Modeling Report

WBIDs 2893K & 2893I Lake Poinsett – St. Johns River above Puzzle Lake – Upper St. Johns River Basin
Nutrients and Dissolved Oxygen

May 22, 2013

Contents

Table of Figures

Table of Tables

Watershed Description

Lake Poinsett lies in southern Brevard County just west of the city of Melbourne. It is an element of the upper St. Johns River, being located about a mile upstream of where US Highway 192 crosses the river. Lake Poinsett and its smaller companion Little Lake Poinsett to the south are bracketed by Lake Hell'n Blazes farther upstream and substantially larger Lake Washington (drinking water supply for the Melbourne area) to the north. Sawgrass, Little Sawgrass, and Hell'n Blazes Lakes are located within SJRWMD's Three Forks Marsh Conservation Area.

Although the land in the immediate vicinity of the 412-acre lake is mostly unaltered, beyond the floodplain there is a very large amount of agricultural and pasture land which is drained by canals leading into the river. The original floodplain is highly impacted by these hydrologic modifications.

The 242.9-square-mile Puzzle Lake planning unit includes portions of Orange, Seminole, Brevard, and Volusia Counties. There are 19 waterbody segments delineated within the planning unit; all are designated as Class III waters. North of Ruth Lake, where the channel of the St. Johns River widens and is intertwined with extensive marshes, this part of the river is called Puzzle Lake. Relic saltwater deposits in the aquifer produce surface water salinities as high as 10 and 11 parts per thousand (DeMort, 1991). Major tributary drainages are Buscombe Creek, Turkey Creek, Buck Lake, Lake Cone, South and Fox Lake, Salt Lake, Loughman Lake, Ruth Lake, Savage Creek, and Christmas Creek. Southand Fox Lakes are natural waterbodies that are now connected by a 0.4 mile navigation canal.

The Lake Poinsett and St. Johns River above Puzzle Lake WBIDs (Figure 1 and Figure 2) are located in Brevard, Orange and Osceola counties.

Figure 1 Location of St. Johns River above Puzzle Lake Watershed and WBID (2893I)

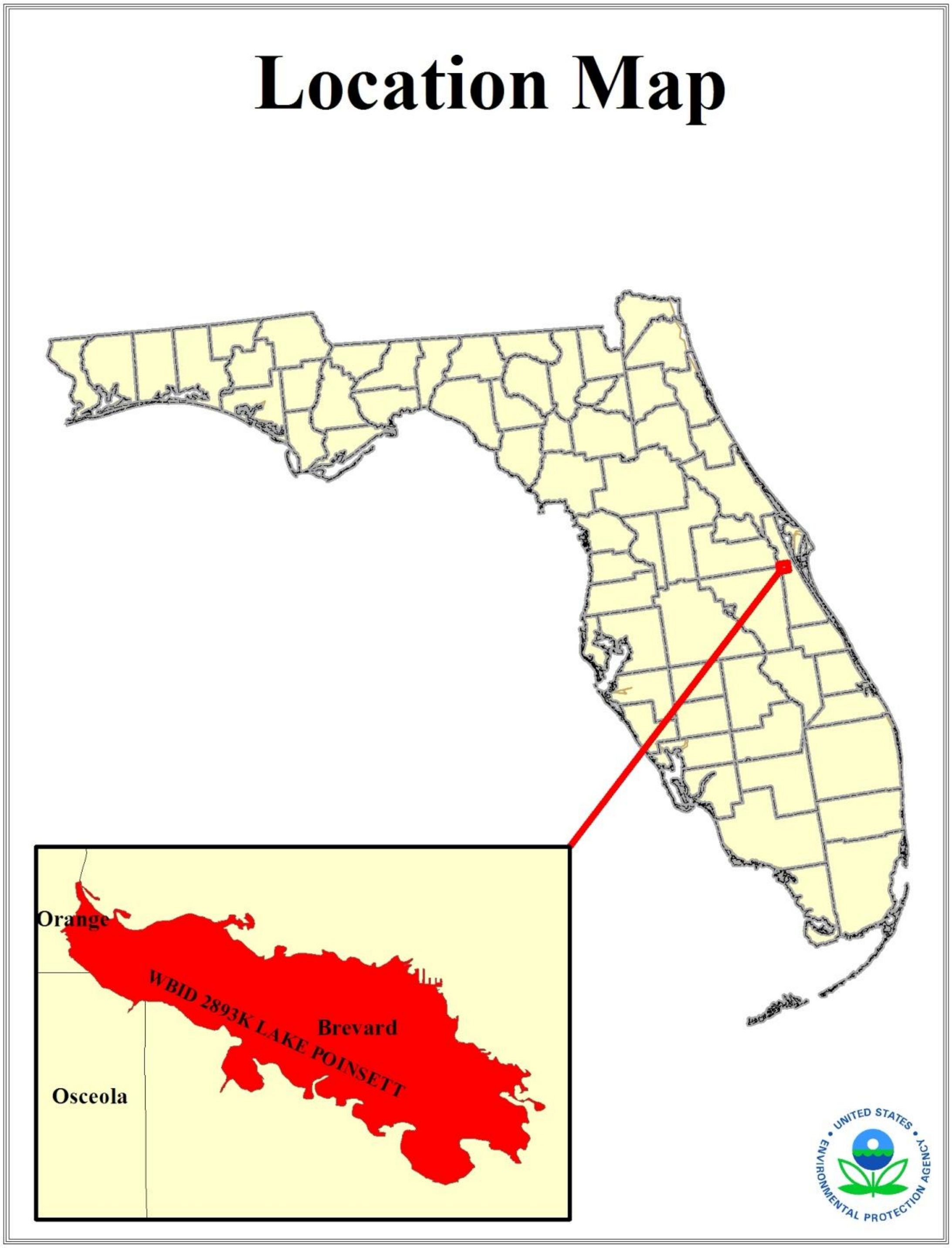


Figure 2 Location of Puzzle Lake (WBID 2893K))

The landuse distribution for the Lake Poinsett and St. Johns River above Puzzle Lake watershed is presented inFigure 3. The predominant landuse in the watershed is agriculture.

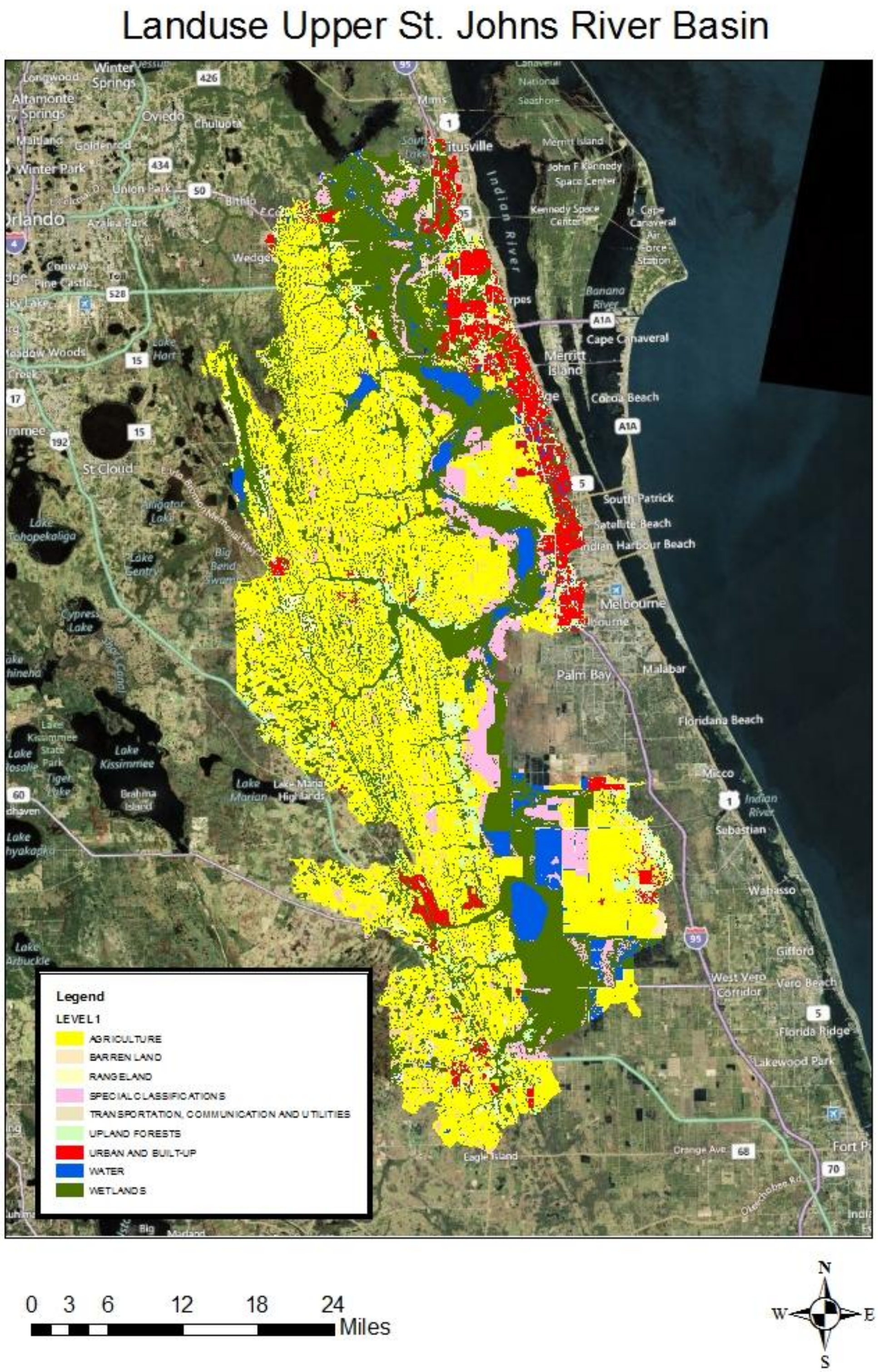


Figure 3 Landuse Distribution for Upper St. Johns River Basin

TMDL Targets

The TMDL reduction scenarios will be done to achieve a Florida's dissolved oxygen concentration of 5 mg/L and insure balanced flora and fauna within Lake Poinsett and St. Johns River above Puzzle Lake or establish the TMDL to be consistent with a natural condition if the dissolved oxygen standard cannot be achieved.

The waterbodies in the Lake Poinsett and St. Johns River above Puzzle Lake WBID are Class III Freshwater with a designated use of Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife. Designated use classifications are described in Florida's water quality standards. See Section 62-302.400, F.A.C. Water quality criteria for protection of all classes of waters are established in Section 62-302.530, F.A.C. Individual criteria should be considered in conjunction with other provisions in water quality standards, including Section 62-302.500 F.A.C., which established minimum criteria that apply to all waters unless alternative criteria are specified. Section 62-302.530, F.A.C. Several of the WBIDs addressed in this report were listed due to elevated concentrations of chlorophyll *a*. While FDEP does not have a streams water quality standard specifically for chlorophyll *a*, elevated levels of chlorophyll *a* are frequently associated with a violation of the narrative nutrient standard, which is described below.

Nutrients Flowing Streams

The designated use of Class III waters is recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife. In 1979, FDEP adopted a narrative criterion for nutrients. FDEP recently adopted numeric nutrient criteria for many Class III waters in the state, including streams, which numerically interprets part of the state narrative criterion for nutrients. While those criteria have been submitted to EPA for review pursuant to section 303(c) of the CWA, EPA has not completed that review. Therefore, for streams in Florida, the applicable nutrient water quality standard for CWA purposes remains the Class III narrative criterion.

As set out more fully below, should any new or revised state criteria for nutrients in streams in Florida become applicable for CWA purposes before this proposed TMDL is established, EPA will consider the impact of such criteria on the target selected for this TMDL.

Also, in November 2010, EPA promulgated numeric nutrient criteria for Class III inland waters in Florida, including streams and lakes. On February 18, 2012, the streams criteria were invalidated by the U.S. District Court for the Northern District of Florida and remanded back to EPA. Should a federally promulgated criterion become effective for CWA purposes before this proposed TMDL is established, EPA will consider the impact of such criteria on the target selected for this TMDL.

Narrative Nutrient Criteria

Florida's narrative nutrient criteria provide:

The discharge of nutrients shall continue to be limited as needed to prevent violations of other standards contained in this chapter. Man induced nutrient enrichment (total nitrogen and total phosphorus) shall be considered degradation in relation to the provisions of Sections 62-302.300, 62-302.700, and 62-4.242. Section 62-302.530(48)(a), F.A.C.

In no case shall nutrient concentrations of a body of water be altered so as to cause an imbalance in natural populations of aquatic flora or fauna. Section 62-302.530(48)(b), F.A.C.

Chlorophyll and dissolved oxygen (DO) levels are often used to indicate whether nutrients are present in excessive amounts. The target for this TMDL is based on levels of nutrients necessary to prevent violations of Florida's DO criterion, set out below.

Florida's adopted numeric nutrient criteria for streams

Florida's recently adopted numeric nutrient criteria interprets the narrative water quality criterion for nutrients in paragraph 62-302.530(48)(b), F.A.C. See section 62-302.531(2). The Florida rule provides that the narrative water quality criteria for nutrients in paragraph 62-302.530(47)(a), F.A.C., continues to apply to all Class III waters. See section 62-302.531(1).

Florida's recently adopted rule applies to streams, including (WBIDs 2893I, 2893K). For streams that do not have a site specific criteria, Florida's rule provides for biological information to be considered together with nutrient thresholds to determine whether a waterbody is attaining 62-302.531(2)(c), F.A.C. The rule provides that the nutrient criteria are attained in a stream segment where information on chlorophyll a levels, algal mats or blooms, nuisance macrophyte growth, and changes in algal species composition indicates there are no imbalances in flora and either the average score of at least two temporally independent SCIs performed at representative locations and times is 40 or higher, with neither of the two most recent SCI scores less than 35, or the nutrient thresholds set forth in Table 1 below are achieved. See section 62-302.531(2)(c).

Florida's rule provides that numeric nutrient criteria are expressed as a geometric mean, and concentrations are not to be exceeded more than once in any three calendar year period. Section 62-302.200 (25)(e), F.A.C.

Table 1 Inland Numeric Nutrient Criteria

Nutrient Watershed Region	Total Phosphorus Nutrient Threshold	Total Nitrogen Nutrient Threshold

Panhandle West	0.06 mg/L	0.67 mg/L
Panhandle East	0.18 mg/L	1.03 mg/L
North Central	0.30 mg/L	1.87 mg/L
Peninsular	0.12 mg/L	1.54 mg/L
West Central	0.49 mg/L	1.65 mg/L
South Florida	No numeric nutrient threshold. The narrative criterion in paragraph 62-302.530(47)(b), F.A.C., applies.	No numeric nutrient threshold. The narrative criterion in paragraph 62-302.530(47)(b), F.A.C., applies.

Dissolved Oxygen Criteria

Numeric criteria for DO are expressed in terms of minimum and daily average concentrations. Section 62-302(30), F.A.C., sets out the water quality criterion for the protection of Class III freshwater waters as:

Shall not be less than 5.0 mg/l. Normal daily and seasonal fluctuations above these levels shall be maintained.

Natural Conditions

In addition to the standards for nutrients, DO and BOD described above, Florida's standards include provisions that address waterbodies which do not meet the standards due to natural background conditions.

Florida's water quality standards provide a definition of natural background:

"Natural Background" shall mean the condition of waters in the absence of man-induced alterations based on the best scientific information available to the Department. The establishment of natural background for an altered waterbody may be based upon a similar unaltered waterbody or on historical pre-alteration data. 62-302.200(15), FAC.

Florida's water quality standards also provide that:

Pollution which causes or contributes to new violations of water quality standards or to continuation of existing violations is harmful to the waters of this State and shall not be allowed. Waters having water quality below the criteria established for them shall be protected and enhanced. However, the Department shall not strive to abate natural conditions. 62-302.300(15) FAC

Biochemical Oxygen Demand Criteria

Biochemical Oxygen Demand (BOD) shall not be increased to exceed values which would cause dissolved oxygen to be depressed below the limit established for each class and, in no case, shall it be great enough to produce nuisance conditions. [FAC 62-302.530 (11)]

Modeling Approach

The modeling approach that was used for the development of the nutrient and dissolved oxygen TMDL for Lake Poinsett and St. Johns River above Puzzle Lake considers 13 years of meteorological and flow conditions. The selection of a longer term continuous simulation insures that average, wet and dry conditions are considered in the TMDL determination. 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 13 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 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) as 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, the 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 7.5) (USEPA, 2011) 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 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, a natural condition. The WASP model will be used to determine the percent reduction in loadings that would be needed to meet water quality standards.

LSPC Application to Lake Poinsett and St. Johns River above Puzzle Lake Watershed

The watershed model was applied to the Lake Poinsett and St. Johns River above Puzzle Lake watershed model for the simulation period of 1996 through 2009. The 1996 year was used to equilibrate the initial conditions in the watershed model (soil moisture, buildup and washoff), from 1997 through 2009 was used to predict flows and loads under current conditions that will be passed onto the water quality model.

Watershed Delineation and Landuse

The surrounding watershed that drains directly to Lake Poinsett and St. Johns River above Puzzle Lake WBID was included in the watershed model. This encompasses land areas outside the delineated Lake Poinsett and St. Johns River above Puzzle Lake WBID. The watershed was delineated into 7 sub basins (Figure 4). The LSPC model will predict flow and loads coming from each of these sub basins into Lake Poinsett and St. Johns River above Puzzle Lake.

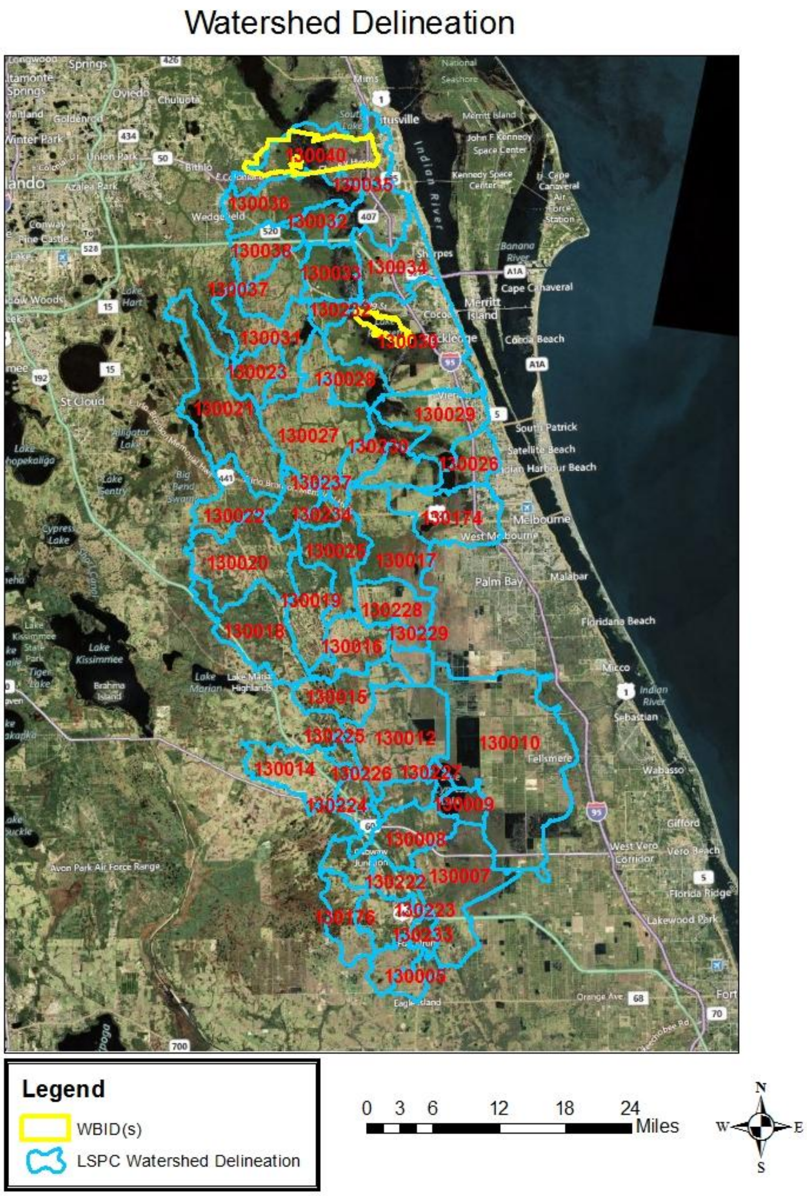


Figure 4 Lake Poinsett and St. Johns River above Puzzle Lake Watershed Delineation

The initial model setup for Lake Poinsett and St. Johns River above Puzzle Lake was obtained from EPA's application of LSPC for the purposes of nutrient criteria development; the model was further refined and calibrated to all local data and gages that were available in the watershed.

Landuse coverage was obtained from the St. Johns River Water Management District (Florida Landuse Classification Code) coverage developed from 2004.

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 5 depicts the hourly rainfall for the Lake Poinsett and St. Johns River above Puzzle Lake (083137) meteorological station. The period of record being simulated during this TMDL development contains average, wet and dry years.

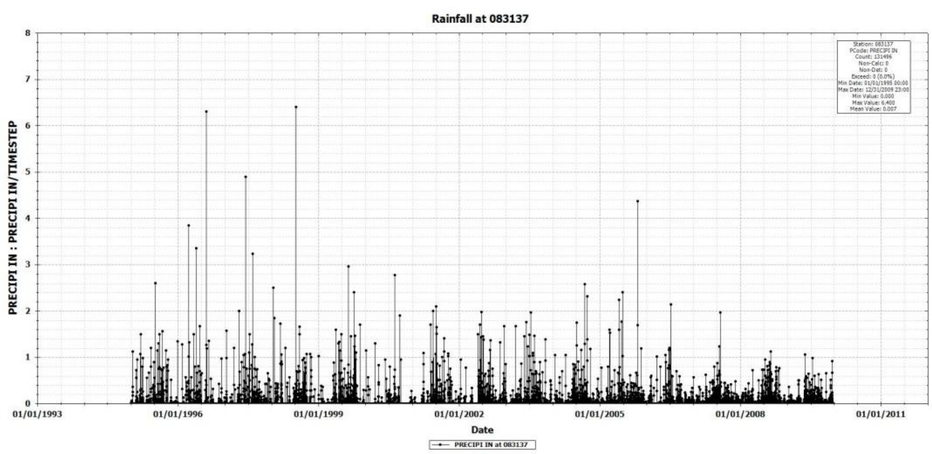


Figure 5 Hourly Rainfall Station 083137

Table 2 provides the annual rainfall for each of the simulation years.

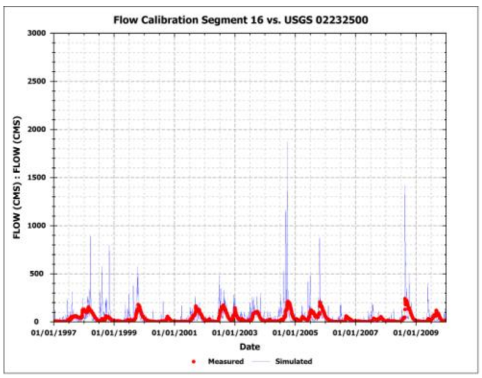
Table 2 Annual Rainfall for Simulation Period

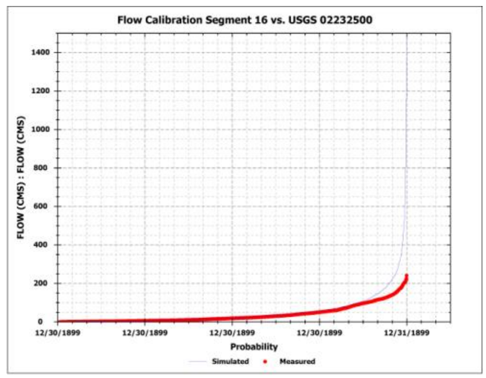
Year	Rainfall (inches)
1/1/1996	67
1/1/1997	62
1/1/1998	63
1/1/1999	76
1/1/2000	65
1/1/2001	30
1/1/2002	58
1/1/2003	69
1/1/2004	62
1/1/2005	72

1/1/2006	66
1/1/2007	41
1/1/2008	57
1/1/2009	67

Hydraulic Calibration

The watershed and water quality model were calibrated for flow by comparing the predict flows to the USGS gage 02232500 Lake Poinsett and St. Johns River above Puzzle Lake Creek near Sunshine Parkway Near Lake Poinsett and USGS gage 02232400 St. Johns River near Cocoa, FL. Figure 6 and Figure 7 illustrates both a quantitative and qualitative comparison of the model flow predictions directly compared to the measurements at the USGS gage.





Calibration Statistics

Station: SEGMENT 5; Parameter: FLOW (CMS)

Statistic	Measured	Simulated
Count:	4748	4746
Mean:	36.543	51.671
Std Dev:	44.465	99.707
Min:	-3.879	0.135
Max:	240.693	1,869.293
5 %tile:	0.934	1.459
10 %tile:	1.841	2.475
90 %tile:	105.622	127.817
95 %tile:	132.679	200.987
Corr (R^2):	0.22	
Mean Abs Error:	40.046	
RMS Error:	89.260	
Norm RMS Error:	1.415	
Index of Agreement:	0.55	

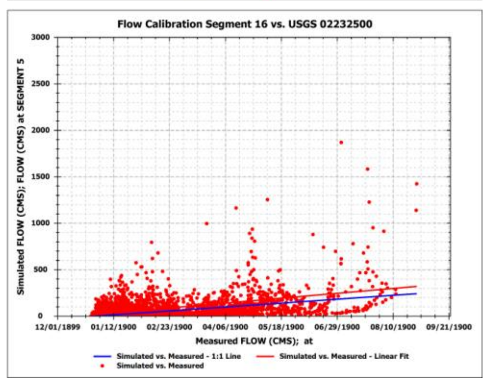
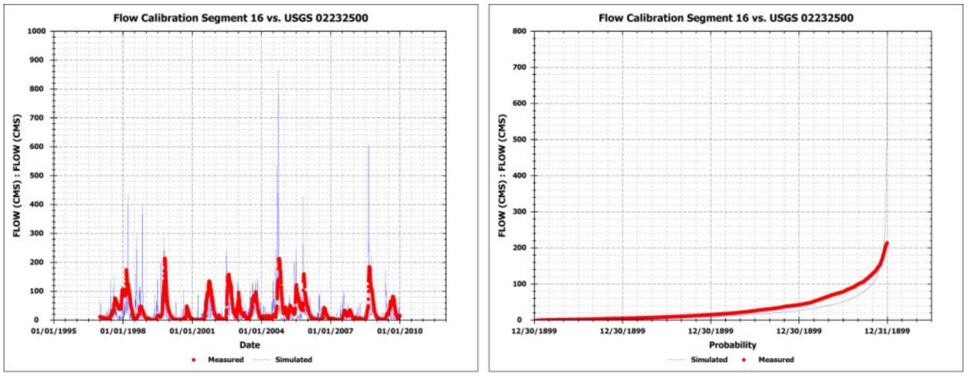


Figure 6 Flow Calibration for Lake Poinsett and St. Johns River above Puzzle Lake Watershed at USGS Gage 02232500



Calibration Statistics

Station: SEGMENT 16; Parameter: FLOW (CMS)

Statistic	Measured	Simulated
Count:	4748	4746
Mean:	31.729	24.041
Std Dev:	40.191	46.263
Min:	-9.401	0.026
Max:	214.075	868.991
5 %tile:	0.481	0.530
10 %tile:	1.274	0.991
90 %tile:	89.764	59.711
95 %tile:	120.630	92.635
Corr (R^2):	0.19	
Mean Abs Error:	26.191	
RMS Error:	46.801	
Norm RMS Error:	1.179	
Index of Agreement:	0.63	

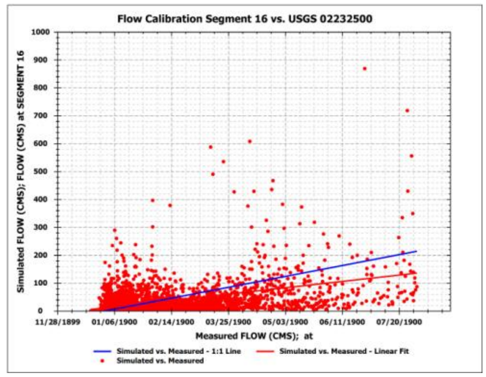


Figure 7 Flow Calibration for Lake Poinsett and St. Johns River above Puzzle Lake Watershed at USGS Gage 0223134

Water Quality Model Application

The WASP water quality model uses the kinematic wave equation to simulate flow and velocity and the basic eutrophication module to predict dissolved oxygen and Chlorophyll a responses to the BOD, total nitrogen and total phosphorus loadings. The waterbody geometry was determined from NHDPlus coverages of the free flowing stream sections.

Model Network

The Lake Poinsett and St. Johns River above Puzzle Lake waterbody was broken into segments for the water quality model. The model segmentation was done based upon the NHDPlus coverage taking into account travel time, pore points for the watershed model and IWR monitoring stations.

Figure 8 illustrates the 20 water quality model segments that are simulated. The LSPC model flows and loads enter the water quality model at segments18, 19, and 20.

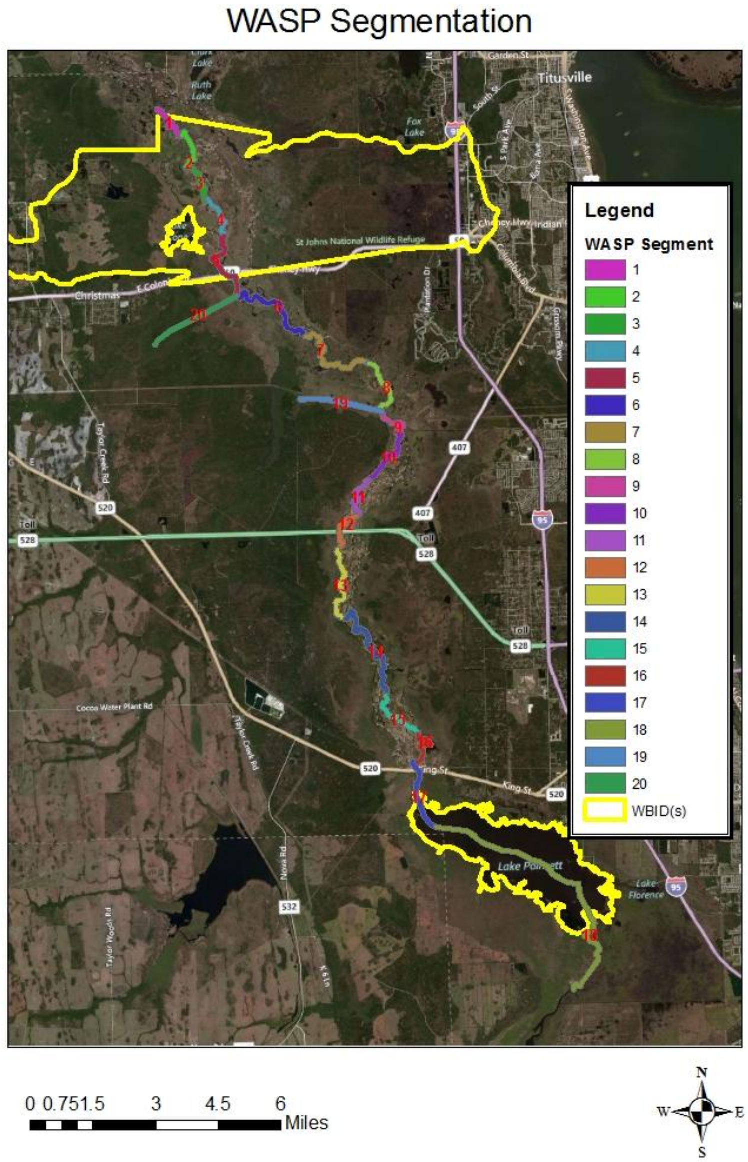


Figure 8 WASP Model Segmentation

Water Quality Model Calibration

The water quality model was calibrated to all available data. The fine tuning of the calibration of the model utilized the IWR station located at the lower end of the WBID that most of the monitoring data.

Table 3 provides a listing of the IWR stations that were used to calibrate the WASP model. All stations that had nutrient, BOD, dissolved oxygen and chlorophyll a measurements were used in the calibration process. The station highlighted in yellow was used for the water quality calibration.

Table 3 Impaired Waters Rule Database Stations used in Water Quality Model Calibration

Station	Station Name	First Date	Last Date
21FLBRA 2893I-A	2893I - Stj Riv Ab Puzzle Lk - end of dirt road	6/19/2007 9:49	################
21FLBRA 2893I-B	2893I - Stj Riv Ab Puzzle Lk - at small cypress on E side	9/5/2007 13:18	################
21FLBRA 2893I-C	2893I - Stj Riv Ab Puzzle Lk - between 2 palms	9/5/2007 13:28	################
21FLBRA 2893I-D	2893I - Stj Riv Ab Puzzle Lk - at point in bend	9/5/2007 13:37	################
21FLBRA 2893K-A	2893K - Lake Poinsett - end of Providence Rd	################	################
21FLGW 30501	SJ3-LR-2003 ST. JOHNS RIVER	################	################
21FLGW 30503	SJ3-LR-2005 ST. JOHNS RIVER	6/29/2006 9:45	6/29/2006 9:47
21FLGW 30504	SJ3-LR-2006 ST. JOHNS RIVER	################	################
21FLGW 30507	SJ3-LR-2009 ST. JOHNS RIVER	################	################
21FLGW 30515	SJ3-LR-2017 ST. JOHNS RIVER	6/29/2006 9:15	6/29/2006 9:17
21FLGW 30518	SJ3-LR-2020 ST. JOHNS RIVER	################	################
21FLGW 30519	SJ3-LR-2021 ST. JOHNS RIVER	################	################
21FLGW 30523	SJ3-LR-2025 ST. JOHNS RIVER	################	################
21FLGW 30527	SJ3-LR-2029 ST. JOHNS RIVER	################	################
21FLGW 30609	SJ3-SS-2059 UNKNOWN SMALL STREAM	################	################
21FLGW 30616	SJ3-SS-2081 UNKNOWN SMALL STREAM	################	################
21FLGW 30622	SJ3-SS-2126 UNKNOWN SMALL STREAM	9/13/2006 9:55	9/13/2006 9:57
21FLGW 30628	SJ3-SS-2172 UNKNOWN SMALL STREAM	################	################
21FLGW 30720	SJ3-SL-2040 UNNAMED LAKE CONNECTED TO ST. JOHNS R.	################	################
21FLGW 36575	Z3-LR-3005 SAINT JOHNS RIVER	################	################
21FLGW 38466	Z3-LR-4010 SAINT JOHNS RIVER	4/26/2010 9:30	4/26/2010 9:32
21FLGW 39283	Z3-LR-4014 SAINT JOHNS RIVER	################	################
21FLORANSJ19	St. Johns at Possum Bluff	################	################
21FLORANSJ19A	St. Johns at Hwy 528	################	################
21FLSJWMLPC	Center of Lake Poinsett	7/8/2004 11:20	8/2/2005 11:10
21FLSJWMLPI	SJR at Lake Poinsett Inlet	7/8/2004 10:50	9/7/2011 11:40
21FLSJWMLPO	SJR at Lake Poinsett Outlet south of SR 520	7/8/2004 11:50	2/7/2012 9:11
21FLWQSPBRE703NL	Lake Poinsett near center (WBID 2893K)	################	################

Table 4 provides a comparison of predicted annual average concentrations versus the annual average concentrations of the measured data. While it is important to capture seasonal variation, duration and frequency of water quality, it is very critical to approximate average conditions in the system. It is during these periods of times that nutrients are expressed.

Table 4 Predicted vs. Observed Annual Average Concentrations

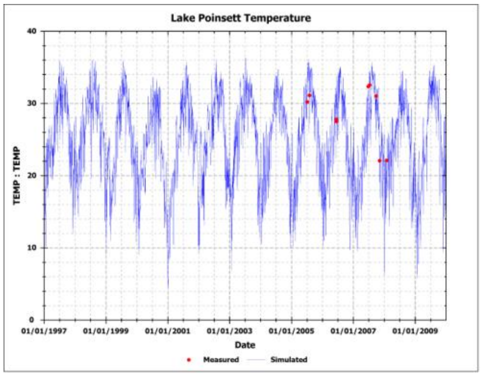
Constituent	Simulated	Observed
BOD (mg/L)	2.32	2.07
Chlorophyll a (ug/L)	4.08	4.38
DO (mg/L)	5.41	6.38
Total Nitrogen (mg/L)	1.72	1.98
Total Phosphorus (mg/L)	0.13	0.14

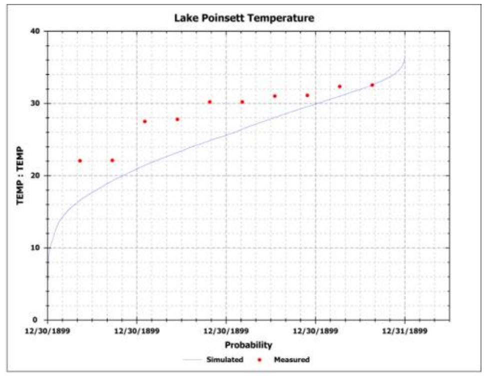
Figure 9 through Figure 32 provide calibration comparison for all of the major water quality constituents in which data is available.

Water Temperature

Water temperature is simulated in the water quality because of its influence on degradation, kinetic transformation, algal growth and decay rates. Because several modeling scenarios will be simulated, such as a natural condition, an estimate of water temperature under this condition could be important.

Figure 9 through Figure 12 illustrates both a quantitative and qualitative comparison of the simulated water temperature compared to the direct measurements.





Calibration Statistics

Station: LAKE POINSETT; Parameter: TEMP

Statistic	Measured	Simulated
Count:	10	10
Mean:	28.686	30.143
Std Dev:	3.850	4.616
Min:	22.060	22.044
Max:	32.530	34.352
5 %tile:	0.000	0.000
10 %tile:	22.065	22.092
90 %tile:	32.512	34.352
95 %tile:	0.000	0.000
Corr (R^2):	0.69	
Mean Abs Error:	2.353	
RMS Error:	2.843	
Norm RMS Error:	0.096	
Index of Agreement:	0.87	

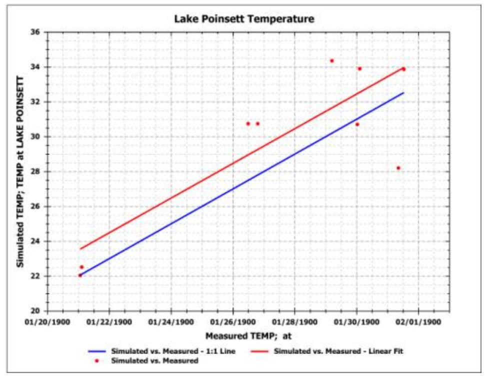
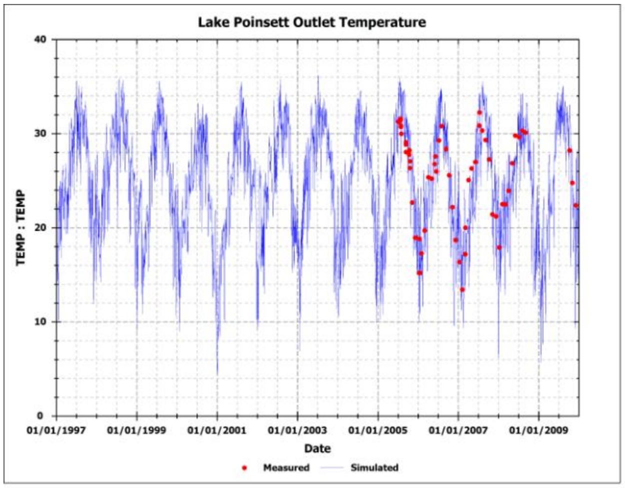
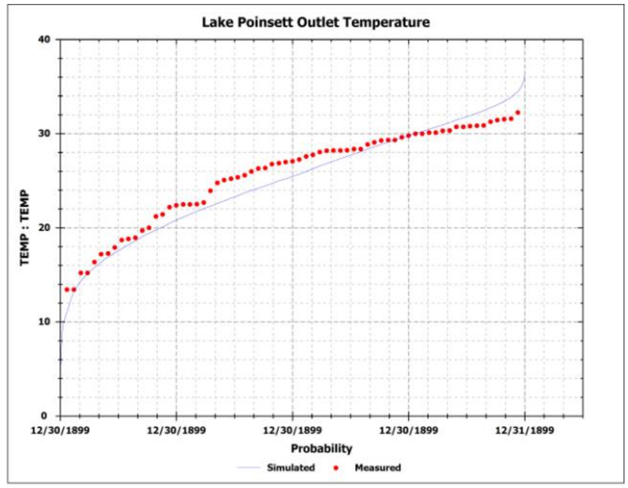


Figure 9 Water Temperature Calibration Lake Poinsett





Calibration Statistics

Station: LAKE POINSETT OUTLET; Parameter: TEMP

Statistic	Measured	Simulated
Count:	67	67
Mean:	25.576	26.405
Std Dev:	5.084	6.475
Min:	13.420	11.491
Max:	32.230	34.831
5 %tile:	15.210	13.339
10 %tile:	17.248	14.934
90 %tile:	30.846	34.113
95 %tile:	31.494	34.825
Corr (R^2):	0.85	
Mean Abs Error:	2.408	
RMS Error:	2.769	
Norm RMS Error:	0.104	
Index of Agreement:	0.94	

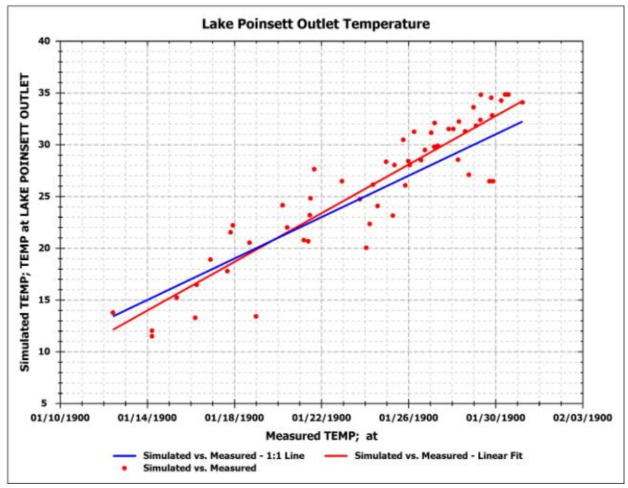
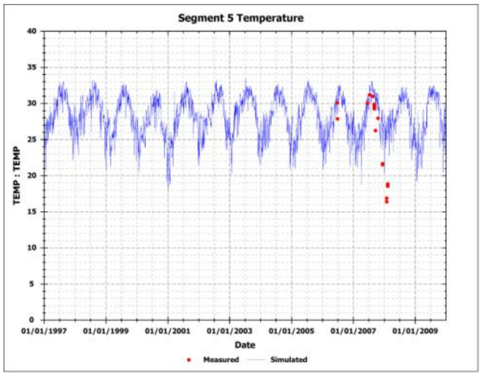
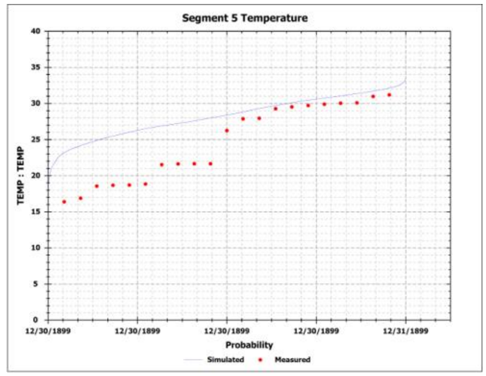


Figure 10 Water Temperature Calibration Lake Poinsett Outlet





Calibration Statistics

Station: SEGMENT 5; Parameter: TEMP

Statistic	Measured	Simulated
Count:	21	21
Mean:	24.623	28.685
Std Dev:	5.340	2.750
Min:	16.380	24.833
Max:	31.180	32.353
5 %tile:	16.429	24.836
10 %tile:	17.206	24.874
90 %tile:	30.790	32.015
95 %tile:	31.159	32.332
Corr (R^2):	0.91	
Mean Abs Error:	4.134	
RMS Error:	4.921	
Norm RMS Error:	0.183	
Index of Agreement:	0.69	

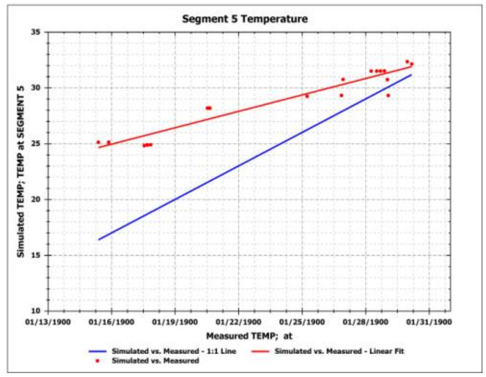
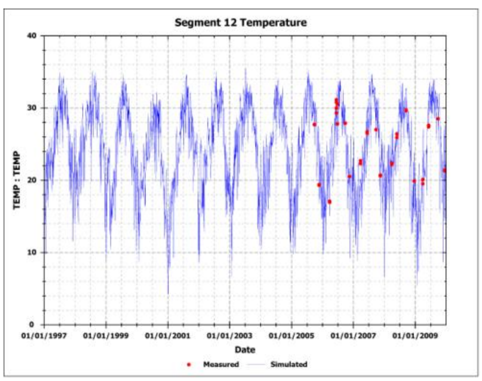
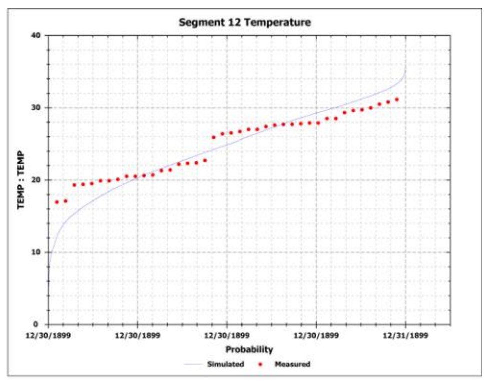


Figure 11 Water Temperature Calibration Segment 5





Calibration Statistics

Station: SEGMENT 12; Parameter: TEMP

Statistic	Measured	Simulated
Count:	40	40
Mean:	24.706	25.307
Std Dev:	4.257	4.413
Min:	16.940	15.770
Max:	31.130	32.614
5 %tile:	17.210	15.913
10 %tile:	19.410	18.598
90 %tile:	29.961	29.929
95 %tile:	30.776	32.479
Corr (R^2):	0.75	
Mean Abs Error:	1.890	
RMS Error:	2.302	
Norm RMS Error:	0.091	
Index of Agreement:	0.92	

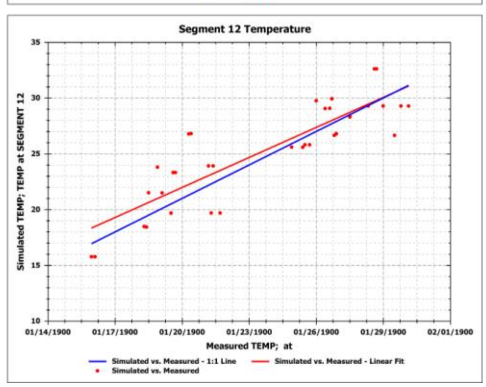
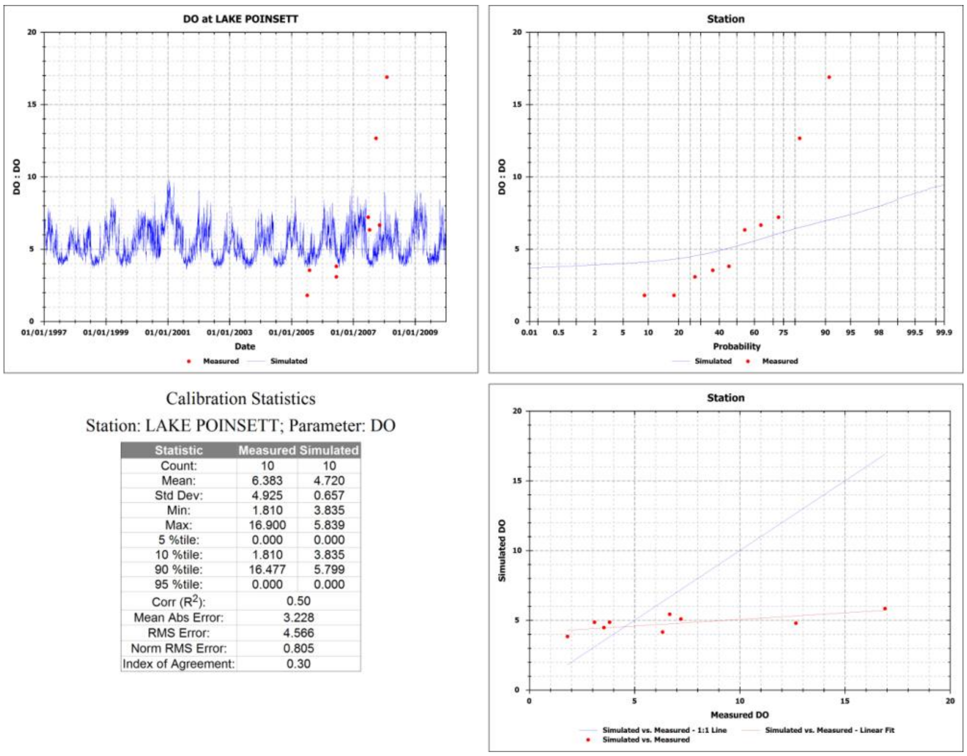


Figure 12 Water Temperature Calibration Segment 12

Dissolved Oxygen

The dissolved oxygen calibration will be important in the development of this TMDL because it will be the primary response variable to determine the reductions.

Figure 13 through Figure 16 illustrates both a quantitative and qualitative comparison of the predicted dissolved oxygen concentrations compared to the direct measurements.

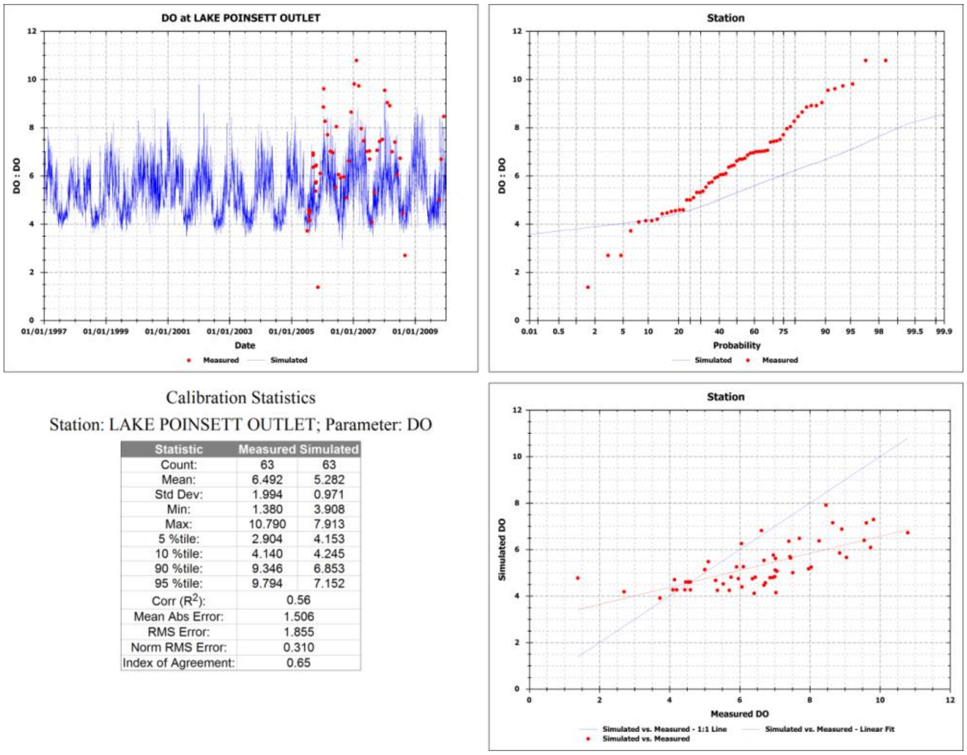


Calibration Statistics

Station: LAKE POINSETT; Parameter: DO

Statistic	Measured	Simulated
Count:	10	10
Mean:	6.383	4.720
Std Dev:	4.925	0.657
Min:	1.810	3.835
Max:	16.900	5.839
5 %tile:	0.000	0.000
10 %tile:	1.810	3.835
90 %tile:	16.477	5.799
95 %tile:	0.000	0.000
Corr (R^2):	0.50	
Mean Abs Error:	3.228	
RMS Error:	4.566	
Norm RMS Error:	0.805	
Index of Agreement:	0.30	

Figure 13 Dissolved Oxygen Calibration Lake Poinsett

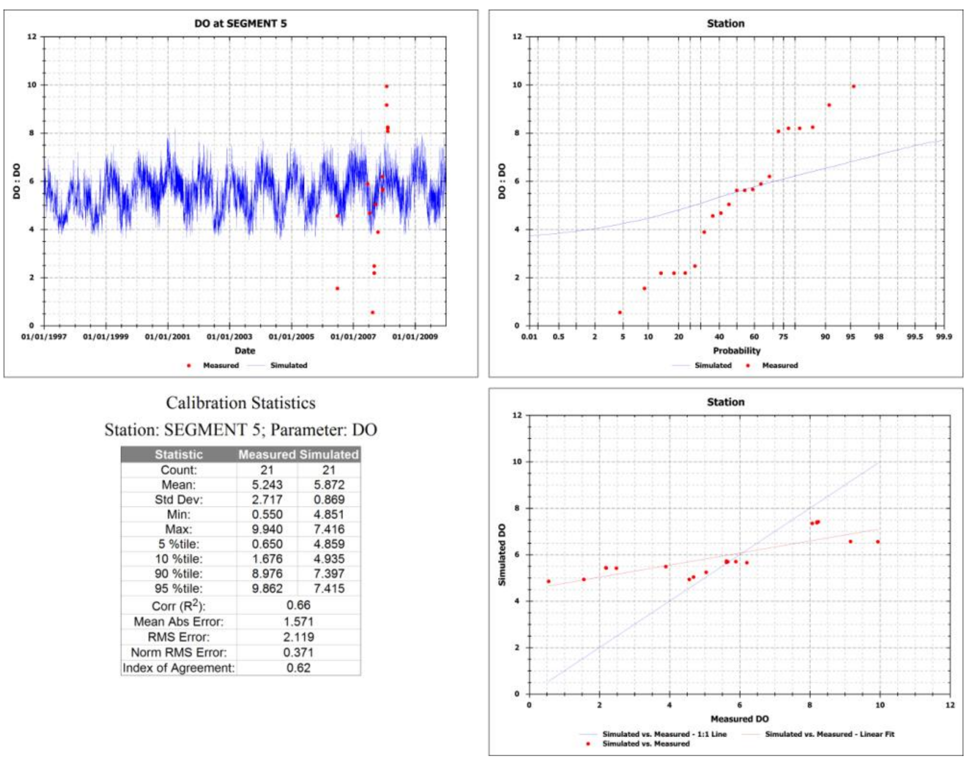


Calibration Statistics

Station: LAKE POINSETT OUTLET; Parameter: DO

Statistic	Measured	Simulated
Count:	63	63
Mean:	6.492	5.282
Std Dev:	1.994	0.971
Min:	1.380	3.908
Max:	10.790	7.913
5 %tile:	2.904	4.153
10 %tile:	4.140	4.245
90 %tile:	9.346	6.853
95 %tile:	9.794	7.152
Corr (R^2):	0.56	
Mean Abs Error:	1.506	
RMS Error:	1.855	
Norm RMS Error:	0.310	
Index of Agreement:	0.65	

Figure 14 Dissolved Oxygen Calibration Lake Poinsett Outlet

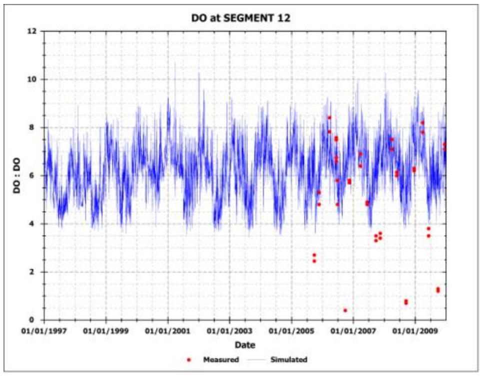


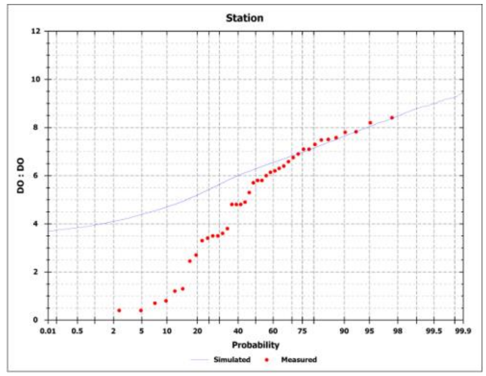
Calibration Statistics

Station: SEGMENT 5; Parameter: DO

Statistic	Measured	Simulated
Count:	21	21
Mean:	5.243	5.872
Std Dev:	2.717	0.869
Min:	0.550	4.851
Max:	9.940	7.416
5 %tile:	0.650	4.859
10 %tile:	1.676	4.935
90 %tile:	8.976	7.397
95 %tile:	9.862	7.415
Corr (R^2):	0.66	
Mean Abs Error:	1.571	
RMS Error:	2.119	
Norm RMS Error:	0.371	
Index of Agreement:	0.62	

Figure 15 Dissolved Oxygen Calibration Segment 5





Calibration Statistics

Station: SEGMENT 12; Parameter: DO

Statistic	Measured	Simulated
Count:	40	40
Mean:	5.013	6.324
Std Dev:	2.381	0.840
Min:	0.400	4.259
Max:	8.400	7.611
5 %tile:	0.415	4.303
10 %tile:	0.840	4.995
90 %tile:	7.778	7.216
95 %tile:	8.181	7.580
Corr (R^2):	0.15	
Mean Abs Error:	1.872	
RMS Error:	2.530	
Norm RMS Error:	0.444	
Index of Agreement:	0.40	

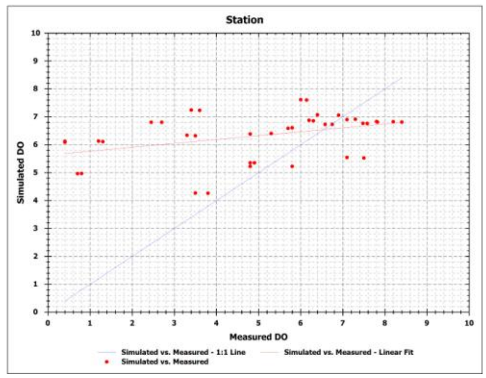
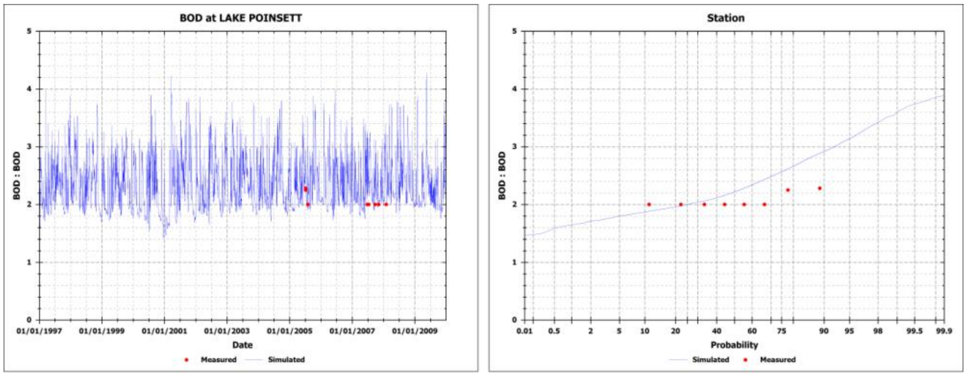


Figure 16 Dissolved Oxygen Calibration Segment 12

Biochemical Oxygen Demand

There is very little BOD data available for the Lake Poinsett and St. Johns River above Puzzle Lake WBID. The following presents BOD data that is available from the IWR Station Lake Poinsett and St. Johns River above Puzzle Lake Creek at Florida Turnpike.

Figure 17 through Figure 20 illustrates both a quantitative and qualitative comparison of the predicted dissolved oxygen concentrations compared to the direct measurements.



Calibration Statistics

Station: LAKE POINSETT; Parameter: BOD

Statistic	Measured	Simulated
Count:	8	8
Mean:	2.066	2.384
Std Dev:	0.123	0.195
Min:	2.000	2.035
Max:	2.280	2.627
5 %tile:	0.000	0.000
10 %tile:	0.000	0.000
90 %tile:	0.000	0.000
95 %tile:	0.000	0.000
Corr (R^2):	0.59	
Mean Abs Error:	0.318	
RMS Error:	0.339	
Norm RMS Error:	0.153	
Index of Agreement:	0.49	

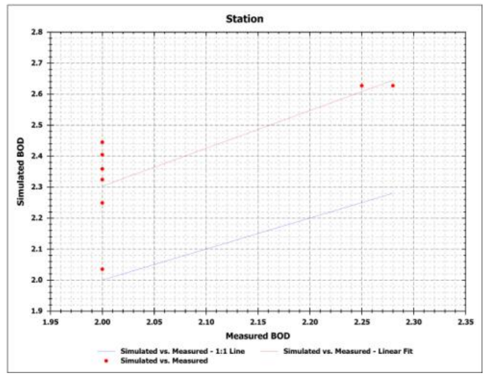
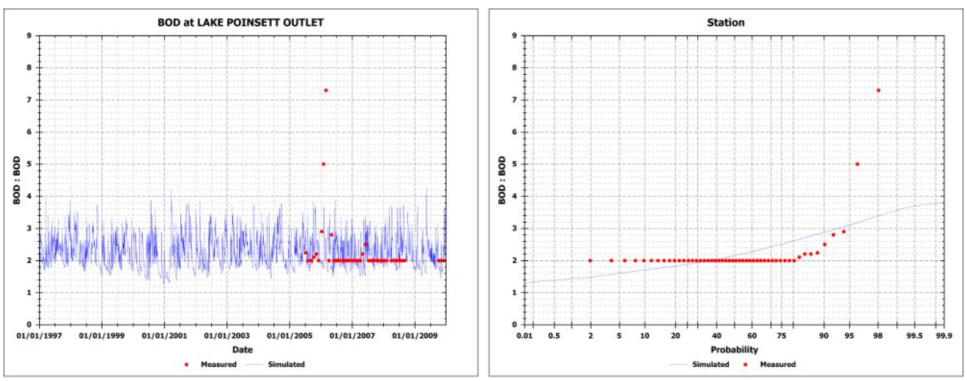


Figure 17 BOD Calibration Lake Poinsett



Calibration Statistics

Station: LAKE POINSETT OUTLET; Parameter: BOD

Statistic	Measured	Simulated
Count:	50	50
Mean:	2.225	2.143
Std Dev:	0.862	0.309
Min:	2.000	1.527
Max:	7.300	3.018
5 %tile:	2.000	1.679
10 %tile:	2.000	1.758
90 %tile:	2.474	2.575
95 %tile:	3.845	2.742
Corr (R^2):	0.02	
Mean Abs Error:	0.444	
RMS Error:	0.946	
Norm RMS Error:	0.435	
Index of Agreement:	0.06	

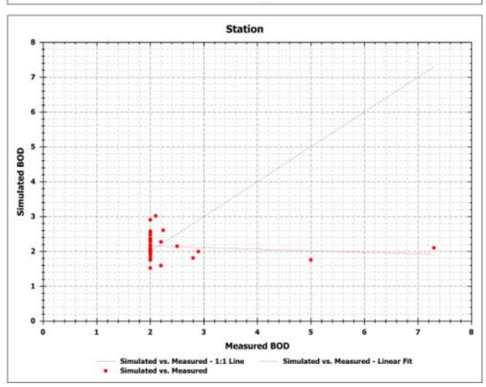
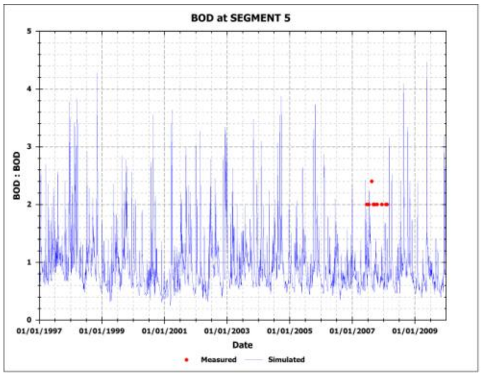
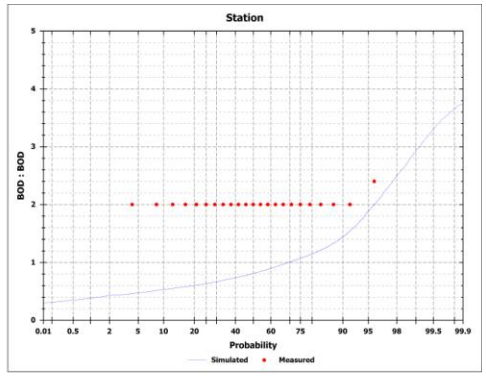


Figure 18 BOD Calibration Lake Poinsett Outlet





Calibration Statistics

Station: SEGMENT 5; Parameter: BOD

Statistic	Measured	Simulated
Count:	23	23
Mean:	2.017	0.830
Std Dev:	0.083	0.118
Min:	2.000	0.675
Max:	2.400	1.049
5 %tile:	2.000	0.675
10 %tile:	2.000	0.675
90 %tile:	2.000	0.949
95 %tile:	2.320	1.029
Corr (R^2):	0.06	
Mean Abs Error:	1.188	
RMS Error:	1.198	
Norm RMS Error:	0.926	
Index of Agreement:	0.14	

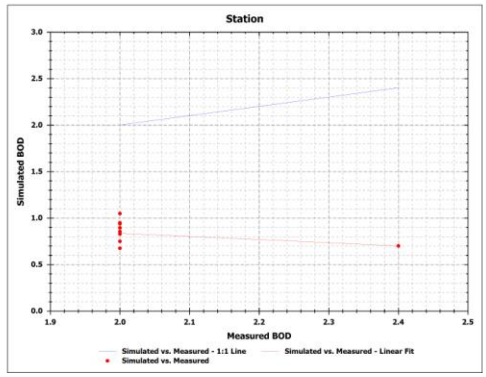
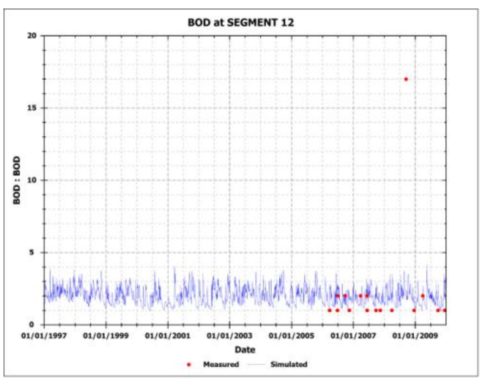
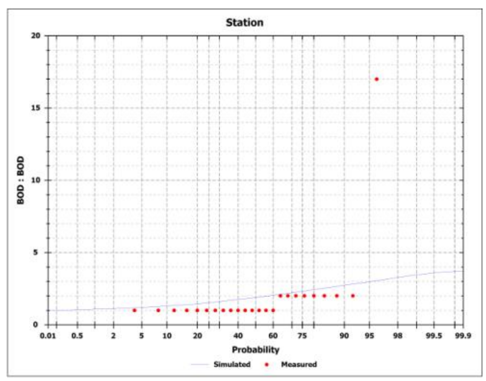


Figure 19 BOD Calibration Segment 5





Calibration Statistics

Station: SEGMENT 12; Parameter: BOD

Statistic	Measured	Simulated
Count:	24	24
Mean:	2.000	1.958
Std Dev:	3.230	0.432
Min:	1.000	1.508
Max:	17.000	2.617
5 %tile:	1.000	1.509
10 %tile:	1.000	1.526
90 %tile:	2.000	2.588
95 %tile:	13.250	2.617
Corr (R^2):	0.00	
Mean Abs Error:	1.403	
RMS Error:	3.210	
Norm RMS Error:	1.635	
Index of Agreement:	0.04	

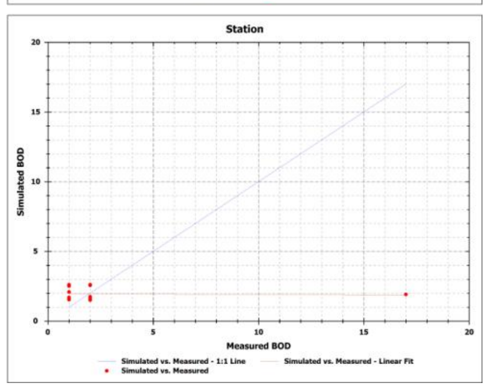
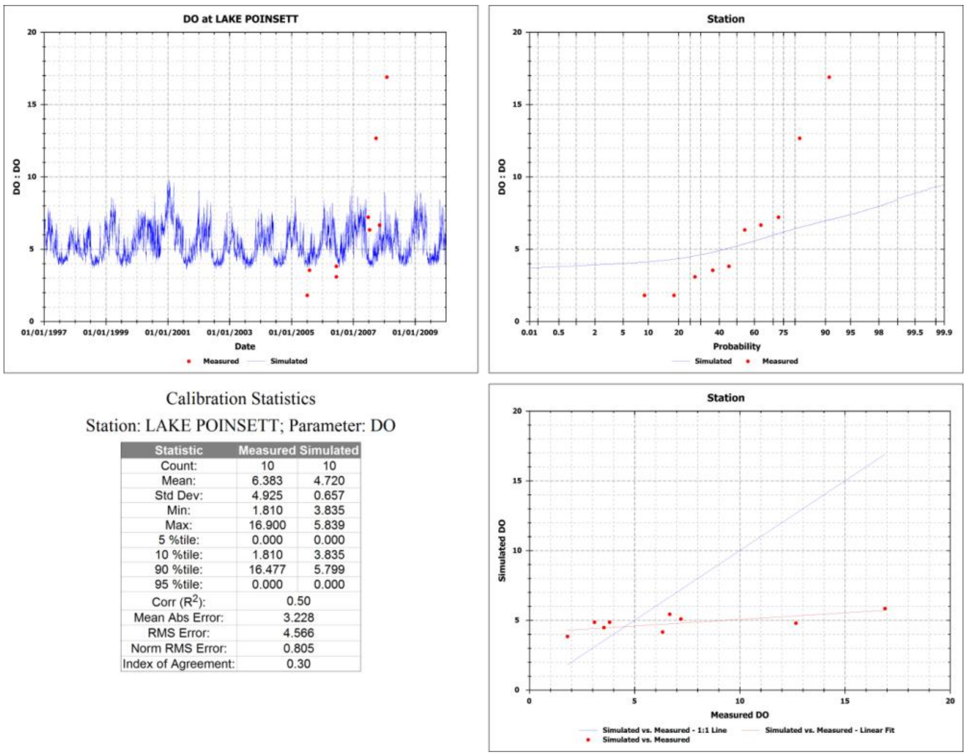


Figure 20 BOD Calibration Segment 12

Chlorophyll a

The following presents chlorophyll a data that is available, most data is associated with the Lake Poinsett Outlet.

Figure 21 through Figure 24illustrates both a quantitative and qualitative comparison of the predicted dissolved oxygen concentrations compared to the direct measurements.

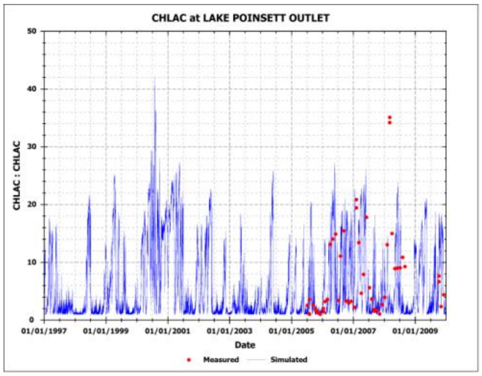


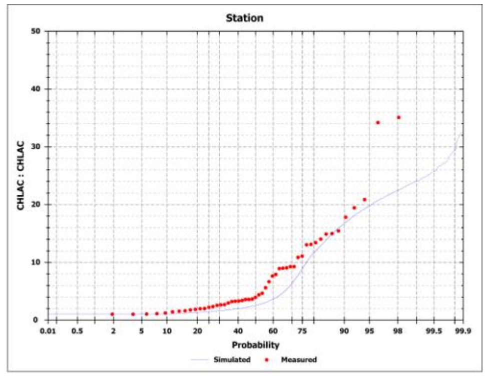
Calibration Statistics

Station: LAKE POINSETT; Parameter: DO

Statistic	Measured	Simulated
Count:	10	10
Mean:	6.383	4.720
Std Dev:	4.925	0.657
Min:	1.810	3.835
Max:	16.900	5.839
5 %tile:	0.000	0.000
10 %tile:	1.810	3.835
90 %tile:	16.477	5.799
95 %tile:	0.000	0.000
Corr (R^2):	0.50	
Mean Abs Error:	3.228	
RMS Error:	4.566	
Norm RMS Error:	0.805	
Index of Agreement:	0.30	

Figure 21 Chlorophyll a Calibration Lake Poinsett





Calibration Statistics

Station: LAKE POINSETT OUTLET; Parameter: CHLAC

Statistic	Measured	Simulated
Count:	51	51
Mean:	7.668	6.192
Std Dev:	7.726	5.877
Min:	1.000	1.421
Max:	35.066	21.727
5 %tile:	1.025	1.426
10 %tile:	1.263	1.553
90 %tile:	17.327	17.231
95 %tile:	26.182	20.830
Corr (R^2):	0.01	
Mean Abs Error:	6.014	
RMS Error:	9.326	
Norm RMS Error:	1.302	
Index of Agreement:	0.37	

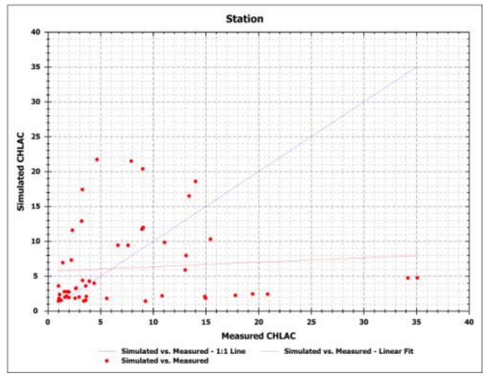
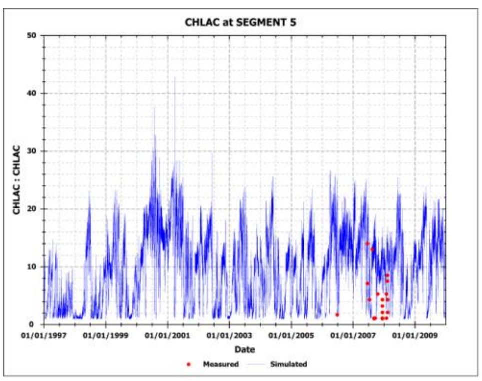
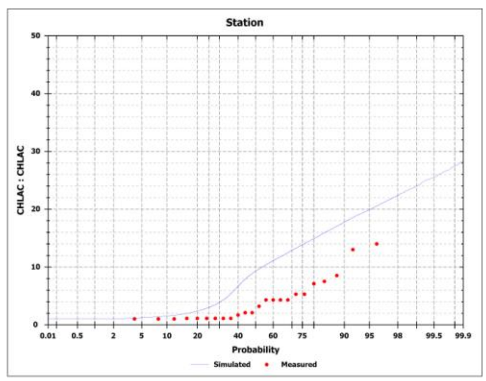


Figure 22 Chlorophyll a Calibration Lake Poinsett Outlet





Calibration Statistics

Station: SEGMENT 5; Parameter: CHLAC

Statistic	Measured	Simulated
Count:	24	24
Mean:	4.025	12.184
Std Dev:	3.715	3.151
Min:	1.000	1.585
Max:	14.000	15.445
5 %tile:	1.000	2.883
10 %tile:	1.000	7.800
90 %tile:	10.750	15.091
95 %tile:	13.750	15.427
Corr (R^2):	0.08	
Mean Abs Error:	8.205	
RMS Error:	9.101	
Norm RMS Error:	1.259	
Index of Agreement:	0.33	

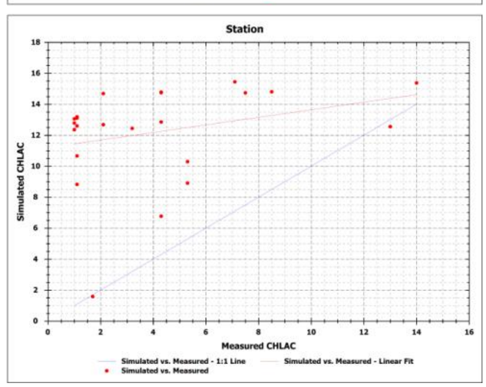
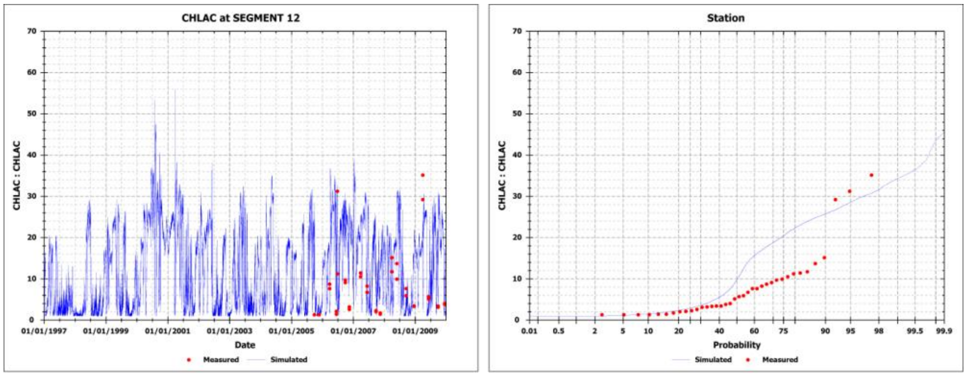


Figure 23 Chlorophyll a Calibration Segment 5



Calibration Statistics

Station: SEGMENT 12; Parameter: CHLAC

Statistic	Measured	Simulated
Count:	38	38
Mean:	7.795	12.501
Std Dev:	8.150	9.768
Min:	1.300	1.383
Max:	35.100	27.672
5 %tile:	1.300	1.415
10 %tile:	1.300	1.764
90 %tile:	16.510	27.319
95 %tile:	31.395	27.580
Corr (R^2):	0.02	
Mean Abs Error:	9.855	
RMS Error:	12.655	
Norm RMS Error:	1.222	
Index of Agreement:	0.48	

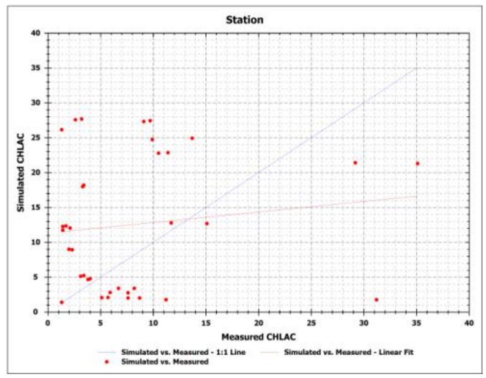
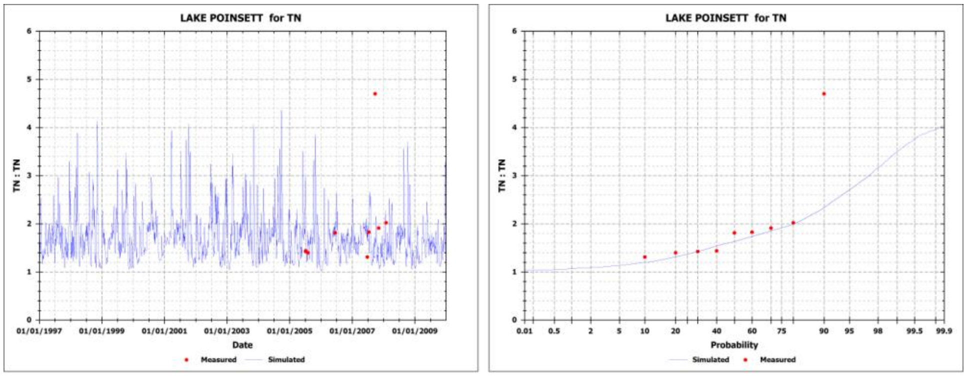


Figure 24 Chlorophyll a Calibration Segment 12

Nitrogen

Figure 25 through Figure 28 illustrates both a quantitative and qualitative comparison of the model predictions for total nitrogen to direct measurements.



Calibration Statistics
Station: LAKE POINSETT; Parameter: TN

Statistic	Measured	Simulated
Count:	9	9
Mean:	1.982	1.782
Std Dev:	1.052	0.367
Min:	1.309	1.240
Max:	4.700	2.317
5 %tile:	0.000	0.000
10 %tile:	1.309	1.240
90 %tile:	4.700	2.317
95 %tile:	0.000	0.000
Corr (R^2):	0.12	
Mean Abs Error:	0.790	
RMS Error:	1.175	
Norm RMS Error:	0.636	
Index of Agreement:	0.03	

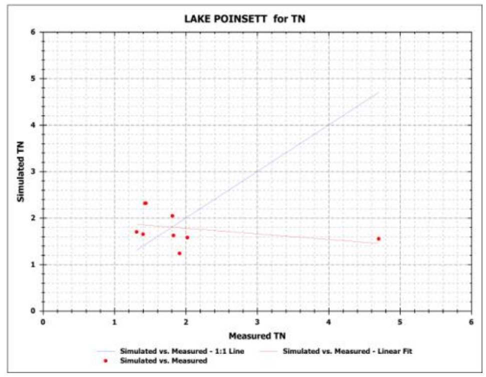
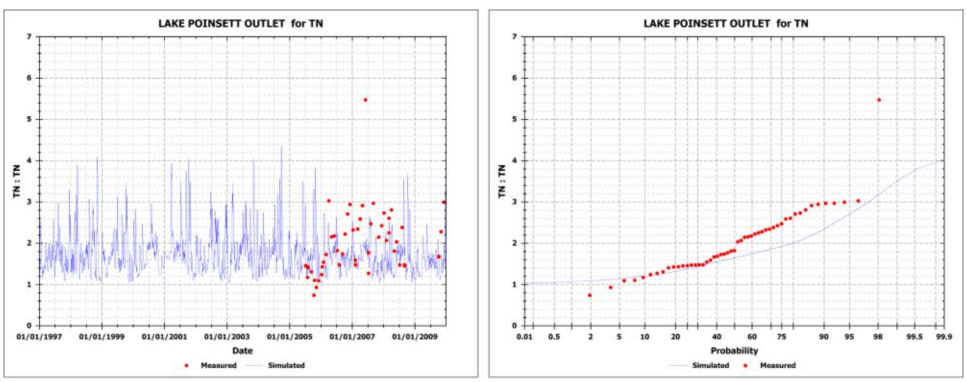


Figure 25 Total Nitrogen Calibration Lake Poinsett



Calibration Statistics
Station: LAKE POINSETT OUTLET; Parameter: TN

Statistic	Measured	Simulated
Count:	51	51
Mean:	2.023	1.612
Std Dev:	0.791	0.332
Min:	0.742	1.034
Max:	5.471	2.545
5 %tile:	1.025	1.102
10 %tile:	1.184	1.173
90 %tile:	2.959	2.045
95 %tile:	3.005	2.328
Corr (R^2):	0.00	
Mean Abs Error:	0.711	
RMS Error:	0.941	
Norm RMS Error:	0.521	
Index of Agreement:	0.25	

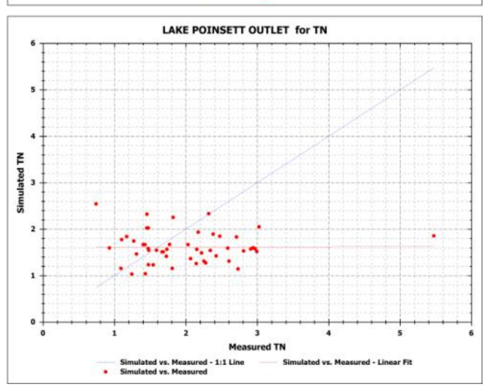
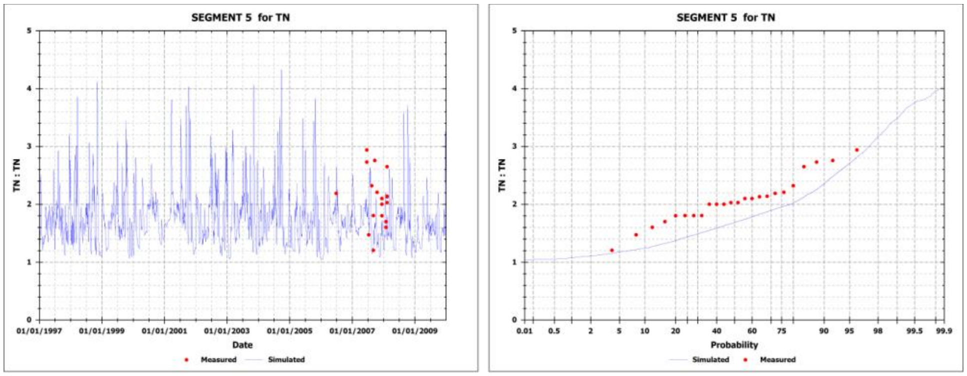


Figure 26 Total Nitrogen Calibration Lake Poinsett Outlet



Calibration Statistics

Station: SEGMENT 5; Parameter: TN

Statistic	Measured	Simulated
Count:	24	24
Mean:	2.063	1.560
Std Dev:	0.411	0.233
Min:	1.204	1.270
Max:	2.940	2.053
5 %tile:	1.271	1.278
10 %tile:	1.536	1.346
90 %tile:	2.744	1.973
95 %tile:	2.895	2.033
Corr (R^2):	0.03	
Mean Abs Error:	0.584	
RMS Error:	0.660	
Norm RMS Error:	0.367	
Index of Agreement:	0.37	

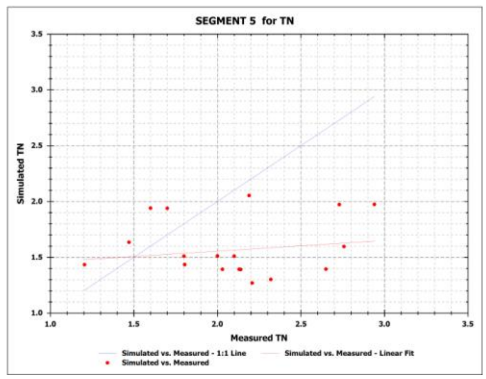
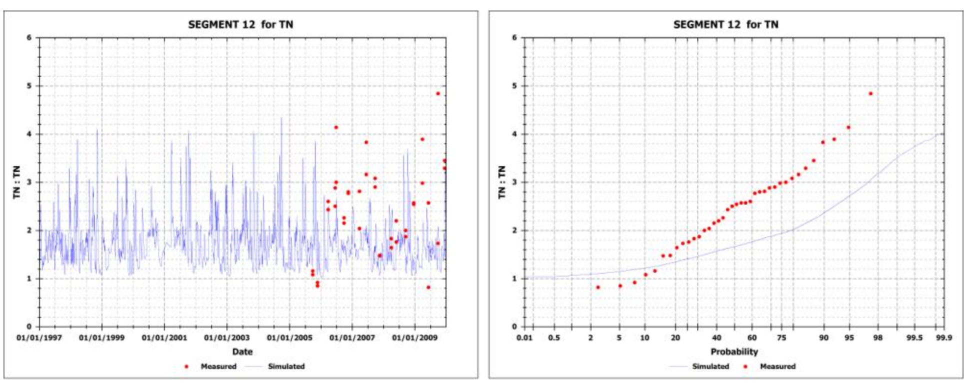


Figure 27 Total Nitrogen Calibration Segment 5



Calibration Statistics

Station: SEGMENT 12; Parameter: TN

Statistic	Measured	Simulated
Count:	38	38
Mean:	2.429	1.715
Std Dev:	0.937	0.323
Min:	0.820	1.066
Max:	4.840	2.372
5 %tile:	0.849	1.066
10 %tile:	1.064	1.272
90 %tile:	3.836	2.123
95 %tile:	4.175	2.371
Corr (R^2):	0.05	
Mean Abs Error:	0.963	
RMS Error:	1.155	
Norm RMS Error:	0.561	
Index of Agreement:	0.30	

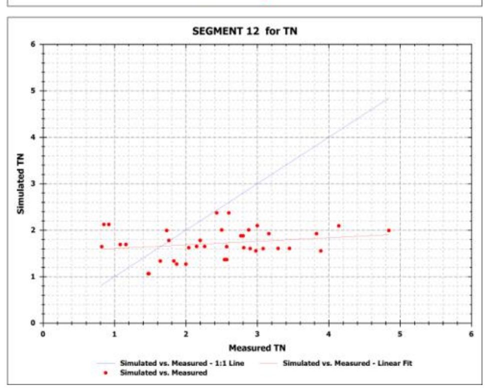
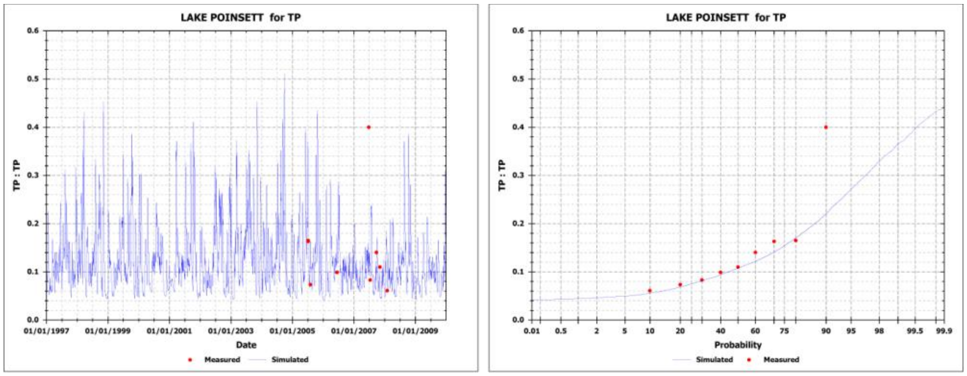


Figure 28 Total Nitrogen Calibration Segment 12

Phosphorus

Figure 29 through Figure 32 illustrates both a quantitative and qualitative comparison of the model predictions for total phosphorus to direct measurements.



Calibration Statistics

Station: LAKE POINSETT; Parameter: TP

Statistic	Measured	Simulated
Count:	9	9
Mean:	0.144	0.145
Std Dev:	0.103	0.072
Min:	0.061	0.061
Max:	0.400	0.261
5 %tile:	0.000	0.000
10 %tile:	0.061	0.061
90 %tile:	0.400	0.261
95 %tile:	0.000	0.000
Corr (R^2):	0.00	
Mean Abs Error:	0.088	
RMS Error:	0.116	
Norm RMS Error:	0.794	
Index of Agreement:	0.31	

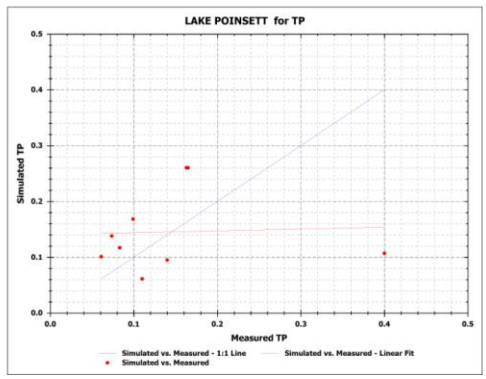
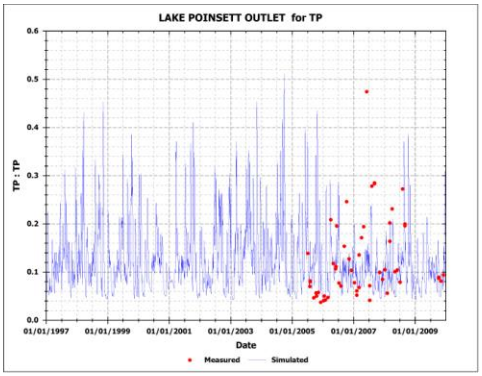
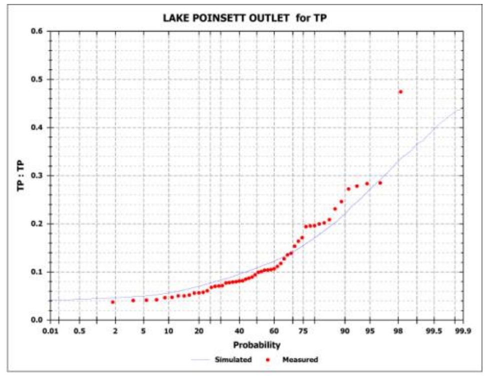


Figure 29 Total Phosphorus Calibration Lake Poinsett





Calibration Statistics

Station: LAKE POINSETT OUTLET; Parameter: TP

Statistic	Measured	Simulated
Count:	54	54
Mean:	0.125	0.110
Std Dev:	0.086	0.051
Min:	0.037	0.042
Max:	0.474	0.262
5 %tile:	0.041	0.047
10 %tile:	0.047	0.057
90 %tile:	0.259	0.185
95 %tile:	0.284	0.225
Corr (R^2):	0.01	
Mean Abs Error:	0.066	
RMS Error:	0.095	
Norm RMS Error:	0.791	
Index of Agreement:	0.38	

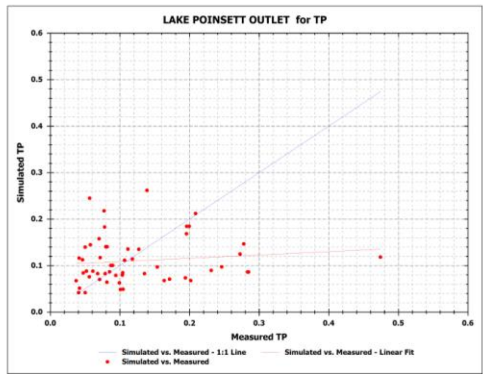
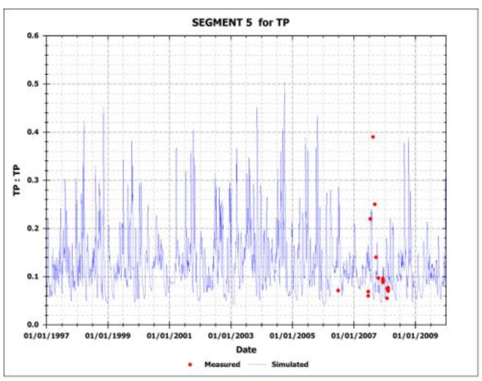
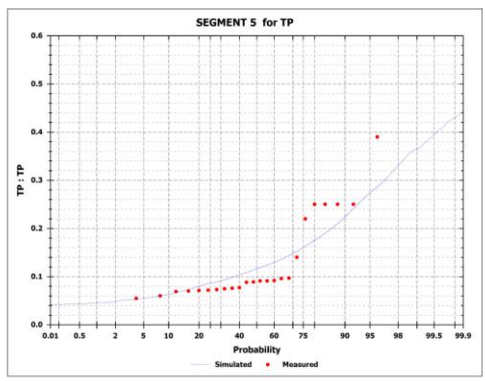


Figure 30 Total Phosphorus Calibration Lake Poinsett Outlet





Calibration Statistics

Station: SEGMENT 5; Parameter: TP

Statistic	Measured	Simulated
Count:	24	24
Mean:	0.129	0.101
Std Dev:	0.089	0.026
Min:	0.055	0.071
Max:	0.390	0.167
5 %tile:	0.056	0.072
10 %tile:	0.065	0.078
90 %tile:	0.250	0.142
95 %tile:	0.355	0.160
Corr (R^2):	0.16	
Mean Abs Error:	0.068	
RMS Error:	0.104	
Norm RMS Error:	0.943	
Index of Agreement:	0.07	

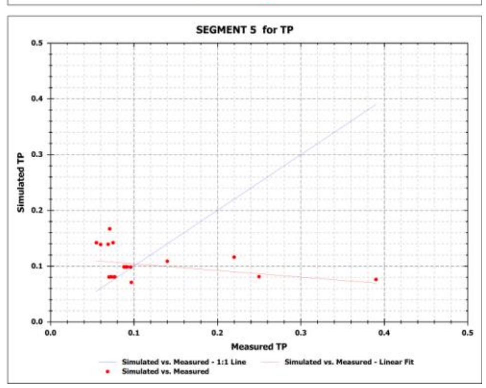
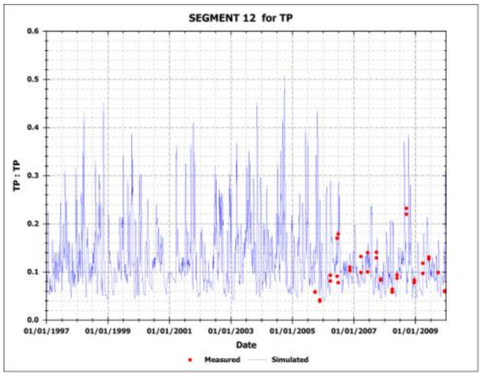
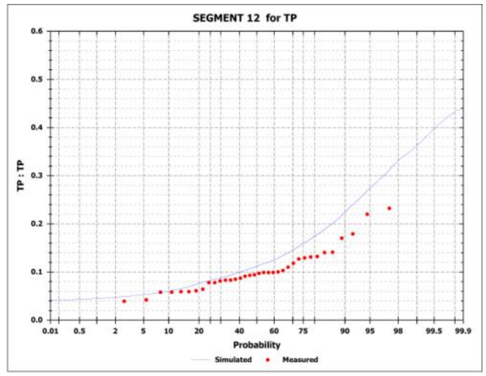


Figure 31 Total Phosphorus Calibration Segment 5





Calibration Statistics

Station: SEGMENT 12; Parameter: TP

Statistic	Measured	Simulated
Count:	36	36
Mean:	0.103	0.123
Std Dev:	0.044	0.049
Min:	0.039	0.046
Max:	0.232	0.227
5 %tile:	0.042	0.046
10 %tile:	0.058	0.065
90 %tile:	0.173	0.208
95 %tile:	0.222	0.226
Corr (R^2):	0.02	
Mean Abs Error:	0.051	
RMS Error:	0.072	
Norm RMS Error:	0.649	
Index of Agreement:	0.37	

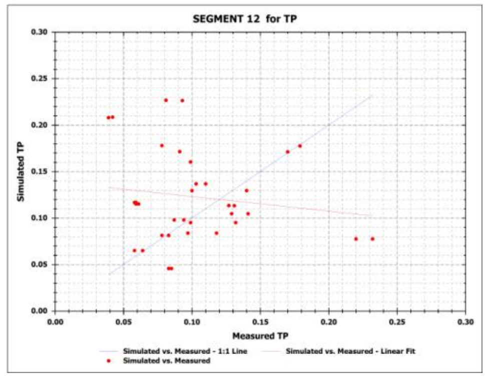


Figure 32 Total Phosphorus Calibration Segment 12

Current Loads

Table 4 provides the annual average total nitrogen, total phosphorus and BOD loads for the period of record 1997 through 2009. It is these loadings that the TMDL load reduction will be calculated from.

Table 5 Annual Average Current Loads (1997-2009)

	Current Condition	
Constituent	WLA (Kg/Yr)	LA (Kg/Yr)
BOD	NA	0
Total Nitrogen	NA	0
Total Phosphorus	NA	0

Modeling Scenarios

Using the calibrated watershed and water quality models, up to two potential modeling scenarios will be developed. The first scenario will be to predict water quality conditions under a natural condition (remove point sources and returning landuses back to upland forests and wetlands). A second scenario will be developed if water quality standards can be met under natural conditions (balanced flora and fauna, dissolved oxygen greater than 5 mg/L); loads would be reduced from the current conditions until standards are met (balanced flora and fauna, dissolved oxygen greater than 5 mg/L)

Natural Condition Analysis

The purpose of the natural condition scenario is to determine the water quality in the Lake Poinsett and St. Johns River above Puzzle Lake watershed without the influences of man. Because of Florida's regulation of not allowing abating of a natural condition, this scenario determines the maximum reduction that could be required. The natural condition scenario makes the following assumptions:

1. All man induced landuses in the watershed model are transformed back to wetlands and upland forest (50:50 & 75:25 ratio).
2. New hydrology is predicted under natural landuse assumption.
3. All point sources are removed (if any).
4. Water quality is predicted using the new flows and loads from the natural condition run from the watershed model.
5. Sediment oxygen demand is reduced based upon the percent reduction in nutrient loads.

Table 6 presents the predicted annual average concentrations under natural conditions. Without the impacts of anthropogenic sources the dissolved oxygen concentration in the Lake Poinsett and St. Johns River above Puzzle Lake watershed. It should be noted that under natural conditions the dissolved oxygen standard of 5 mg/l would not be achieved. The natural condition scenario will be used to set the maximum loads for the TMDL.

Table 6 Natural Condition Annual Average Model Predictions

Constituent	Lake Poinsett	Lake Poinsett Outlet	Segment 12	Segment 5
BOD (mg/L)	1.62	1.41	1.41	0.72
Chlorophyll a (ug/L)	4.90	6.69	10.12	7.63
DO (mg/L)	6.78	6.32	7.31	6.76
Total Nitrogen (mg/L)	1.33	1.33	1.33	1.34
Total Phosphorus (mg/L)	0.06	0.06	0.06	0.06

Table 7 provides the annual average model predictions for total nitrogen, total phosphorus, and dissolved oxygen under a natural condition.

Table 7 Annual Average Loadings for Natural Condition

	Natural Condition	
Constituent	WLA (kg/yr)	LA (kg/yr)
BOD	NA	0
Total Nitrogen	NA	0
Total Phosphorus	NA	0

Figure 33 shows the probability distribution for dissolved oxygen concentration in Lake Poinsett and St. Johns River above Puzzle Lake under current and the natural condition scenario.

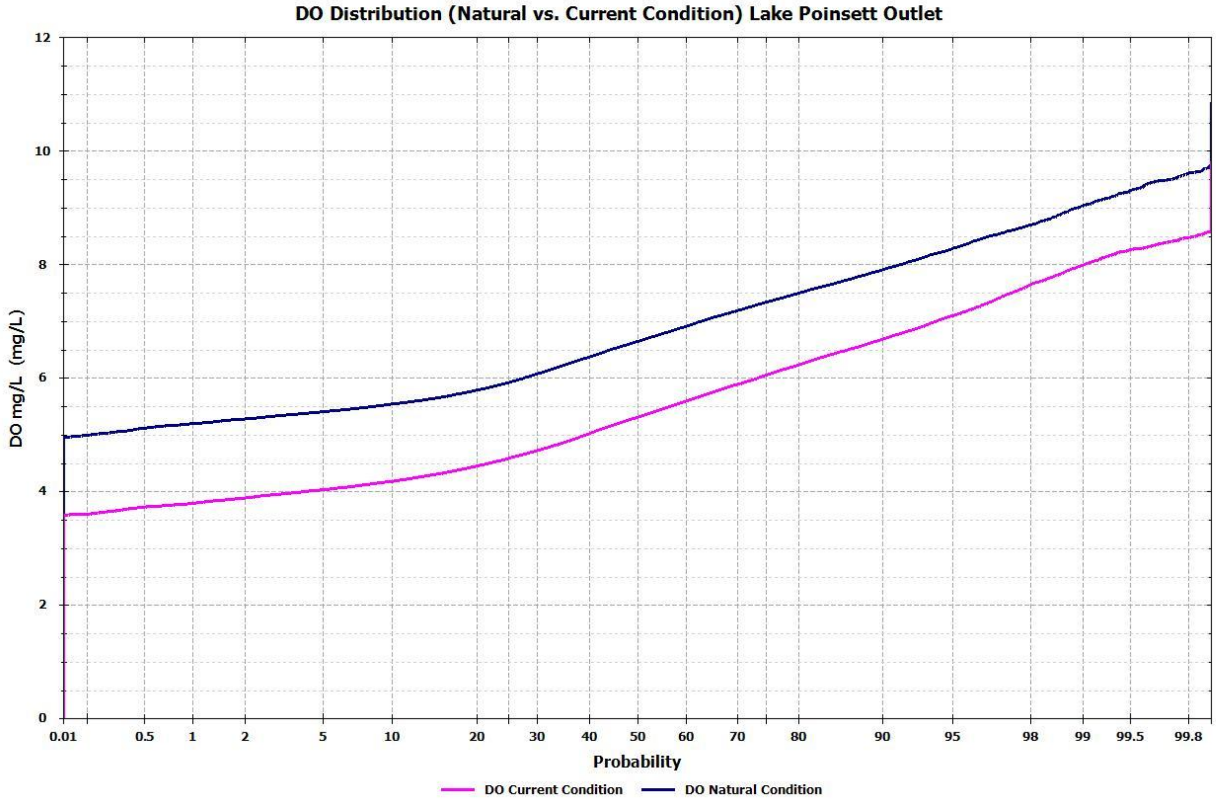


Figure 33 Dissolved Oxygen Concentration Probability Current vs. Natural Condition

TMDL Load Reductions

Because water quality standards cannot be met under natural conditions no other scenarios were conducted. The TMDL will be set to the natural conditions.

TMDL Determination

The TMDL load reduction was determined by reducing the current conditions to the natural conditions. The annual average loadings are given in Table 8 along with the prescribed load reductions.

Table 8 TMDL Determination

	Current Condition		TMDL Condition			
Constituent	WLA (kg/yr)	LA (kg/yr)	WLA (kg/yr)	NPDES Stormwater % Reduction	LA (kg/yr)	LA % Reduction
BOD	NA	0	NA	NA	0	#DIV/0!
Total Nitrogen	NA	0	NA	NA	0	#DIV/0!
Total Phosphorus	NA	0	NA	NA	0	#DIV/0!

Note: Both the watershed and water quality models including calibration and scenario input files are available upon request.