US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT

Modeling Report

WBID 3075 Wolf Creek– Upper St. Johns River Basin
Nutrients and Dissolved Oxygen

May 22, 2013

Contents

Watershed Description 1
TMDL Targets 2
Nutrients 3
Narrative Nutrient Criteria 3
Florida's adopted numeric nutrient criteria for streams 3
Dissolved Oxygen Criteria 4
Natural Conditions 5
Biochemical Oxygen Demand Criteria 5
Modeling Approach 5
LSPC Watershed Model 6
WASP Water Quality Model 6
LSPC Application to Wolf Creek Watershed 6
Watershed Delineation and Landuse 6
Meteorological Information 7
Hydraulic Calibration 8
Water Quality Model Application 9
Model Network 9
Water Quality Model Calibration 10
Water Temperature 11
Dissolved Oxygen 12
Biochemical Oxygen Demand 13
Chlorophyll a 14
Nitrogen 15
Phosphorus 16
Current Loads 17
Modeling Scenarios 18
Natural Condition Analysis 18

US EPA ARCHIVE DOCUMENT

TMDL Load Reductions 19
TMDL Determination 20

Table of Figures

Figure 1 Location of Wolf Creek Watershed and WBID 1
Figure 2 Landuse Distribution for Wolf CreekWatershed 2
Figure 3 Wolf Creek Watershed Delineation 7
Figure 4 Hourly Rainfall Station 083137 8
Figure 5 Flow Calibration for Wolf Creek Watershed 9
Figure 6 WASP Model Segmentation 10
Figure 7 Water Temperature Calibration 12
Figure 8 Dissolved Oxygen Calibration 13
Figure 9 BOD Calibration 14
Figure 10 Chlorophyll a Calibration 15
Figure 11 Total Phosphorus Calibration 17
Figure 12 Dissolved Oxygen Concentration Probability Current vs. Natural Condition 19

Table of Tables

Table 1 Inland Numeric Nutrient Criteria 4
Table 2 Wolf Creek LSPC Sub Basin Landuse Distribution 7
Table 3 Annual Rainfall for Simulation Period 8
Table 4 Impaired Waters Rule Database Stations used in Water Quality Model Calibration 10
Table 5 Predicted vs. Observed Annual Average Concentrations 11
Table 6 Current Loads (1997-2009) 17
Table 7 Natural Condition Annual Average Model Predictions 18
Table 8 Annual Average Loadings for Natural Condition 19
Table 9 TMDL Determination 20

US EPA ARCHIVE DOCUMENT

Watershed Description

The 47.6-square-kilometer Wolf Creek planning unit is located at the southern tip of the basin in Osceola County. Wolf Creek is the main waterbody segment delineated within the planning unit.

The Wolf Creek WBID (Figure 1) is located in Osceola County and eventually drains to the St. Johns River.

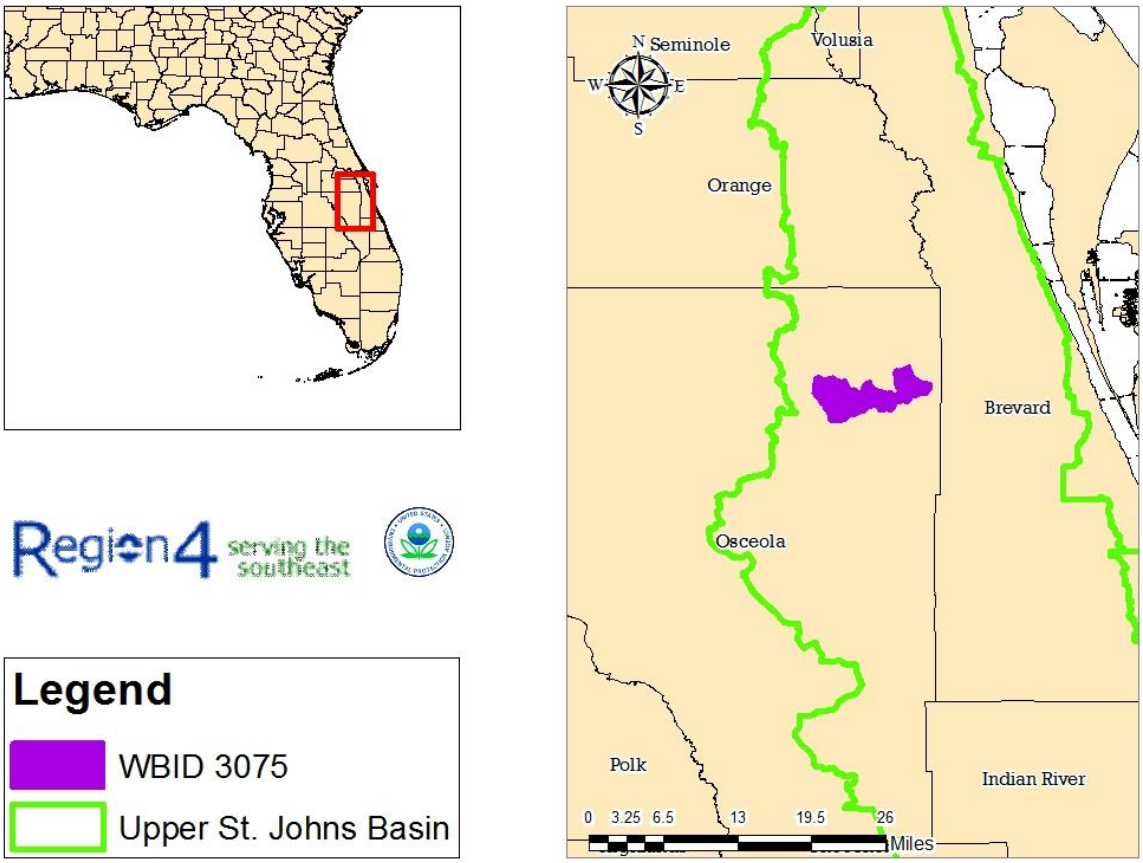


Figure 1. Location of Wolf Creek Watershed and WBID

The landuse distribution for the Wolf Creek watershed is presented in Figure 2. The predominant landuse in the watershed is pasture agriculture.

US EPA ARCHIVE DOCUMENT

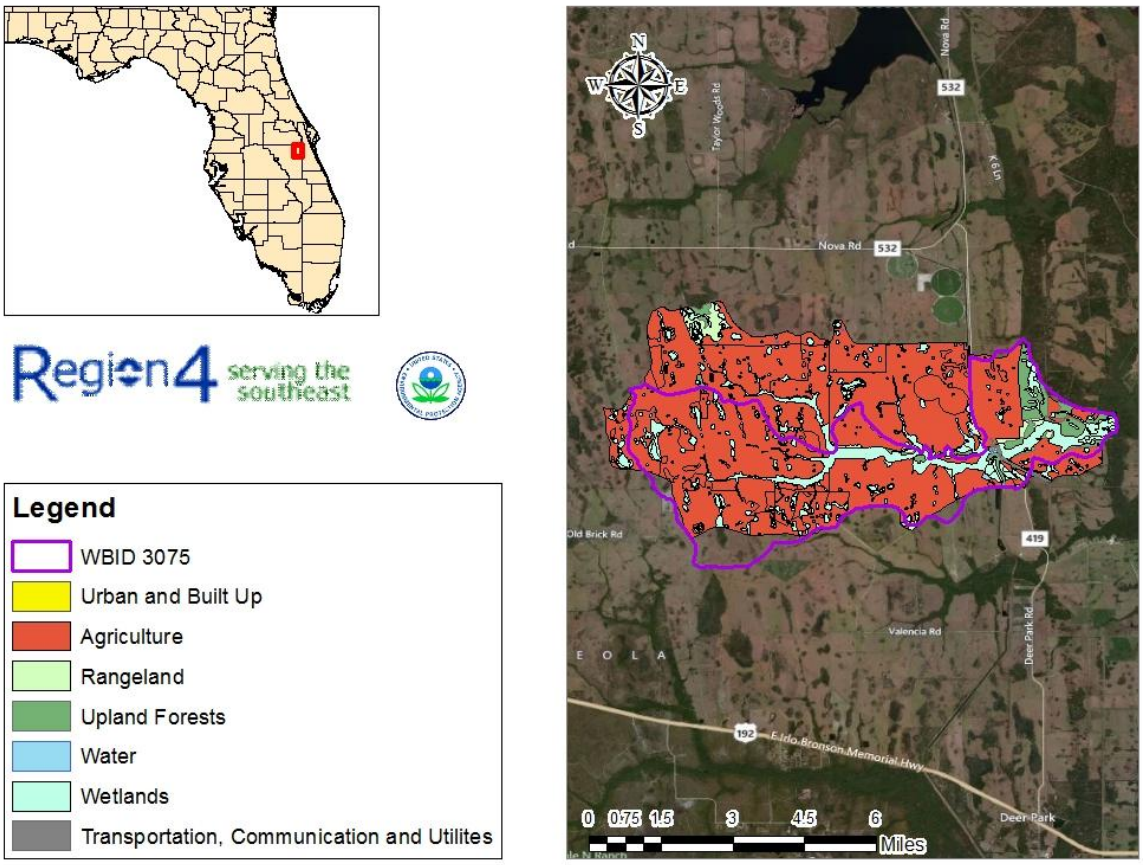


Figure 2. Landuse Distribution for Wolf Creek Watershed

TMDL Targets

The TMDL reduction scenarios will be done to achieve a Florida's dissolved oxygen criteria of 5 mg/L and insure balanced flora and fauna within Fort Drum or establish the TMDL to be consistent with a natural condition if the dissolved oxygen standard cannot be achieved.

The waterbodies in the Wolf Creek 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

US EPA ARCHIVE DOCUMENT

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

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.

Also, in November 2010, EPA promulgated numeric nutrient criteria for Class III inland waters in Florida, including streams. 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.

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 WBID 3075. 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

US EPA ARCHIVE DOCUMENT

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.

US EPA ARCHIVE DOCUMENT

Natural Conditions

In addition to the standards for nutrients, DO and BOD (Biochemical Oxygen Demand) 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

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 Wolf Creek 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.

US EPA ARCHIVE DOCUMENT

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 are calibrated to current conditions and natural conditions. The WASP model is used to determine the percent reduction in loadings that are needed to meet water quality standards.

LSPC Application to Wolf Creek Watershed

The watershed model was applied to the Wolf Creek 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 Wolf Creek WBID was included in the watershed model. This encompasses land areas outside the delineated Wolf Creek WBID. The watershed was delineated into 2 sub basins (Figure 3). The LSPC model will predict flow and loads coming from each of these sub basins into Wolf Creek.

US EPA ARCHIVE DOCUMENT

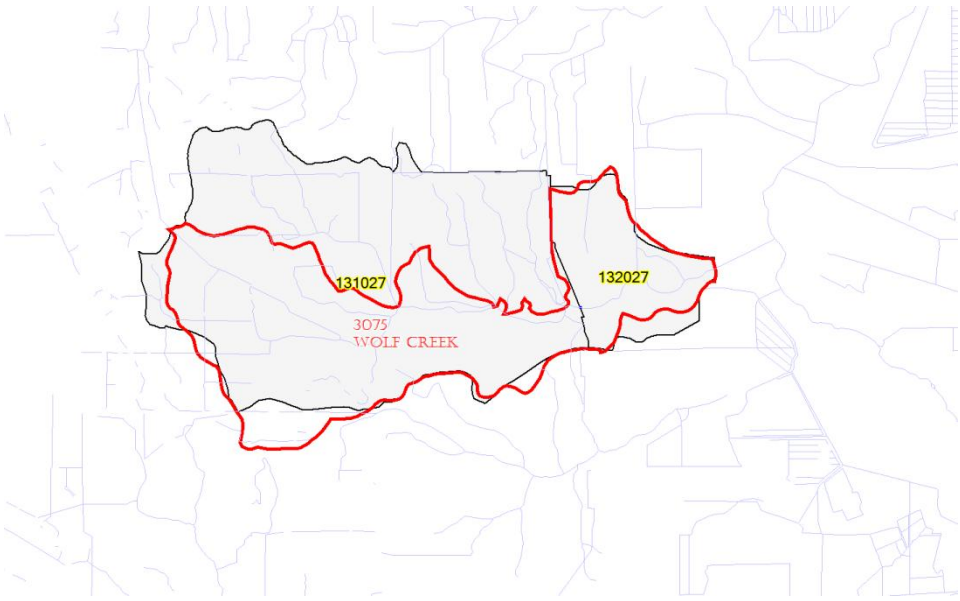


Figure 3. Wolf Creek Watershed Delineation

The initial model setup for Wolf Creek was obtained from EPA's application of LSPC for the purposes of nutrient criteria development; the model was further refined and calibrated to 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. **Error! Reference source not found.** provides the landuse distribution for each of the 2 sub basins being modeled.

Table 2. Wolf Creek LSPC Sub Basin Landuse Distribution

Subbasin Name	Beach	Water	Low Int Dev Perv	Low Int Dev Imperv	Med Int Dev Perv	Med Int Dev Imperv	High Int Dev Perv	High Int Dev Imperv	Rangeland	Forest	Golf	Pasture	Crop	Wetland	All Other Imperv	Totals (acres)
131027	0.0	26.4	0.0	0.0	0.0	0.0	0.0	0.0	88.9	82.3	0.0	9186.9	921.8	1814.9	1.2	12122.3
132027	0.0	1.0	5.0	0.0	0.0	0.0	53.6	0.0	72.8	570.5	0.0	973.5	596.7	696.0	2.6	2971.8

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 4 depicts the hourly rainfall for the Wolf Creek (083137) meteorological station. The period of record being simulated during this TMDL development contains average, wet and dry years.

US EPA ARCHIVE DOCUMENT

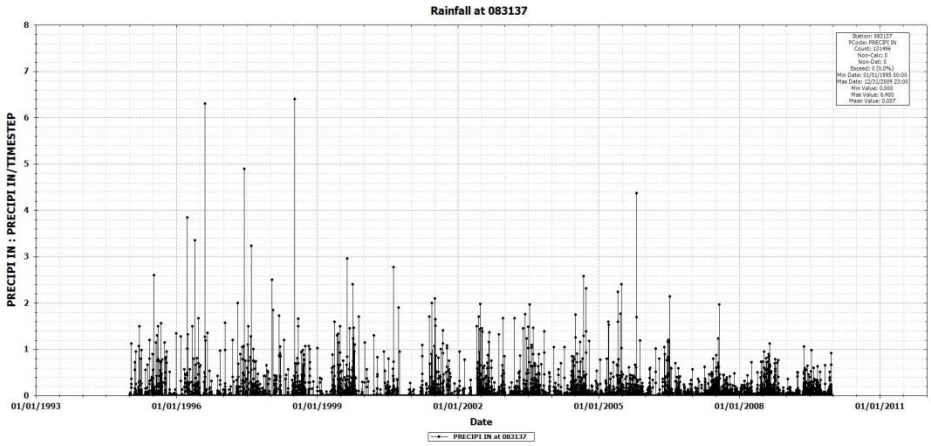


Figure 4. Hourly Rainfall Station 083137

Table 3 provides the annual rainfall for each of the simulation years.

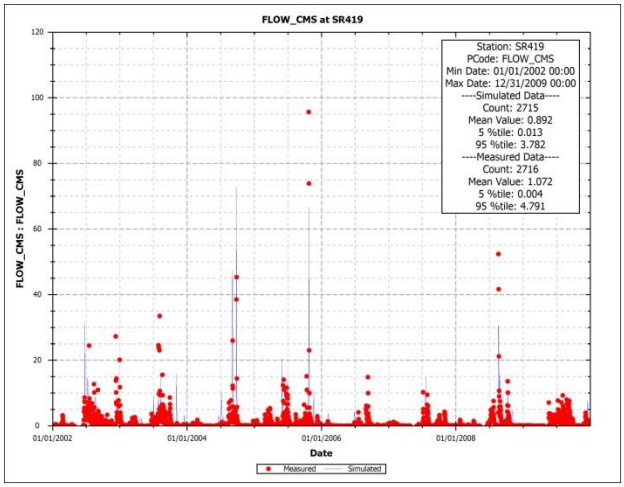
Table 3. Annual Rainfall for Simulation Period

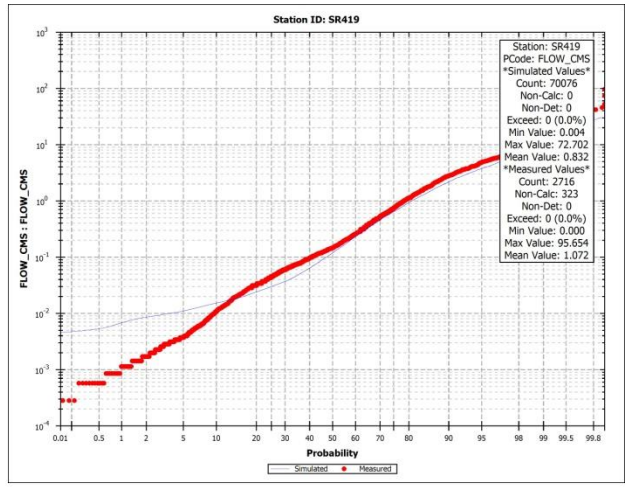
Year	Rainfall (inches)
1/1/1996	67
1/1/1997	62
1/1/1998	63
1/1/1999	76
1/1/2000	65
1/1/2001	30
1/1/2002	58
1/1/2003	69
1/1/2004	62
1/1/2005	72
1/1/2006	66
1/1/2007	41
1/1/2008	57
1/1/2009	67

Hydraulic Calibration

The watershed and water quality model were calibrated for flow by comparing the predict flows to the USGS gage 02232200 WOLF CREEK NEAR DEER PARK, FL. Figure 5 illustrates both a quantitative and qualitative comparison of the model flow predictions directly compared to the measurements at the USGS gage.

US EPA ARCHIVE DOCUMENT





Calibration Statistics

Station: SR419; Parameter: FLOW_CMS

Statistic	Measured	Simulated
Count:	2716	2715
Mean:	1.072	0.892
Std Dev:	3.664	2.898
Min:	0.000	0.004
Max:	95.654	72.396
5 %tile:	0.004	0.013
10 %tile:	0.011	0.018
90 %tile:	2.802	2.292
95 %tile:	4.791	3.782
Corr (R^2):	0.38	
Mean Abs Error:	0.946	
RMS Error:	2.959	
Norm RMS Error:	1.080	
Index of Agreement:	0.75	

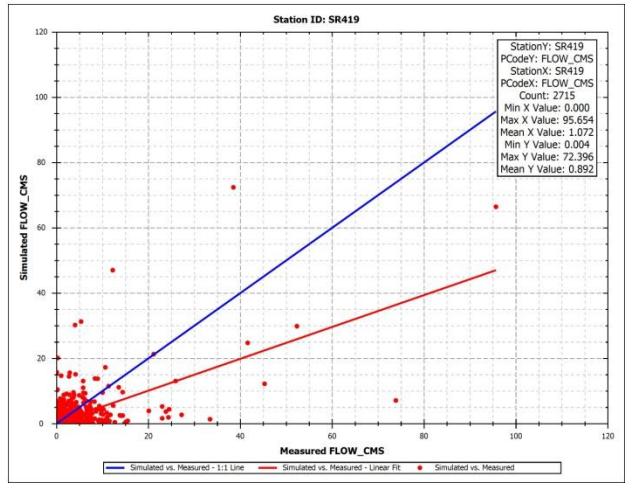


Figure 5. Flow Calibration for Wolf Creek Watershed

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 Wolf Creek 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 6 illustrates the 3 water quality model segments that are simulated. The LSPC model flows and loads enter the water quality model at segments WASP SR419 (stormwater pond at State Road 419) and WASP LSPC2.

US EPA ARCHIVE DOCUMENT

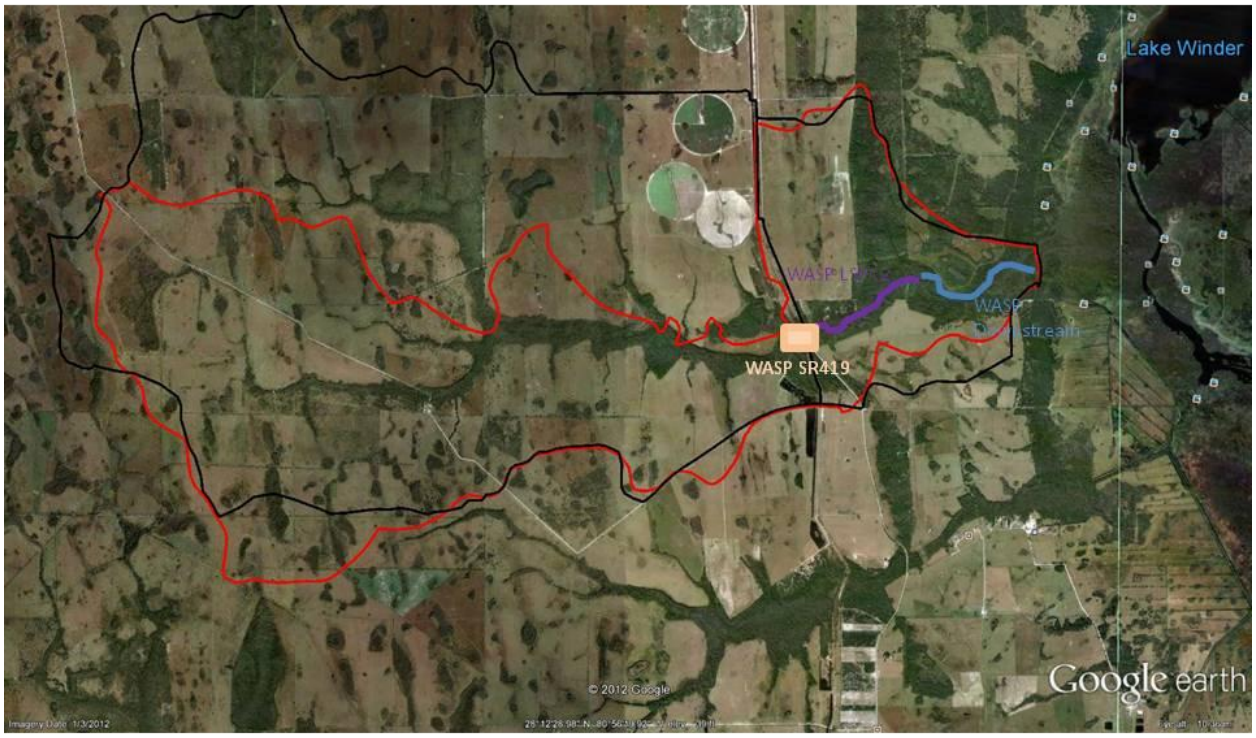


Figure 6. WASP Model Segmentation

Water Quality Model Calibration

The water quality model was calibrated to all available data in IWR 44. For Wolf Creek, data within the domain of the WASP grid existed at Wolf Creek at SR 419 stations.

Table 4 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.

Table 4. Impaired Waters Rule Database Stations used in Water Quality Model Calibration

Station	Station Name	First Date	Last Date
21FLBRA 3075-A	3075 - Wolf Creek - bridge on CR 419	6/26/2007 14:47	5/15/2008 11:20
21FLCEN 20010465	Wolf Creek at S.R. 419	3/3/2003 9:39	1/5/2010 10:23
21FLSJWMNWOLF	Wolf Creek at SR419 bridge	7/10/2002 9:30	3/31/2011 12:10

US EPA ARCHIVE DOCUMENT

Table 5 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 critical to approximate average conditions in the system. It is during these periods of times that nutrients are expressed.

Table 5. Predicted vs. Observed Annual Average Concentrations

Constituent	Simulated	Observed
BOD (mg/L)	1.85	1.78
Chlorophyll a (ug/L)	3.26	1.39
DO (mg/L)	4.57	4.45
Total Nitrogen (mg/L)	1.16	1.39
Total Phosphorus (mg/L)	0.08	0.09

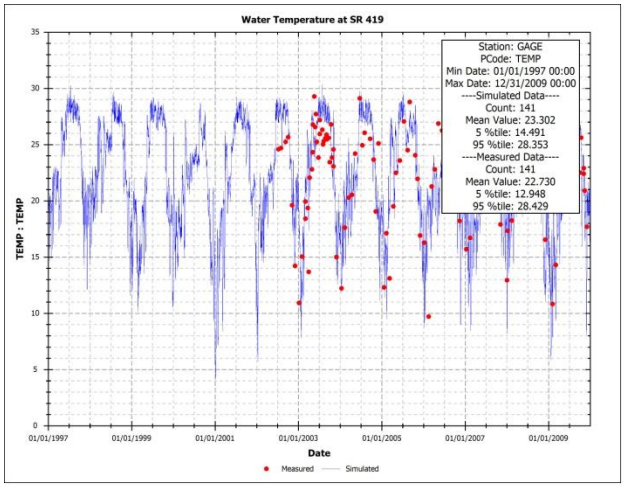
Figure 7 through **Error! Reference source not found.** provide calibration comparison for all of the major water quality constituents in which data is available.

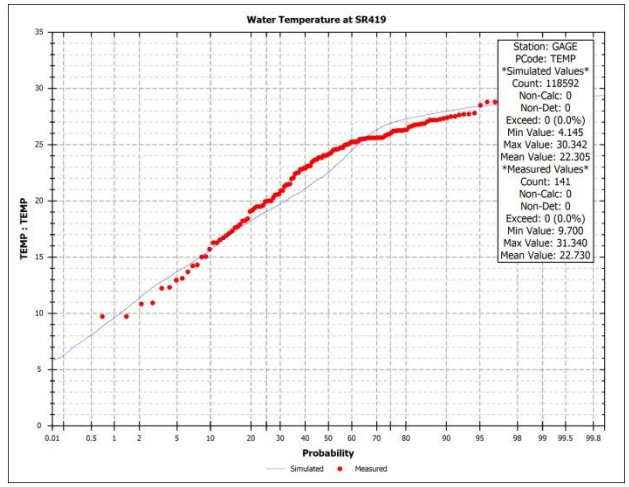
Water Temperature

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 7 illustrates both a quantitative and qualitative comparison of the simulated water temperature compared to the direct measurements.

US EPA ARCHIVE DOCUMENT





Calibration Statistics

Station: GAGE; Parameter: TEMP

Statistic	Measured	Simulated
Count:	141	141
Mean:	22.730	23.302
Std Dev:	4.626	4.885
Min:	9.700	8.139
Max:	31.340	30.270
5 %tile:	12.948	14.491
10 %tile:	15.816	16.483
90 %tile:	27.358	28.160
95 %tile:	28.429	28.353
Corr (R^2):	0.60	
Mean Abs Error:	2.573	
RMS Error:	3.240	
Norm RMS Error:	0.139	
Index of Agreement:	0.87	

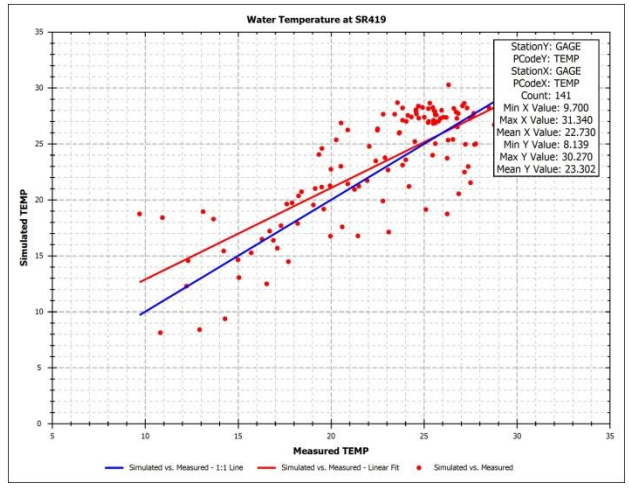


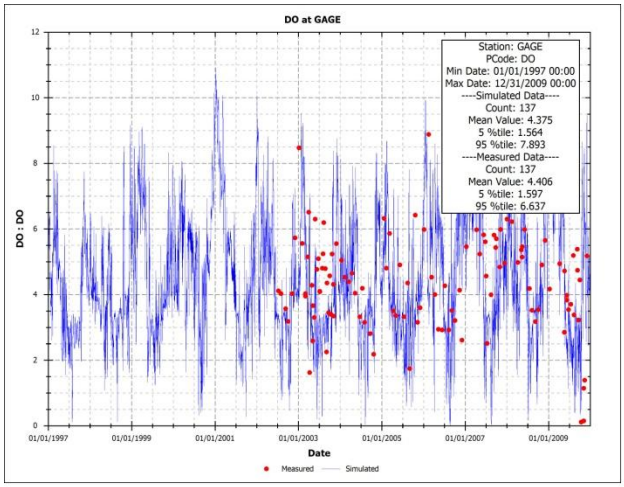
Figure 7. Water Temperature Calibration

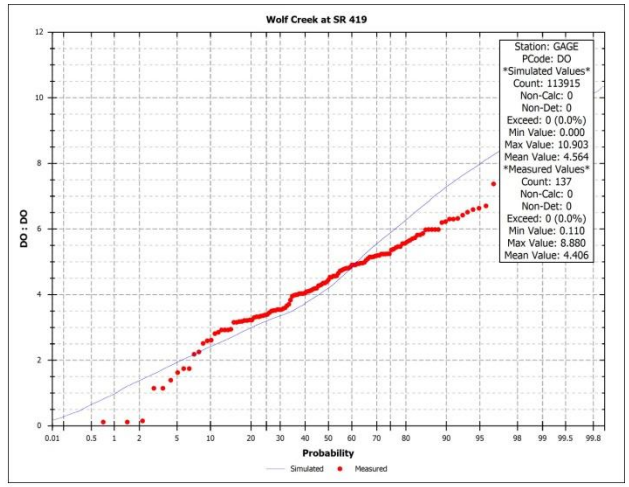
Dissolved Oxygen

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 8 illustrates both a quantitative and qualitative comparison of the predicted dissolved oxygen concentrations compared to the direct measurements.

US EPA ARCHIVE DOCUMENT





Calibration Statistics

Station: GAGE; Parameter: DO

Statistic	Measured	Simulated
Count:	137	137
Mean:	4.406	4.375
Std Dev:	1.567	1.955
Min:	0.110	0.672
Max:	8.880	9.398
5 %tile:	1.597	1.564
10 %tile:	2.606	2.459
90 %tile:	6.236	7.435
95 %tile:	6.637	7.893
Corr (R^2):	0.11	
Mean Abs Error:	1.615	
RMS Error:	2.044	
Norm RMS Error:	0.454	
Index of Agreement:	0.60	

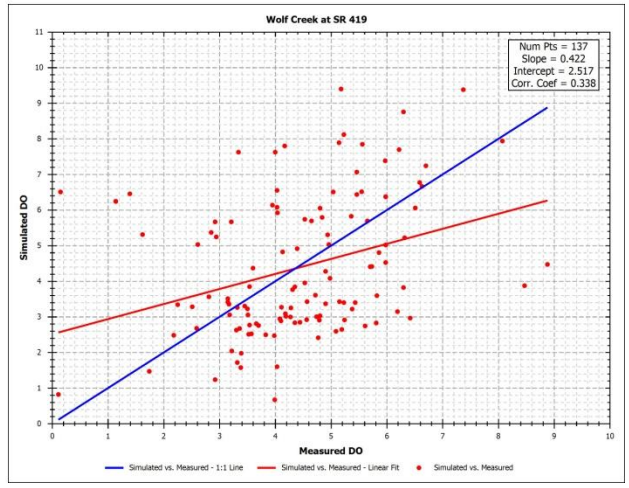


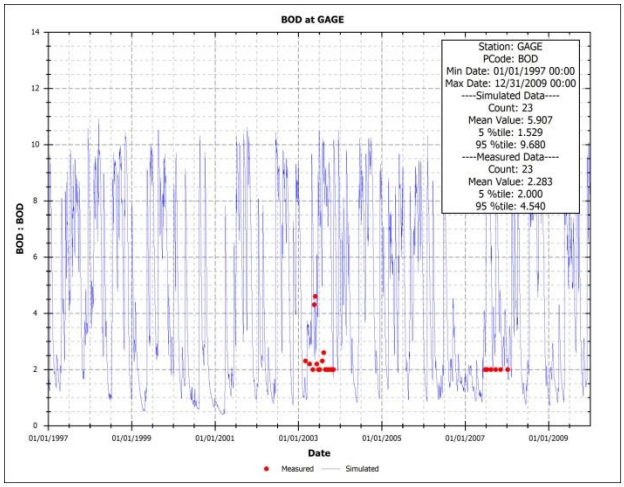
Figure 8. Dissolved Oxygen Calibration

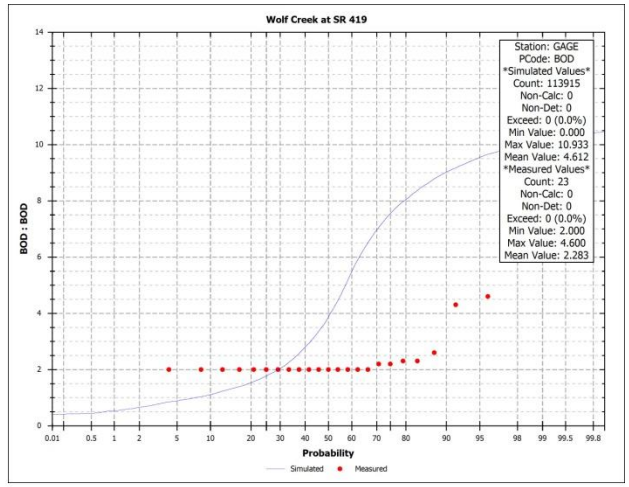
Biochemical Oxygen Demand

There is very little BOD data available for the Wolf Creek WBID. The following presents BOD data that is simulated ultimate BOD versus measured 5-day BOD.

Figure 9 illustrates both a quantitative and qualitative comparison of the predicted dissolved oxygen concentrations compared to the direct measurements.

US EPA ARCHIVE DOCUMENT





Calibration Statistics

Station: GAGE; Parameter: BOD

Statistic	Measured	Simulated
Count:	23	23
Mean:	2.283	5.907
Std Dev:	0.702	2.546
Min:	2.000	1.366
Max:	4.600	9.791
5 %tile:	2.000	1.529
10 %tile:	2.000	2.393
90 %tile:	3.620	9.226
95 %tile:	4.540	9.680
Corr (R^2):	0.07	
Mean Abs Error:	3.843	
RMS Error:	4.548	
Norm RMS Error:	1.259	
Index of Agreement:	0.41	

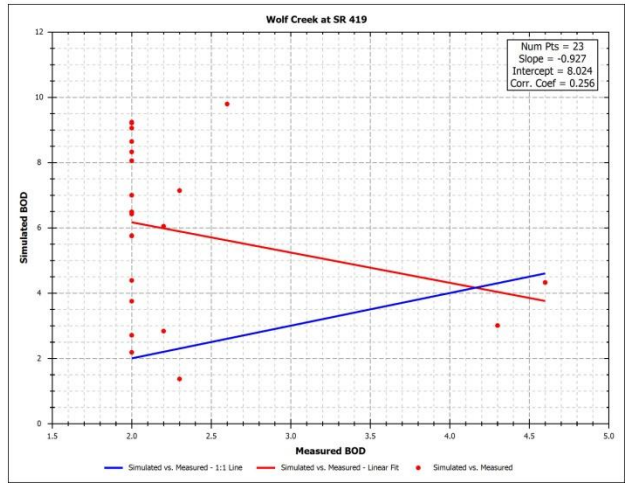


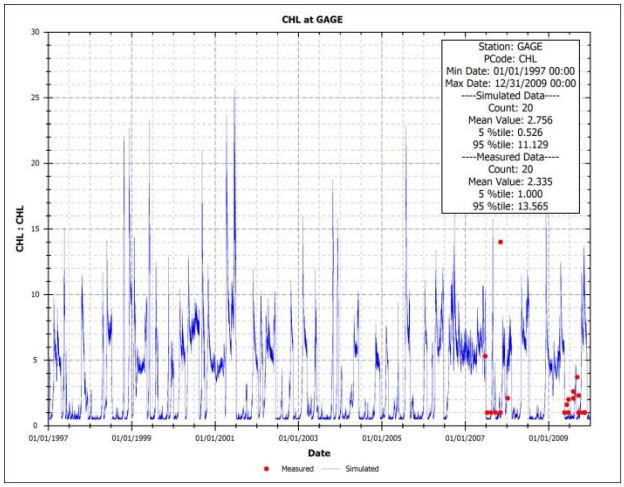
Figure 9. BOD Calibration

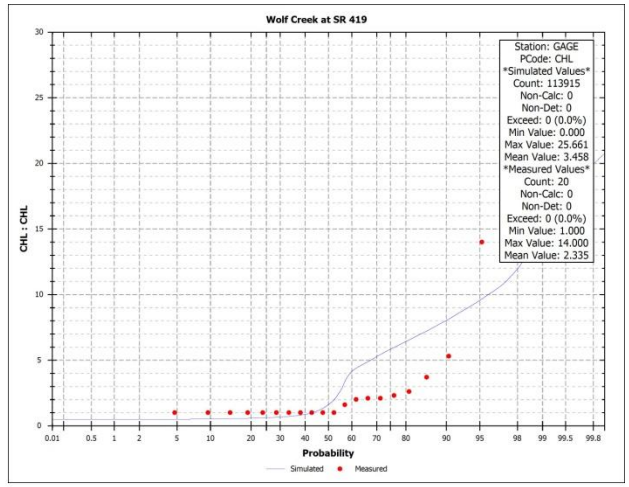
Chlorophyll a

There is minimal corrected chlorophyll-a data available for the Wolf Creek WBID.

Figure 10 illustrates both a quantitative and qualitative comparison of the predicted dissolved oxygen concentrations compared to the direct measurements.

US EPA ARCHIVE DOCUMENT





Calibration Statistics

Station: GAGE; Parameter: CHL

Statistic	Measured	Simulated
Count:	20	20
Mean:	2.335	2.756
Std Dev:	2.966	3.634
Min:	1.000	0.522
Max:	14.000	11.217
5 %tile:	1.000	0.526
10 %tile:	1.000	0.590
90 %tile:	5.140	9.441
95 %tile:	13.565	11.129
Corr (R^2):	0.01	
Mean Abs Error:	2.870	
RMS Error:	4.795	
Norm RMS Error:	2.047	
Index of Agreement:	0.29	

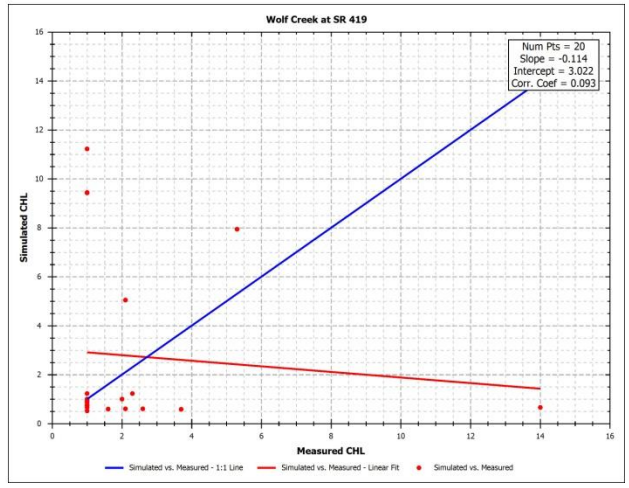
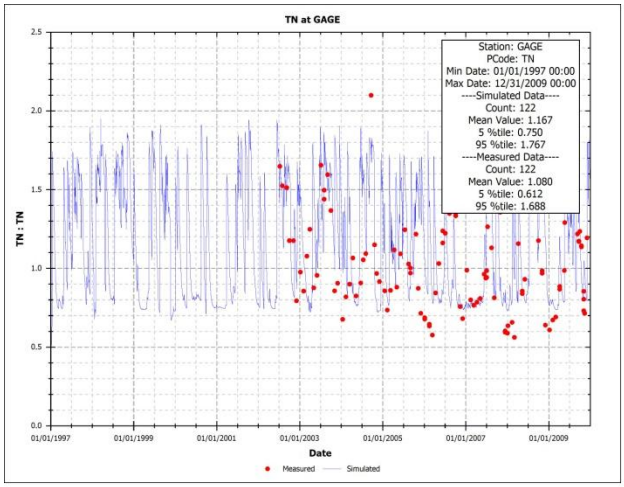


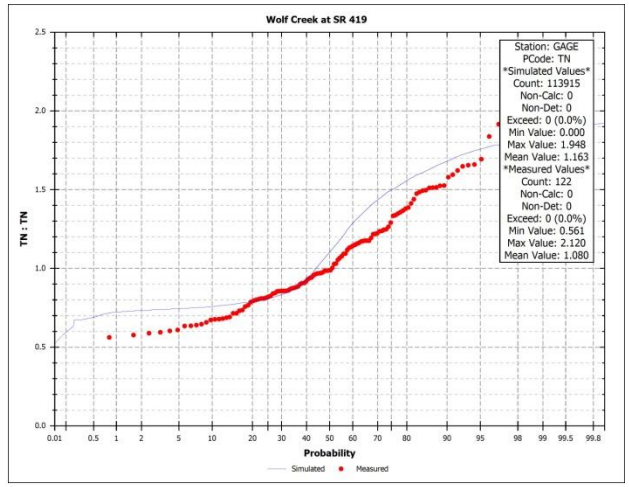
Figure 10 Chlorophyll a Calibration

Nitrogen

Error! Reference source not found. illustrates both a quantitative and qualitative comparison of the model predictions for total nitrogen to direct measurements.

US EPA ARCHIVE DOCUMENT

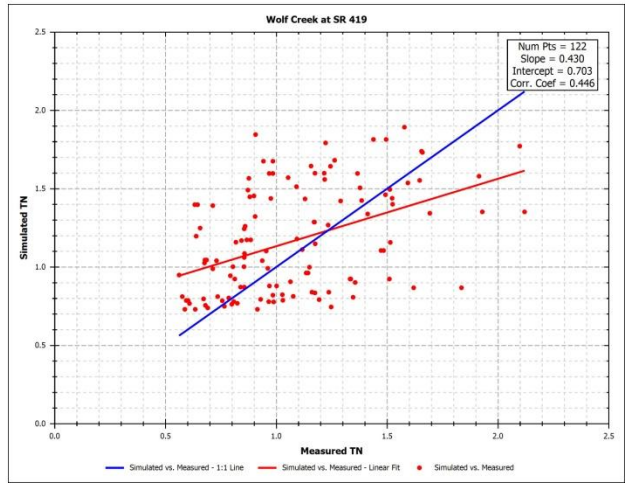




Calibration Statistics

Station: GAGE; Parameter: TN

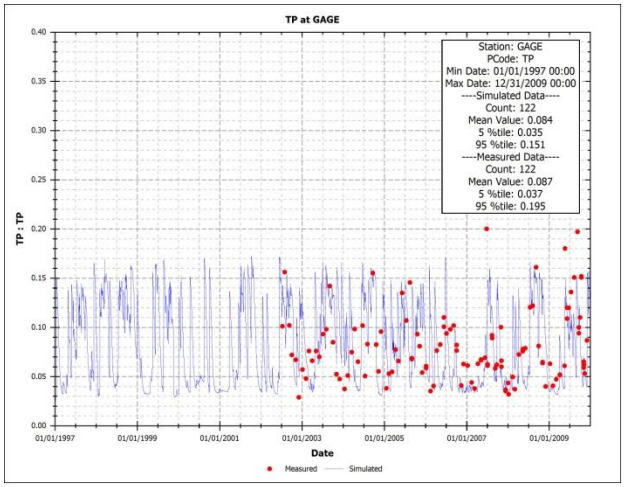
Statistic	Measured	Simulated
Count:	122	122
Mean:	1.080	1.167
Std Dev:	0.348	0.336
Min:	0.561	0.730
Max:	2.120	1.893
5 %tile:	0.612	0.750
10 %tile:	0.673	0.778
90 %tile:	1.562	1.644
95 %tile:	1.688	1.767
Corr (R^2):	0.20	
Mean Abs Error:	0.296	
RMS Error:	0.370	
Norm RMS Error:	0.323	
Index of Agreement:	0.67	

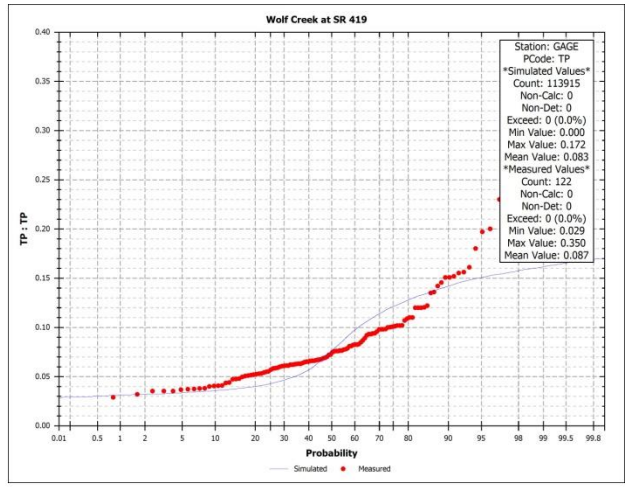


Phosphorus

Figure 11 illustrates both a quantitative and qualitative comparison of the model predictions for total phosphorus to direct measurements.

US EPA ARCHIVE DOCUMENT





Calibration Statistics

Station: GAGE; Parameter: TP

Statistic	Measured	Simulated
Count:	122	122
Mean:	0.087	0.084
Std Dev:	0.049	0.039
Min:	0.029	0.031
Max:	0.350	0.166
5 %tile:	0.037	0.035
10 %tile:	0.040	0.038
90 %tile:	0.151	0.138
95 %tile:	0.195	0.151
Corr (R^2):	0.14	
Mean Abs Error:	0.037	
RMS Error:	0.050	
Norm RMS Error:	0.555	
Index of Agreement:	0.60	

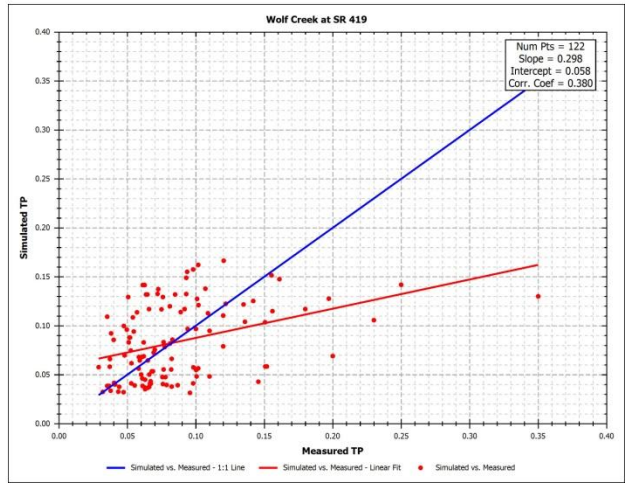


Figure 11. Total Phosphorus Calibration

Current Loads

Table 6 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 are calculated from.

Table 6. Current Loads (1997-2009)

	Current Condition	
Constituent	WLA (kg/yr)	LA (kg/yr)
BOD	NA	58,132
Total Nitrogen	NA	34,062
Total Phosphorus	NA	3,182

US EPA ARCHIVE DOCUMENT

Modeling Scenarios

Using the calibrated watershed and water quality models, up to two potential modeling scenarios will be developed. The first scenario predicts water quality conditions under a natural condition (remove point sources and returning landuses back to upland forests and wetlands). A second scenario is 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 Fort Drum 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 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 (SOD) is reduced based upon the percent reduction in nutrient loads. Existing SOD conditions for Wolf Creek were estimated as 2.5 g O^2/m^2/day. The natural conditions scenario assumed an SOD rate of 40% of the existing conditions value.

Table 7 presents the predicted annual average concentrations under natural conditions. While the annual average DO concentration is 5.62 mg/l, without the impacts of anthropogenic sources, the dissolved oxygen concentration in the Wolf Creek watershed is less than 5 mg/l for 46% of the simulated time period (Figure 12). 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 7 Natural Condition Annual Average Model Predictions

Constituent	Natural
BOD (mg/L)	1.16
Chlorophyll a (ug/L)	2.78
DO (mg/L)	5.62
Total Nitrogen (mg/L)	0.59
Total Phosphorus (mg/L)	0.05

US EPA ARCHIVE DOCUMENT

Table 8 provides the annual average model predictions for total nitrogen, total phosphorus, and BOD loading under a natural condition.

Table 8 Annual Average Loadings for Natural Condition

	Natural Condition	
Constituent	WLA (kg/yr)	LA (kg/yr)
BOD	NA	34,230
Total Nitrogen	NA	18,714
Total Phosphorus	NA	886

Figure 12 shows the probability distribution for dissolved oxygen concentration in Wolf Creek under current and the natural condition scenario.

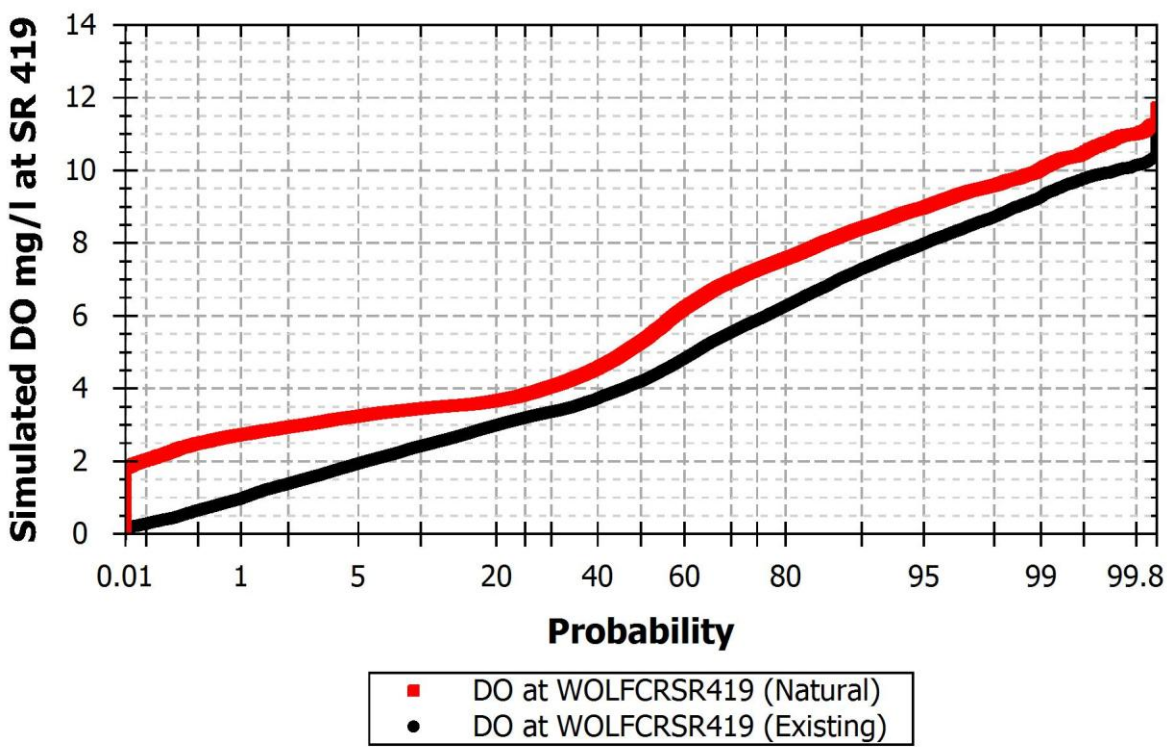


Figure 12 Dissolved Oxygen Concentration Probability Current vs. Natural Condition

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.

US EPA ARCHIVE DOCUMENT

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 9 along with the prescribed load reductions.

Table 9 TMDL Determination

	Current Condition		TMDL Condition		MS4	LA
Constituent	WLA (kg/yr)	LA (kg/yr)	WLA (kg/yr)	LA (kg/yr)	% Reduction	% Reduction
BOD	NA	58,132	NA	34,230	NA	41%
Total Nitrogen	NA	34,062	NA	18,714	NA	45%
Total Phosphorus	NA	3,182	NA	886	NA	72%

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

US EPA ARCHIVE DOCUMENT