

US EPA ARCHIVE DOCUMENT

Appendix A:

Modeling Report

St. Johns River above Lake George

WBID: 2893Z

Nutrients and Dissolved Oxygen

September 30, 2009



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1. Watershed Description

The St. Johns River above Lake George is the segment just upstream of entering Lake George. It is located in the very northeast corner of Lake County and about ¼ of the WBID is in Volusia County

St. Johns River above Lake George is in the St Johns River Watershed area. WBID 2893Z were listed as not attaining its designated uses on Florida's 1998 303(d) list for Nutrients and Dissolved Oxygen. Figure 1 provides the location of St. Johns River above Lake George.

Location Map



Figure 1 Location Map St. Johns River above Lake George

2. TMDL Targets

The TMDL target to be evaluated in this modeling report is to meet the St. Johns River above Lake George dissolved oxygen standard of 5 mg/l..

3. Modeling Approach

A water quality modeling framework was used to simulate biological oxygen demand (BOD), nutrients (total nitrogen and total phosphorus), and chlorophyll a (Chla) and dissolved oxygen dissolved oxygen for the time period of 2002 through 2008. The receiving waterbody model was Water Quality Analysis Simulation Program (WASP 7.3) (USEPA, 2007). The WASP model integrates the USGS measured flows and the measured water quality concentrations to simulate water quality responses in: nitrogen, phosphorus, chlorophyll a and dissolved oxygen. 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.

3.1. Meteorological

Pertinent meteorological data was obtained from the National Weather Service (NWS) WBAN station number 2838: Melbourne International Airport near Melbourne, Florida.

Figure 2 provides a time series plot of daily rainfall for the simulation period.

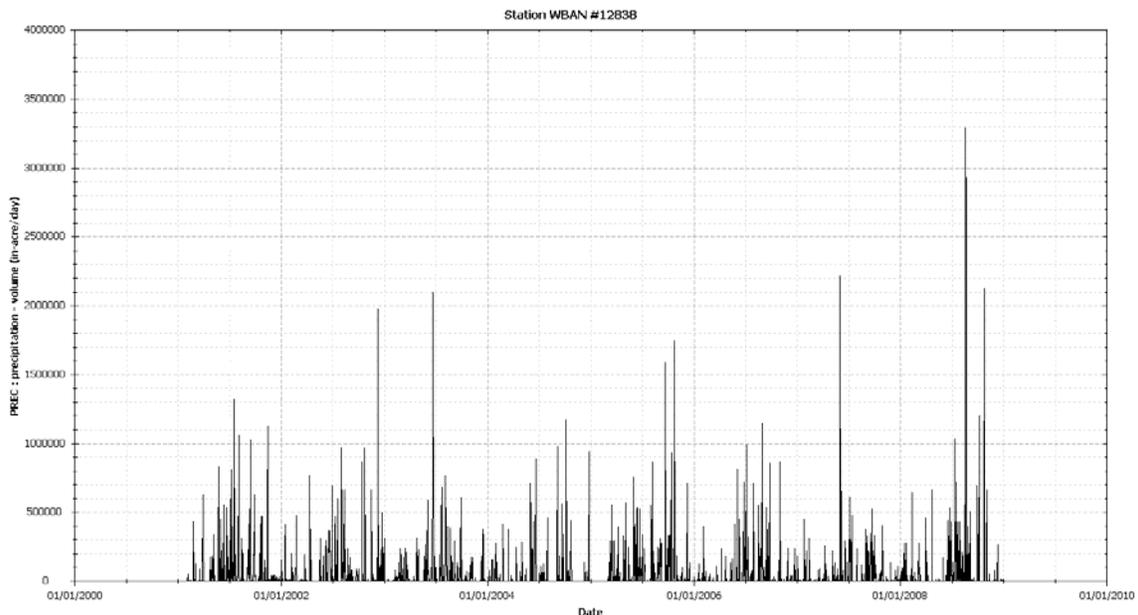


Figure 2 Rainfall for St. Johns River above Lake George and Watershed

Table 1 shows the annual average rainfall for each of the years simulated.

Table 1 Annual Rainfall

Year	Rainfall (Inches)
2002	42
2002	51
2003	43
2004	34
2005	55
2006	40
2007	38
2008	70

3.1.1. Flow

Flows were taken directly from the St. Johns River above Lake George USGS gage (USGS 02236125).

3.1.2. BOD and Nutrient Loadings

The water quality input concentrations were taken directly from 21FLSJRWMSJR40 and 21FLGW3515 Station. The nutrient loads in Table 2 were calculated by taking the average concentration times the USGS flow.

Table 2 St. Johns River above Lake George & Nutrient Loads (2002-2008)

Subbasin	Total Nitrogen Load (kg/yr)	Total Phosphorus Load (kg/yr)	BOD Load (kg/yr)
Watershed above St. Johns River above Lake George including WBID 2893Z	4,212,961	241,626	9,293,296

3.2. St. Johns River above Lake George Water Quality Model

The St. Johns River above Lake George WASP water quality model integrates the measured flows and concentrations from the collected data to simulate water quality responses in: nitrogen, phosphorus, chlorophyll a and dissolved oxygen. A 4 segment WASP water quality model was set up to model the Lake

3.2.1. WASP Model

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. Table 3 provides the basic kinetic rates used in the model.

Table 3 WASP Kinetic Rates

WASP Kinetic Parameters	Value
Global Reaeration Rate Constant @ 20 °C (per day)	0.25
Sediment Oxygen Demand (g/m2/day)	2.5 for Large River Segments
Phytoplankton Maximum Growth Rate Constant @20 °C (per day)	1.75
Phytoplankton Carbon to Chlorophyll Ratio	75
BOD (1) Decay Rate Constant @20 °C (per day)	0.06
Ammonia, nitrate, phosphorus rates @20 °C (per day)	0.05 to 0.1

The St. Johns River above Lake George WASP model DO and Chla predictions were compared to St. Johns River above Lake George water quality data station 21FLSJRWMLPI.

Table 4 provides the annual average calibration summary of the comparison between the WASP St. Johns River above Lake George segment and the St. Johns River above Lake George Station for total nitrogen, total phosphorus, chlorophyll a and dissolved oxygen. Figure 3 to Figure 6 illustrates the comparisons of model results and data at the same location.

Table 4 Model Calibration Summary

St. Johns River above Lake George 21FLSJWMJGS	2002–2008 Data Average	2002-2008 Model Average
Total Nitrogen (mg/l)	1.36	1.4
Total Phosphorus (mg/l)	0.078	0.8
Average DO (mg/l)	5.5	5.7
Chla (ug/l)	10.5	10.3
Flow (cms)	98	98

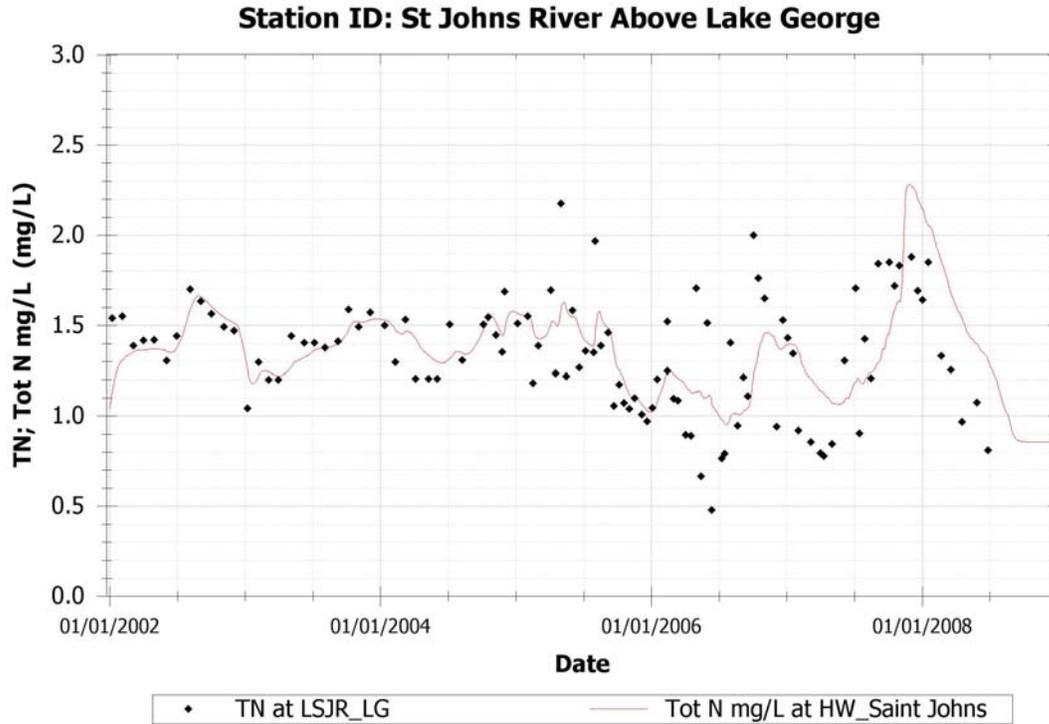


Figure 3 WASP Calibration for Total Nitrogen in St. Johns River above Lake George

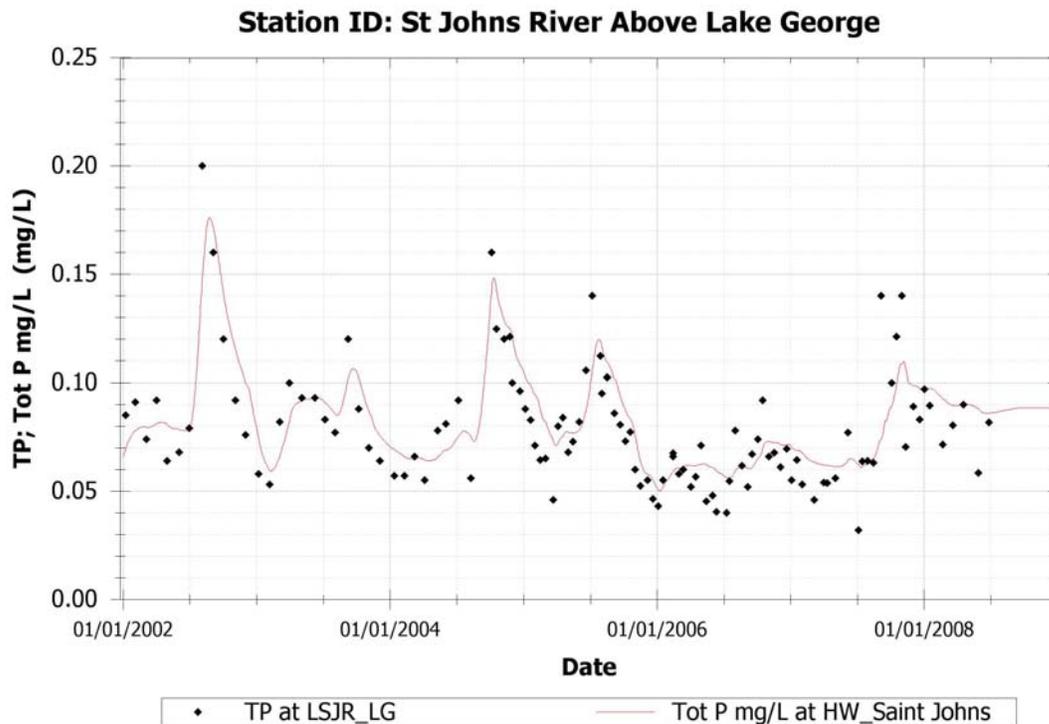


Figure 4 WASP Calibration for Total Phosphorus in St. Johns River above Lake George

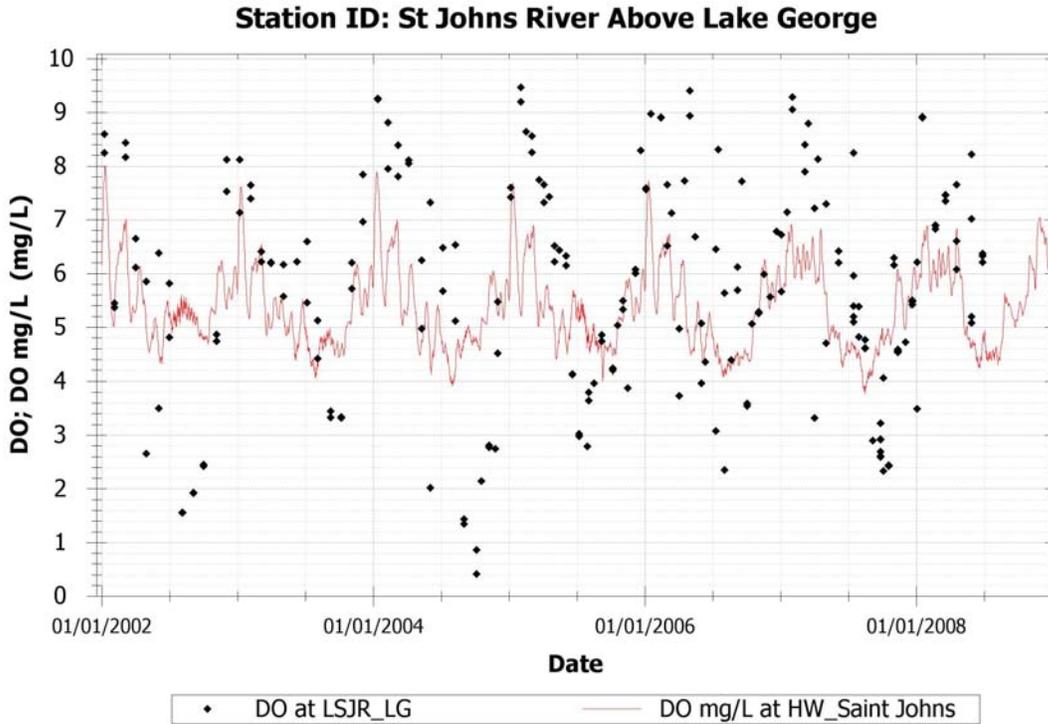


Figure 5 WASP Calibration for Dissolved Oxygen in St. Johns River above Lake George

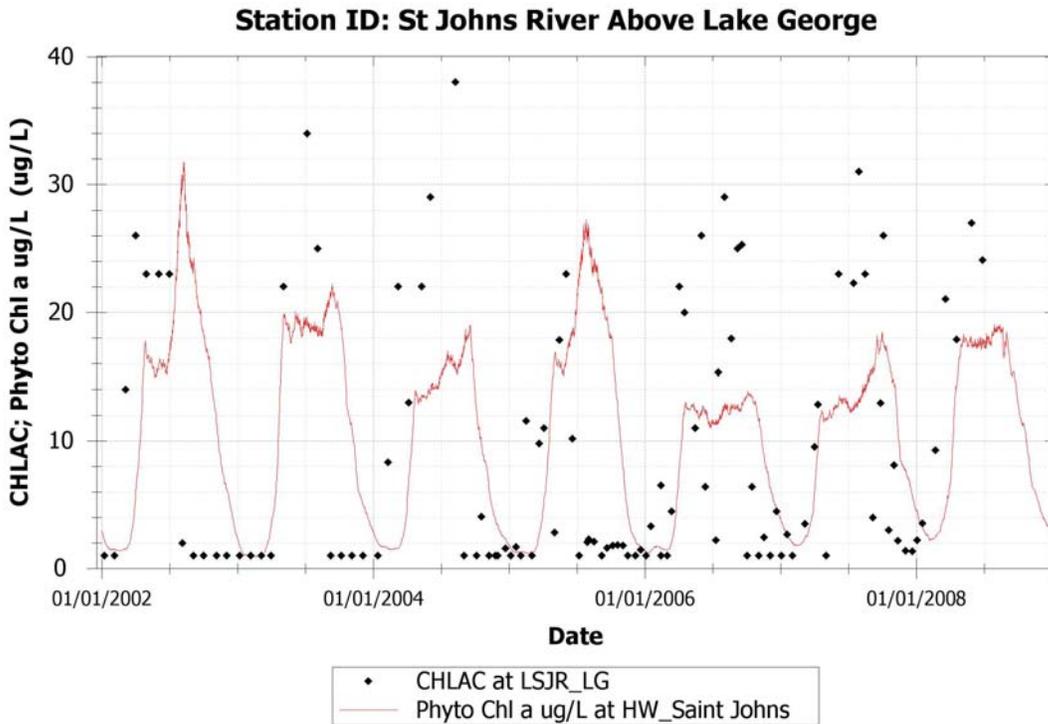


Figure 6 WASP Calibration for Total Nitrogen in St. Johns River above Lake George

Table 5 presents the annual average predictions for BOD, total nitrogen, total phosphorus and dissolved oxygen.

Table 5 Existing Condition Annual Average Model Predictions

St. Johns River above Lake George @ 21FLSJWMJGS	2002-2008 Model Prediction Annual Average
BOD (mg/l)	3
Total Nitrogen (mg/l)	1.4
Total Phosphorus (mg/l)	0.08
DO avg (mg/l)	5.7
DO min (mg/l)	3.5
<i>Chla</i> (ug/l)	10.3

4. Model Scenarios

To determine the appropriate reductions in load to achieve the applicable water quality standards two scenarios were simulated. The scenarios investigate the natural conditions (no man-made loadings) and a 50% reduction in nutrient and BOD loadings.

4.1. St. Johns River above Lake George Watershed Natural Condition Analysis

St. Johns River above Lake George nutrient loads was calculated from estimated natural BOD, TN and TP concentrations. Table 6 provides the natural loads and Table 9 provides the natural annual average model predictions for total nitrogen, total phosphorus, chlorophyll a, dissolved oxygen.

Table 6 Natural Condition Annual Average Nutrient Loads

Subbasin	Total Nitrogen Load (kg/yr)	Total Phosphorus Load (kg/yr)	BOD Load (kg/yr)
St. Johns River above Lake George Watershed	2,478,212	108,422	3,717,318

Table 7 presents the predicted annual average concentrations under natural conditions. Without the impacts of anthropogenic sources the dissolved oxygen concentration in the St. Johns River above Lake George and would achieve the dissolved oxygen standard of 5 mg/l.

Table 7 Natural Condition Annual Average Model Predictions

St. Johns River above	2002-2008 Model
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Lake George	Prediction Annual Average
BOD (mg/l)	1.2
Total Nitrogen (mg/l)	0.8
Total Phosphorus (mg/l)	0.035
DO avg (mg/l)	7.2
DO minimum (mg/l)	5.8
<i>Chla</i> (ug/l)	6

4.2. TMDL Reduction

The TMDL load reduction was set to the fifty percent reduction scenario. The waterbodies can meet the dissolved oxygen standard under natural conditions; there is assimilative capacity for oxygen demanding materials. The fifty percent reduction concentrations, load and corresponding percent reductions are in Table 8 and Table 9.

Table 8 Fifty Percent Reduction Scenario

St. Johns River above Lake George	2002-2008 Model Prediction Annual Average
BOD (mg/l)	1.5
Total Nitrogen (mg/l)	0.8
Total Phosphorus (mg/l)	0.039
DO avg (mg/l)	6.5
DO minimum (mg/l)	5.0
<i>Chla</i> (ug/l)	7.5

Table 9 TMDL 50% Percent Reduction Scenario

St. Johns River above Lake George Watershed	Total Nitrogen Load (kg/yr)	Total Phosphorus Load (kg/yr)	BOD Load (kg/yr)
Existing	4,212,961	241,626	9,293,296
Fifty Percent Reduction	2,478,212	120,813	4,646,648
Percent Reduction	41%	50%	50%