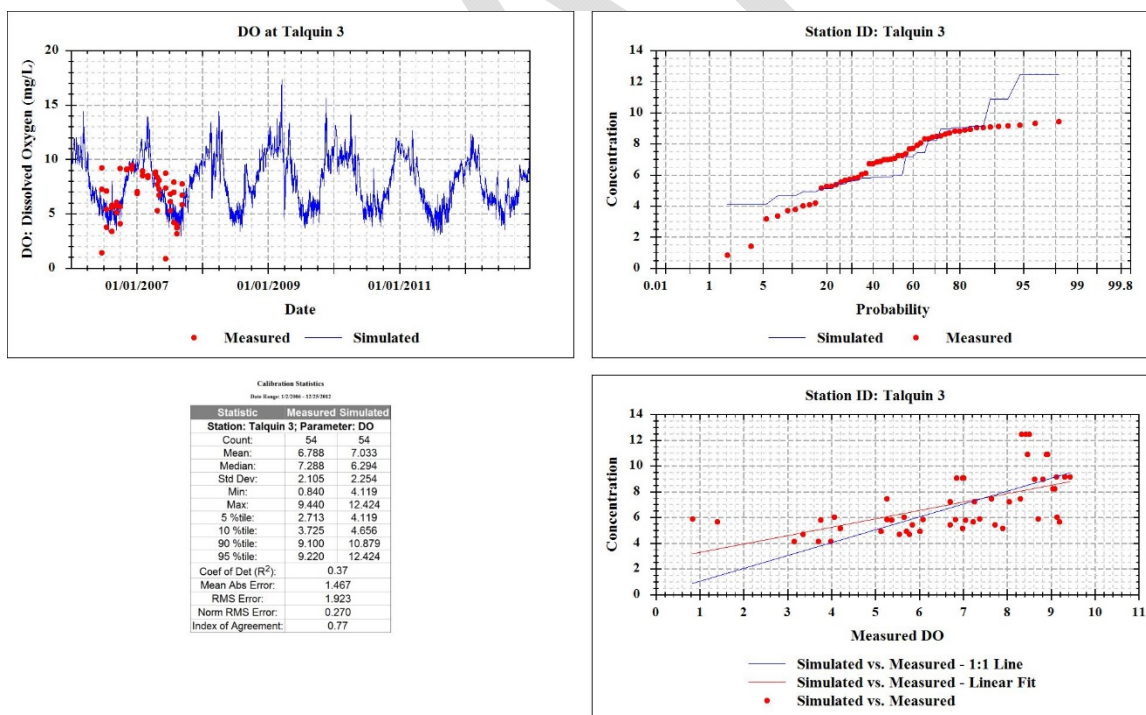


Figure 38 21FLLEONLCT0W3045084521: Talquin 3 for Dissolved Oxygen

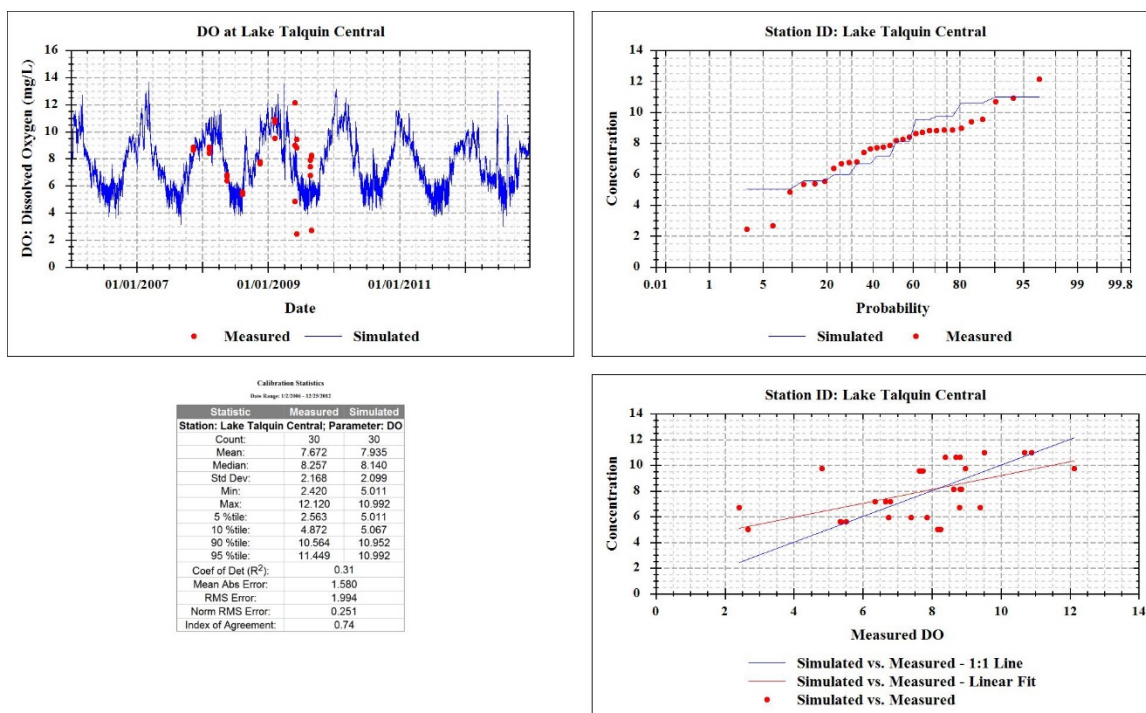


Figure 39 21FLLEONT0E3044084556: Lake Talquin Central for Dissolved Oxygen

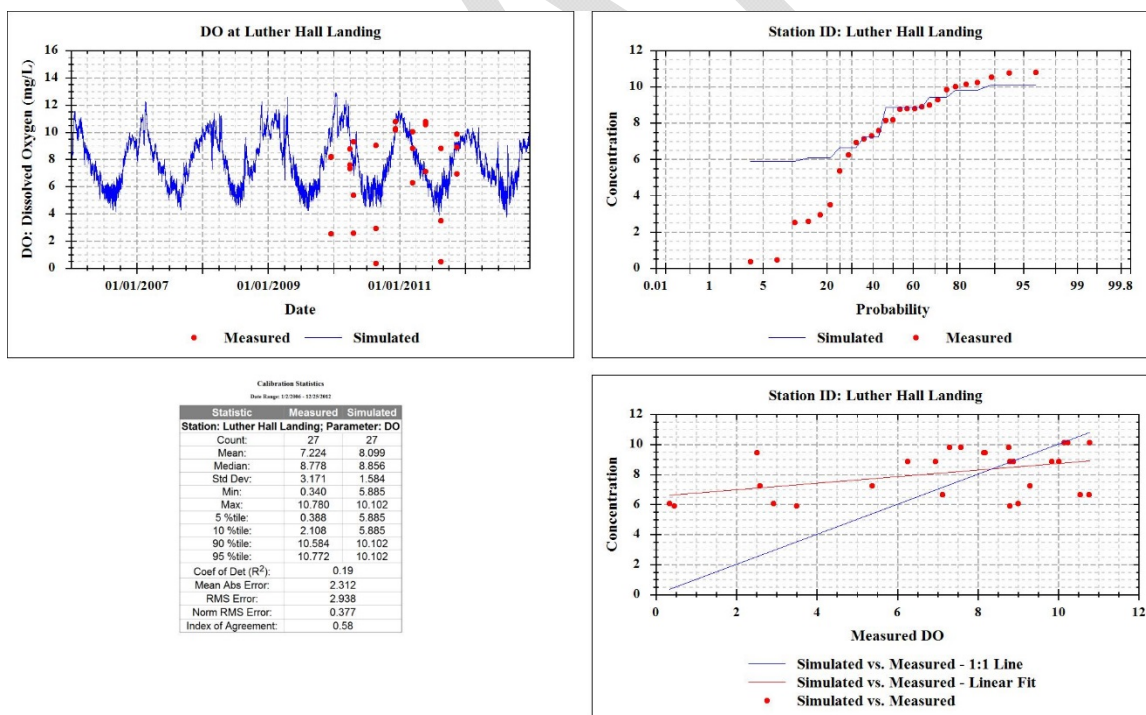


Figure 40 21FLLEONLCT03042384172: Lake Talquin near Luther Hall Landing for Dissolved Oxygen

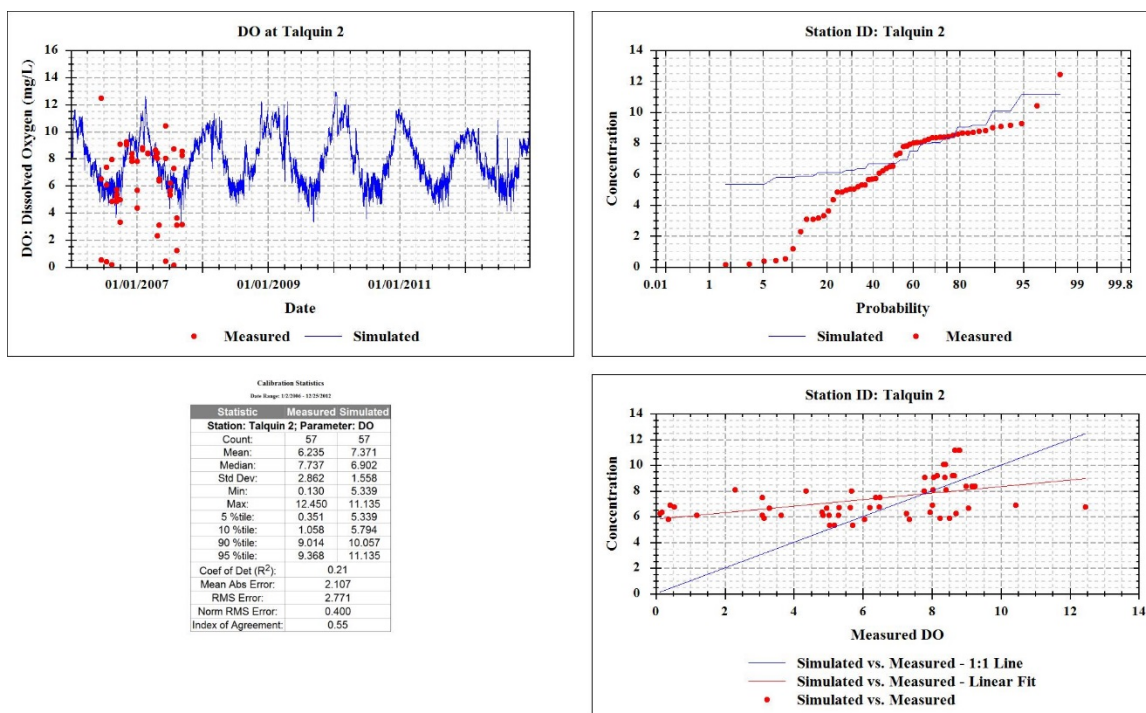


Figure 41 21FLLEONLCT0L3042284573: Talquin 2 for Dissolved Oxygen

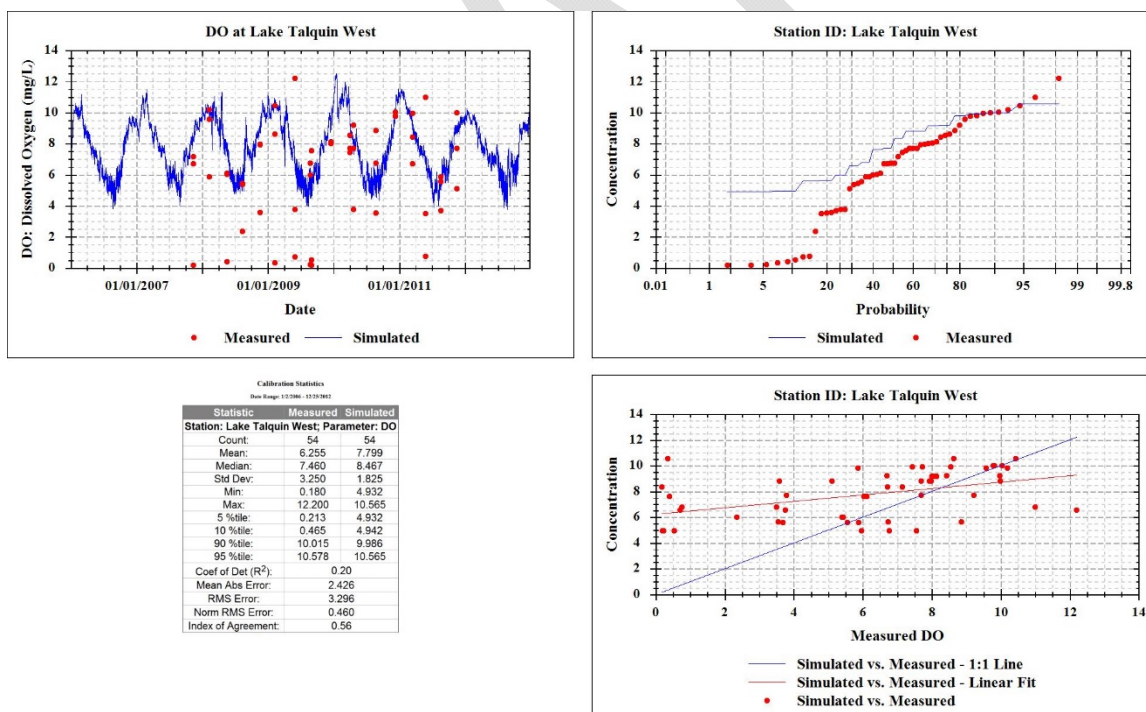


Figure 42 21FLLEONT0D3041488461: Lake Talquin West for Dissolved Oxygen

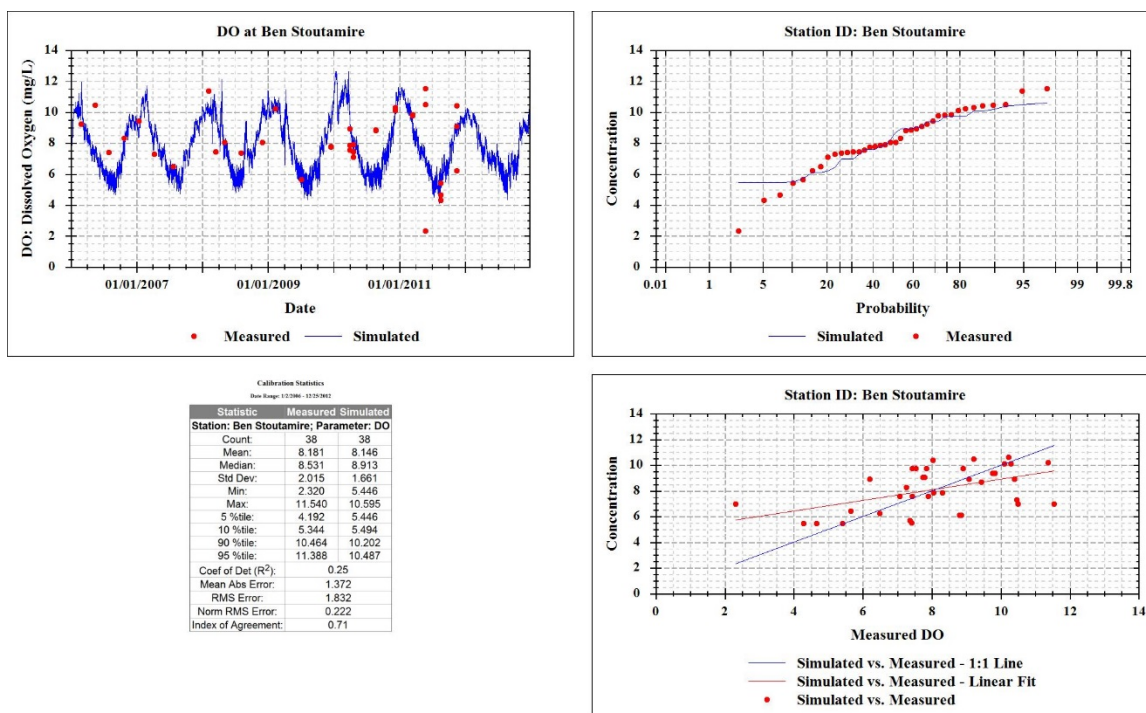


Figure 43 21FLLEONLCOC3040784610: Lake Talquin (Ben Stoutamire Boat Landing) for Dissolved Oxygen

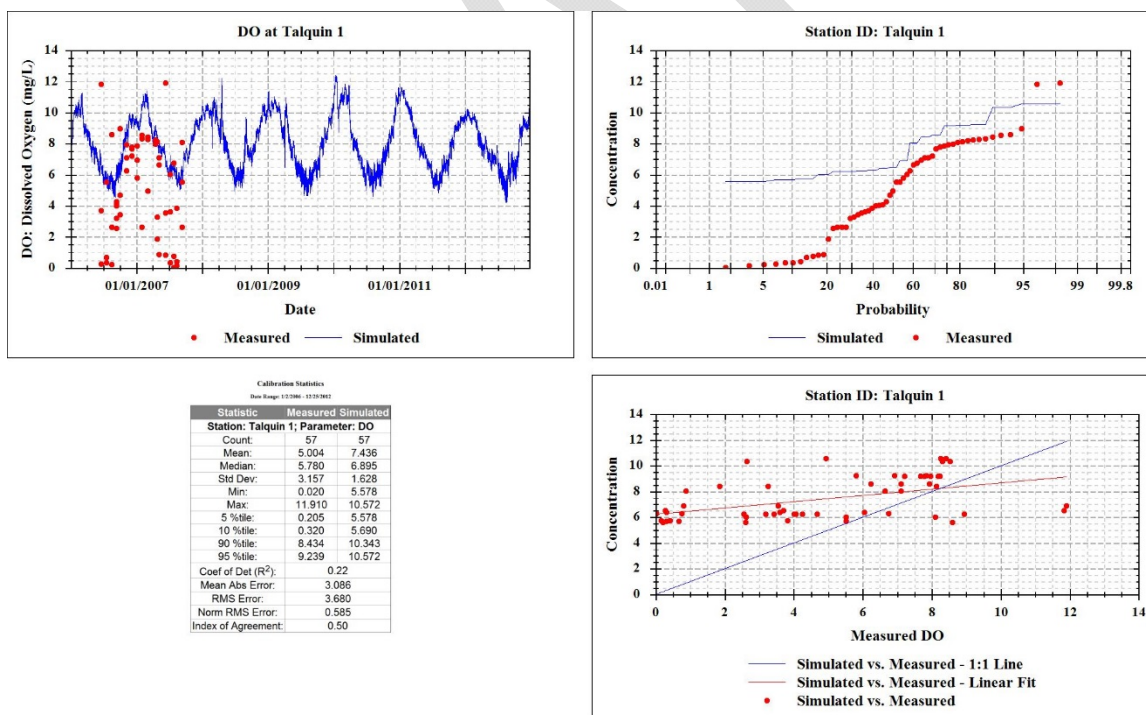


Figure 44 21FLLEONLCT0B3040284630: Talquin 1 for Dissolved Oxygen

Chlorophyll a

Figure 45 through Figure 55 illustrate a quantitative and qualitative comparison of the predicted chlorophyll-a concentrations to direct field measurements.

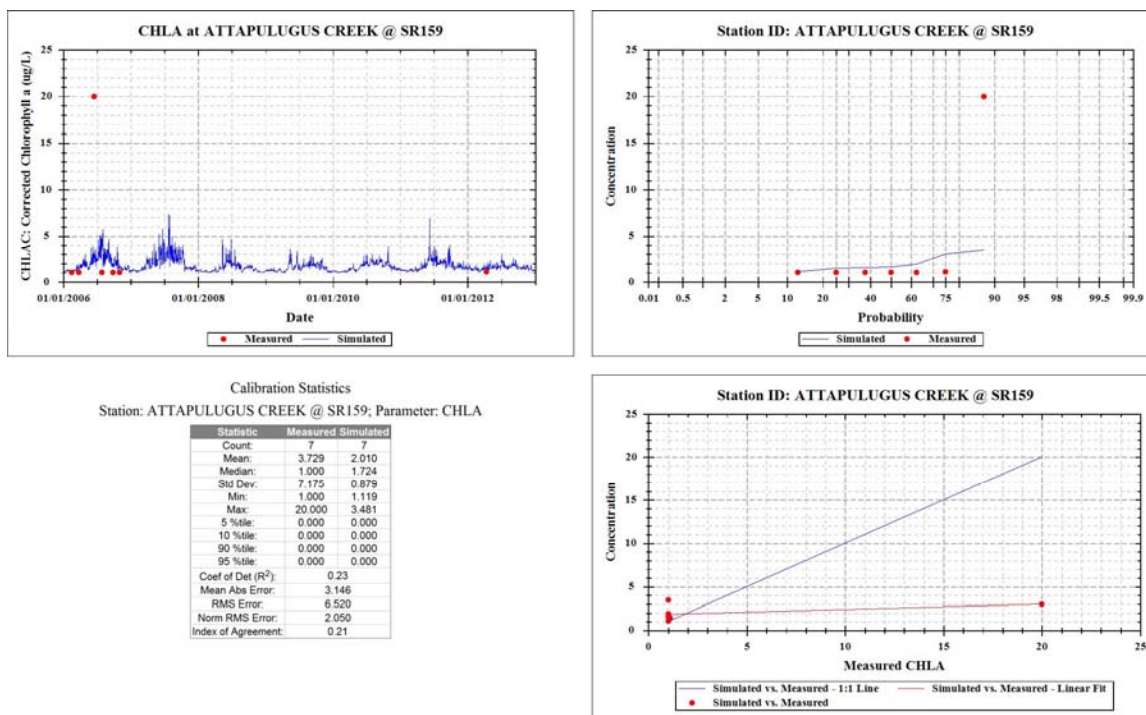


Figure 45 Chlorophyll a Calibration Attapulugus Creek at SR 159

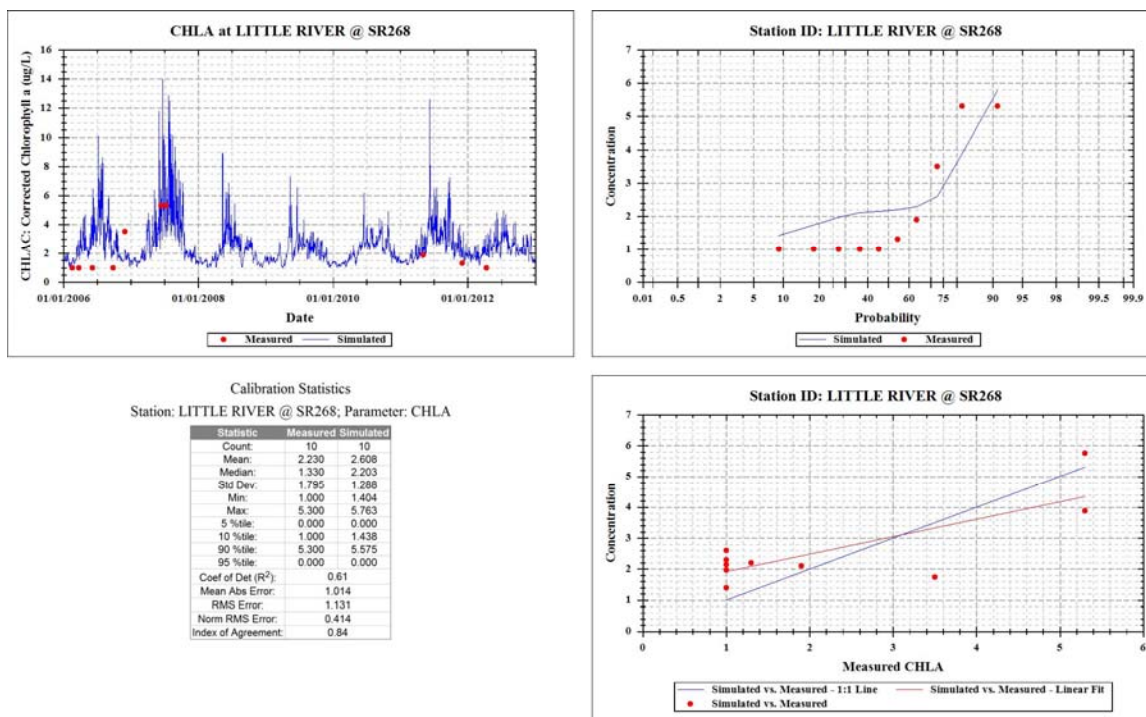


Figure 46 Chlorophyll a Calibration Little River at SR 268

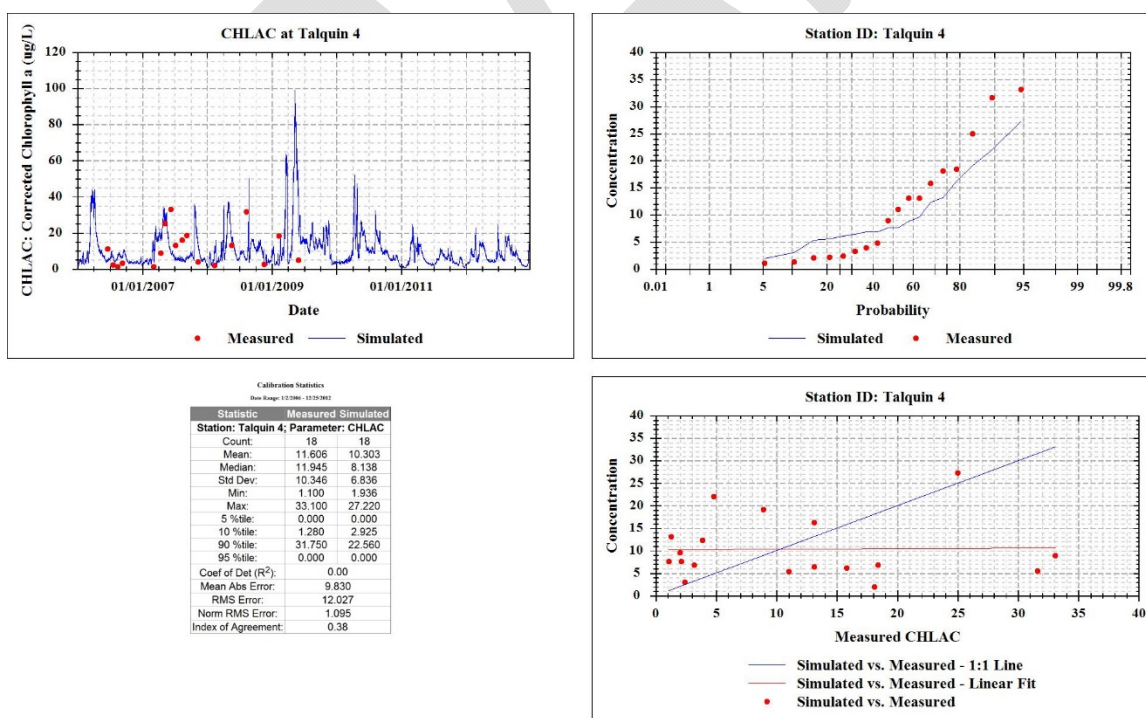


Figure 47 21FLLEONLCT0C3045884492: Talquin 4 for Chlorophyll a

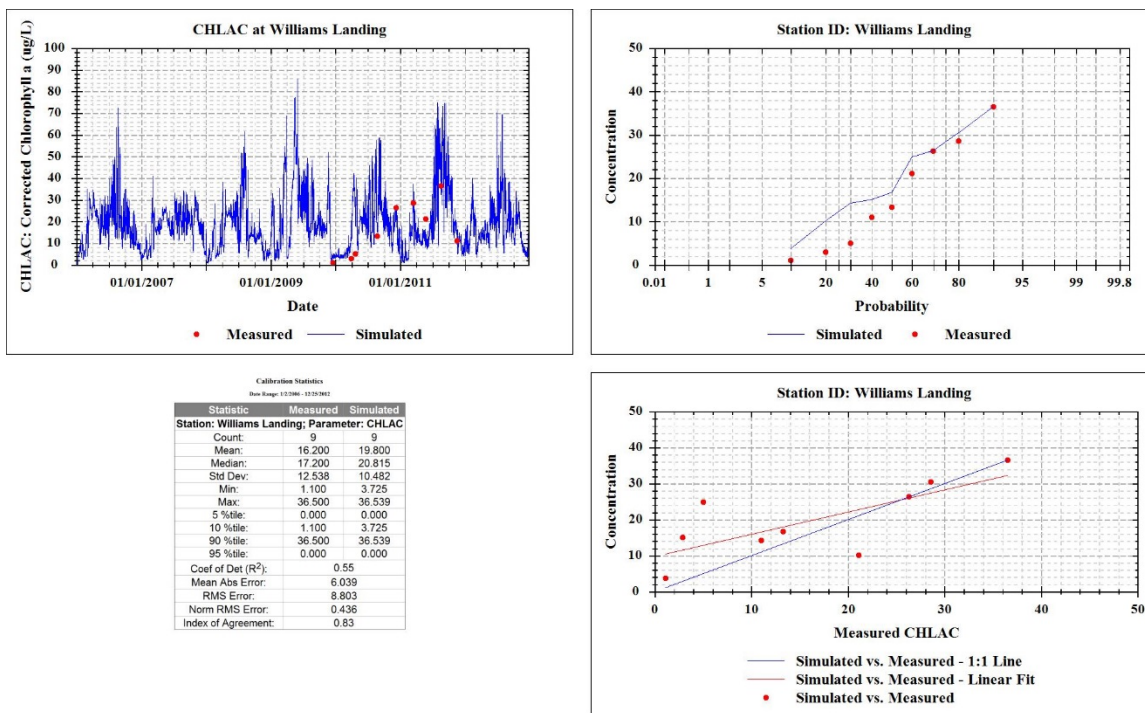


Figure 48 21FLLEONLCT03045184523: Lake Talquin near Williams Landing for Chlorophyll a

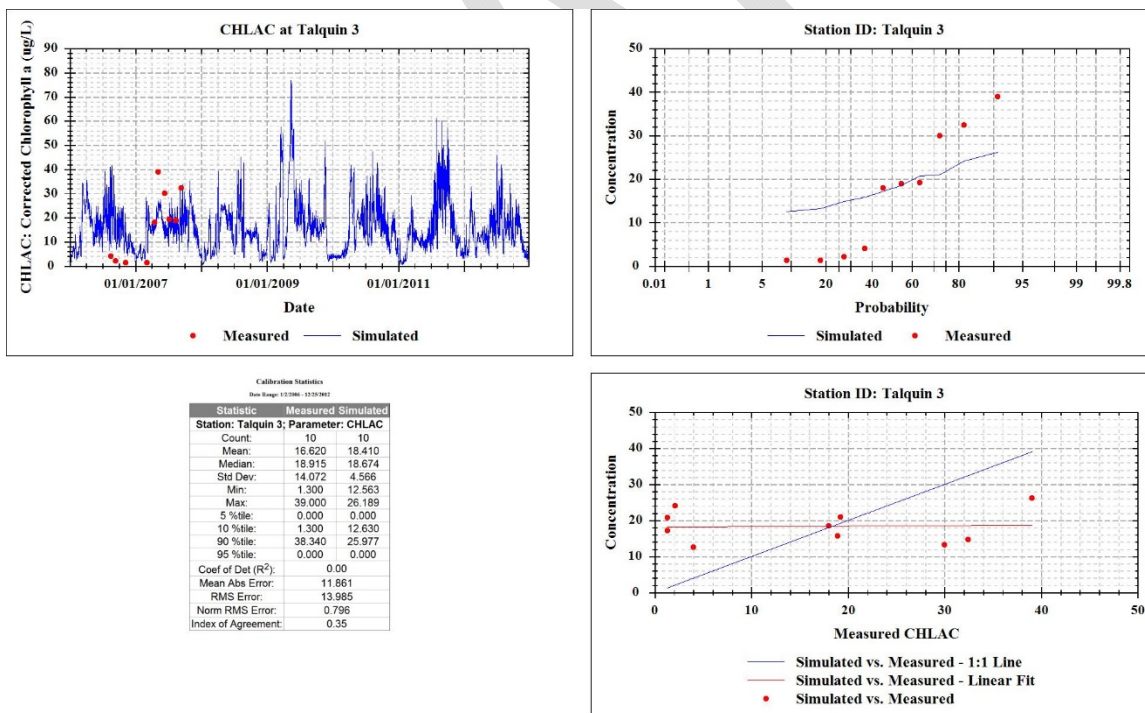


Figure 49 21FLLEONLCT0W3045084521: Talquin 3 for Chlorophyll a

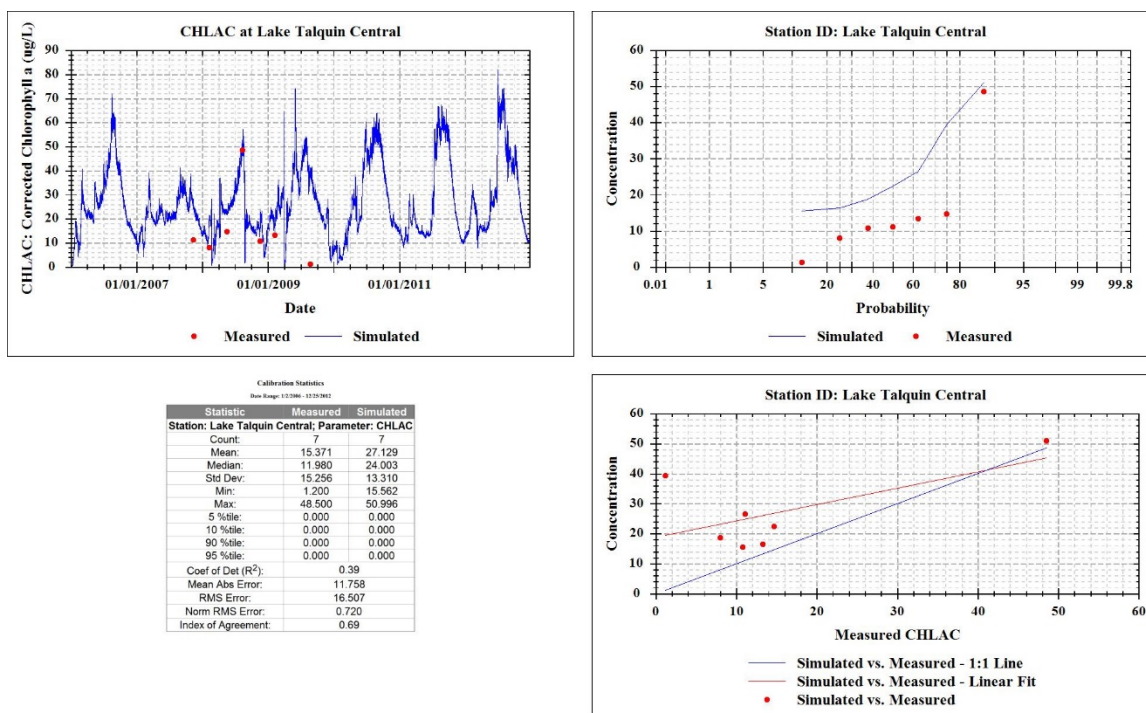


Figure 50 21FLLEONT0E3044084556: Lake Talquin Central for Chlorophyll a

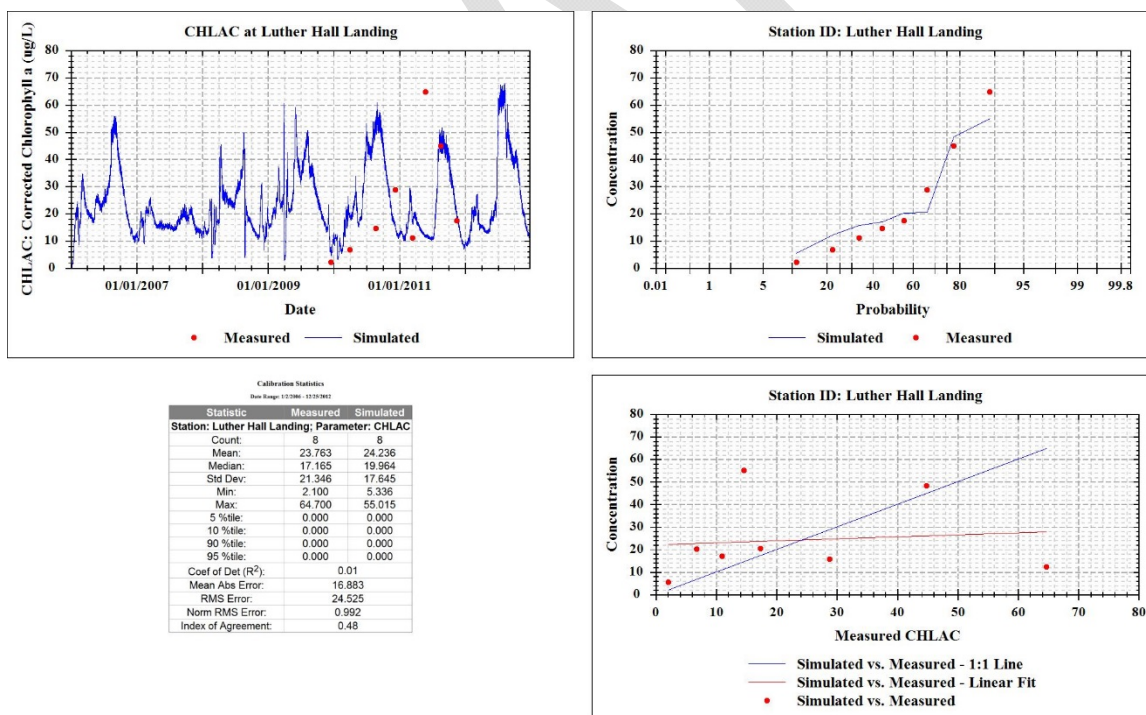


Figure 51 21FLLEONLCT03042384172: Lake Talquin near Luther Hall Landing for Chlorophyll a

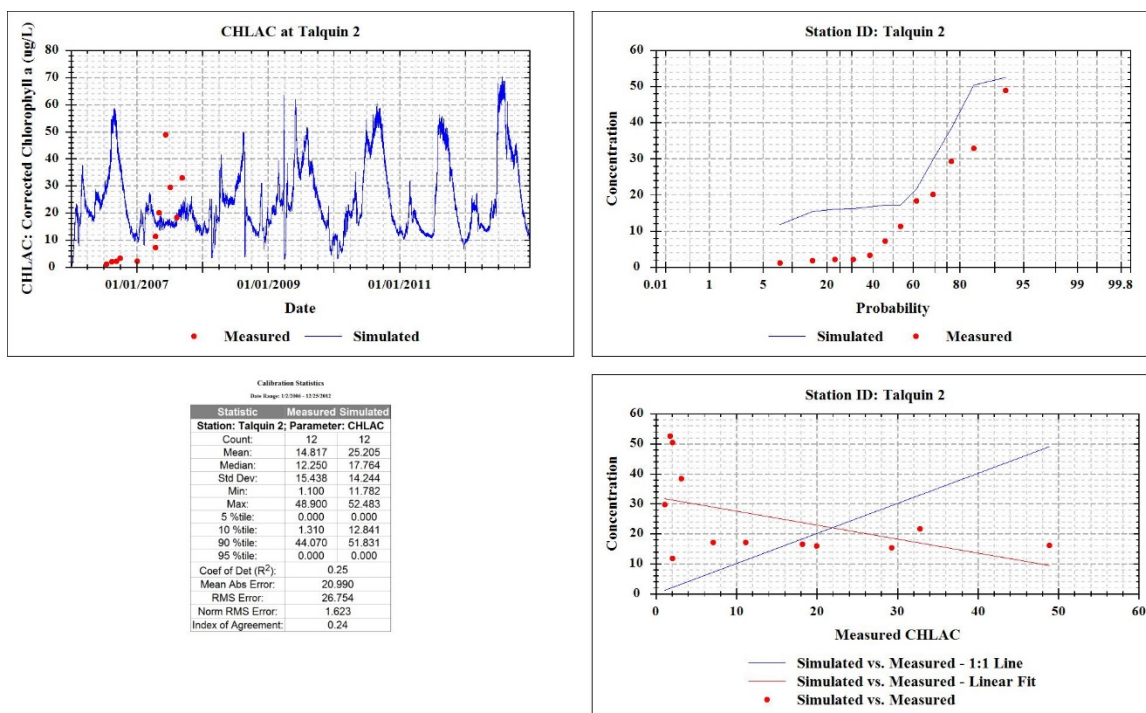


Figure 52 21FLLEONLCT0L3042284573: Talquin 2 for Chlorophyll a

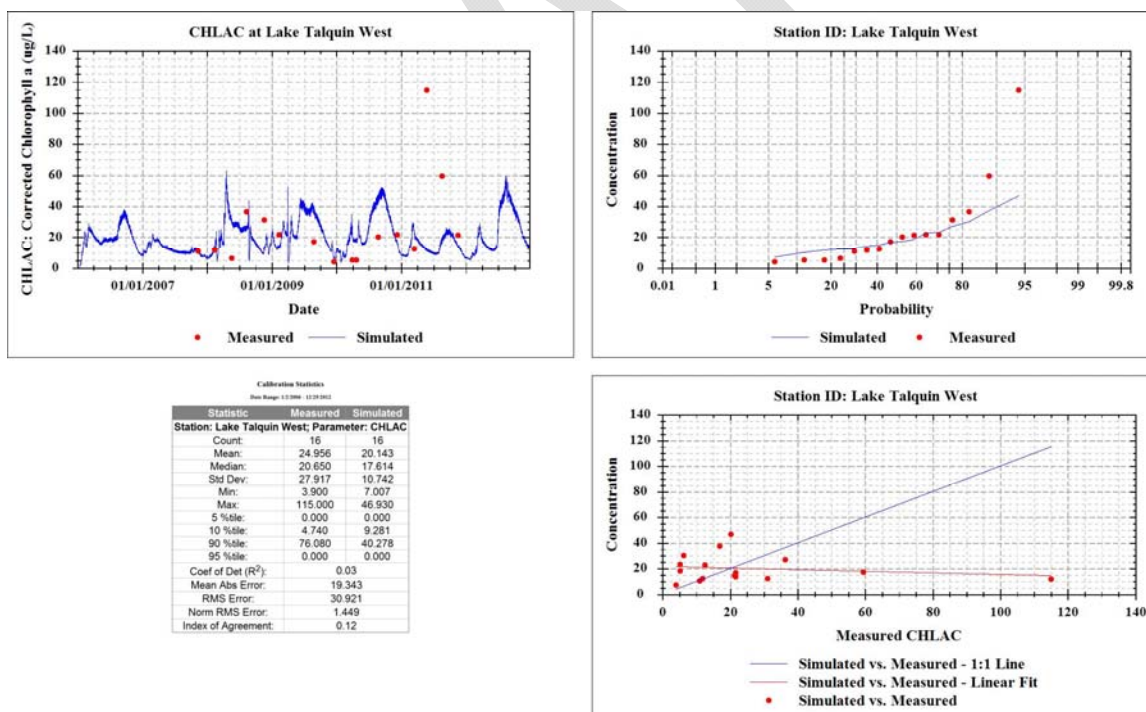


Figure 53 21FLLEONT0D3041488461: Lake Talquin West for Chlorophyll a

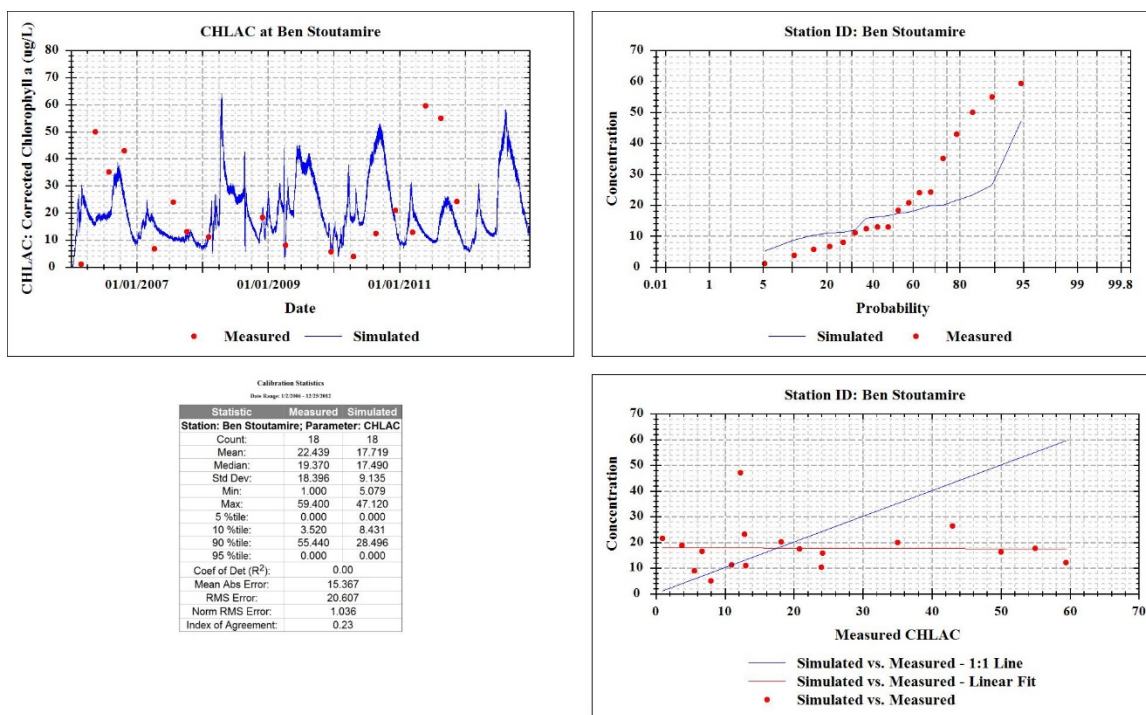


Figure 54 21FLLEONLCOC3040784610: Lake Talquin (Ben Stoutamire Boat Landing) for Chlorophyll a

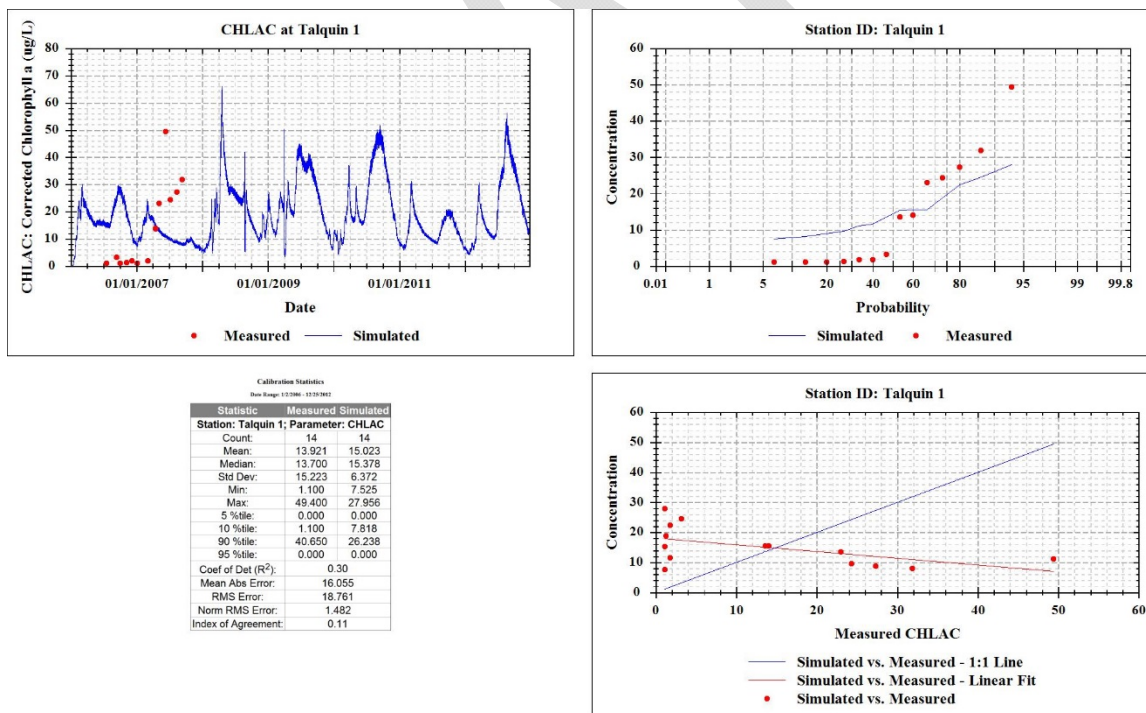


Figure 55 21FLLEONLCOT0B3040284630: Talquin 1 for Chlorophyll a

Nitrogen

Figure 56 through Figure 73 illustrate quantitative and qualitative comparisons of the model predictions for total nitrogen, NH_4 , and NO_3O_2 to available direct field measurements.

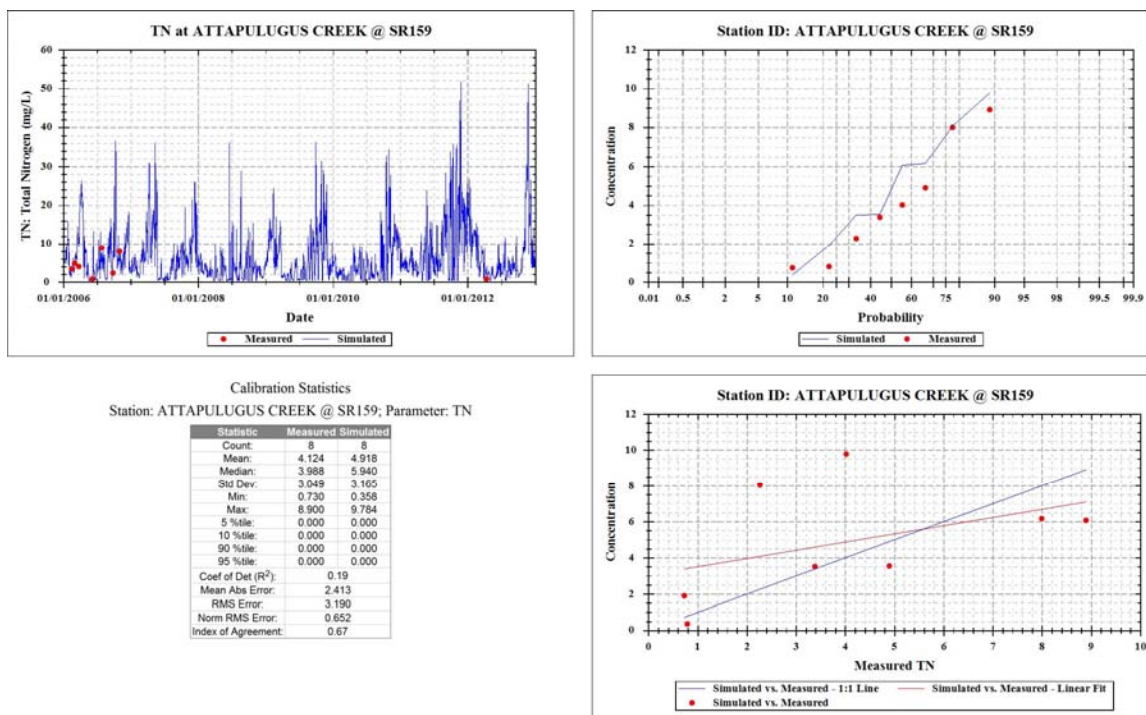


Figure 56 Total Nitrogen Calibration Attapulugus Creek at SR 159

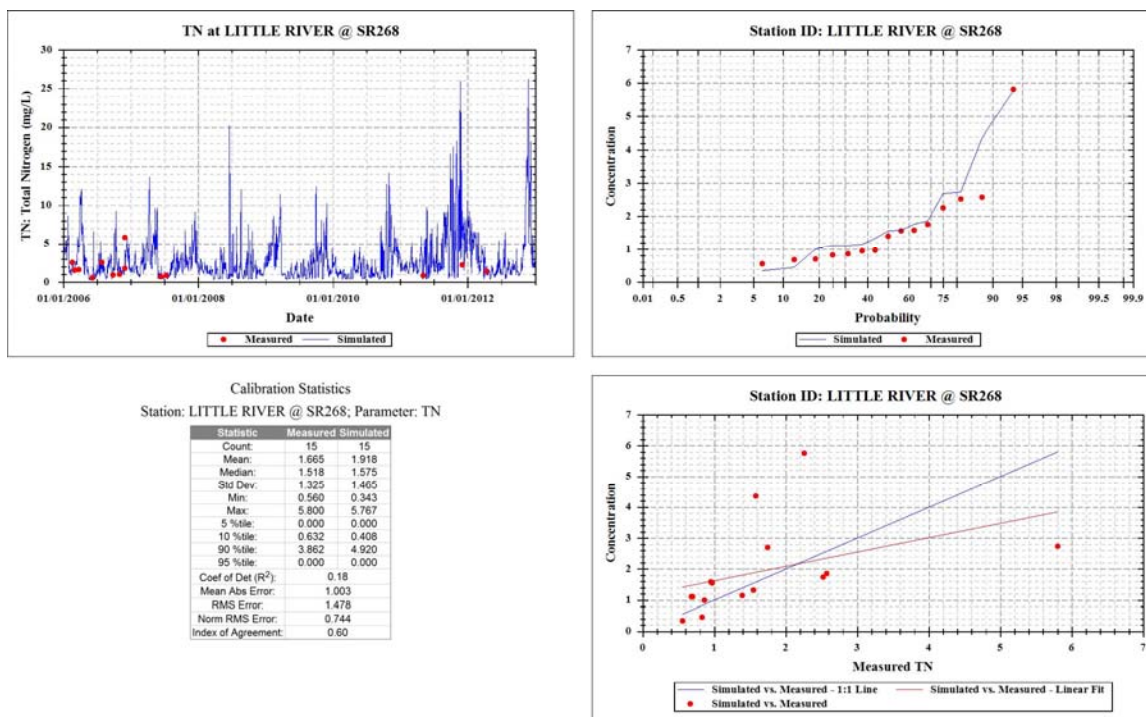


Figure 57 Total Nitrogen Calibration Little River at SR 268

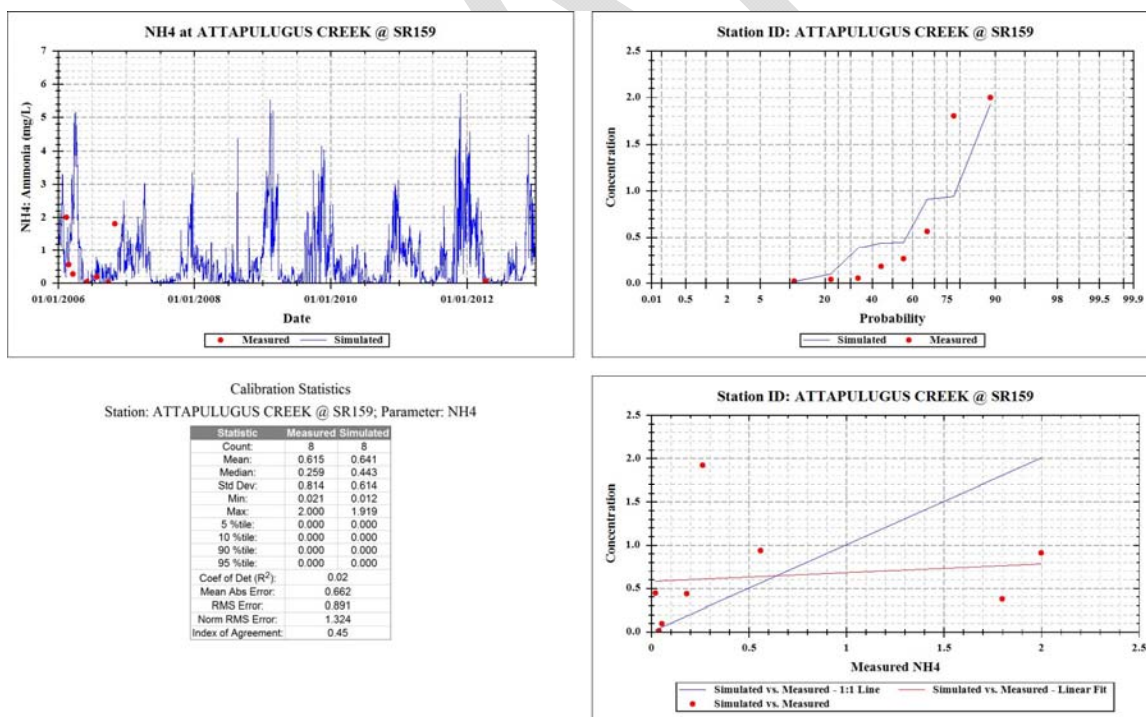


Figure 58 NH4 Calibration Attapulugus Creek at SR 159

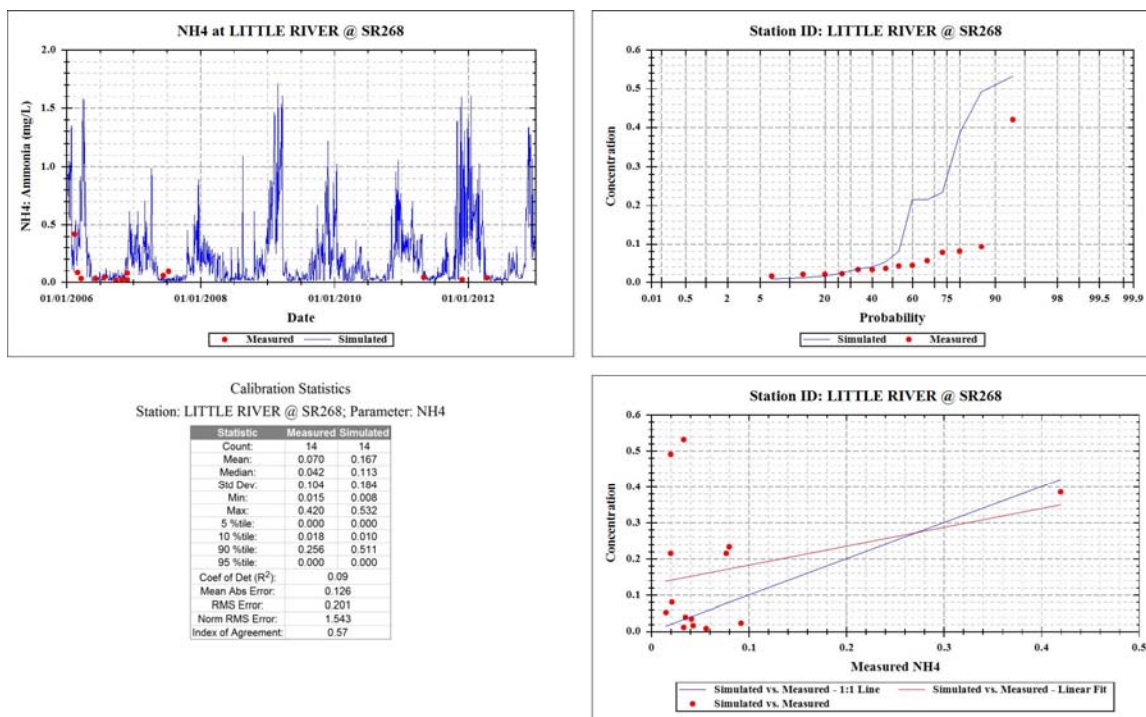


Figure 59 NH4 Calibration Little River at SR 268

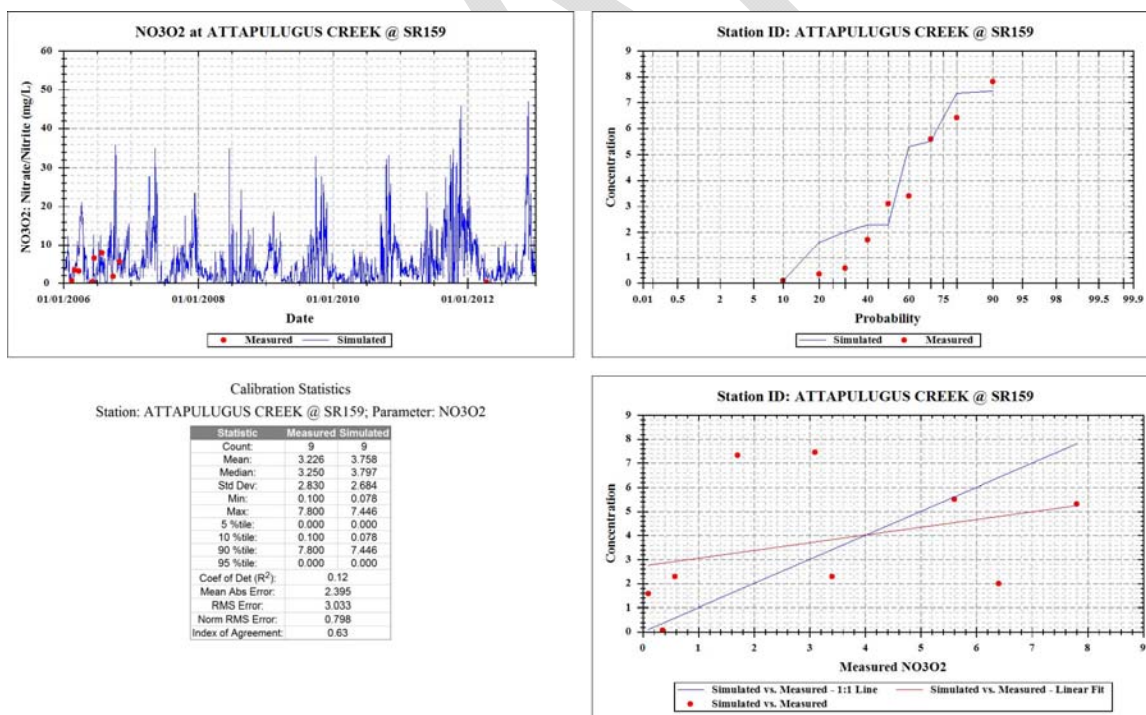


Figure 60 Nitrate/Nitrite Calibration Attapulugus Creek at SR 159

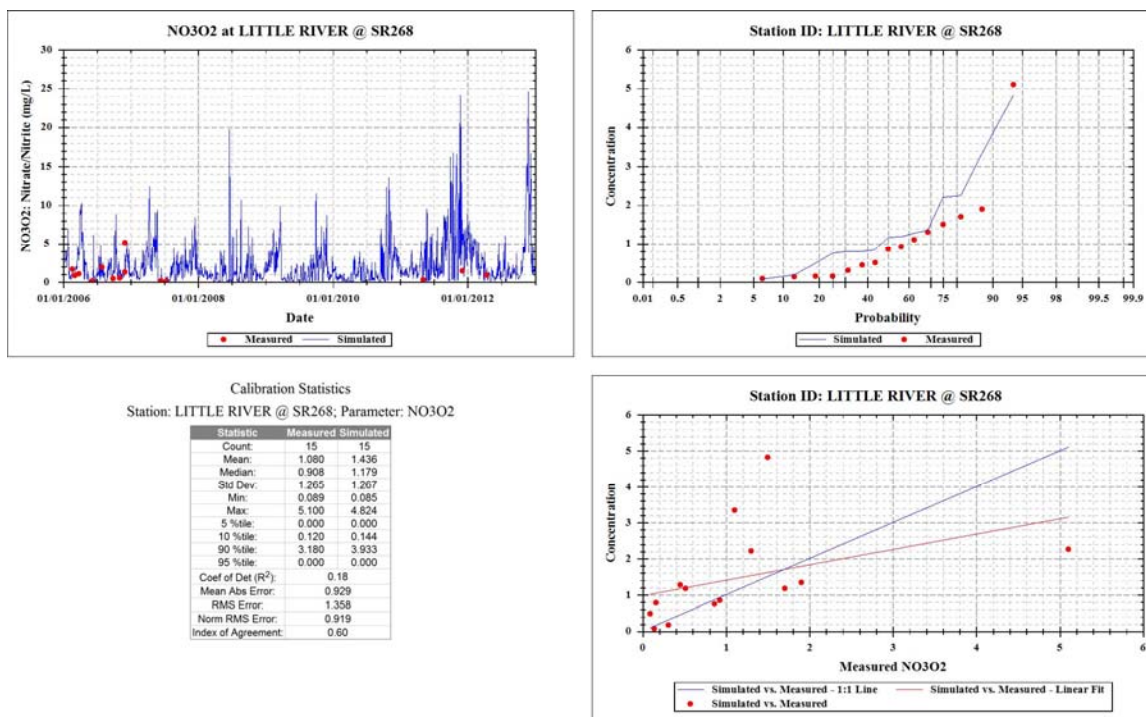


Figure 61 Nitrate/Nitrite Calibration Little River at SR 268

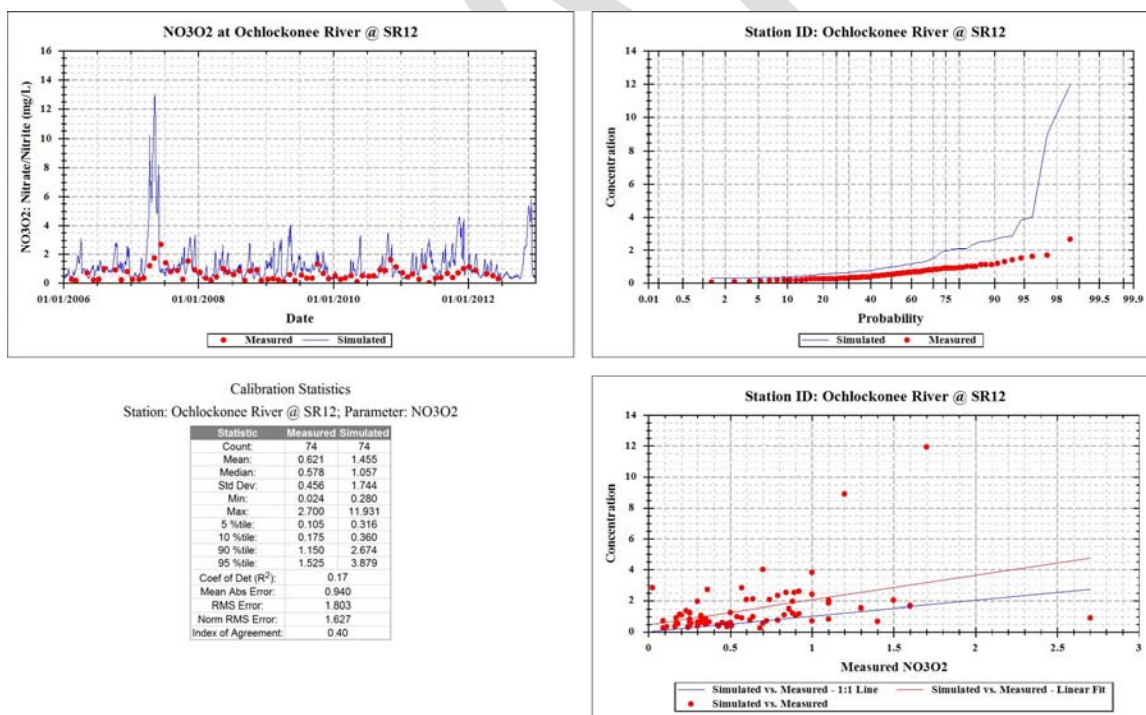


Figure 62 Total Nitrogen Calibration Ochlockonee River at SR 12

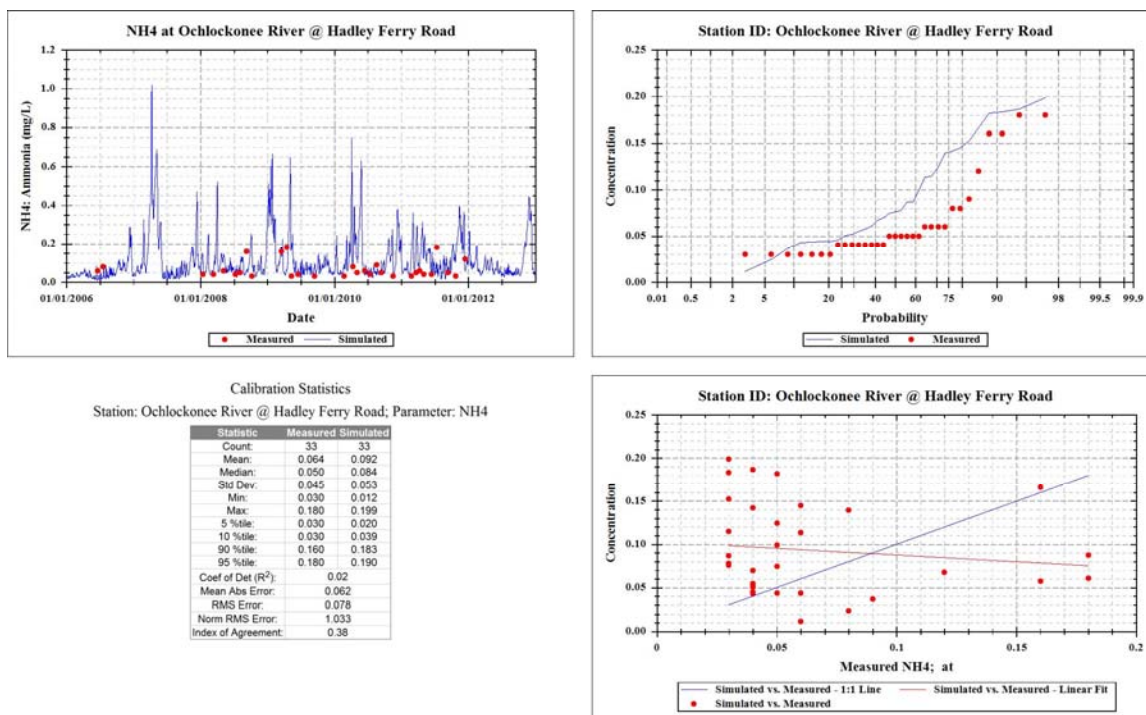
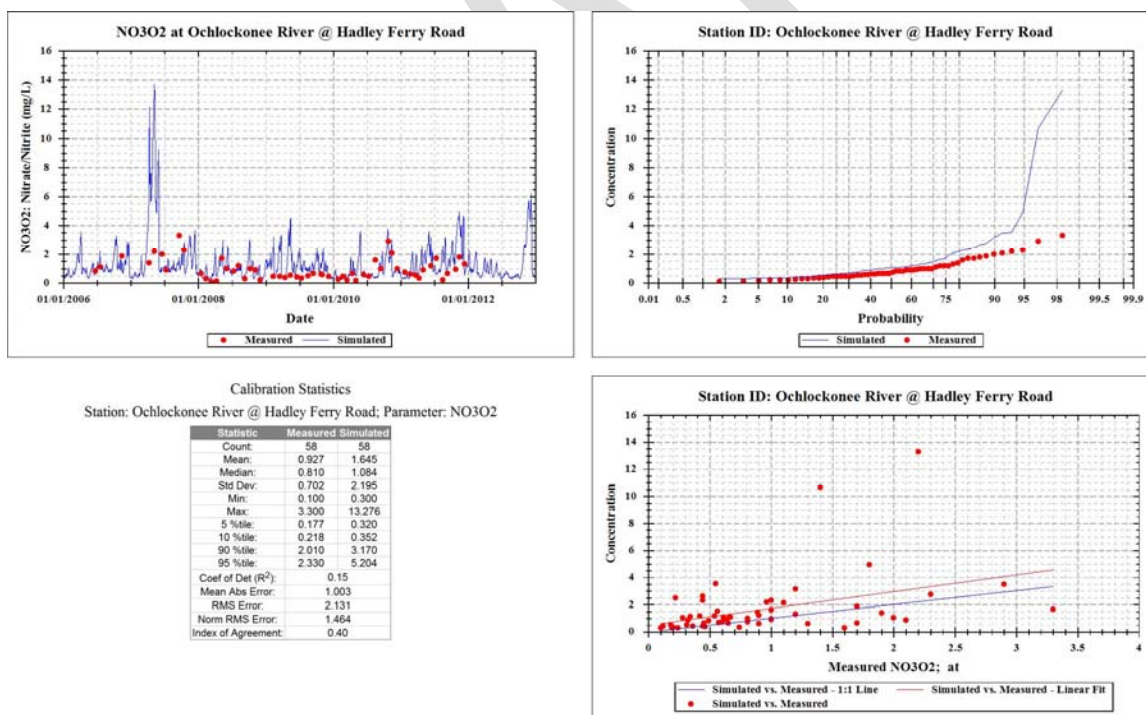
Figure 63 NH₄ Calibration Ochlockonee River Near Hadley Road

Figure 64 Nitrate/Nitrite Calibration Ochlockonee River Near Hadley Road

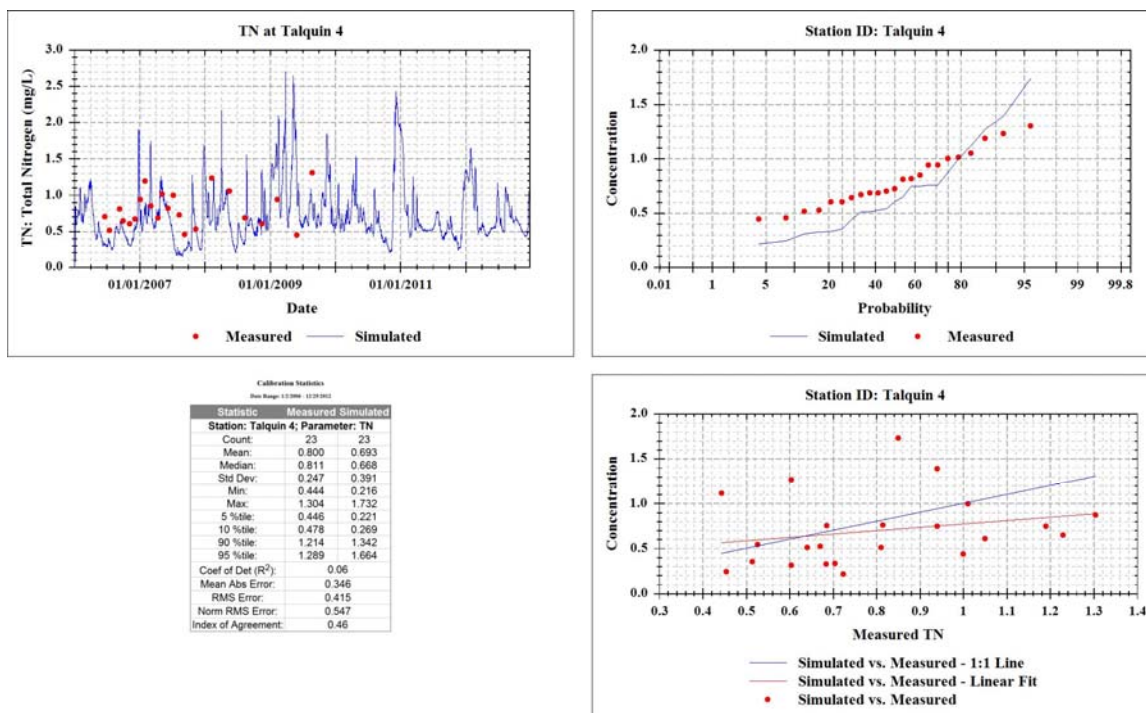


Figure 65 21FLLEONLCT0C3045884492: Talquin 4 for Total Nitrogen

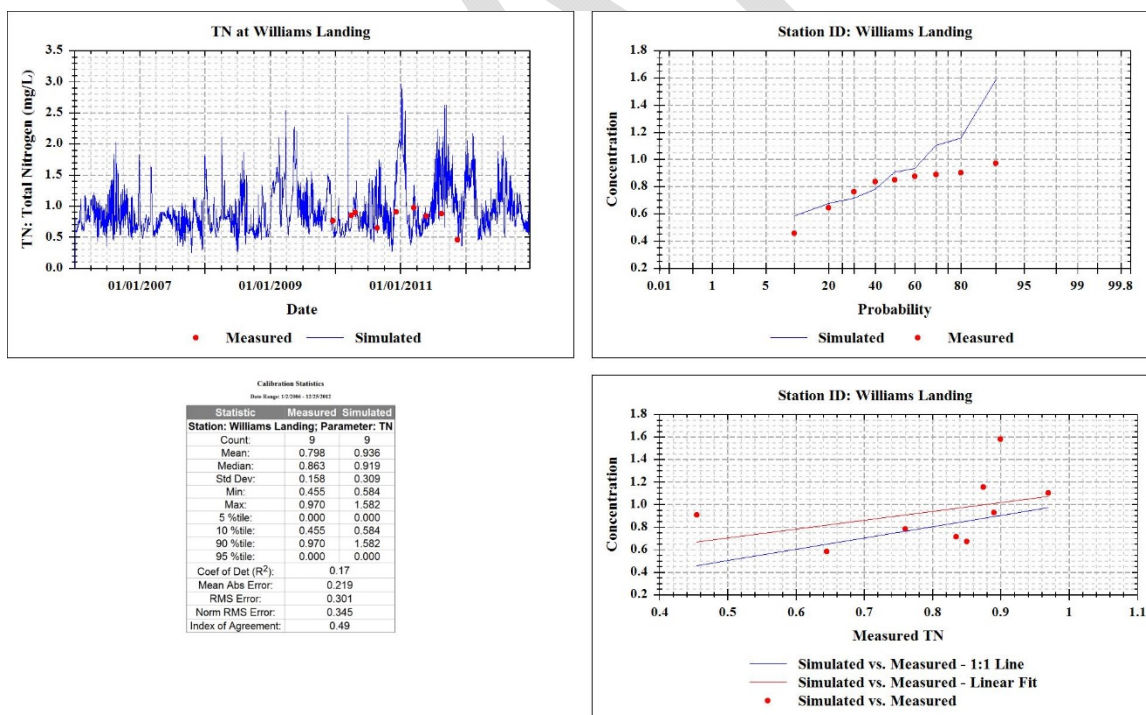


Figure 66 21FLLEONLCT03045184523: Lake Talquin near Williams Landing for Total Nitrogen

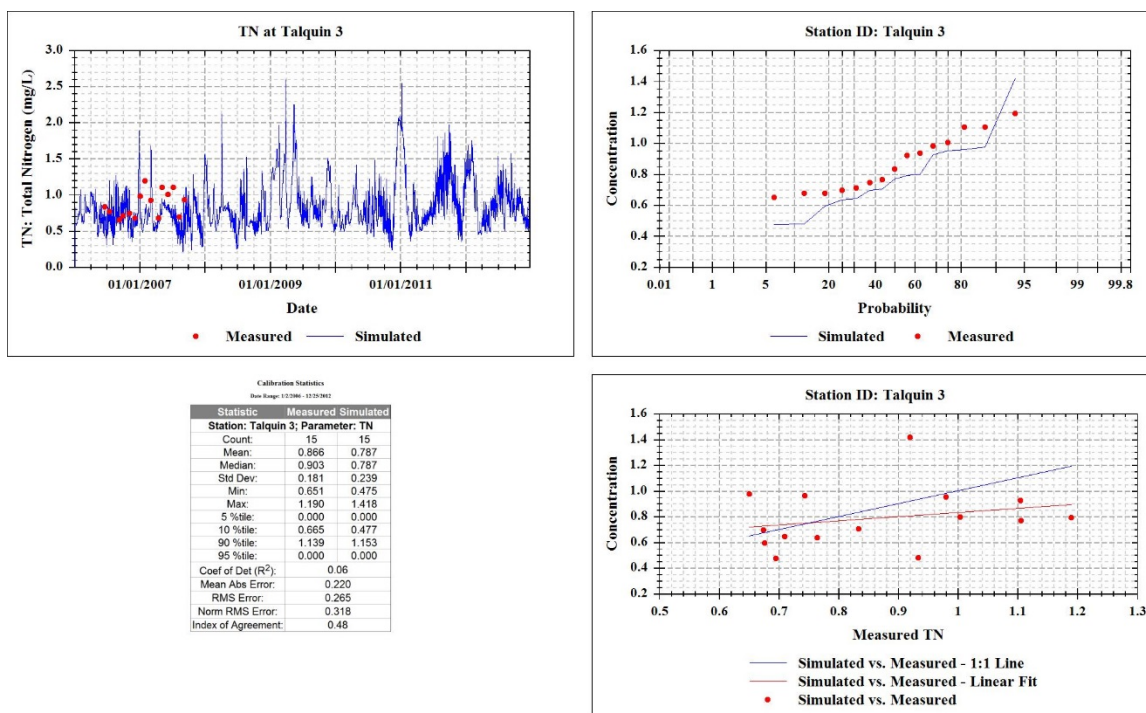


Figure 67 21FLLEONCT0W3045084521: Talquin 3 for Total Nitrogen

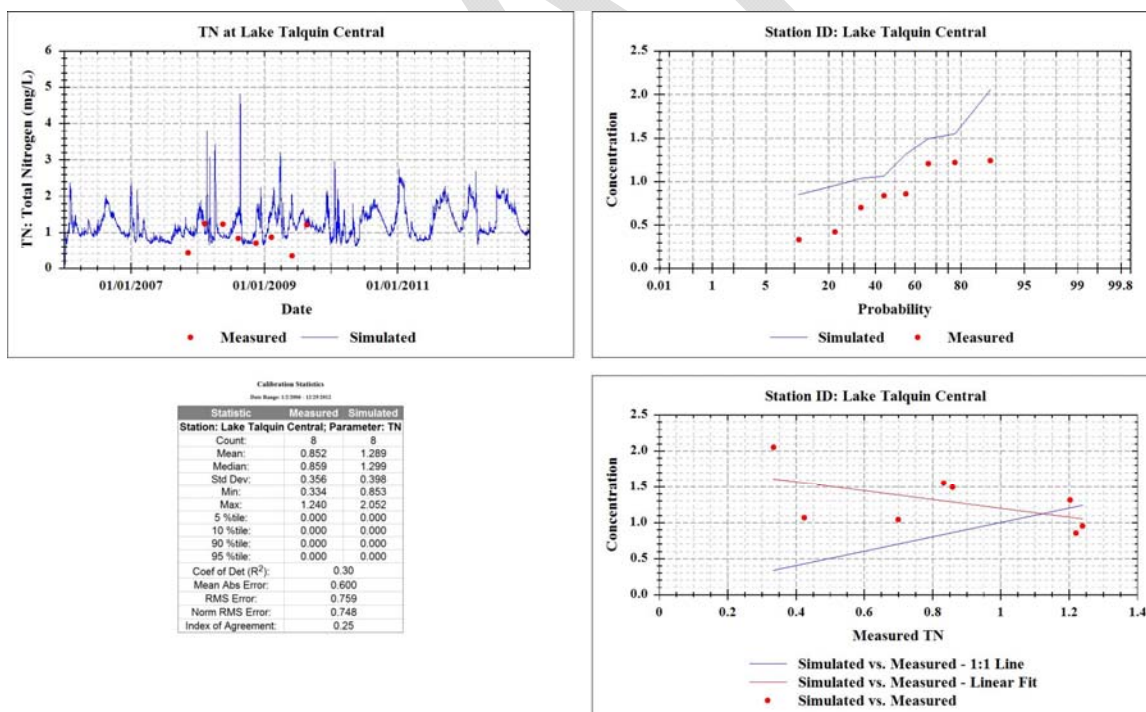


Figure 68 21FLLEONT0E3044084556: Lake Talquin Central for Total Nitrogen

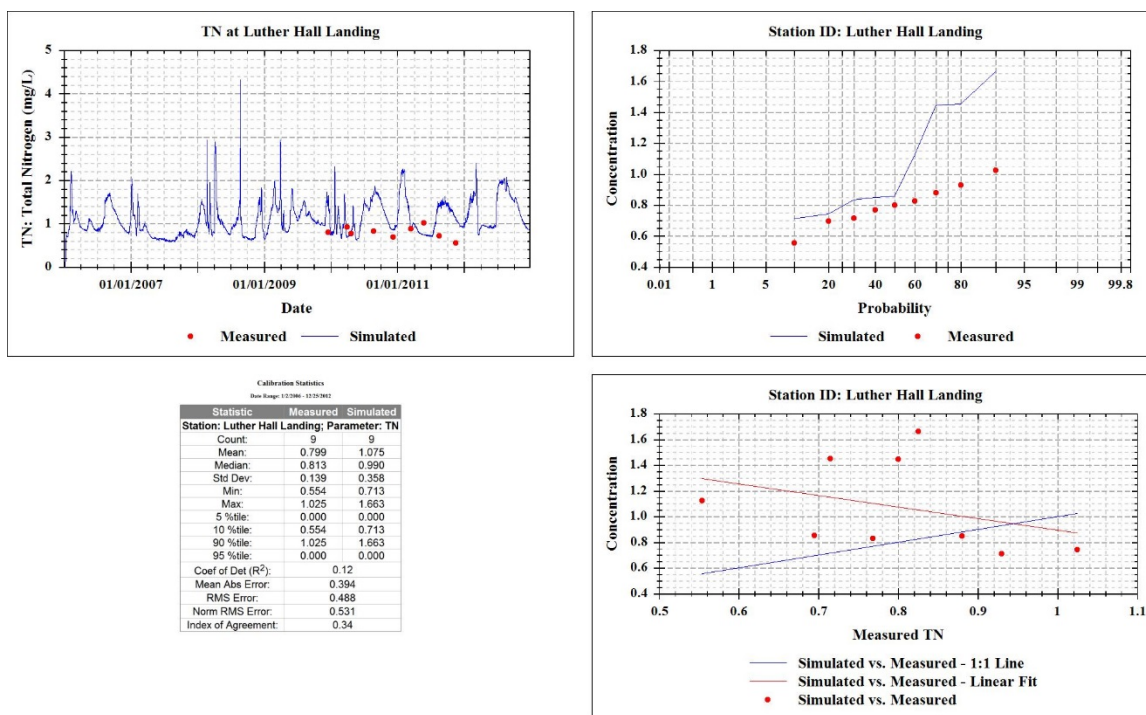


Figure 69 21FLLEONLCT03042384172: Lake Talquin near Luther Hall Landing for Total Nitrogen

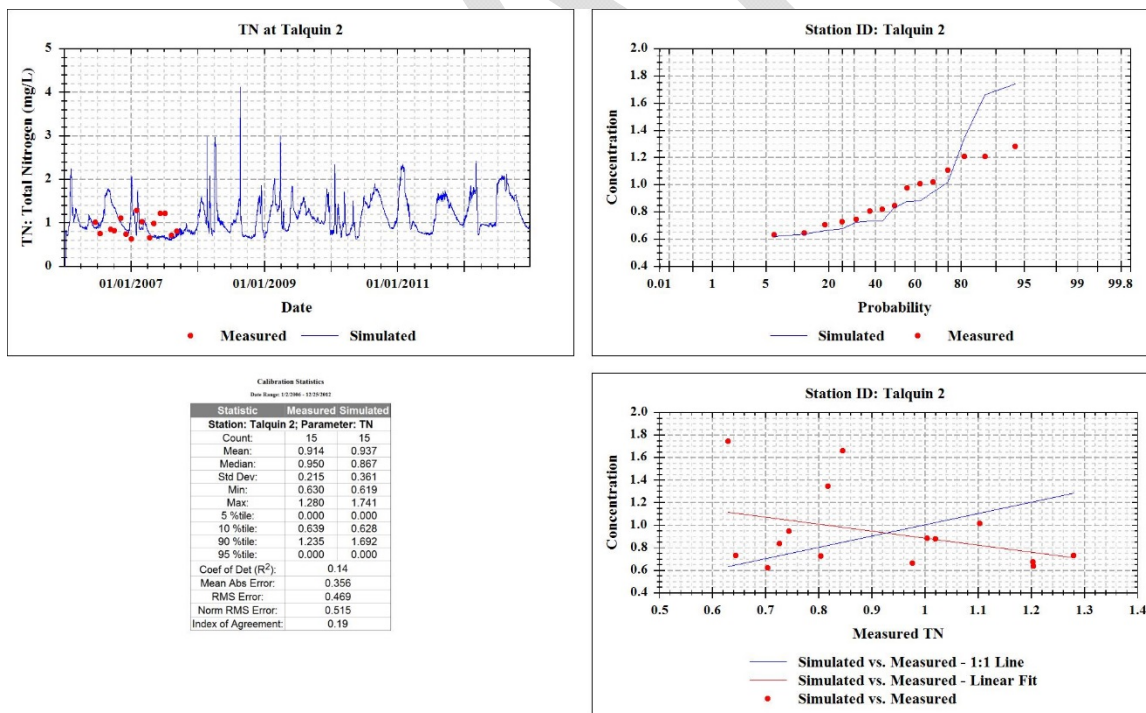


Figure 70 21FLLEONLCT0L3042284573: Talquin 2 for Total Nitrogen

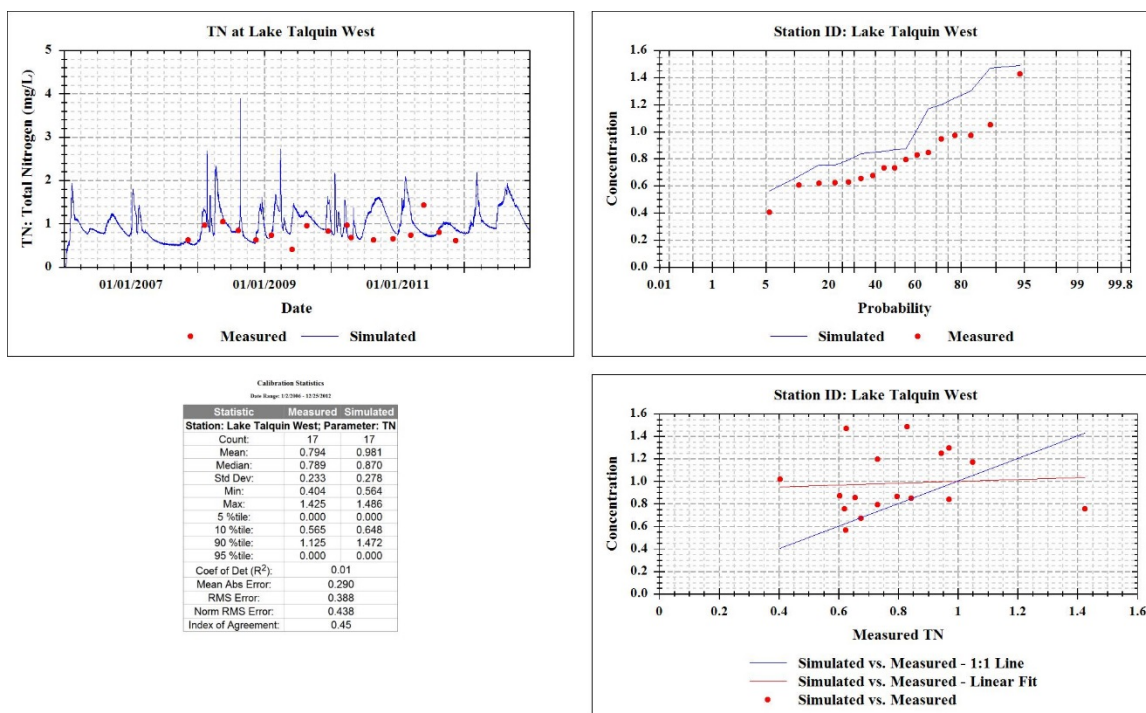


Figure 71 21FLLEONT0D3041488461: Lake Talquin West for Total Nitrogen

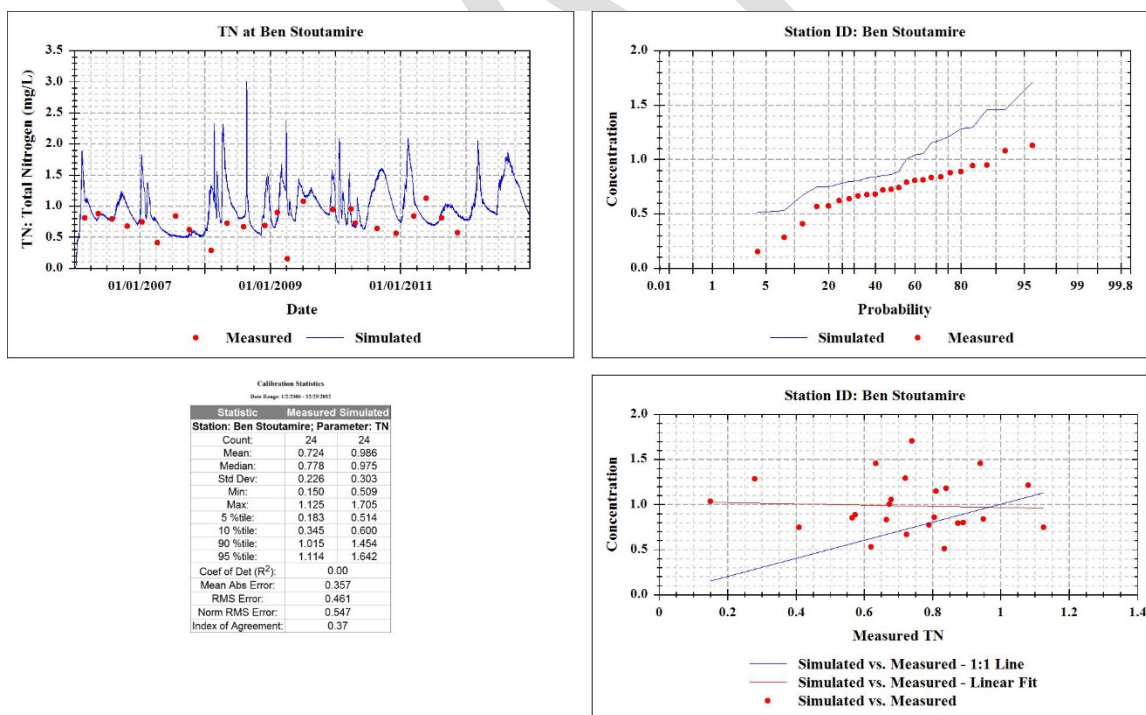


Figure 72 21FLLEONLCOC3040784610: Lake Talquin (Ben Stoutamire Boat Landing) for Total Nitrogen

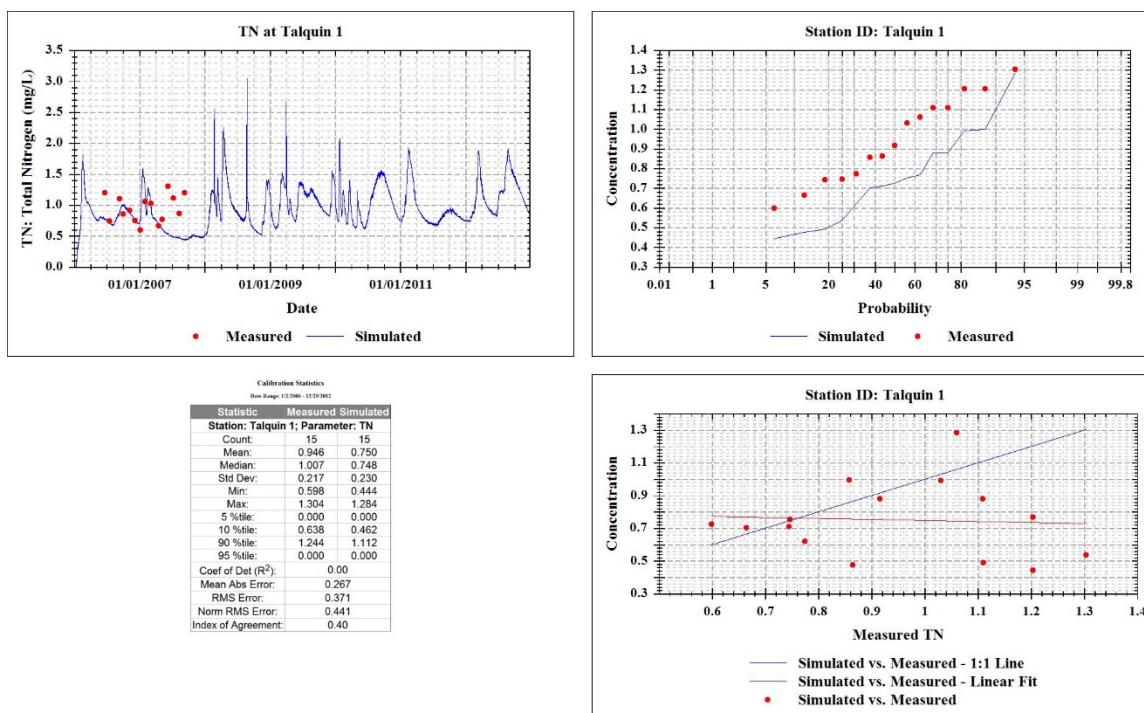


Figure 73 21FLLEONLCT0B3040284630: Talquin 1 for Total Nitrogen

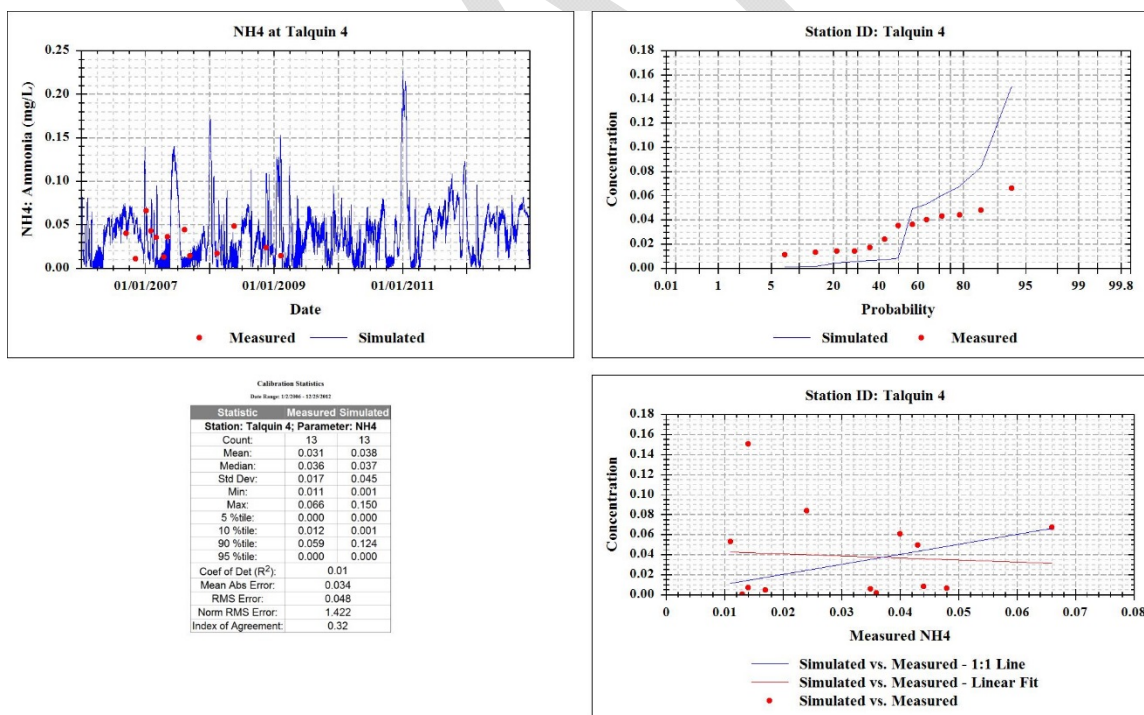


Figure 74 21FLLEONLCT0C3045884492: Talquin 4 for Ammonia

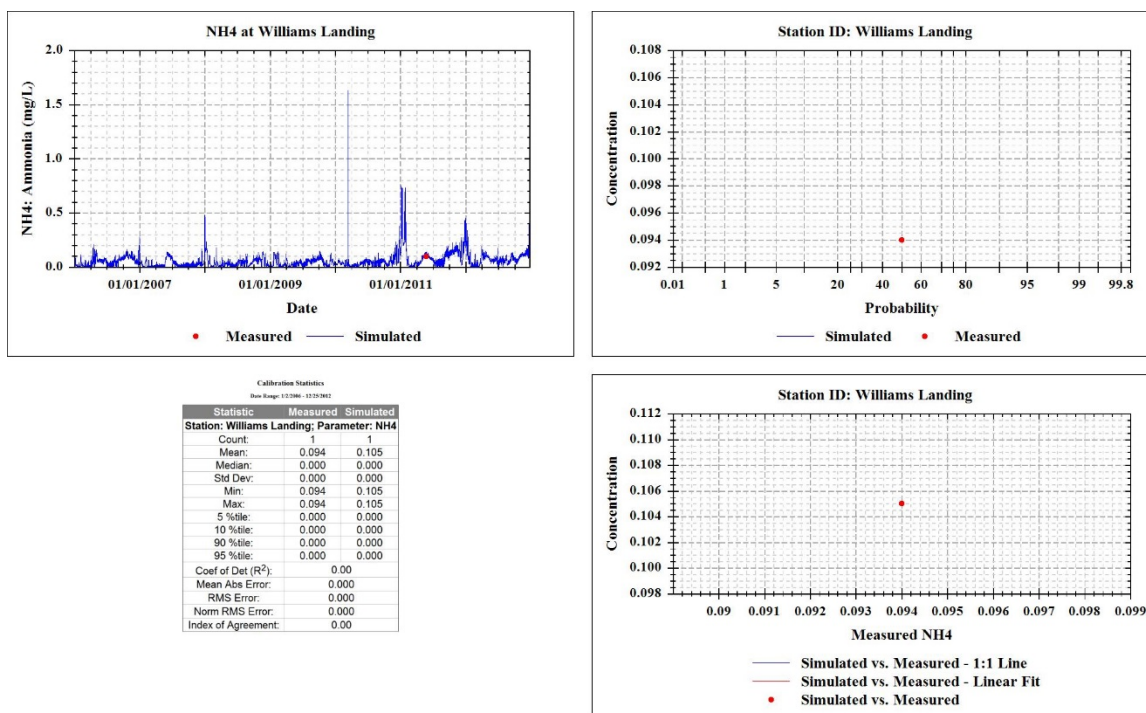


Figure 75 21FLLEONLCT03045184523: Lake Talquin near Williams Landing for Ammonia

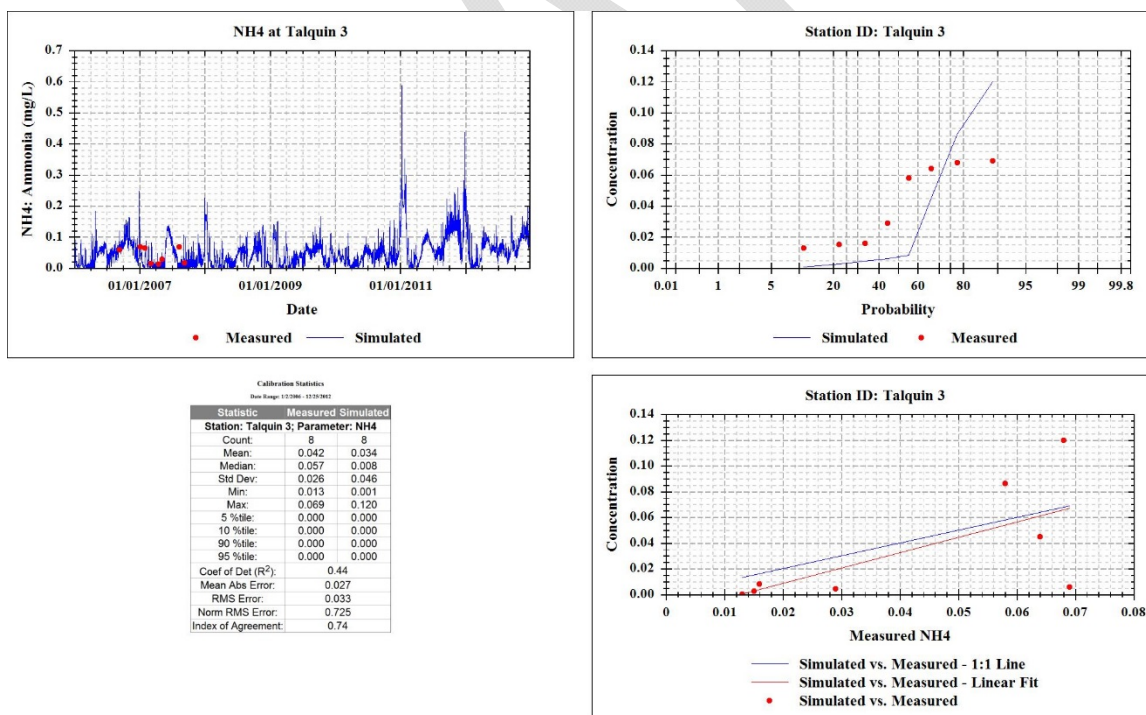


Figure 76 21FLLEONLCT0W3045084521: Talquin 3 for Ammonia

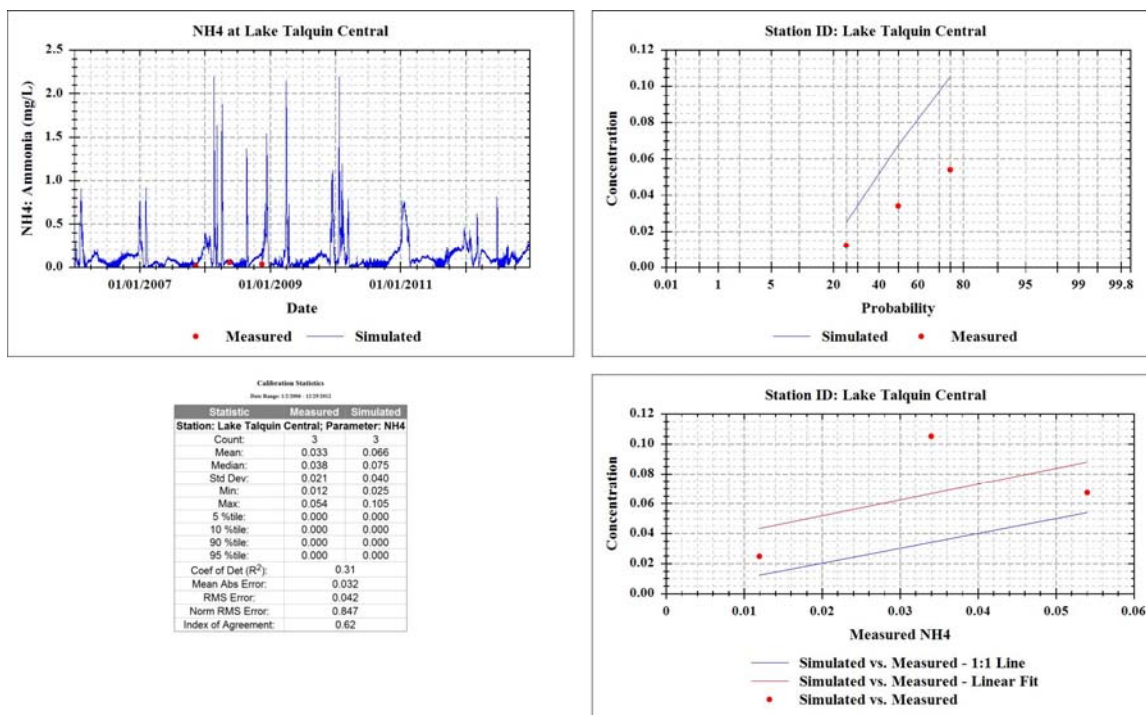


Figure 77 21FLLEONT0E3044084556: Lake Talquin Central for Ammonia

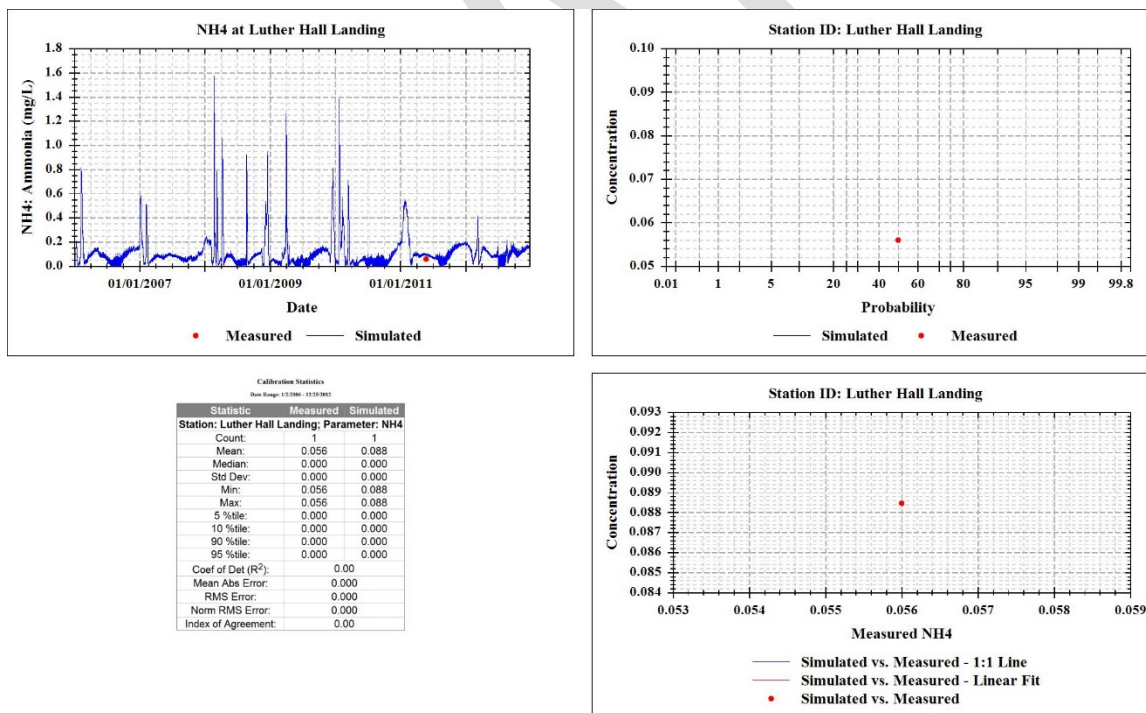


Figure 78 21FLLEONLCT03042384172: Lake Talquin near Luther Hall Landing for Ammonia

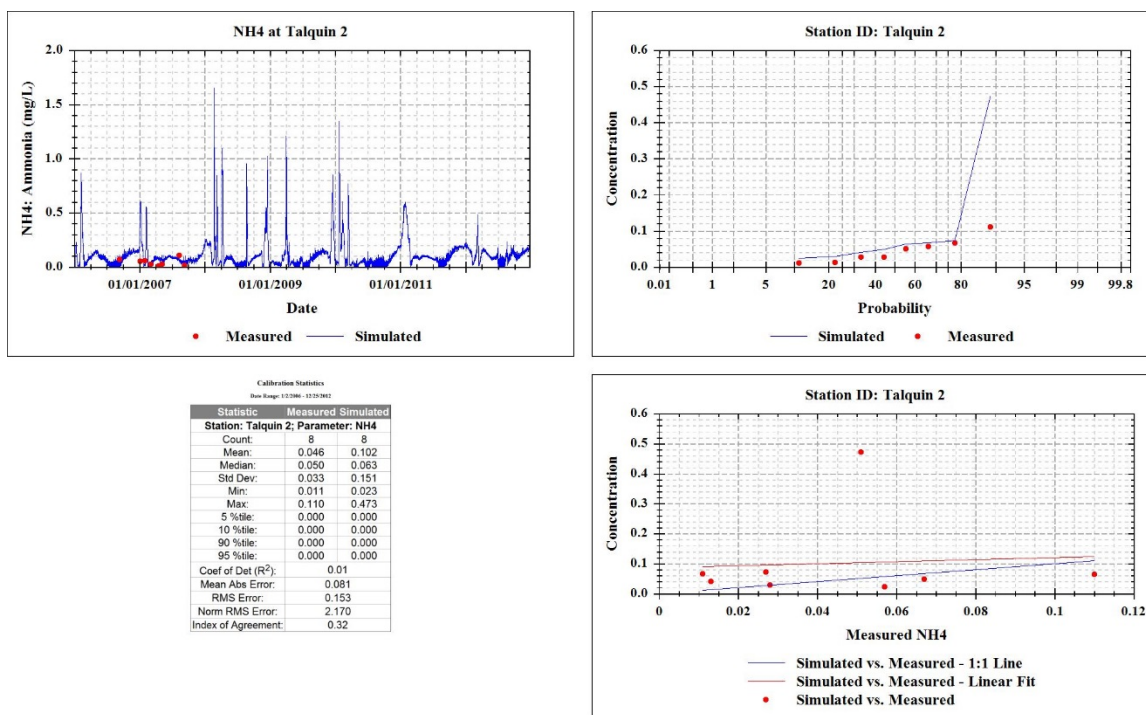


Figure 79 21FLLEONLCT0L3042284573: Talquin 2 for Ammonia

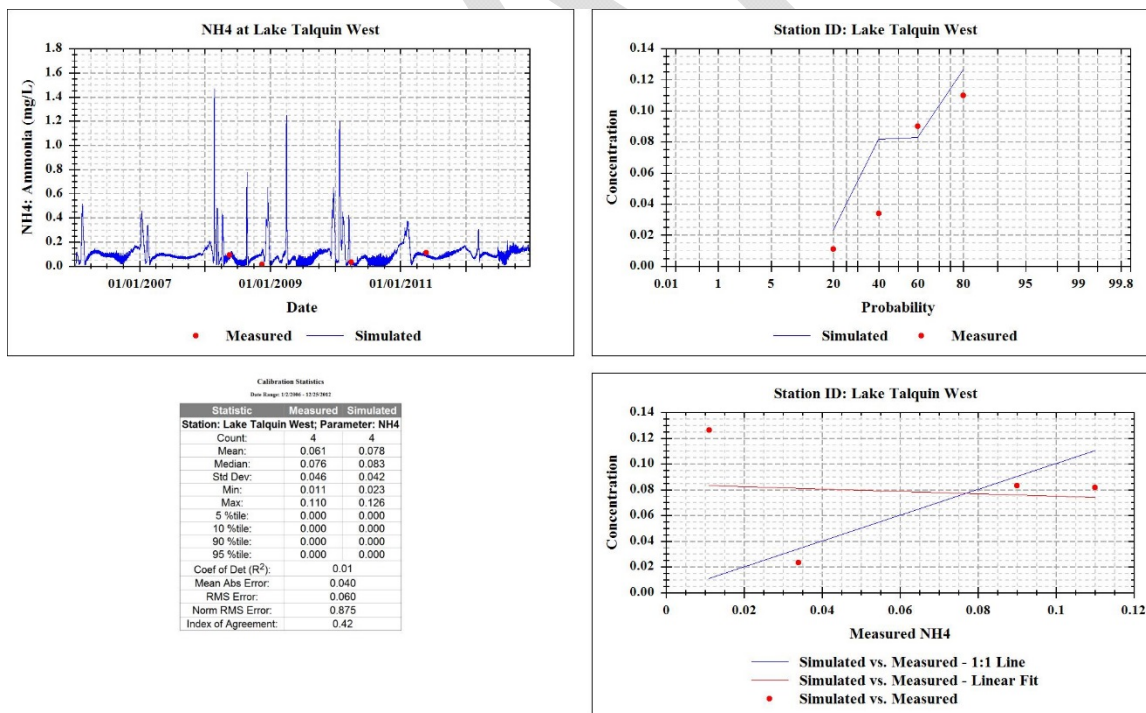


Figure 80 21FLLEONT0D3041488461: Lake Talquin West for Ammonia

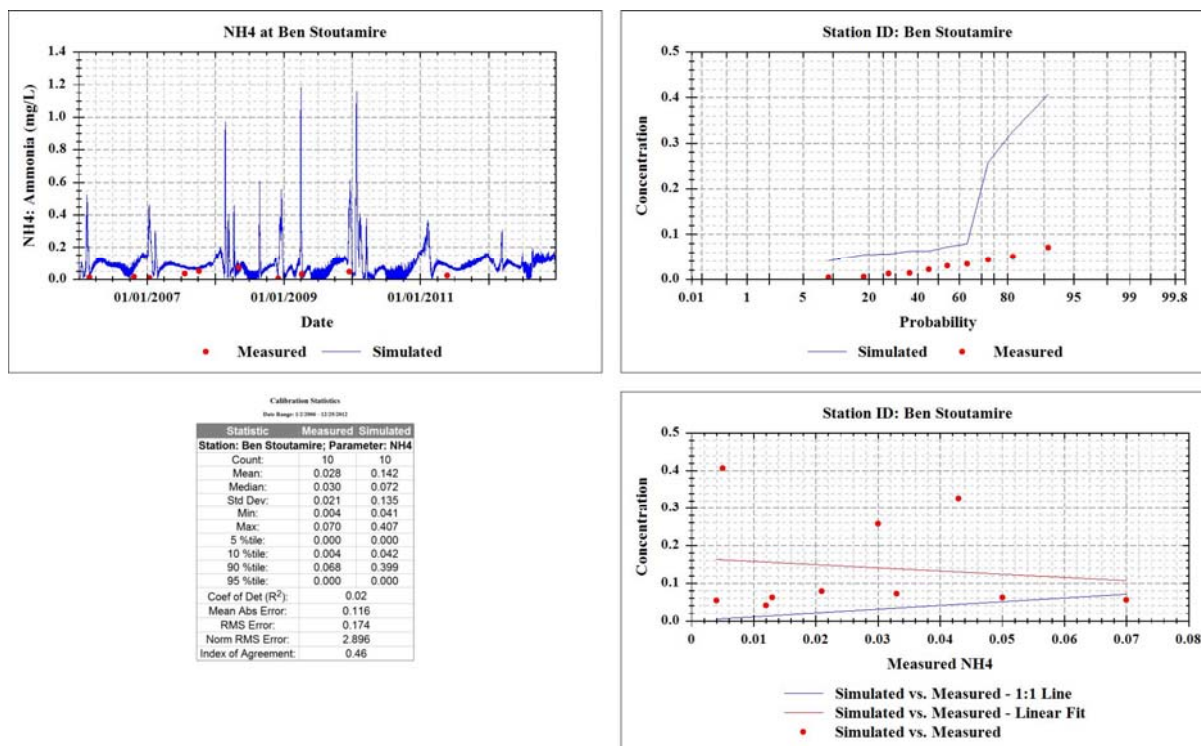


Figure 81 21FLLEONLCOC3040784610: Lake Talquin (Ben Stoutamire Boat Landing) for Ammonia

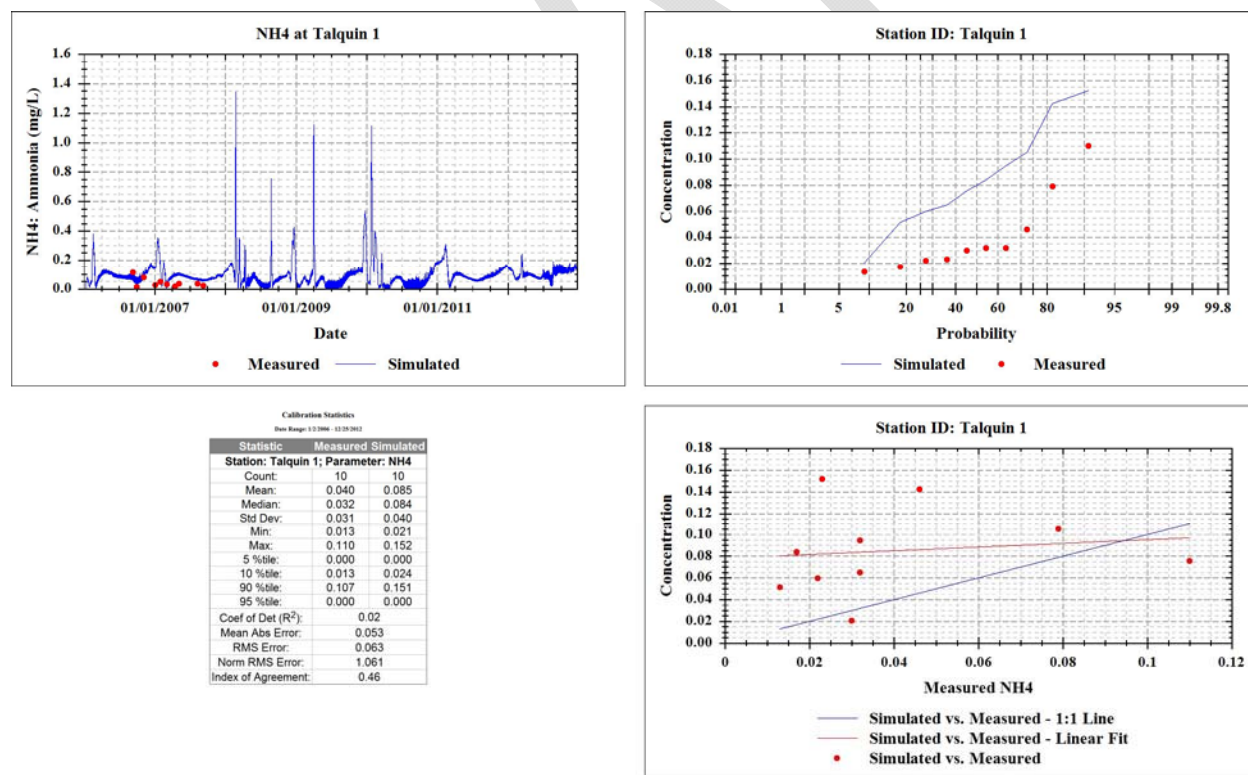


Figure 82 21FLLEONLCT0B3040284630: Talquin 1 for Ammonia

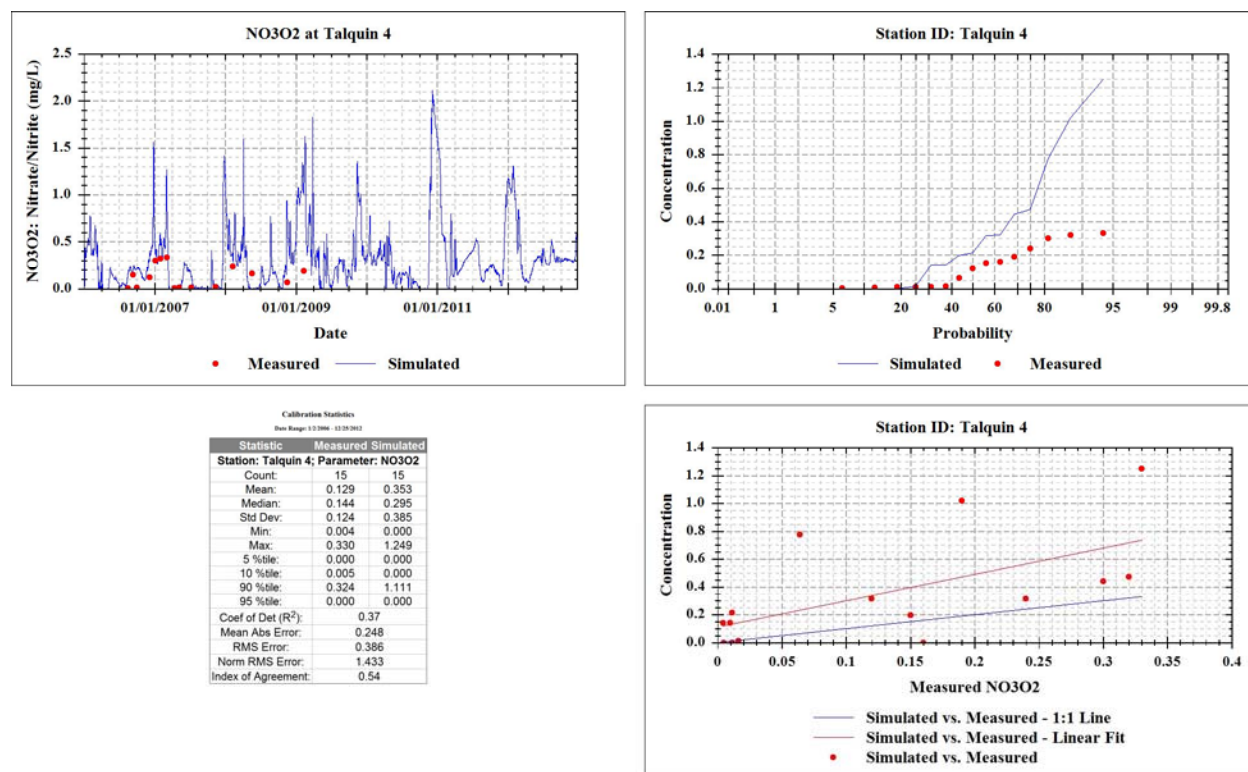


Figure 83 21FLLEONLCT0C3045884492: Talquin 4 for Nitrate

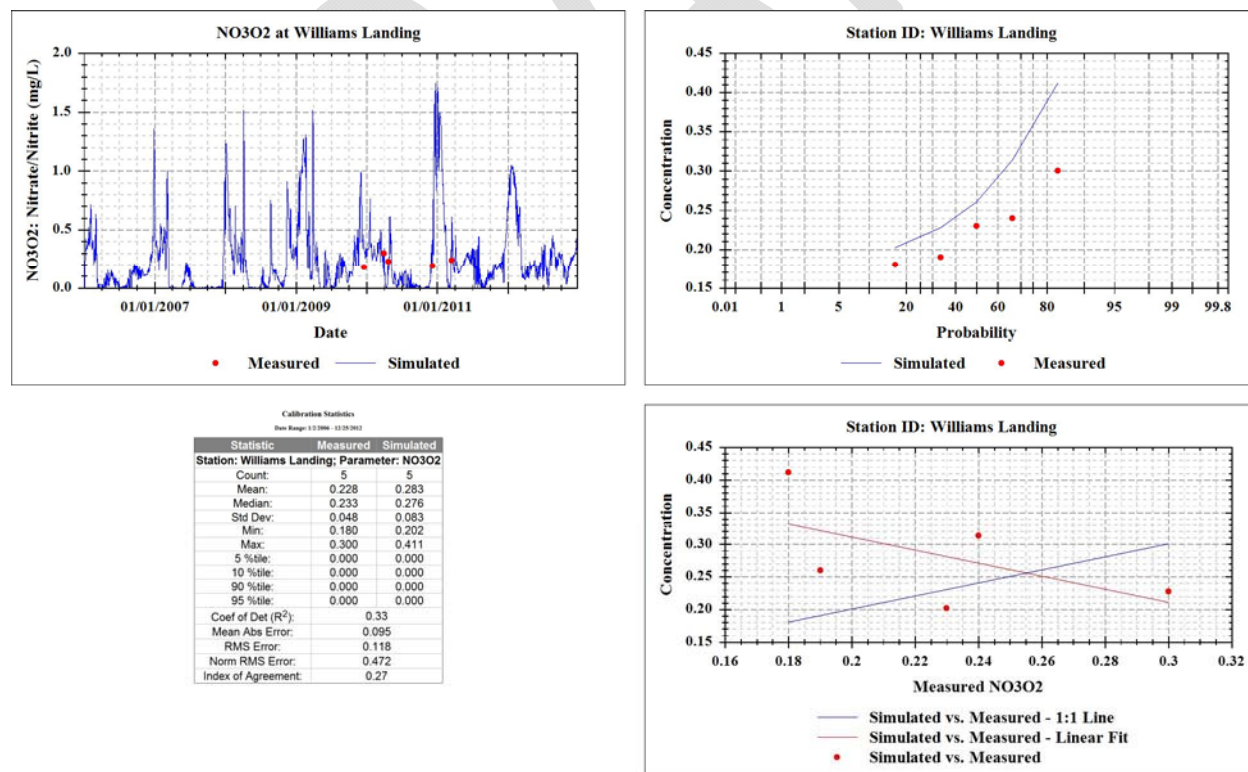


Figure 84 21FLLEONLCT03045184523: Lake Talquin near Williams Landing for Nitrate

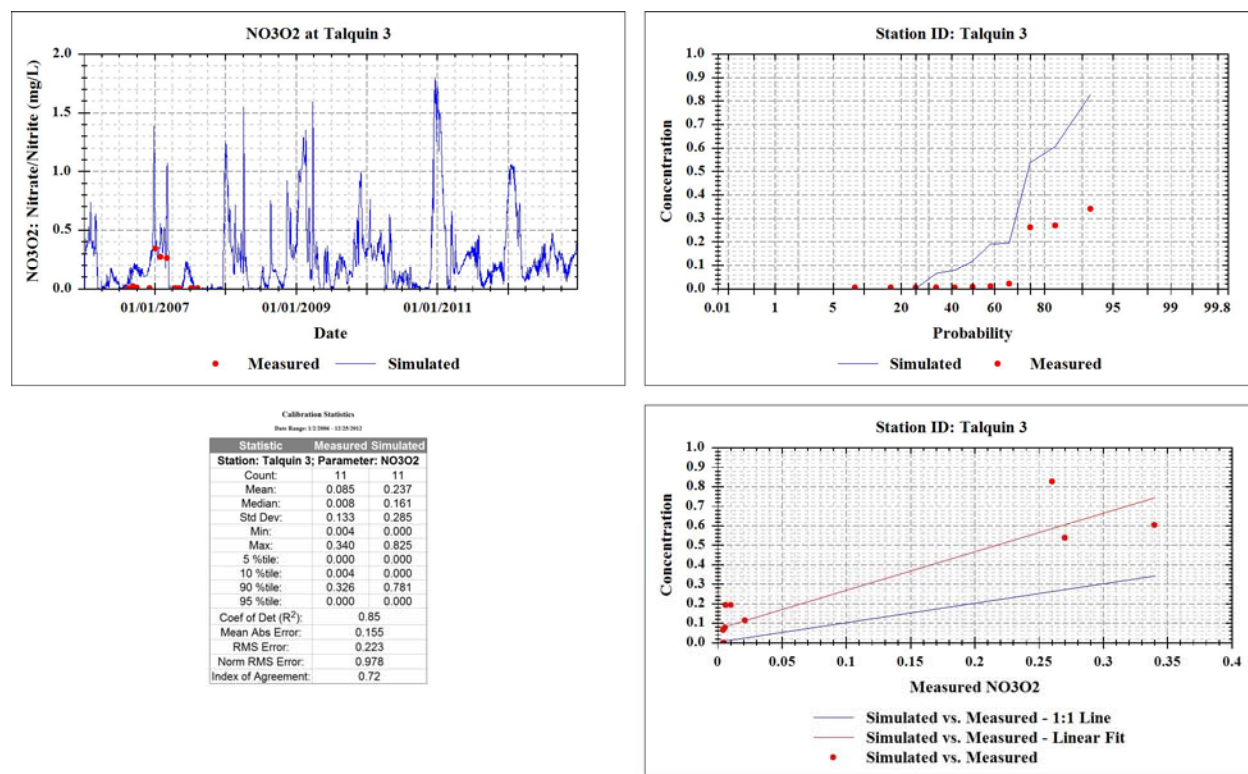


Figure 85 21FLLEONLCT0W3045084521: Talquin 3 for Nitrate

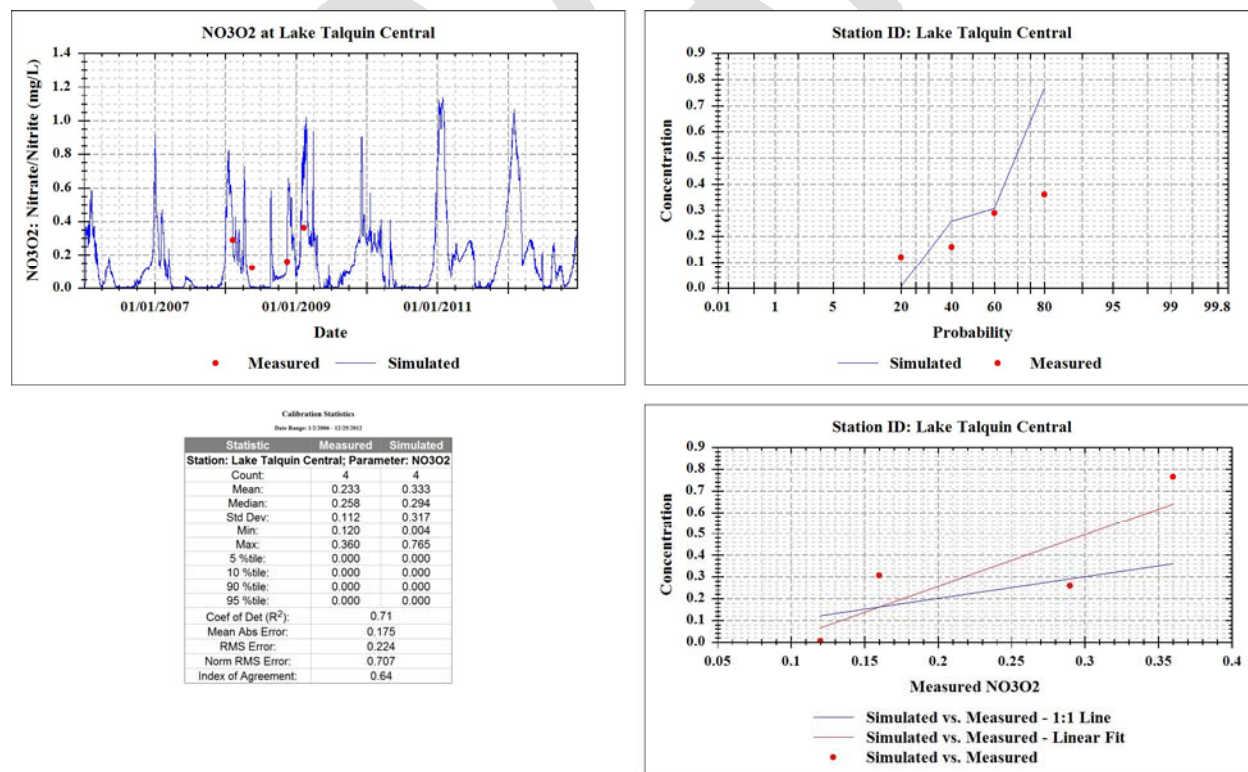


Figure 86 21FLLEONT0E3044084556: Lake Talquin Central for Nitrate

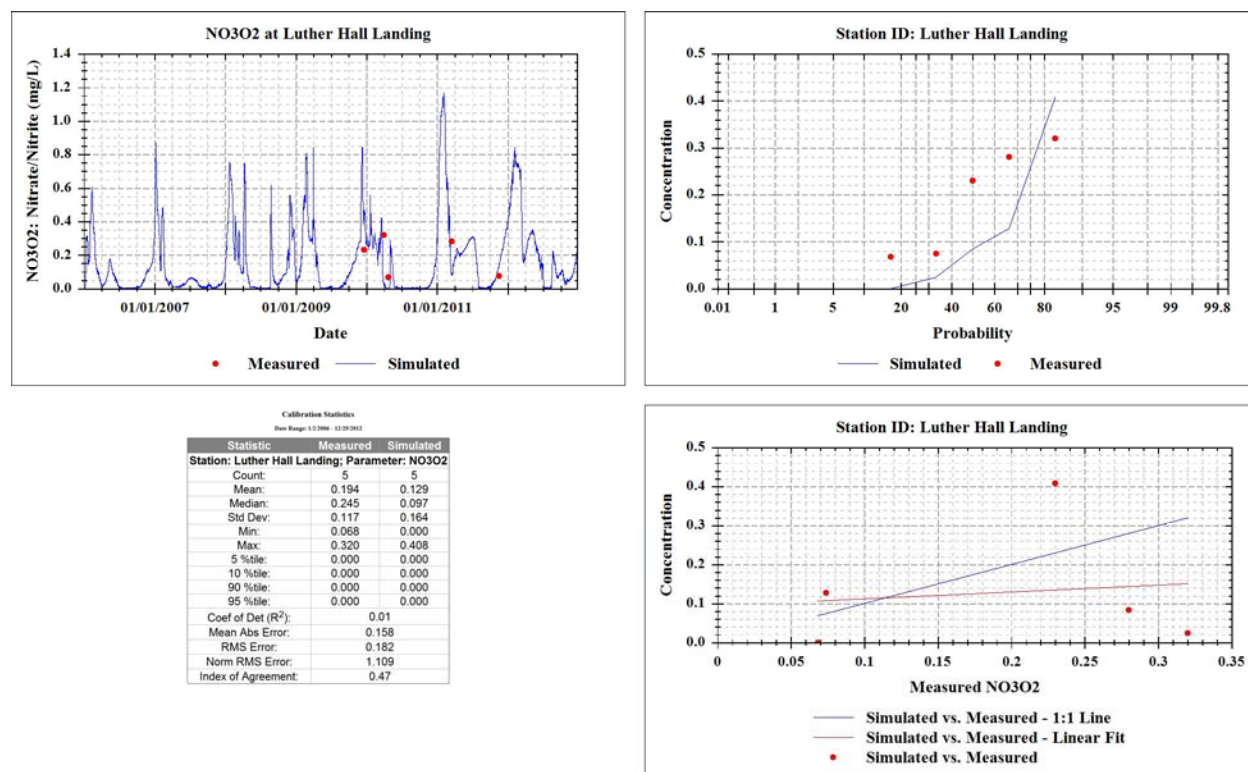


Figure 87 21FLLEONLCT03042384172: Lake Talquin near Luther Hall Landing for Nitrate

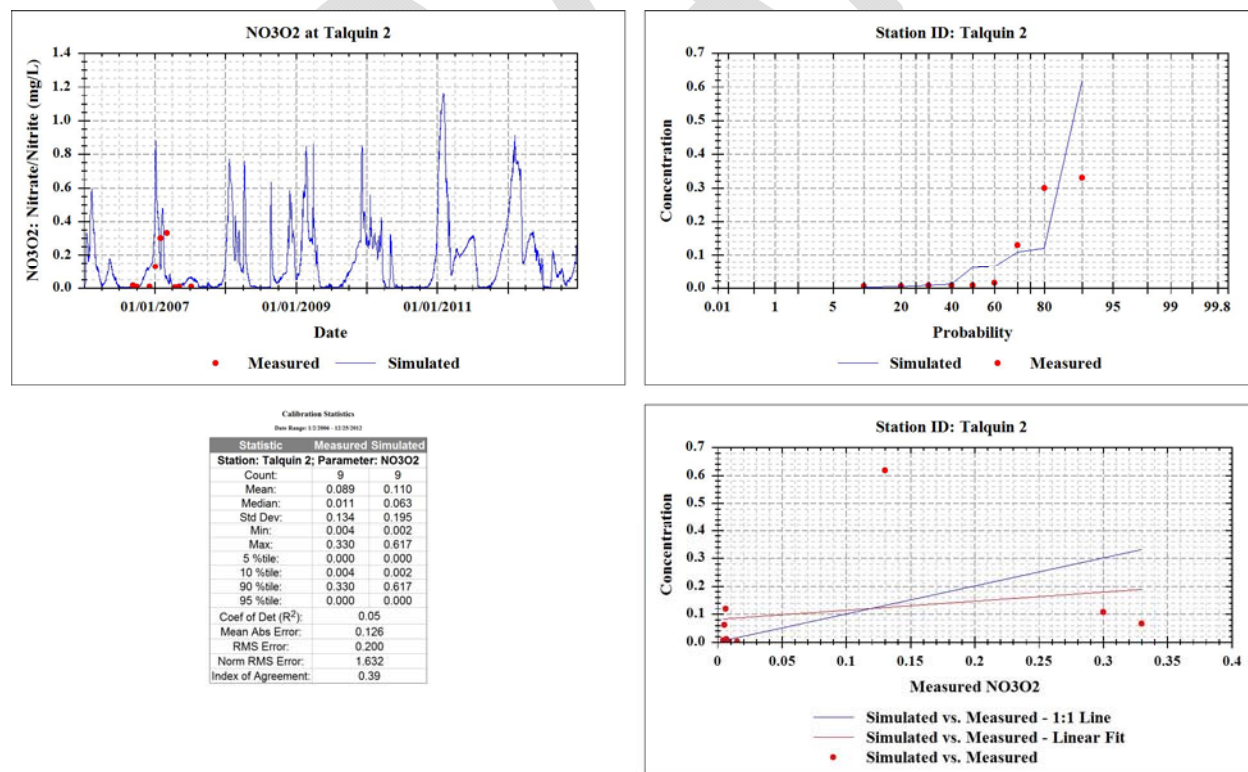


Figure 88 21FLLEONLCT0L3042284573: Talquin 2 for Nitrate

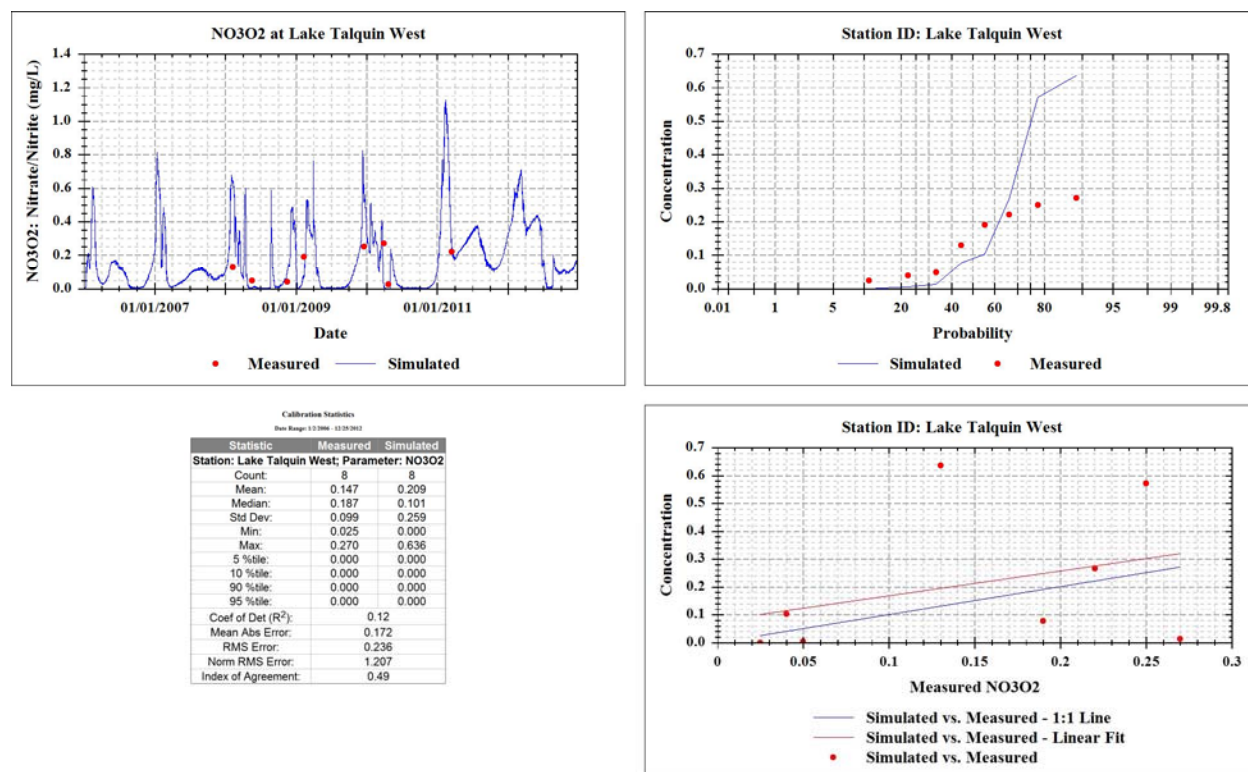


Figure 89 21FLLEONT0D3041488461: Lake Talquin West for Nitrate

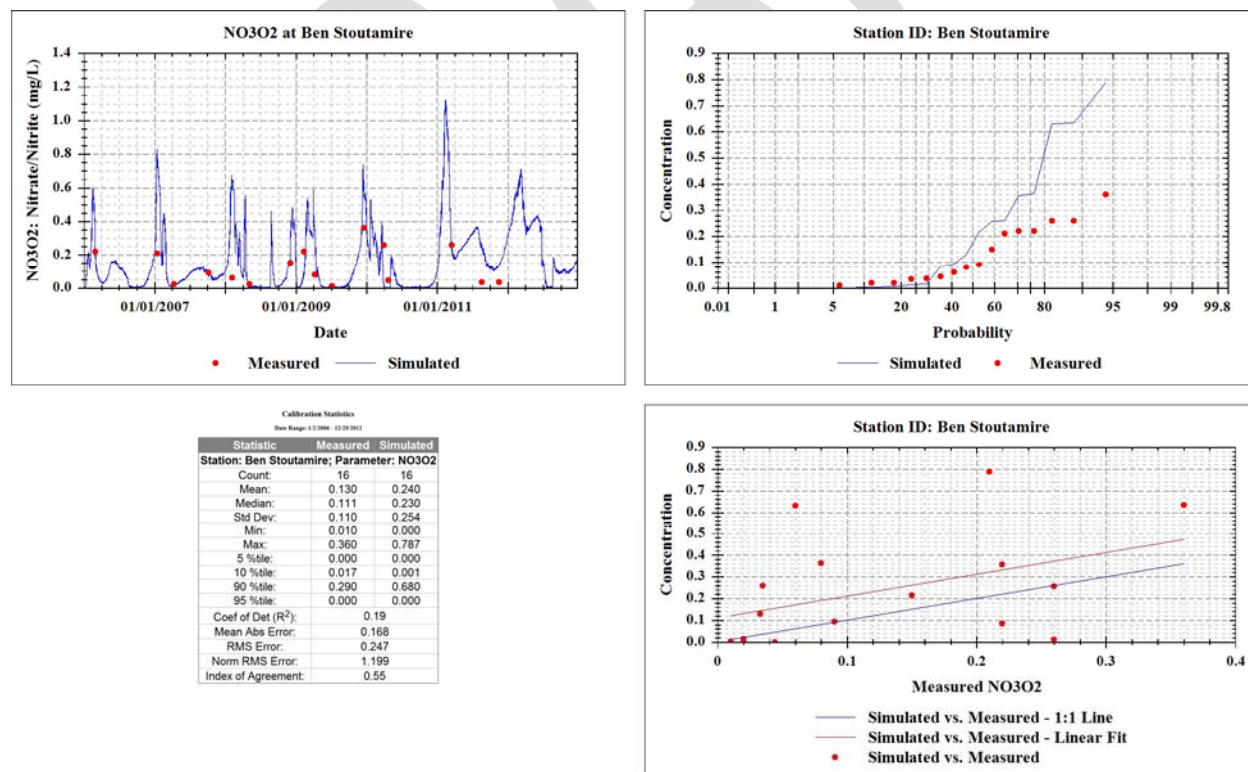


Figure 90 21FLLEONLCOC3040784610: Lake Talquin (Ben Stoutamire Boat Landing) for Nitrate

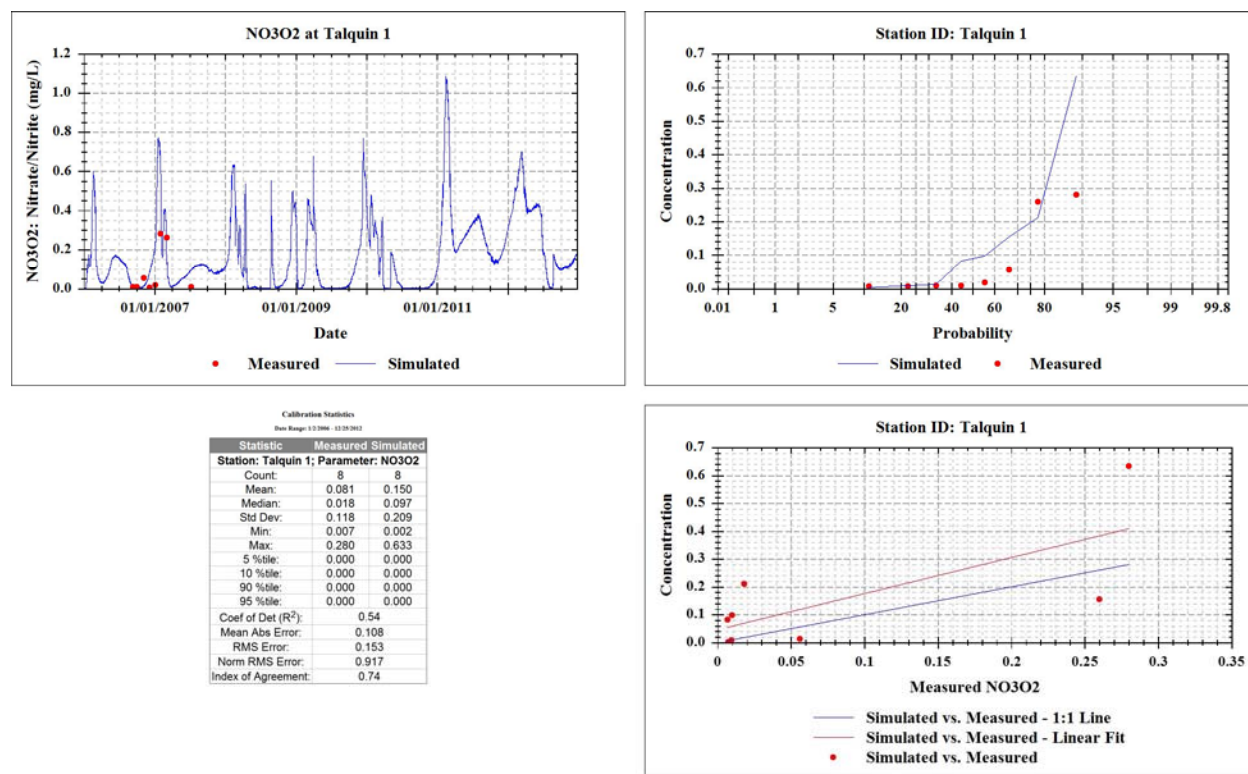


Figure 91 21FLLEONLCT0B3040284630: Talquin 1 for Nitrate

Phosphorus

Figure 92 through Figure 106 illustrate quantitative and qualitative comparison of the model predictions for total phosphorus and ortho-phosphate to direct field measurements.

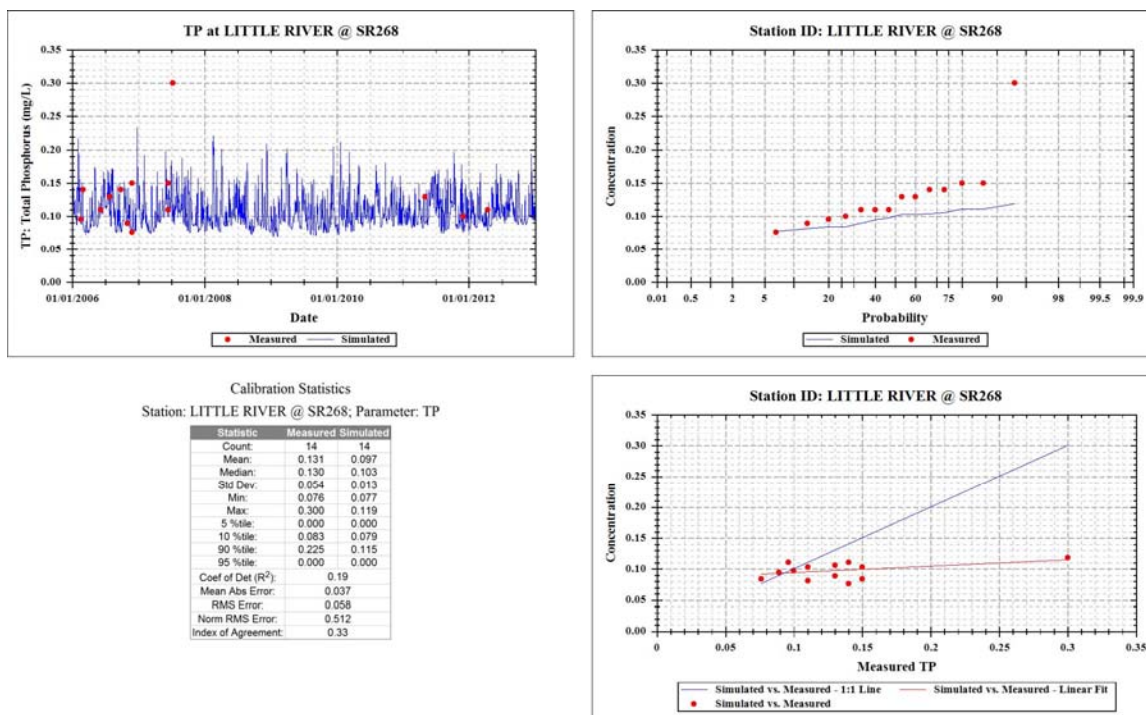


Figure 92 Total Phosphorus Calibration Little River @ SR268

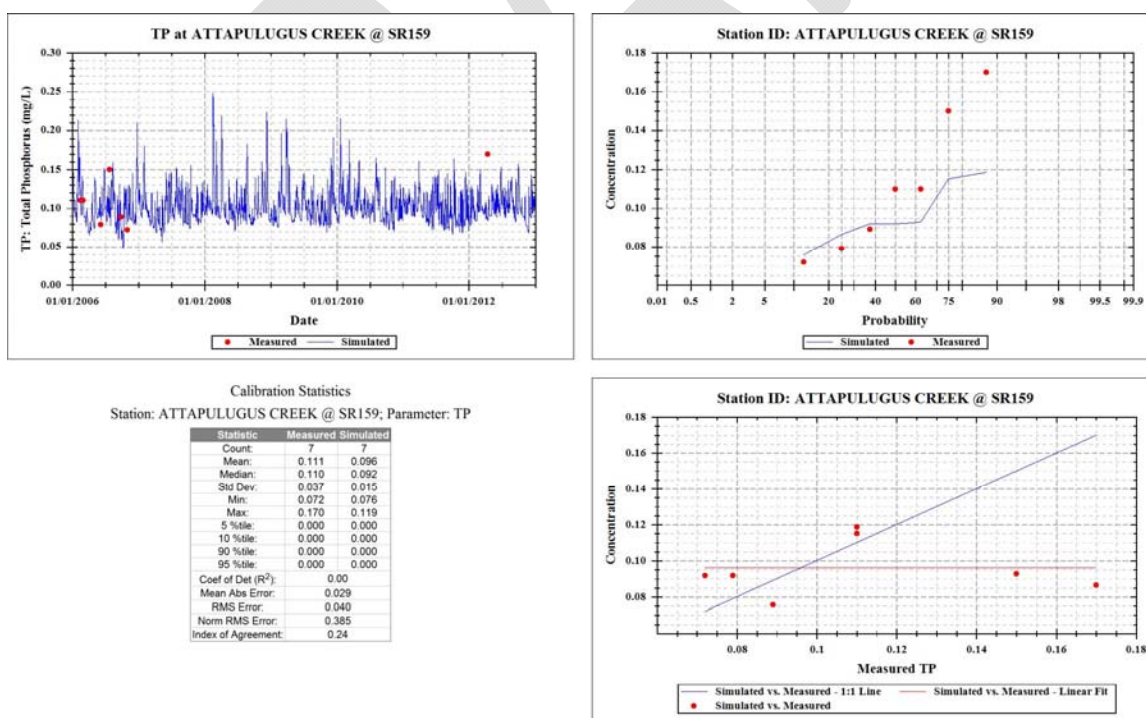


Figure 93 Total Phosphorus Calibration Attapulugus Creek at SR 159

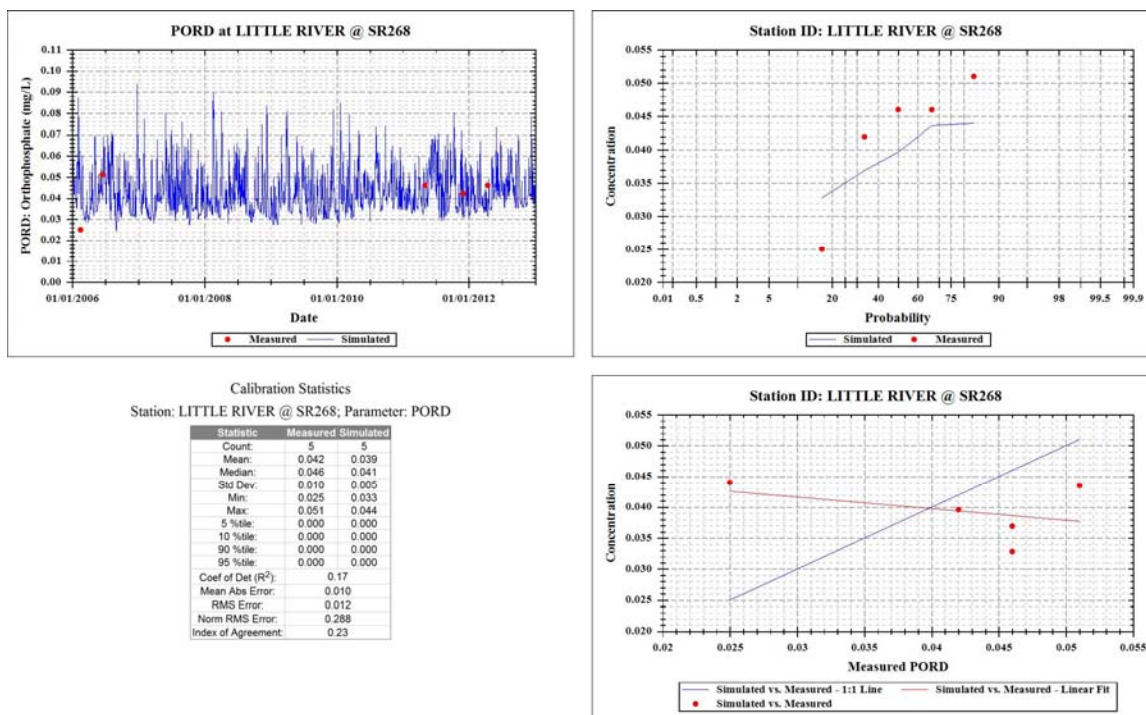


Figure 94 Ortho-Phosphate Calibration Little River @ SR268

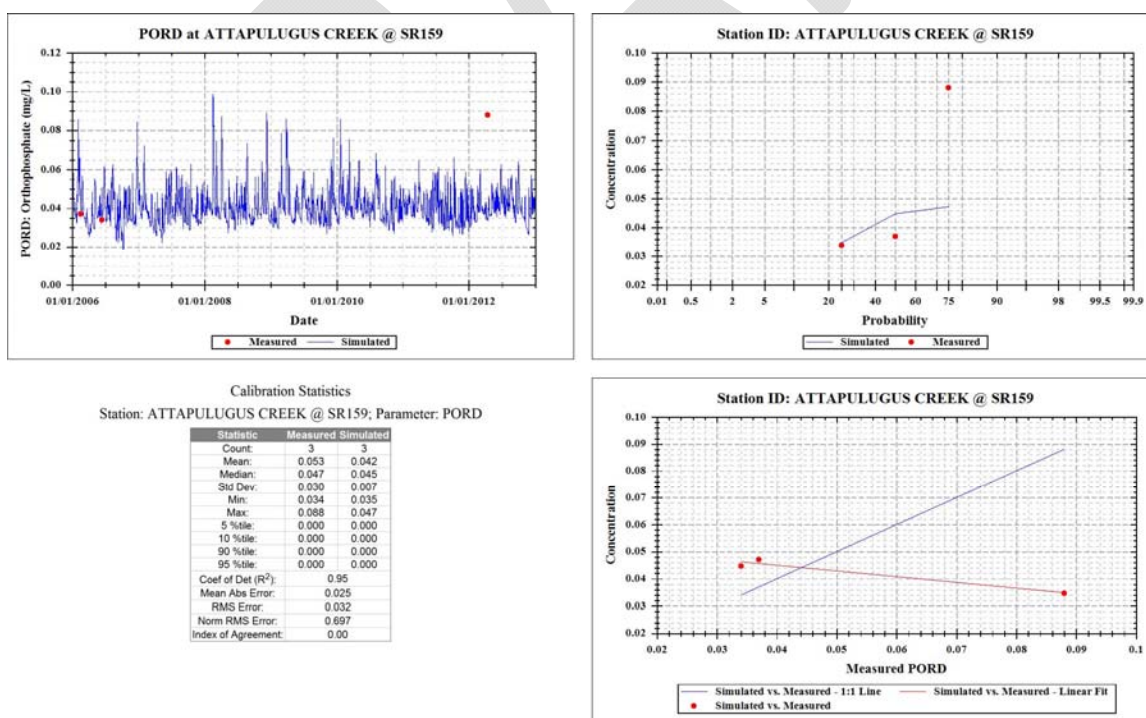


Figure 95 Ortho-Phosphate Calibration Attapulgus Creek at SR 159

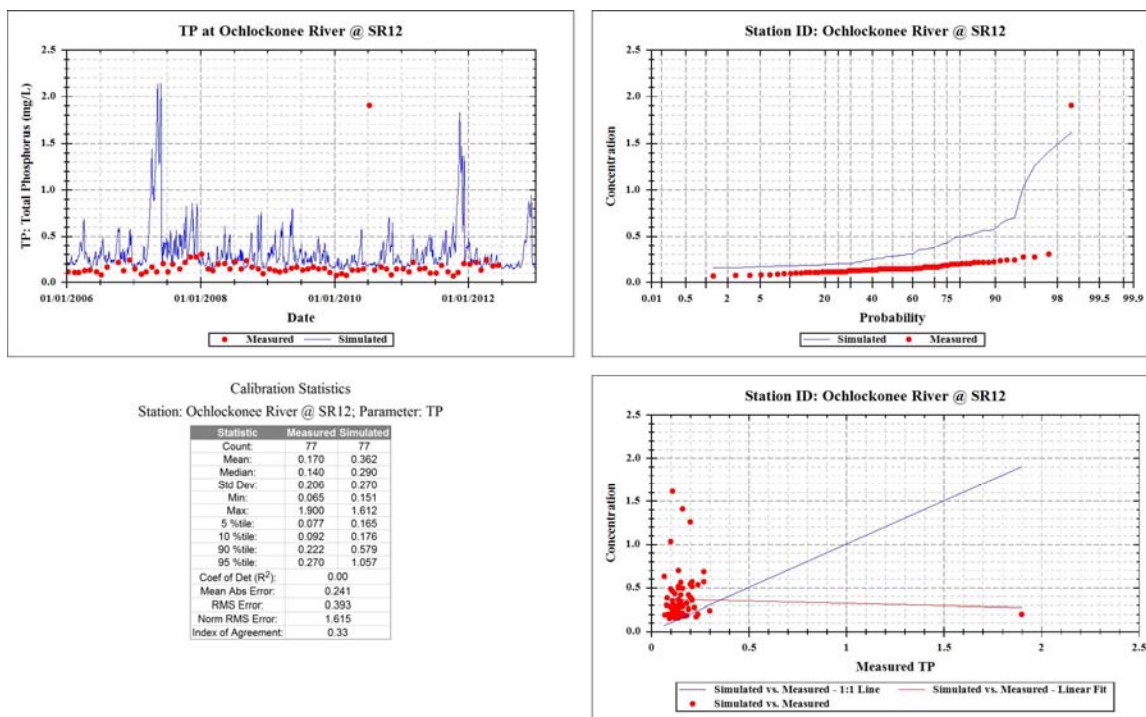


Figure 96 Total Phosphorus Calibration Ochlockonee River at SR 12

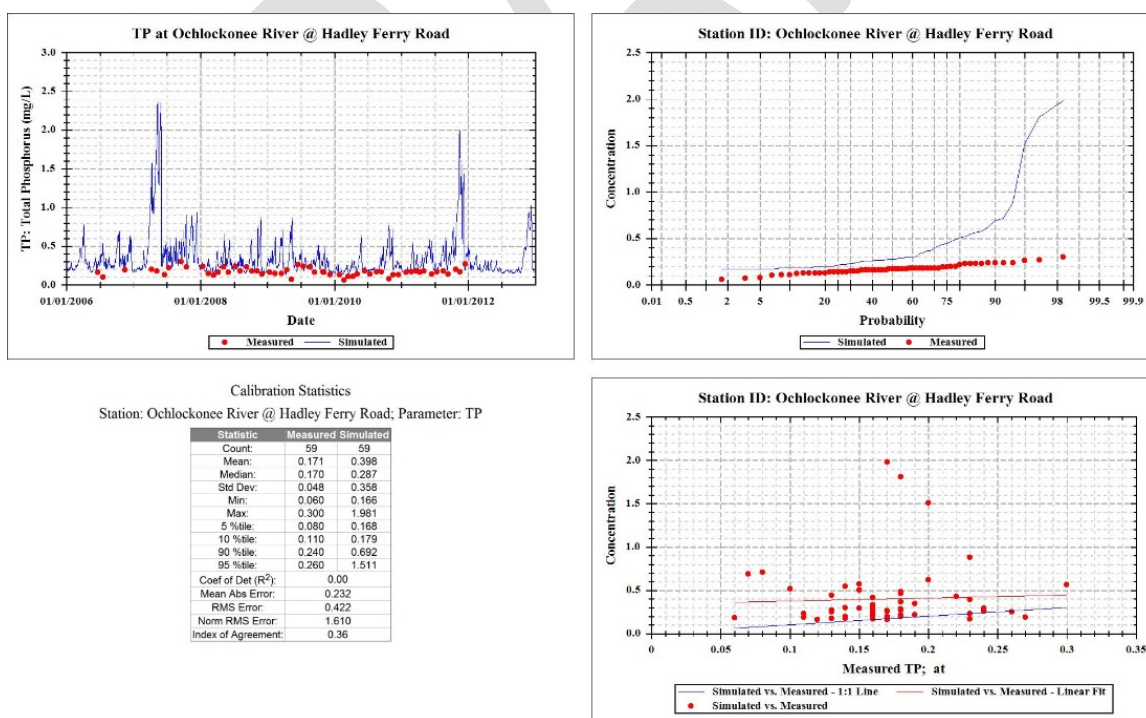


Figure 97 Total Phosphorus Calibration Ochlockonee River near Hadley Road

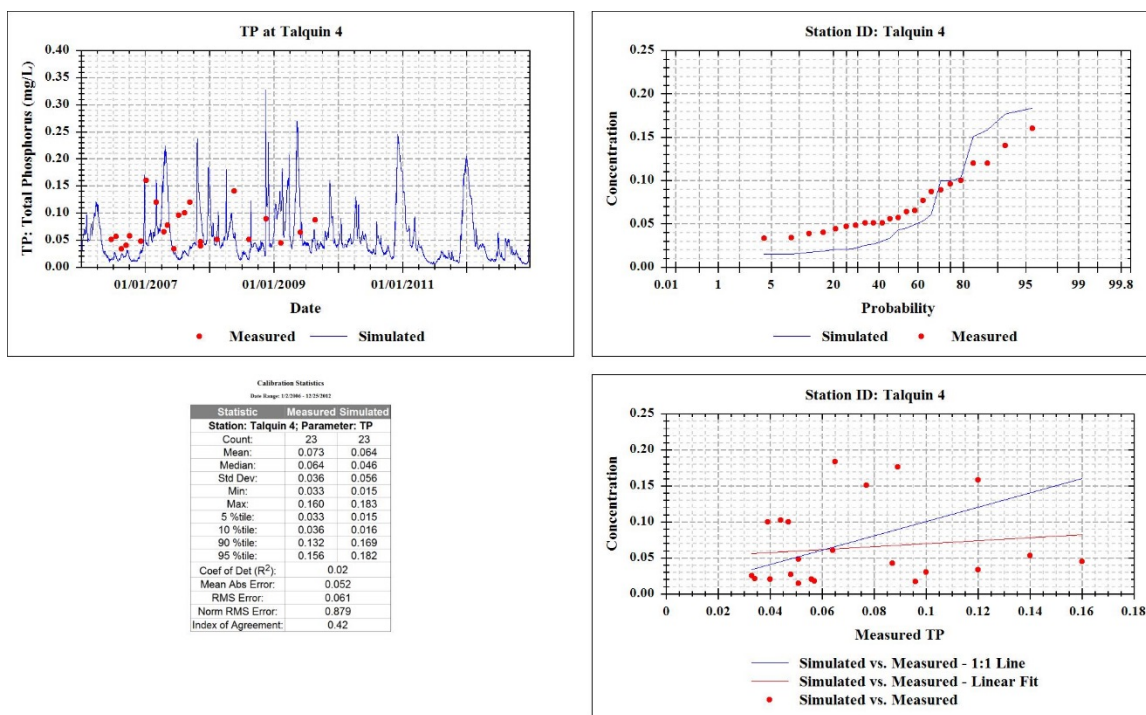


Figure 98 21FLLEONLCT0C3045884492: Talquin 4 for Total Phosphorus

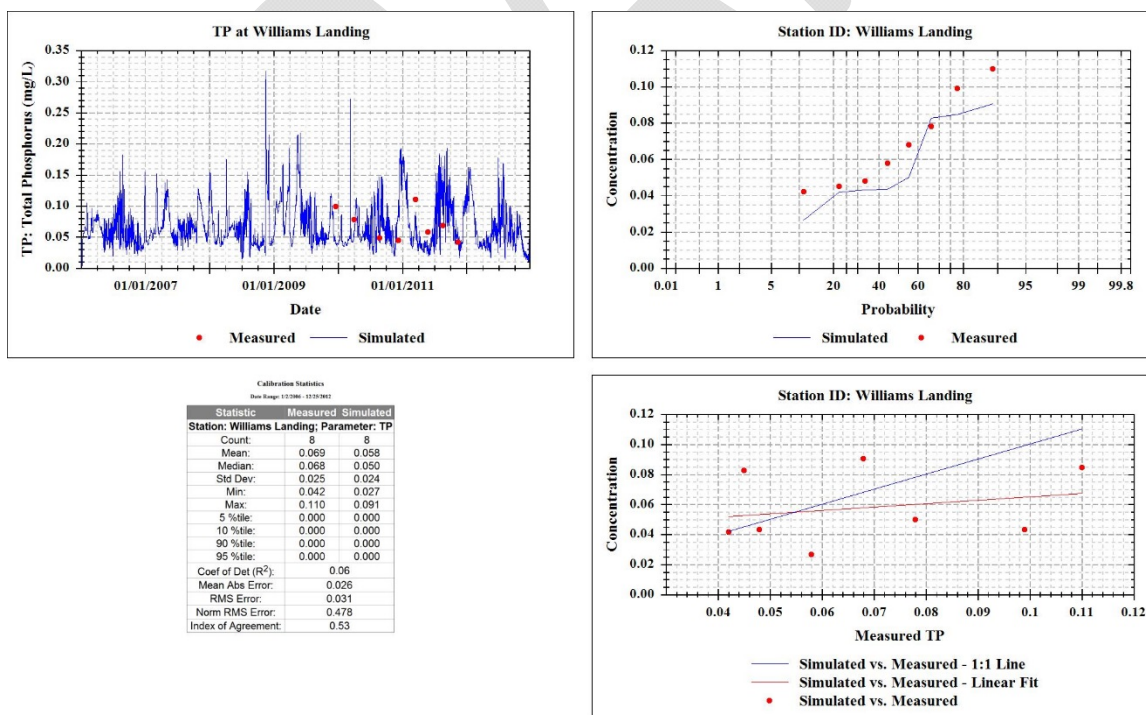


Figure 99 21FLLEONLCT03045184523: Lake Talquin near Williams Landing for Total Phosphorus

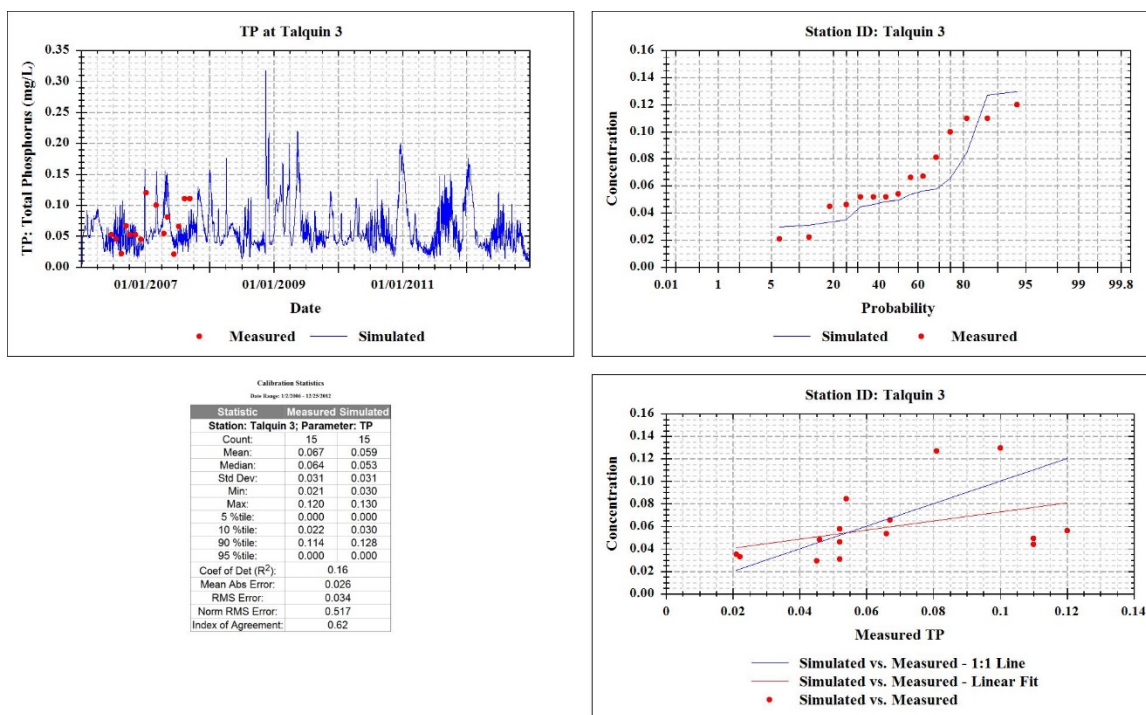


Figure 100 21FLLEONLCT0W3045084521: Talquin 3 for Total Phosphorus

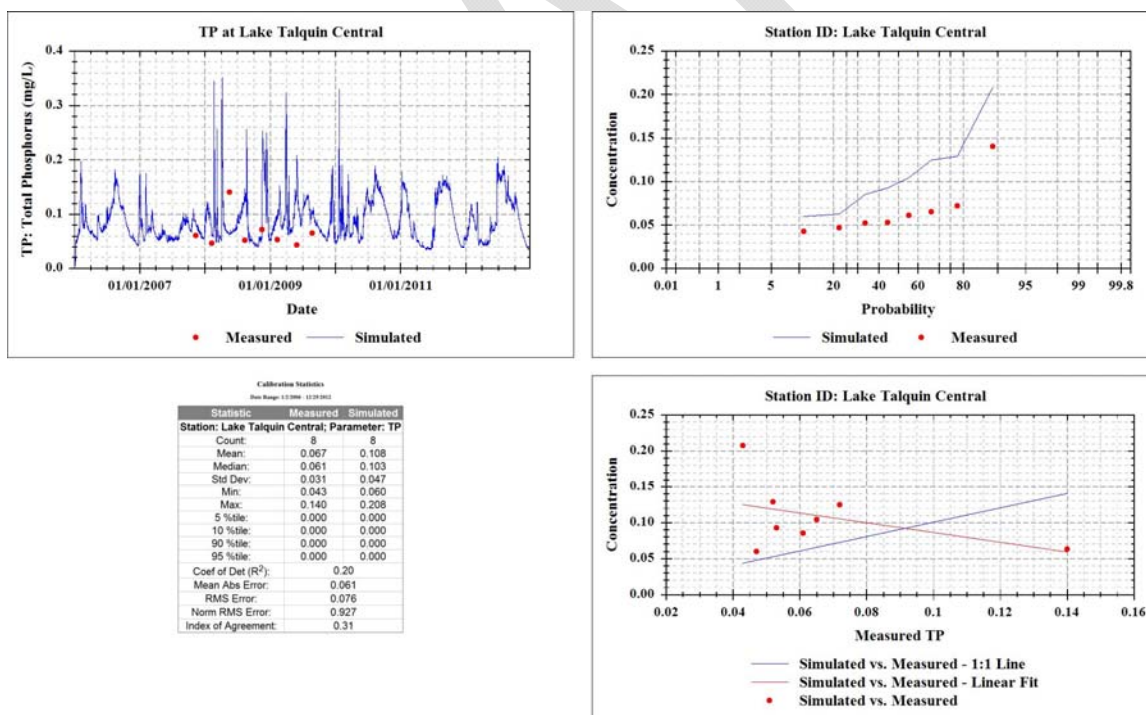


Figure 101 21FLLEONT0E3044084556: Lake Talquin Central for Total Phosphorus

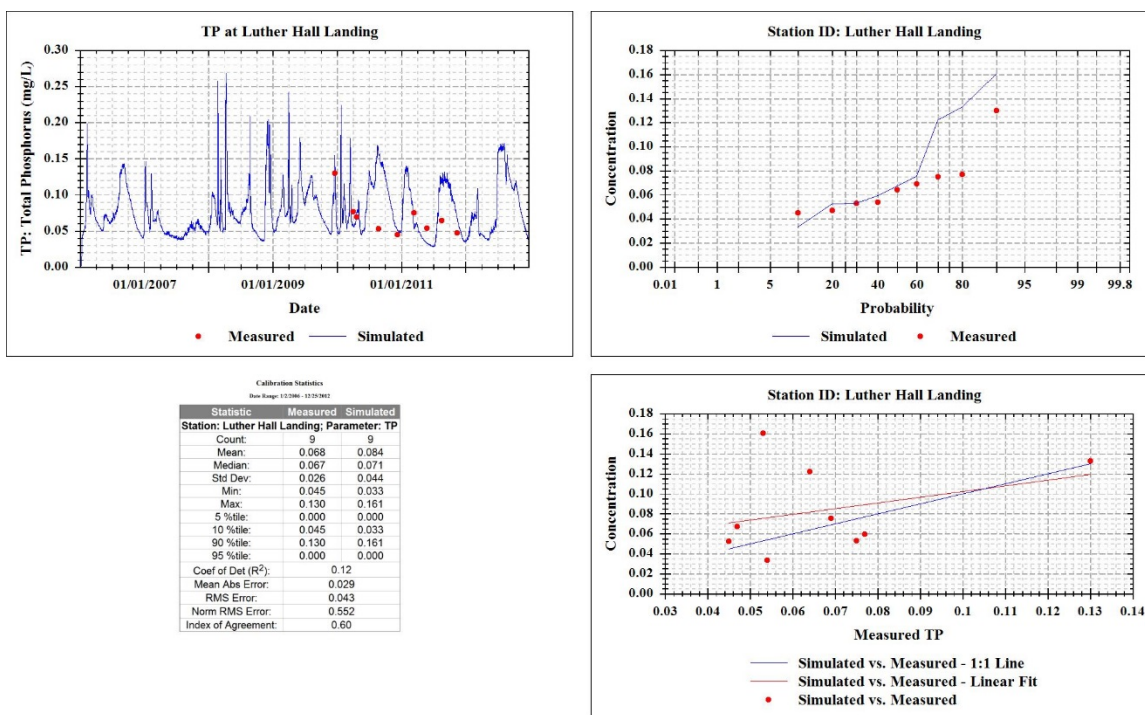


Figure 102 21FLLEONLCT03042384172: Lake Talquin near Luther Hall Landing for Total Phosphorus

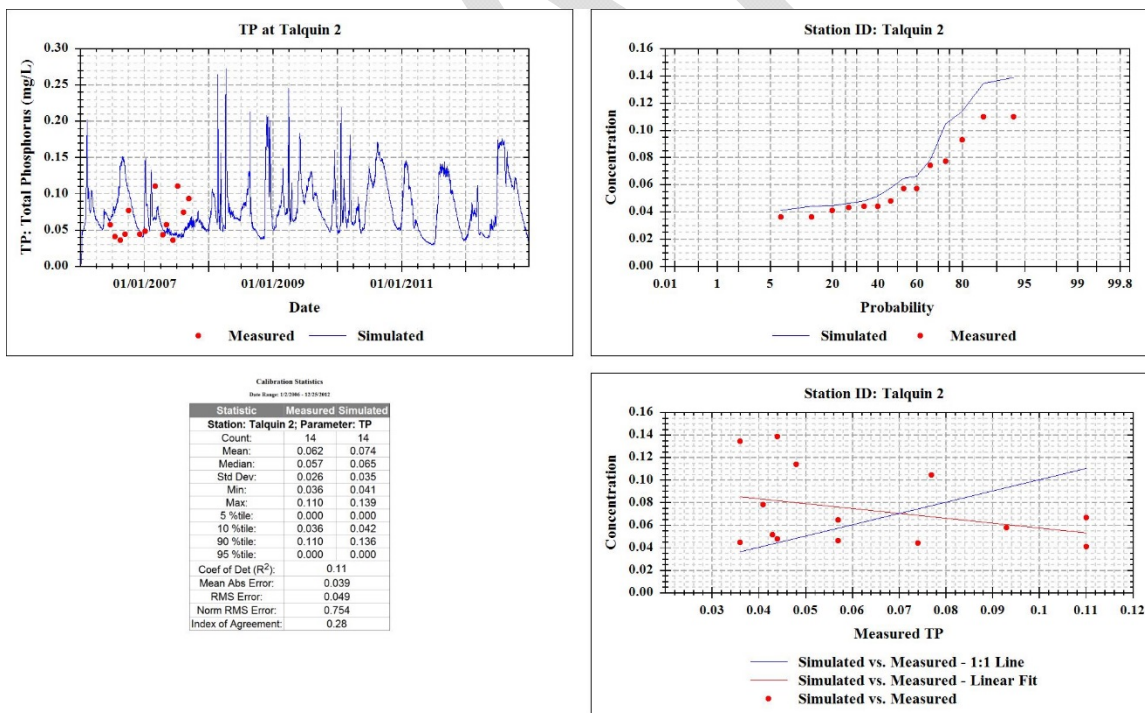


Figure 103 21FLLEONLCT0L3042284573: Talquin 2 for Total Phosphorus

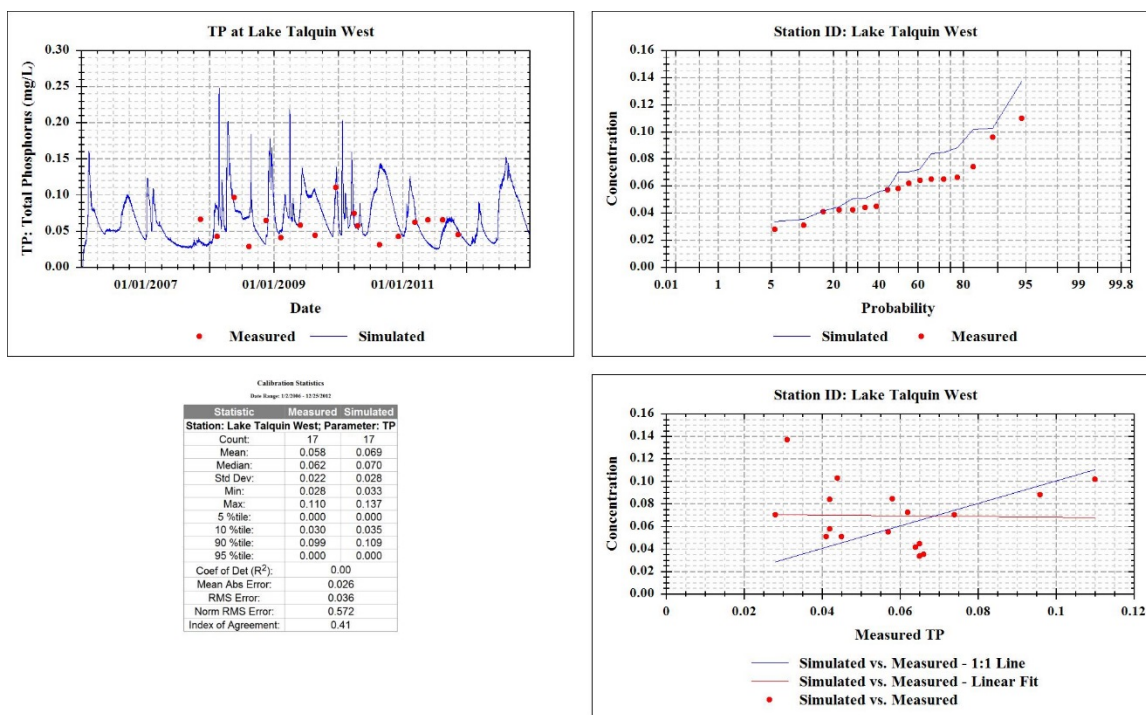


Figure 104 21FLLEONT0D3041488461: Lake Talquin West for Total Phosphorus

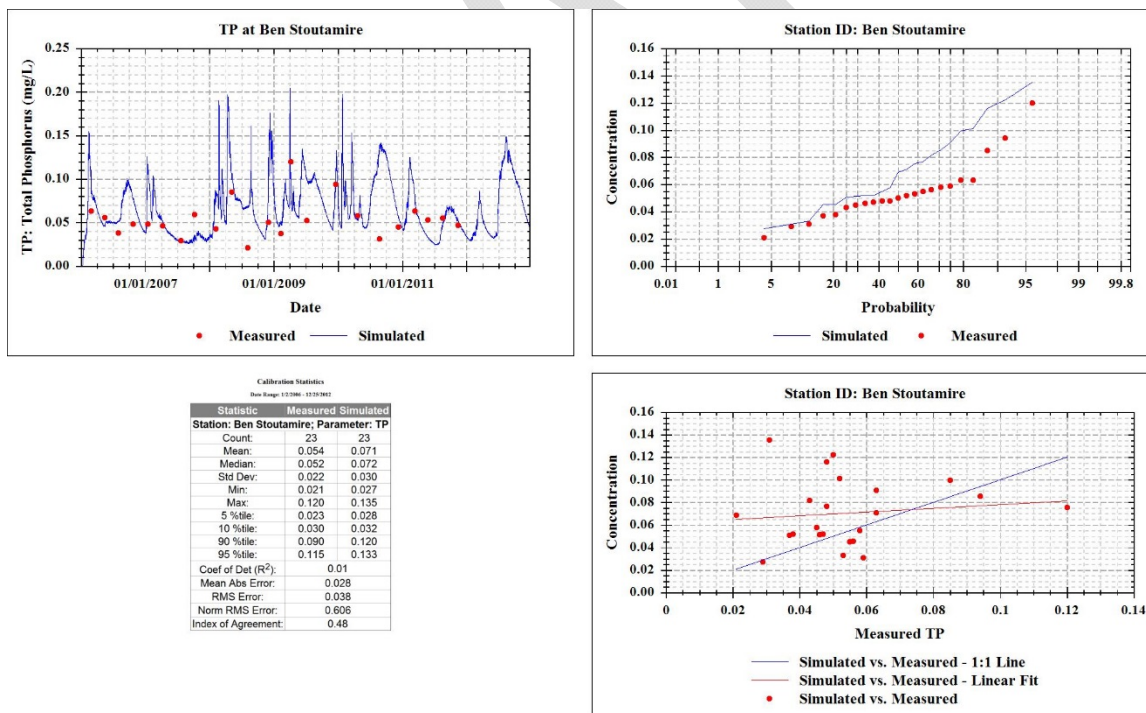


Figure 105 21FLLEONLCOC3040784610: Lake Talquin (Ben Stoutamire Boat Landing) for Total Phosphorus

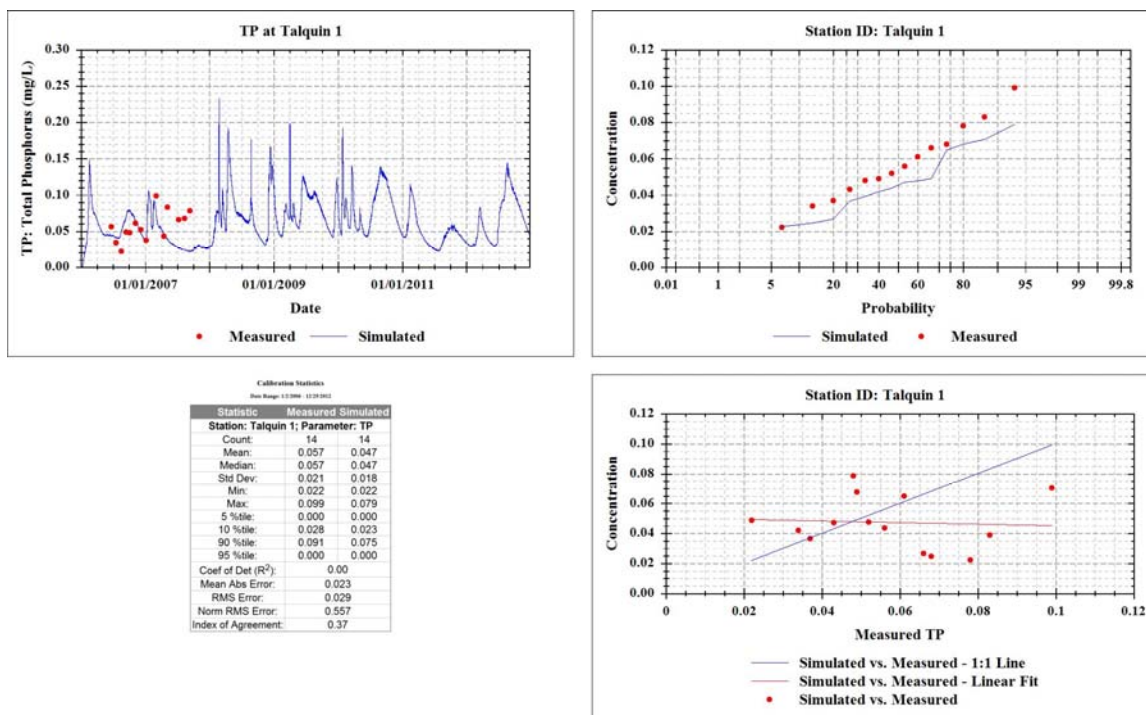


Figure 106 21FLLEONLCT0B3040284630: Talquin 1 for Total Phosphorus

Longitudinal Profile

Figure 107 through Figure 112 compare the annual average predicted concentrations with the annual average measured concentrations. This provides a good comparison of the nutrient dynamics and algal growth as the watershed loads moves through lake Talquin.

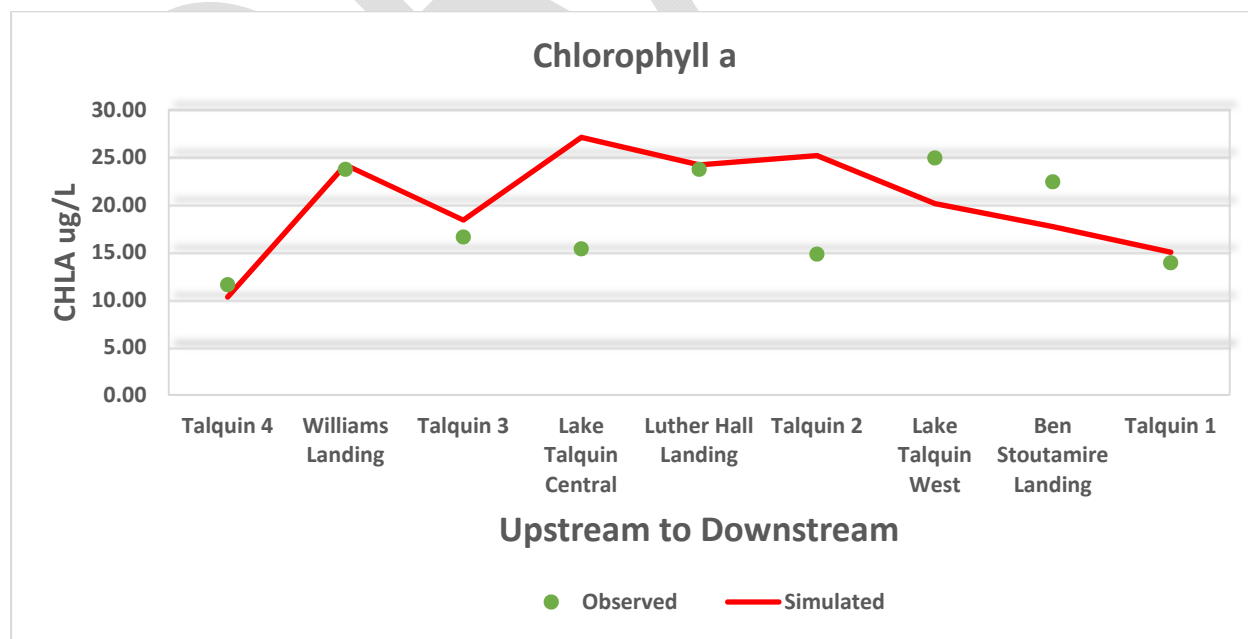


Figure 107 Longitudinal Profile -- Chlorophyll a

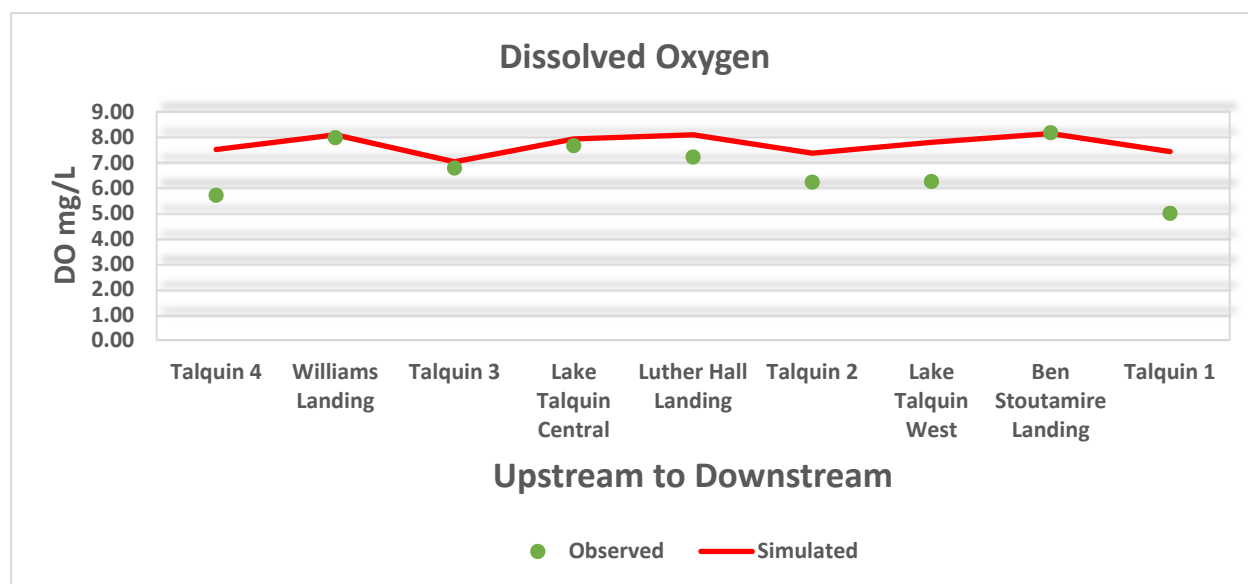


Figure 108 Longitudinal Profile -- Dissolved Oxygen

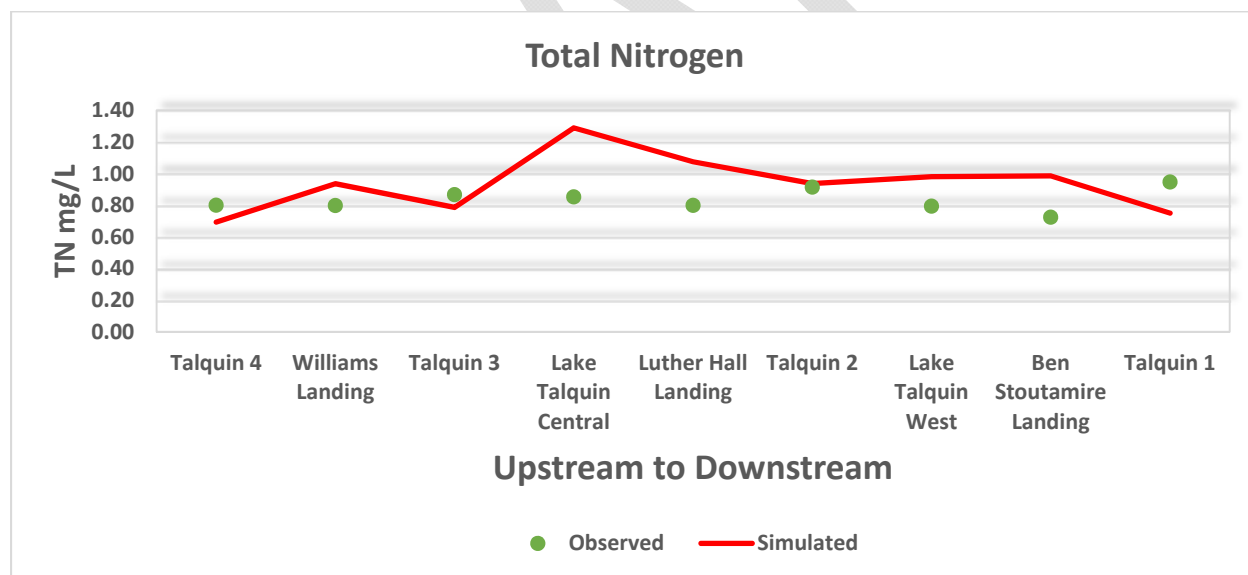


Figure 109 Longitudinal Profile -- Total Nitrogen

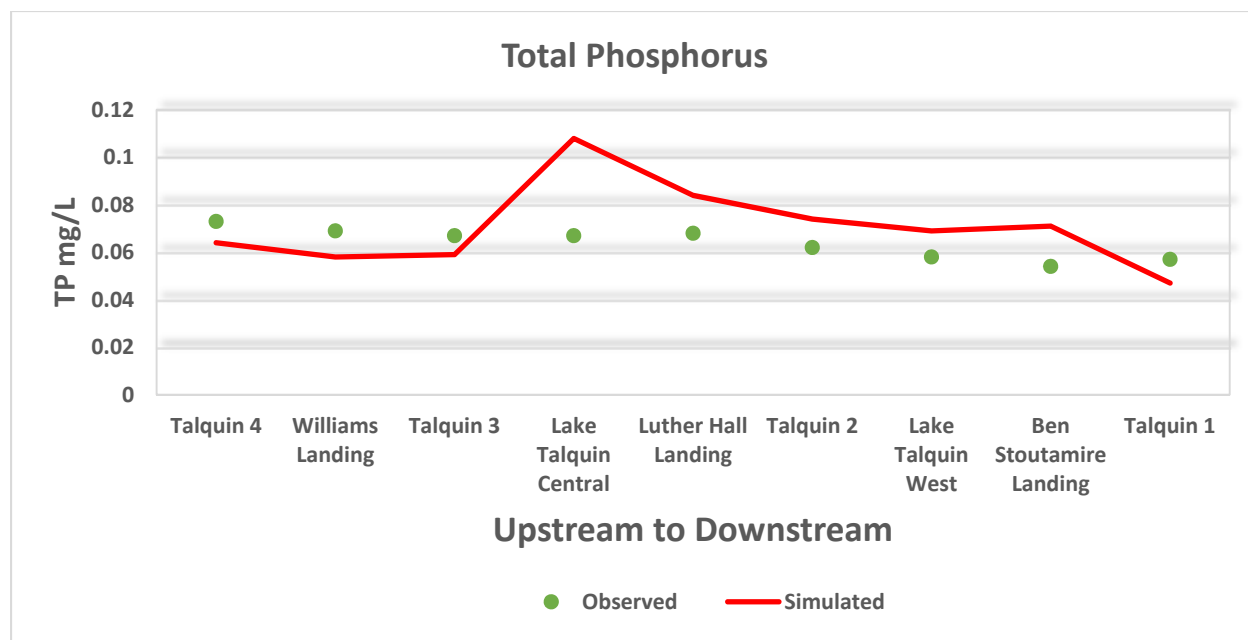


Figure 110 Longitudinal Profile -- Total Phosphorus

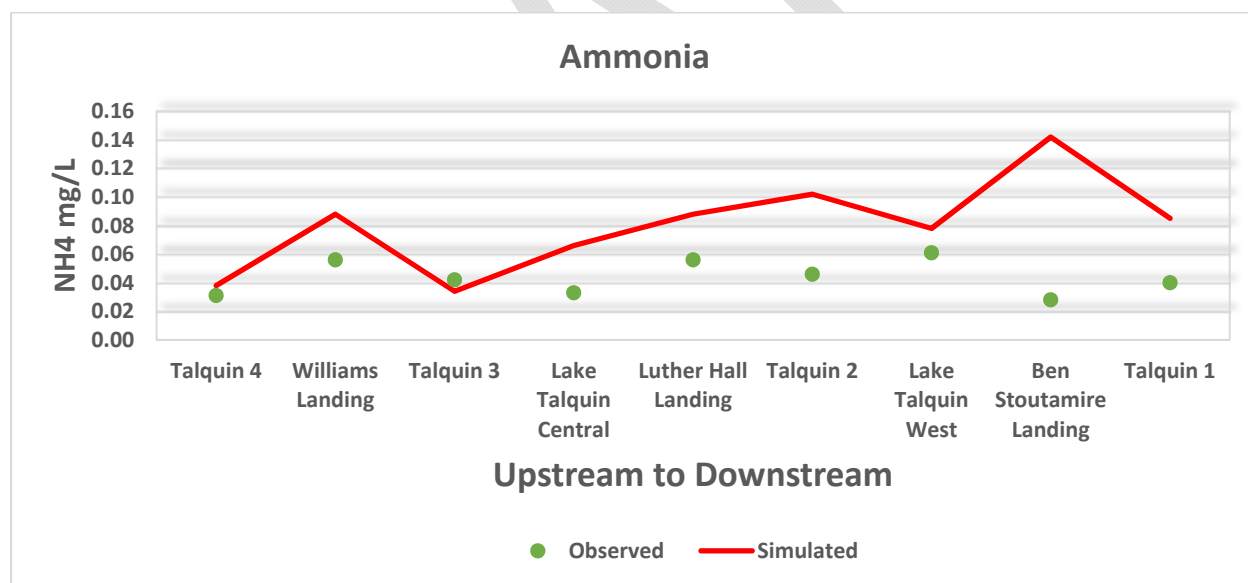


Figure 111 Longitudinal Profile -- Ammonia

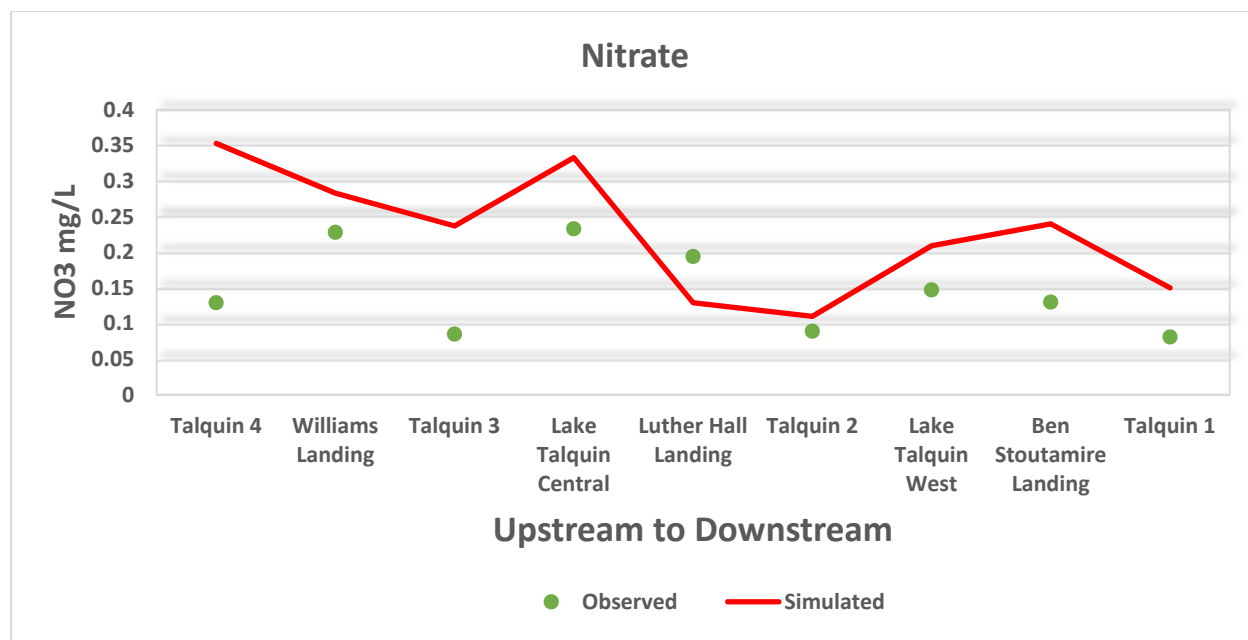


Figure 112 Longitudinal Profile -- Nitrate

Lake Talquin Load Analysis

Using the predicted time series of flows and loads from the Ochlockonee and Little River water quality models a load analysis was conducted. Loads were calculated from daily flows and concentrations from the terminal model segments (inlets to the Lake model). Load analysis was conducted at the segments that correspond to the Georgia/Florida state line.

Figure 113 provides a comparison of the percentage of the watershed land area that is in each state. With 73% of the watershed area in Georgia it is expected that most of the loading to Lake Talquin will come from Georgia.

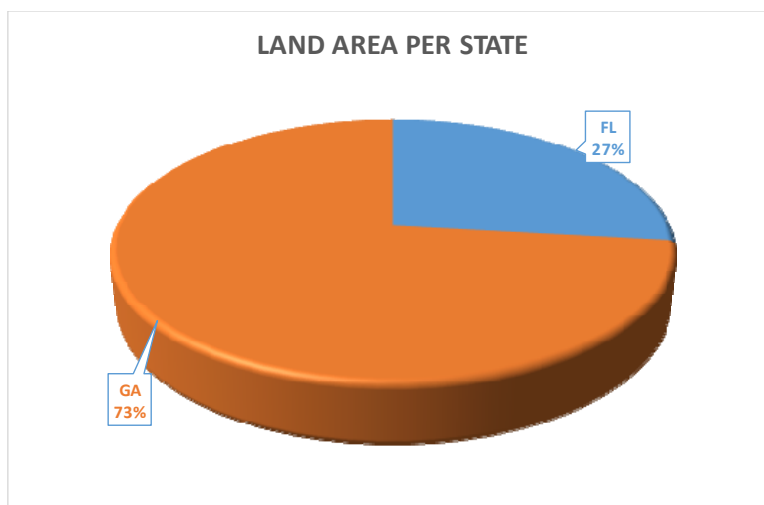


Figure 113 Percent Land Area for Watershed by State

Flows

Figure 114 illustrates the predicted annual average daily flows at the inlet of Lake Talquin from the Ochlockonee and Little Rivers. The figure shows the simulation period considers a wide range of hydraulic conditions. This simulation period provides a wide range of flow and loading conditions.

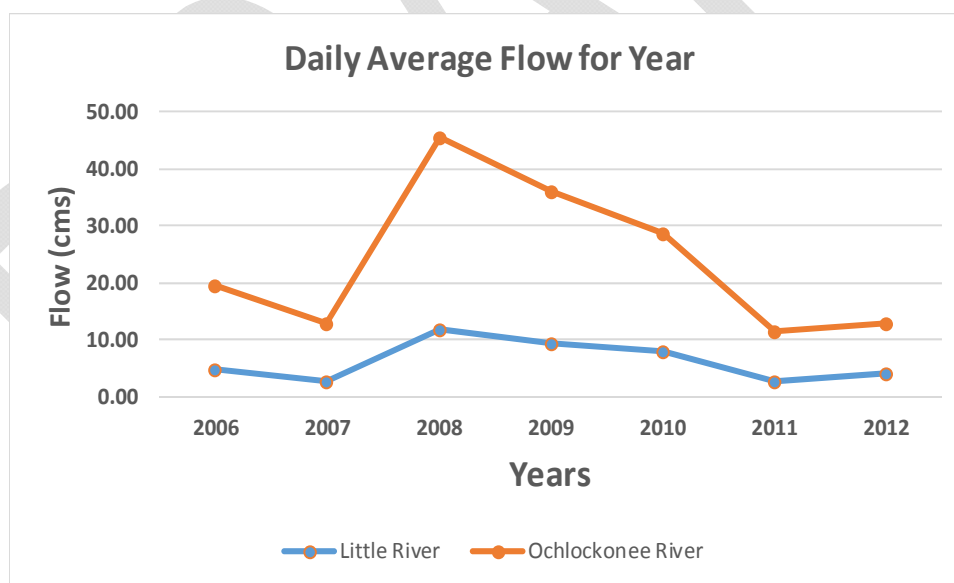


Figure 114 Annual Daily Average Flow at Lake Talquin Inlet

Lake Talquin Nutrient Load Analysis

The following provides an analysis of the nutrient loadings to Lake Talquin. The loadings were calculated using the predicted flows and concentrations predicted by the river water quality

models. Therefore these loads do account for nutrient cycling in the watershed. Table 6 provides the nutrient loads to Lake Talquin by year and river basin.

Table 6 Nutrient Loads by River Basin (Kg/Yr)

Year	Little River		Ochlockonee River	
	TN	TP	TN	TP
2006	25233	1971	45069	5175
2007	16303	1042	35615	4976
2008	45697	5203	90563	9140
2009	40563	3989	82033	7803
2010	31035	3197	54963	5986
2011	20089	943	30820	3753
2012	25199	1504	31390	2913
Average	29160	2550	52922	5678

Figure 115 shows an analysis of the percentage of the total nitrogen load coming from the Ochlockonee and Little River basins.

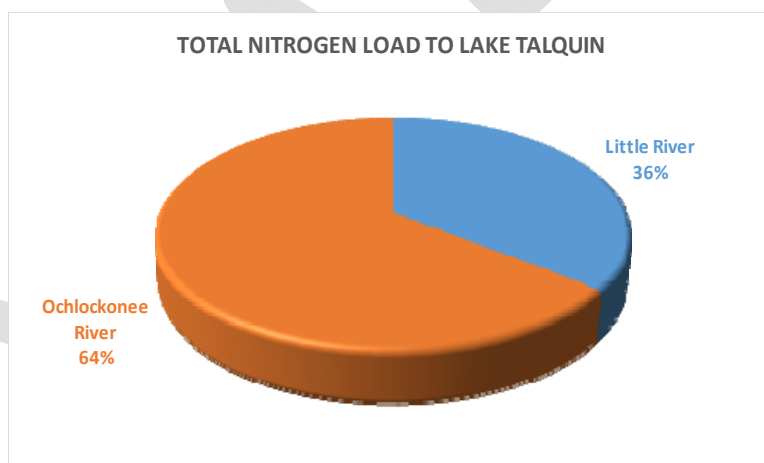


Figure 115 Total Nitrogen Loading to Lake Talquin from Ochlockonee and Little River

Figure 116 shows an analysis of the percentage of the total phosphorus load coming from the Ochlockonee and Little River basins.

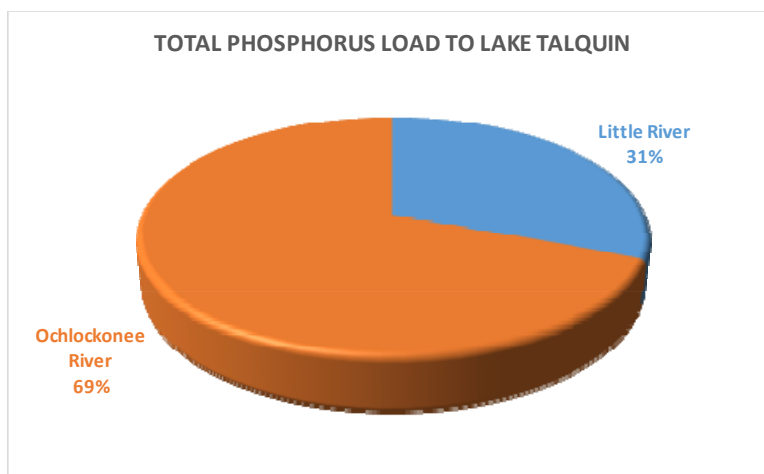


Figure 116 Total Phosphorus Loading to Lake Talquin from Ochlockonee and Little River

Point and Non-Point Source Analysis

Model simulations were conducted with and without the permitted discharges to determine their contribution to the nutrient loads to Lake Talquin. Table 7 provides the annual loads of nutrients attributed to the point sources in each river basin.

Table 7 Point Source Nutrient Loads (Kg/Yr) to Lake Talquin for each River Basin

Year	Little River		Ochlockonee River	
	TN	TP	TN	TP
2006	15722	59	16667	3091
2007	10883	29	16113	3570
2008	20887	37	20088	3690
2009	20845	33	18718	2979
2010	15972	42	18667	3261
2011	15085	36	14065	2661
2012	17822	46	14233	1884
Average	16745	40	16936	3019

Figure 117 - Figure 120 provides an analysis of the nutrient sources for Ochlockonee and Little River. Using the model simulations (current loadings & no point sources) the percent of loadings coming from point and non-point source can be compared.

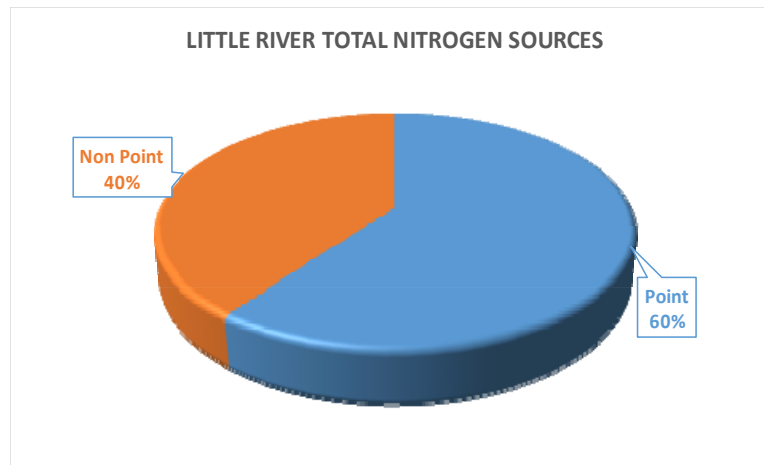


Figure 117 Total Nitrogen Source Analysis for Little River

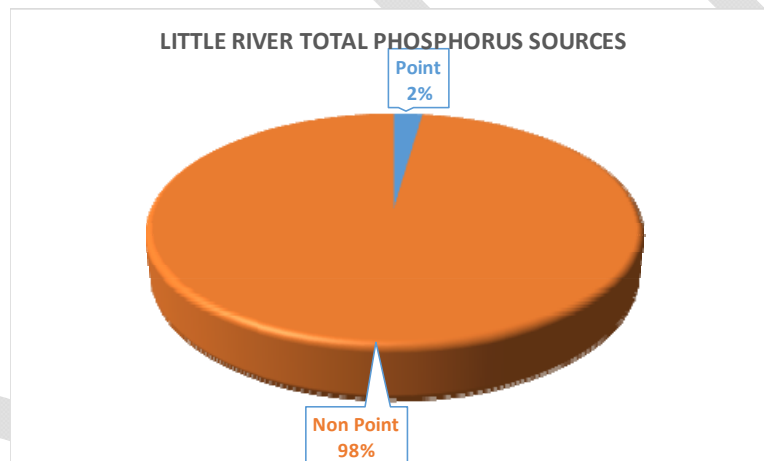


Figure 118 Total Phosphorus Source Analysis for Little River

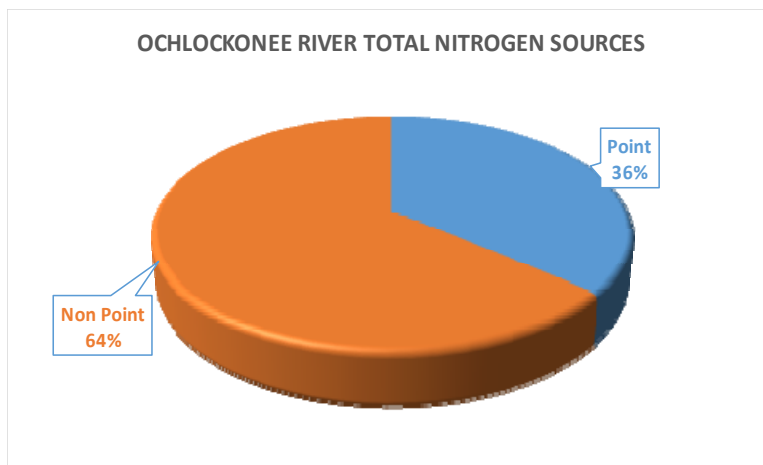


Figure 119 Total Nitrogen Source Analysis for Ochlockonee River

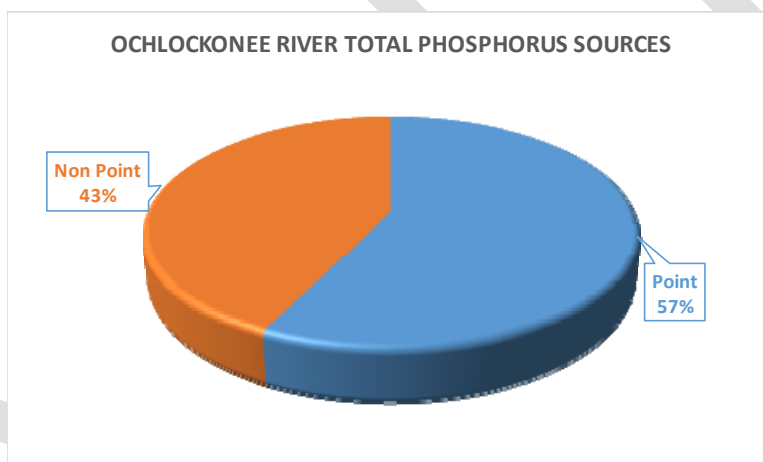


Figure 120 Total Phosphorus Source Analysis for Ochlockonee River

State Loadings

A loading analysis was conducted to determine the amount of nutrient loads coming from both states in Lake Talquin. The State of Georgia's nutrient loadings to Lake Talquin were calculated by using the simulated daily flows and concentrations corresponding to the segments at the Georgia/Florida Stateline. Florida's nutrient contribution was calculated by taking the current loading to Lake Talquin minus the Georgia loadings at the Stateline.

Figure 121 and Figure 122 illustrate the annual total nutrient load by state for Little River over the simulation period.

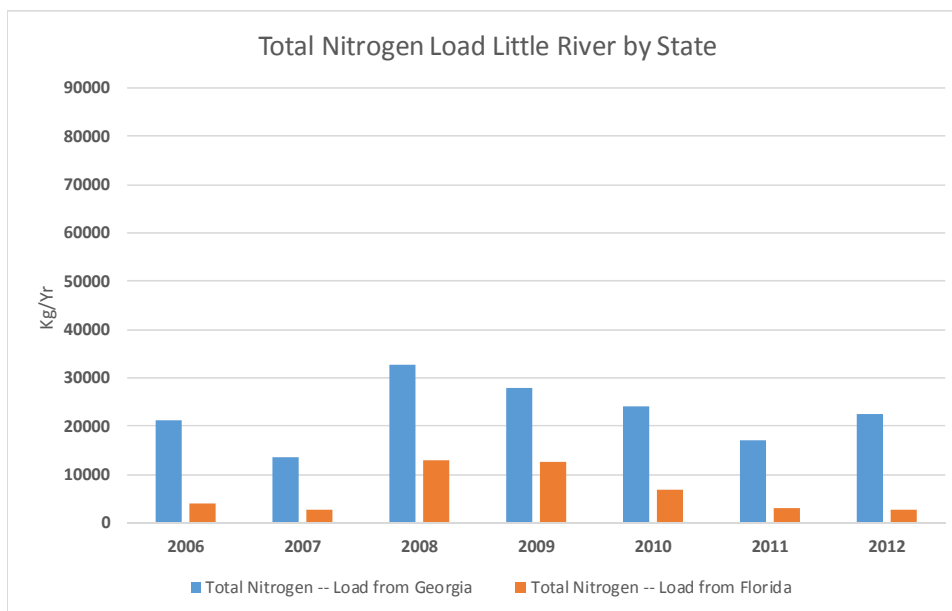


Figure 121 Annual Total Nitrogen Loads by State for Little River

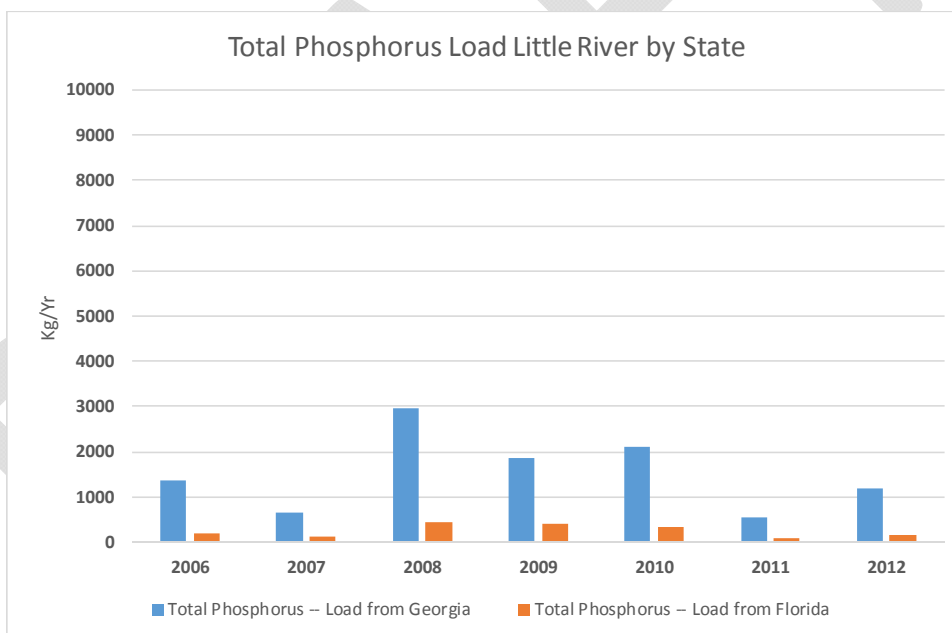


Figure 122 Annual Total Phosphorus Loads by State for Little River

Figure 123 and Figure 124 illustrate the annual total nutrient load by state for Ochlockonee River over the simulation period.

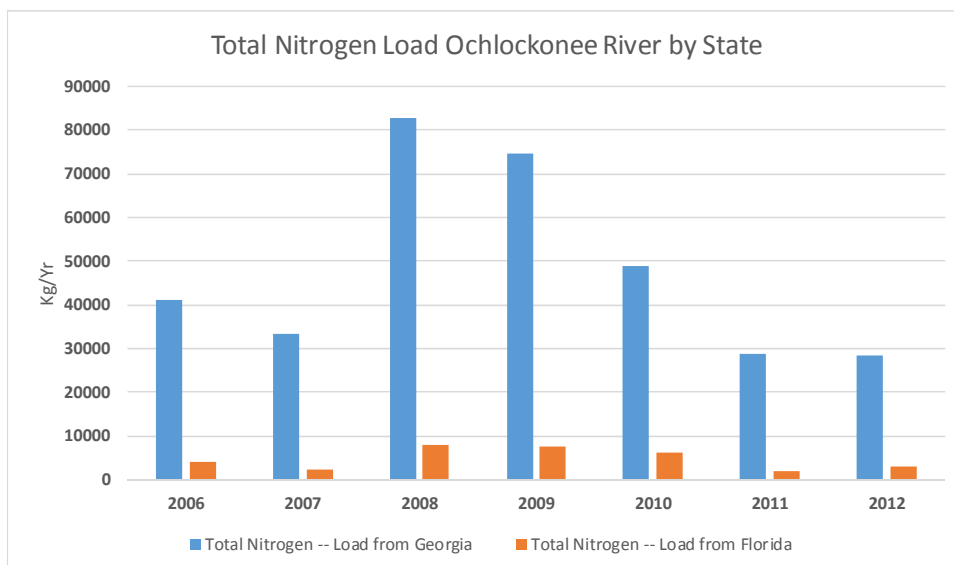


Figure 123 Annual Total Nitrogen Loads by State for Ochlockonee River

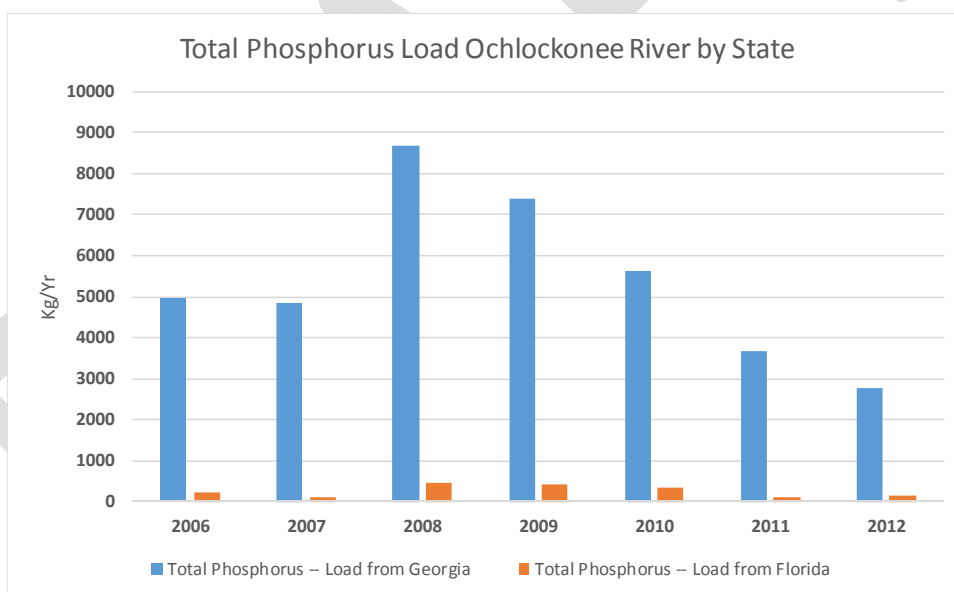


Figure 124 Annual Total Phosphorus Loads by State for Ochlockonee River

Figure 125 and Figure 126 illustrates the percentages of total nitrogen and total phosphorus coming from each state that enters Lake Talquin.

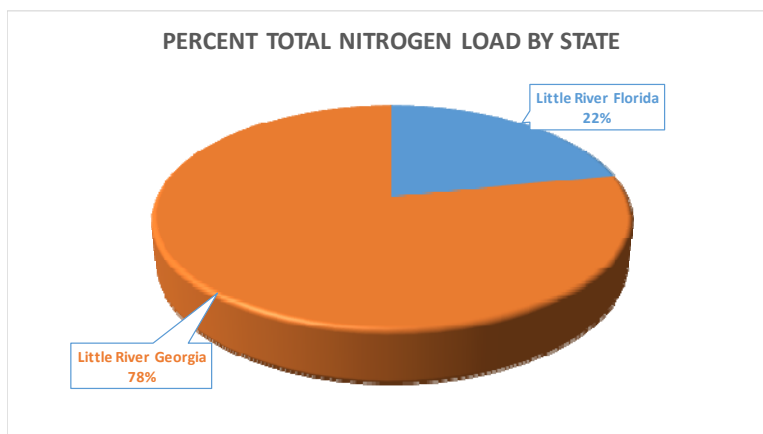


Figure 125 Percentage of Total Nitrogen Load to Lake Talquin by State

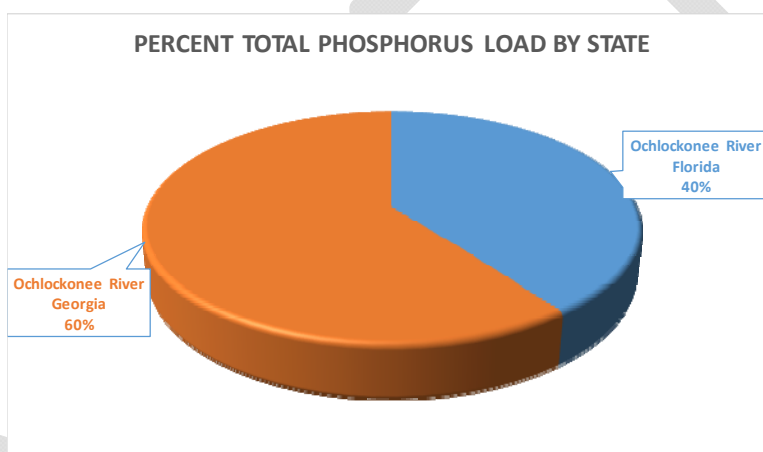


Figure 126 Percentage of Total Phosphorus Load to Lake Talquin by State

Point Sources Data Inputs

Point sources discharging into the Ochlockonee River and the Little River were input into the corresponding WASP model. Descriptions of the included point sources, the utilized data sources, and the methods used to calculate unavailable data are provided in the sections below. No significant point sources discharge directly to Lake Talquin or its immediate watersheds (those not simulated in the Ochlockonee and Little Rivers). The distributed models and model inputs include spreadsheets that were used to characterize the point sources.

Ochlockonee River

The Ochlockonee River WASP model includes four municipal wastewater treatment plants (WWTP) and one food processing facility as point sources for BOD, and TN. TP is also included for the WWTPs. All parameters associated with the point sources were added into the Ochlockonee

River WASP model as concentration boundary inputs with separate surface flow functions. (Figure 127)

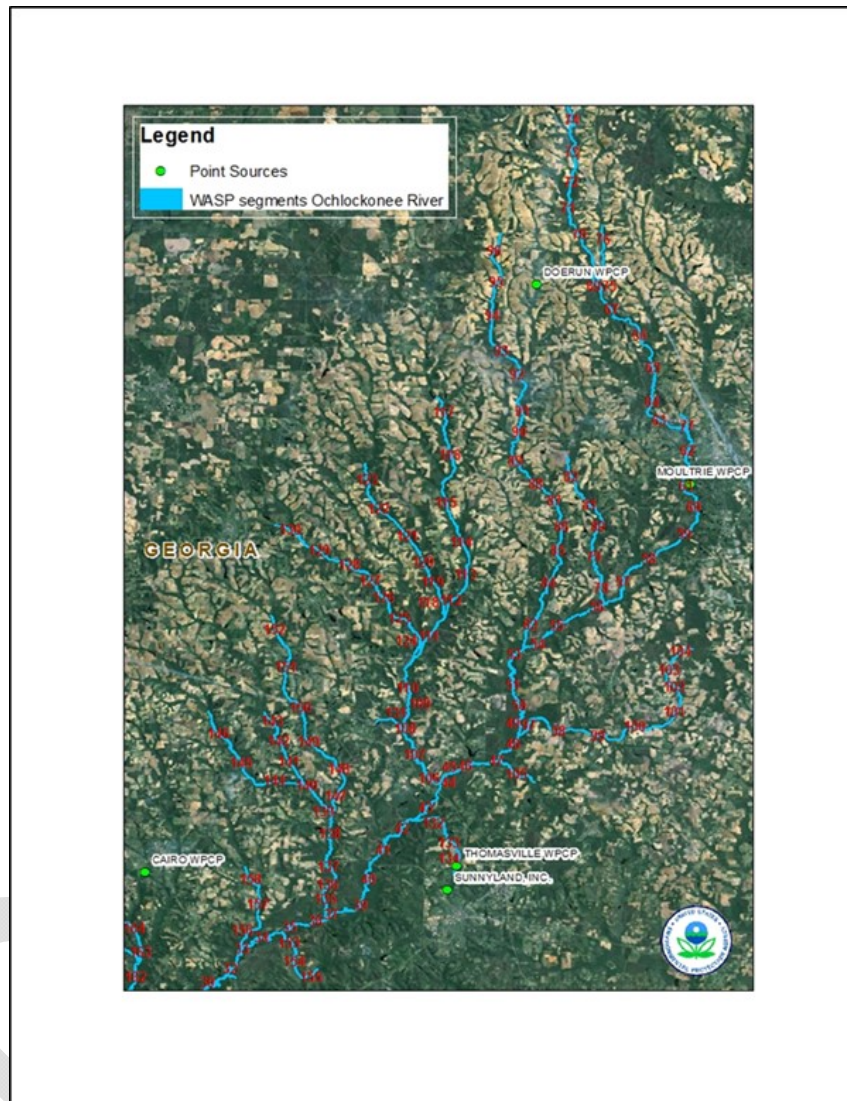


Figure 127 Location of Point Sources along the Ochlockonee River

The total annual loads, along with the Chlorophyll-a concentrations at the outflow of the Ochlockonee River WASP model, are depicted below in Figure 128- Figure 131.

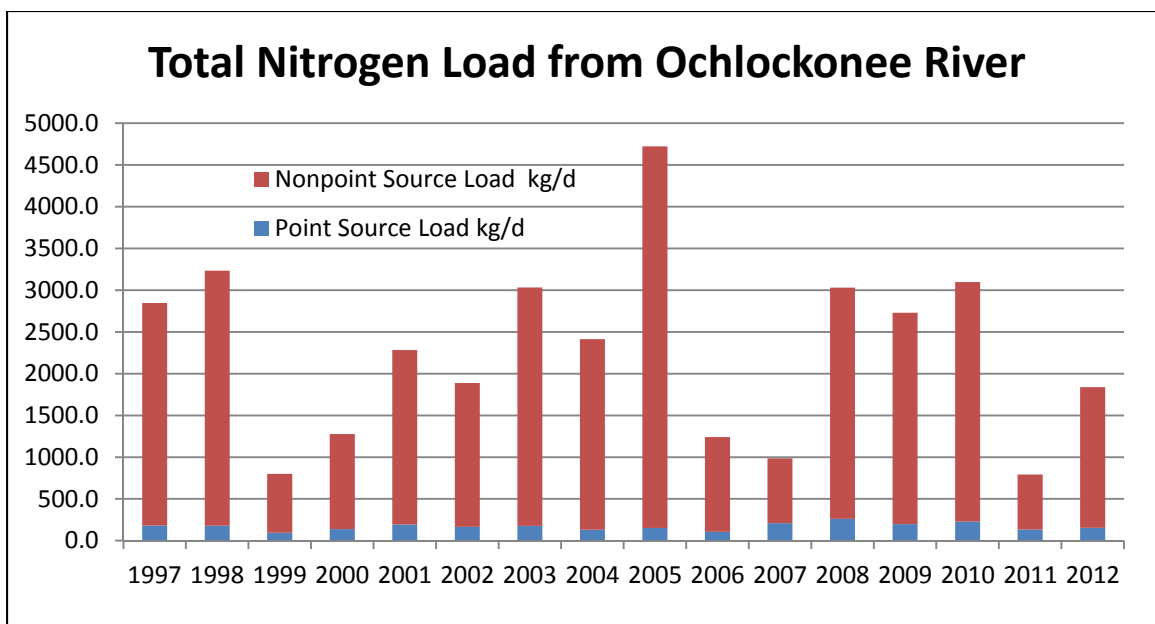


Figure 128 Total Nitrogen Load from Point Sources in Ochlockonee River

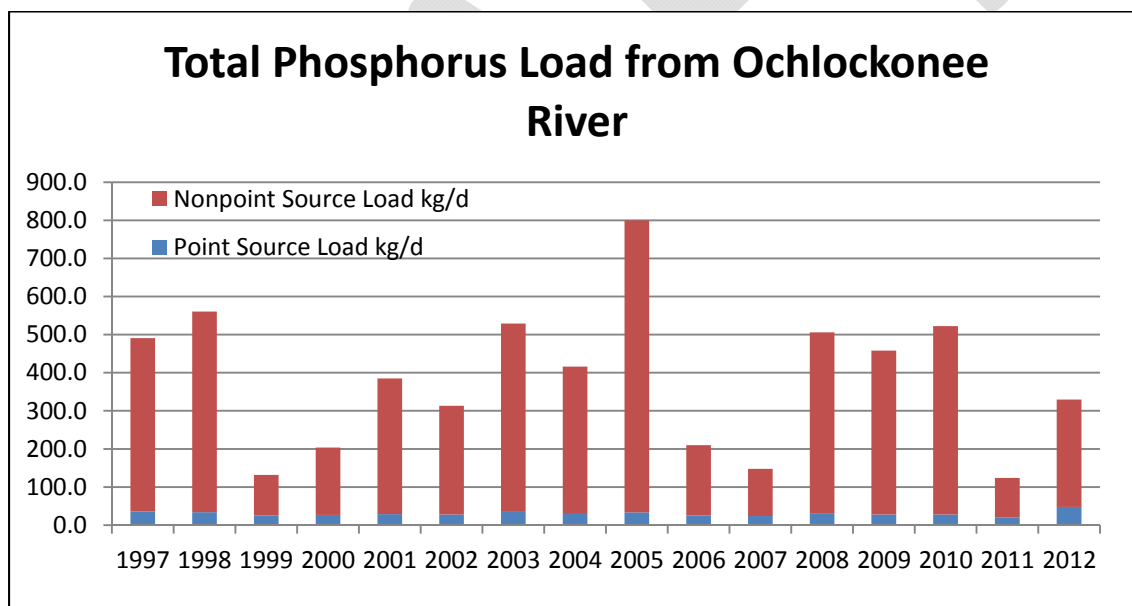


Figure 129 Total Phosphorus Load from Point Sources in Ochlockonee River

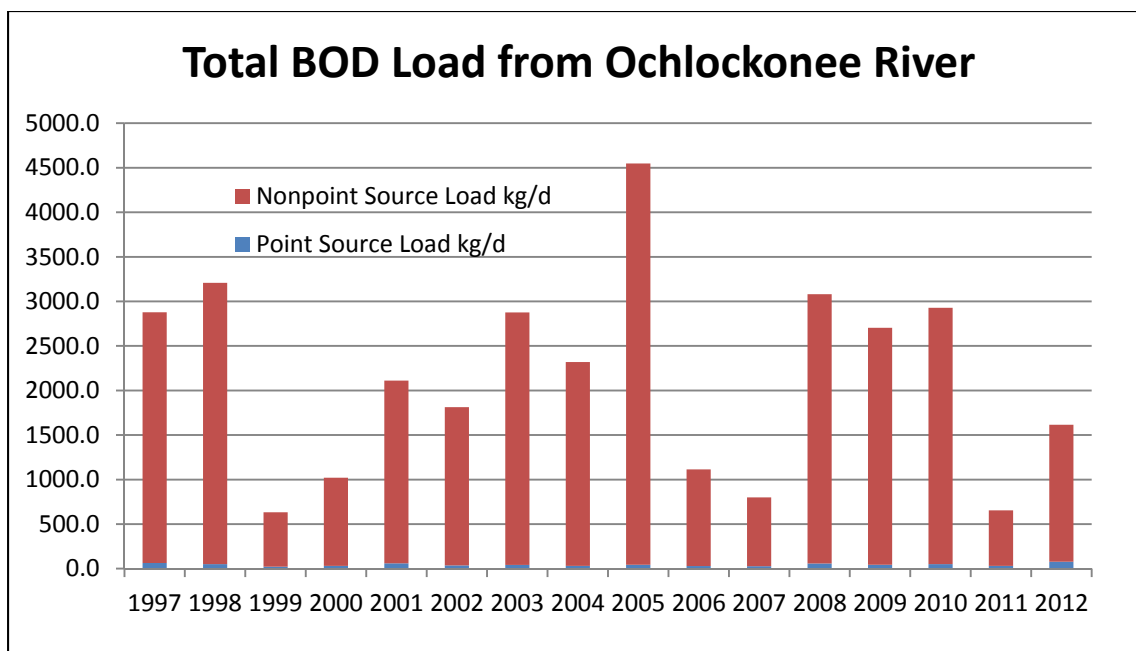


Figure 130 BOD Load from Point Sources in Ochlockonee River

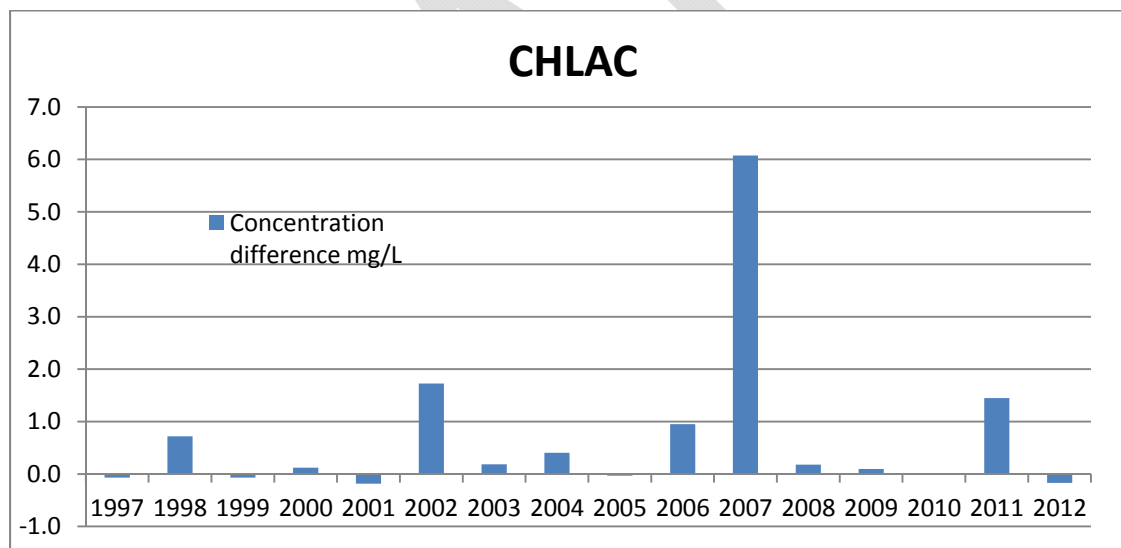


Figure 131 CHLAC Concentration Change Due to Point Sources in Ochlockonee River

The following paragraphs discuss each point source individually.

Thomasville WPCP – Permit #GA0024082

DMR data stored on PCS and ICIS was used for the BOD, flow, and ammonia monthly input values. However, no data was identified in PCS or ICIS for TP (PO₄ and Organic P) or NO_x and Organic N (Table 8). All of these parameters are needed in order to run the WASP model. A review of EPA's file for this facility located two permit applications and some limited TKN sampling data from 2012. This data was used to calculate an average ratio for Ammonia/TN,

NO_x/TN, and Organic N/TN. These ratios were used to calculate NO_x and Organic N based on the Ammonia concentrations provided in DMR. Due to spikes in NO_x concentrations when ammonia concentrations were high, a maximum TN target of 20.60 (the maximum of the two TN values presented in the permits applications) was added to the model. The average TP value was also calculated by using the permit applications. Due to no additional data available, a percentage allotment of 70% PO₄ and 30% Organic P was assumed.

Table 8 Thomasville DMR Data

Parameter	# of Obs	Start Date	End Date	Mean	Min	Max
Ammonia	192	1/1/1997	12/7/2012	0.338	0.010	2.000
Nitrate	84	1/1/2006	12/7/2012	17.927	8.430	35.000
DON	84	1/2/2006	12/7/2012	1.042	0.200	4.920
DIP	84	1/2/2006	12/7/2012	1.902	1.000	7.000
DOP	84	1/2/2006	12/7/2012	0.862	0.000	15.800
BOD	192	1/1/1997	12/7/2012	5.424	2.000	17.500
DO	127	6/30/2002	12/31/2012	6.554	5.200	7.600
Flow	192	1/1/1997	12/7/2012	0.171	0.000	0.453

Moultrie WPCP – Permit # GA0024660

DMR data stored on PCS and ICIS was used for the BOD, flow, and ammonia monthly input values. However, no data was identified in PCS or ICIS for TP (PO₄ and Organic P) or NO_x and Organic N (Table 9). All of these parameters are needed in order to run the WASP model. A review of EPA's file for this facility located two permit applications. This data was used to calculate an average ratio for Ammonia/TN, NO_x/TN, and Organic N/TN. These ratios were used to calculate NO_x and Organic N based on the Ammonia concentrations provided in DMR. Due to spikes in NO_x concentrations when ammonia concentrations were high, a maximum TN target of 22.7 (the maximum of the two TN values presented in the permits applications) was added to the model. The average TP value was also calculated by using the permit applications. Due to no additional data available, a percentage allotment of 70% PO₄ and 30% Organic P was assumed.

Table 9 Moultrie DMR Data

Parameter	# of Obs	Start Date	End Date	Mean	Min	Max
Ammonia	192	1/1/1997	12/7/2012	0.562	0.000	7.000
Nitrate	84	1/2/2006	12/7/2012	16.660	1.560	26.500
DON	84	1/2/2006	12/7/2012	9.200	0.000	68.000
DIP	84	1/2/2006	12/7/2012	4.523	1.400	9.000
DOP	84	1/2/2006	12/7/2012	0.351	0.000	1.500
BOD	192	1/1/1997	12/7/2012	4.091	1.000	24.000

DO	192	1/31/1997	12/31/2012	7.352	3.300	9.300
Flow	192	1/1/1997	12/7/2012	0.133	0.068	0.296

Cairo WPCP – Permit # GA0025771

DMR data stored on PCS and ICIS was used for the BOD, flow, and ammonia monthly input values (Table 10). However, Cairo was not discharging to a stream during from 1998 until 2006. Cairo was operating under a land application permit at that time. For this model, a zero discharge (i.e. load) was assumed during those years. GAEPD provided the BOD, flow and ammonia monthly values for 2006. However, no data was identified in PCS or ICIS, or available from GAEPD, for NO_x and Organic N. These parameters are needed in order to run the WASP model. A review of EPA's file for this facility located a permit application. This data was used to calculate an average ratio for Ammonia/TN, NO_x/TN, and Organic N/TN. GAEPD provided the TP and Ortho P data for the years 2006 through 2012. This data was used as the monthly input values for phosphorus. Since no data was available for 1997-98, the average TP value was used for those years.

Table 10 Cairo DMR Data

Parameter	# of Obs	Start Date	End Date	Mean	Min	Max
Ammonia	99	1/1/1997	12/4/2012	0.900	0.000	4.710
Nitrate	84	1/1/2006	12/4/2012	3.326	0.160	8.180
DON	84	1/1/2006	12/4/2012	1.573	0.080	3.870
DIP	84	1/1/2006	12/4/2012	0.185	0.000	0.990
DOP	84	1/1/2006	12/4/2012	0.323	0.000	0.790
BOD	99	1/1/1997	12/4/2012	5.500	0.000	12.000
DO	72	1/31/2007	12/31/2012	7.358	6.000	10.000
Flow	99	1/1/1997	12/4/2012	0.060	0.000	0.148

Doerun WPCP – Permit # GA0021717

This facility is a minor wastewater treatment plant and therefore, no DMR data was available. A review of EPA's file for this facility located a permit application. The permit application contained sampling results for ammonia, NO_x, TKN and phosphorus. Since this was the only data available it was used as the monthly data inputs in the WASP model. Additionally, the permit provided permit limits for BOD and flow. These limits were used in the model.

Sunnyland (aka Genesis Project/Affinity) Permit # GA001279

This facility is a frozen food plant. The DMR data stored on PCS and ICIS was used for the monthly BOD, flow and ammonia input values (Table 11). Several gaps in data were present on the in the databases. A search of the PCS website indicated that the gaps in data occurred whenever there was no discharge from the facility. Therefore, in the WASP model, whenever no flow was listed a zero flow and concentration was assumed for that time period. No data was found regarding phosphorus in PCS, ICIS or during a file review. Therefore, a phosphorus load was not added to the model for this point source.

Table 11 Sunnyland DMR Data

Parameter	# of Obs	Start Date	End Date	Mean	Min	Max
Ammonia	192	1/1/1997	12/7/2012	0.147	0.000	8.500
Nitrate	84	1/2/2006	12/7/2012	0.033	0.000	0.426
DON	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DIP	84	1/2/2006	12/7/2012	0.471	0.000	5.900
DOP	84	1/2/2006	12/7/2012	0.075	0.000	0.840
BOD	192	1/1/1997	12/7/2012	3.300	0.000	115.500
DO	124	9/30/2002	12/31/2012	1.031	0.000	10.800
Flow	192	1/1/1997	12/7/2012	0.005	0.000	0.237

Facilities Not Included in the Model

The following permitted facilities were not included in this model:

- Pelham WPCP – Permit # GA0025518 – This facility was a minor wastewater treatment plant. According to GAEPD, the facility closed out their permit in the 1990s. Therefore, it was not included in the WASP model.
- W.B. Roddenbery Company – Permit # GA0001660 – According to the PCS data, this facility was first permitted in 1997. A review of the EPA's files on this facility determined all production ceased on July 2002. Since the facility was only active for five years, TN and TP were not regulated by the permit, and it was only a minor permitted facility, it was not included in the WASP model.
- The remaining permits are for mining facilities (Permits # GA0047503, GA0047511, GA0047520, and GA0032409) and three of the four permits are no longer active. Additionally none of the mining permits have limits for TN or TP. For these reasons, the mining permits were not included in the WASP model.

Little River

The Little River model includes two significant point sources: Quincy WPCP and BASF Attapulgus Plant (Figure 132). Quincy is a major domestic wastewater treatment plant while BASF is a major industrial discharger.

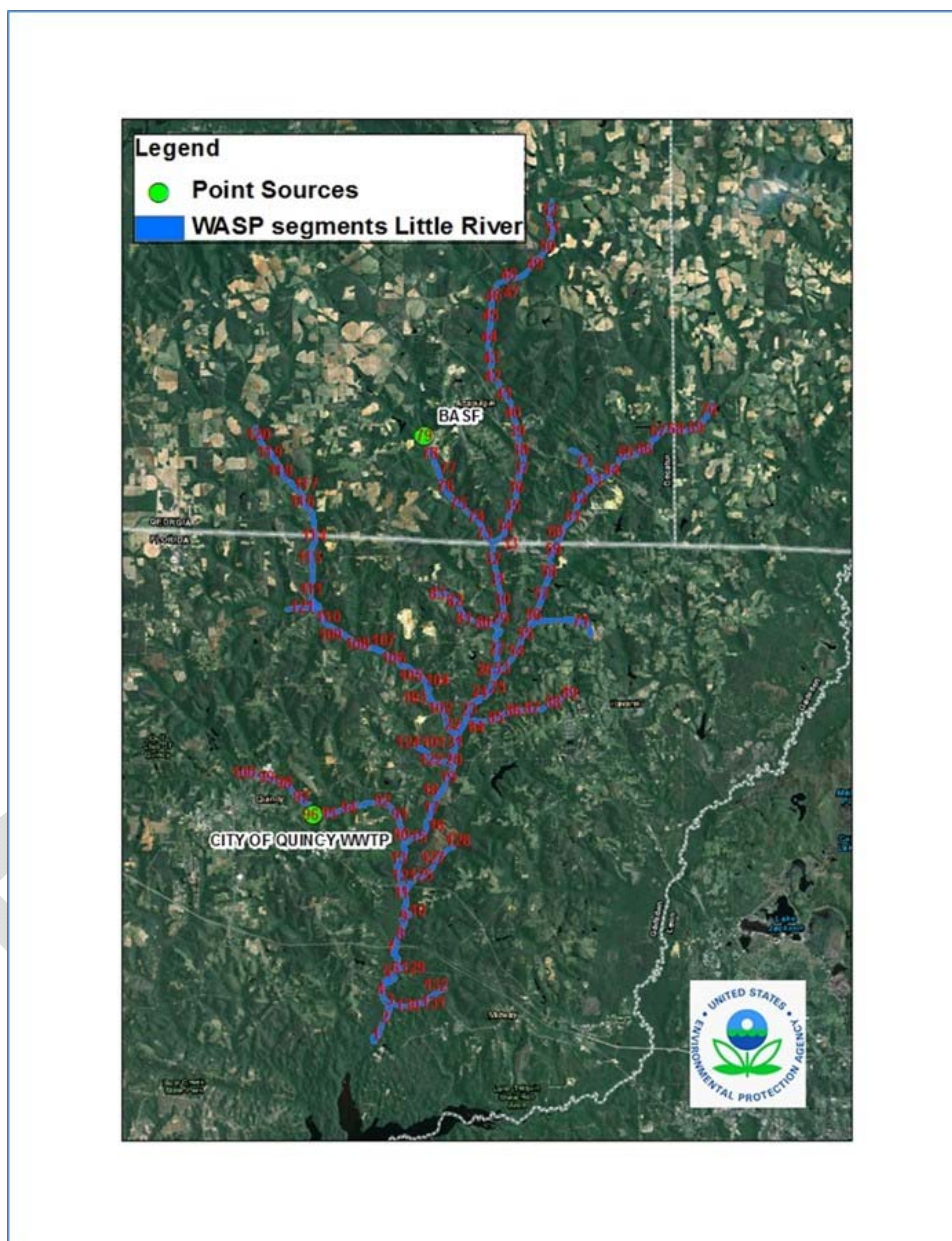


Figure 132 – Little River Simulated NPDES Dischargers

The total annual nutrient loads at the outflow of the Little River WASP model, are depicted below in Figure 133 and Figure 134.

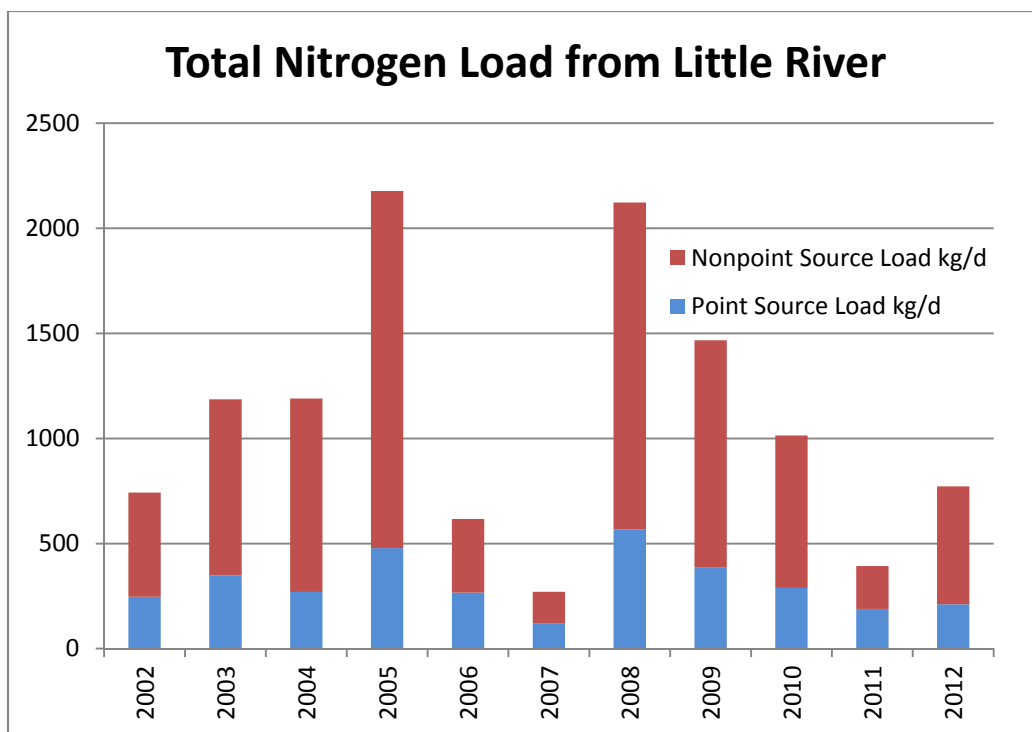


Figure 133 Total Nitrogen Load from Point Sources in Little River (Daily Average)

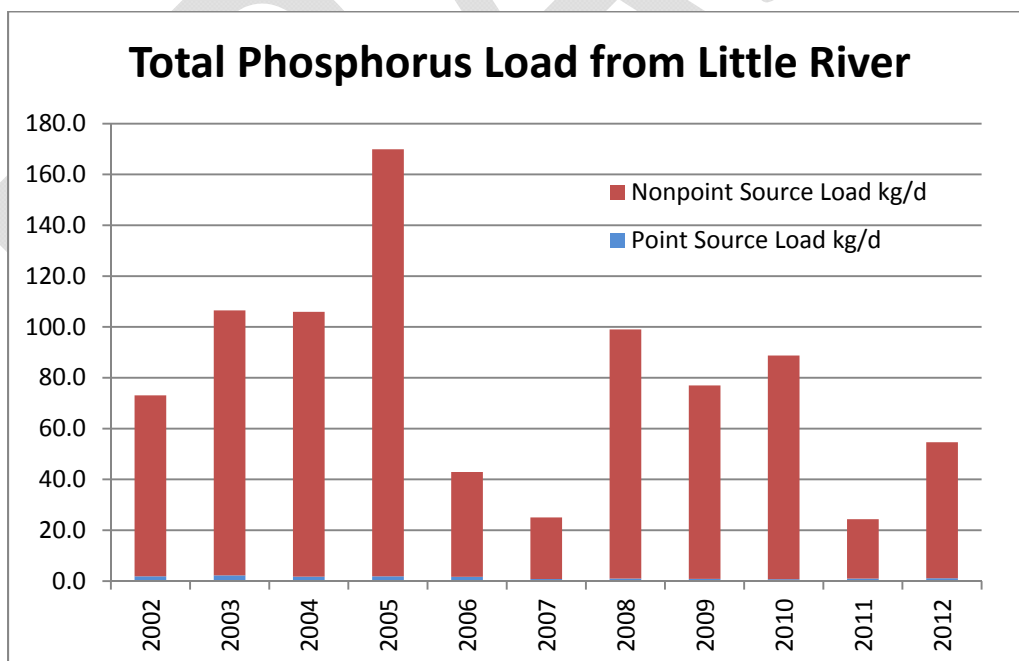


Figure 134 Total Phosphorus Load from Point Sources in Little River

The following paragraphs discuss each point source.

Quincy WPCP – Permit # FL0029033

This facility discharges out of a single outfall (001)(Table 12). Monthly DMR data retrieved from ICIS and PCS are used to load effluent flows and pollutant concentrations for total nitrogen, total phosphorus and BOD5. Data for the period 1996 through 2012 are available. For individual nutrient speciation, limited PO₄, TKN and NH₃ data from the facility's most recent permit application is used to estimate nutrient fractions. These values compare reasonably well with ambient and observed nutrient fractions such that the ambient speciation applied to LSPC output was also used for this facilitate for efficiency (3% NH₃, 23% NO₃NO₂, 74% Org N, 40% PO₄, 60% Org P). Reported monthly dissolved oxygen concentrations are put directly into the model. Stepwise interpolations are used in the model to emulate the DMR monthly values.

Table 12 Quincy DMR Data

Parameter	# of Obs	Start Date	End Date	Mean	Min	Max
Ammonia	30	5/11/2006	8/27/2012	9.271	0.200	29.600
Nitrate	30	5/11/2006	8/27/2012	37.507	0.800	180.000
DON	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DIP	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DOP	2	1/1/2006	12/31/2012	0.000	0.000	0.000
BOD	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DO	2	1/1/2006	12/31/2012	7.000	7.000	7.000
Flow	2557	1/1/2006	12/31/2012	0.005	0.000	0.200

BASF Attapulugus Plant – Permit # GA0001678

The BASF facility maintains two permitted outfalls (001 and 002)(Table 13 & Table 14). Monthly DMR data for this facility is unavailable before 2002 in ICIS, and facility data is no longer archived in PCS. Therefore, BASF nutrient contributions are only simulated from 2002 to 2012. Because of BASF's relatively significant total nitrogen contribution to Little River, water quality stations used for calibration downstream of this discharge can only be calibrated for this time period. The BASF facility reports NH₄ loads, but not TN nor NO₃NO₂. A French drain closure operational study (Brown and Caldwell) in the permit file contains very limited nitrogen speciation data suggesting a ratio of NO₃/TN of 63.5%, NH₄/TN of 36.5% with no appreciable Org N present. In addition, TP and PO₄ loads are assumed to be negligible based on monitoring in this same report. Therefore, existing NH₄ loads were used to estimate NO₃NO₂ loads based on these ratios cited in this study. Reported CBOD loads are placed directly into the model. For this discharger, reported DMR data is periodically incremental (especially in outfall 002) and so the data are placed into the model at the middle of the reported month and linearly interpolated between individual data points for a cohesive time series of loads.

The BASF facility, for the period 2002-2012, contributes 97% of the point source TN load.

Table 13 BASF001 DMR

Parameter	# of Obs	Start Date	End Date	Mean	Min	Max
Ammonia	883	1/2/2006	12/31/2012	32.874	0.042	108.000
Nitrate	885	1/2/2006	12/31/2012	170.194	3.820	408.000
DON	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DIP	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DOP	2	1/1/2006	12/31/2012	0.000	0.000	0.000
BOD	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DO	2	1/1/2006	12/31/2012	7.000	7.000	7.000
Flow	2557	1/1/2006	12/31/2012	0.026	0.000	0.214

Table 14 BASF002 DMR

Parameter	# of Obs	Start Date	End Date	Mean	Min	Max
Ammonia	30	5/11/2006	8/27/2012	9.271	0.200	29.600
Nitrate	30	5/11/2006	8/27/2012	37.507	0.800	180.000
DON	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DIP	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DOP	2	1/1/2006	12/31/2012	0.000	0.000	0.000
BOD	2	1/1/2006	12/31/2012	0.000	0.000	0.000
DO	2	1/1/2006	12/31/2012	7.000	7.000	7.000
Flow	2557	1/1/2006	12/31/2012	0.005	0.000	0.200