Water Quality Modeling Report
In
Owens Branch (WBID 1675)

September, 2009

Prepared By:

1 Introduction

Owens Branch (WBID 1675), a tributary to the Alafaya River, is located in the southwest portion of Florida near the City of Tampa. It is an undeveloped watershed (73 percent) with development sparsely scattered throughout. There are no point sources that discharge to this WBID.

The water quality simulation model, WASP7, was used to analyze the Owens Branch watershed (WBID 1675). WASP7 was selected because it is part of EPA's tool box, can represent the basic processes determined to be important in this analysis, has a proven track record, and evaluates the effects of seasonality. The initial model setup was performed in a GIS platform. Literature reviewed event mean concentrations (EMCs) were looked at as a potential way to set boundary conditions. After looking at this, it was determined that the boundaries would be better to set to the mean concentration of the data.

Owens Branch has a very limited dataset. As such, an approach had to be developed which recognized this situation and still produced a defensible product.

2 Data Review

Data for the WBID were observed in three of six segments, at a total of eight stations.

2.1 WATER TEMPERATURE

Three of the six segments in Owens Branch have measured water temperature data. Water temperature observations at these station was made in approximately monthly intervals. Segment 6 has the greatest amount of records, with data being collected at four different stations over a four-year period. Segments 4 and 6 both have observations in 2005 and 2008, with the greatest amount of observations made in 2005. The time series from these observation locations are presented in Figures 1through 3.

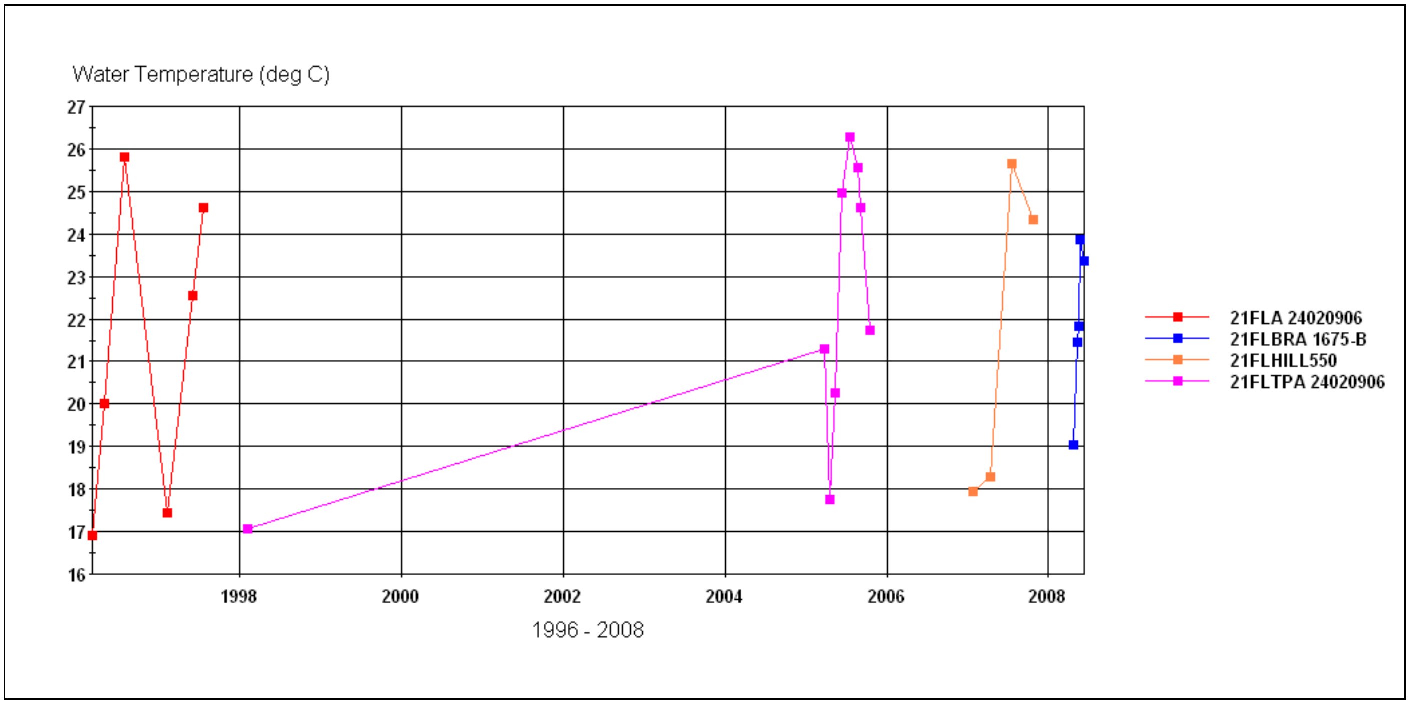


Figure 1. Water Temperature Observations in Owens Branch Segment 2 (WBID 1675).

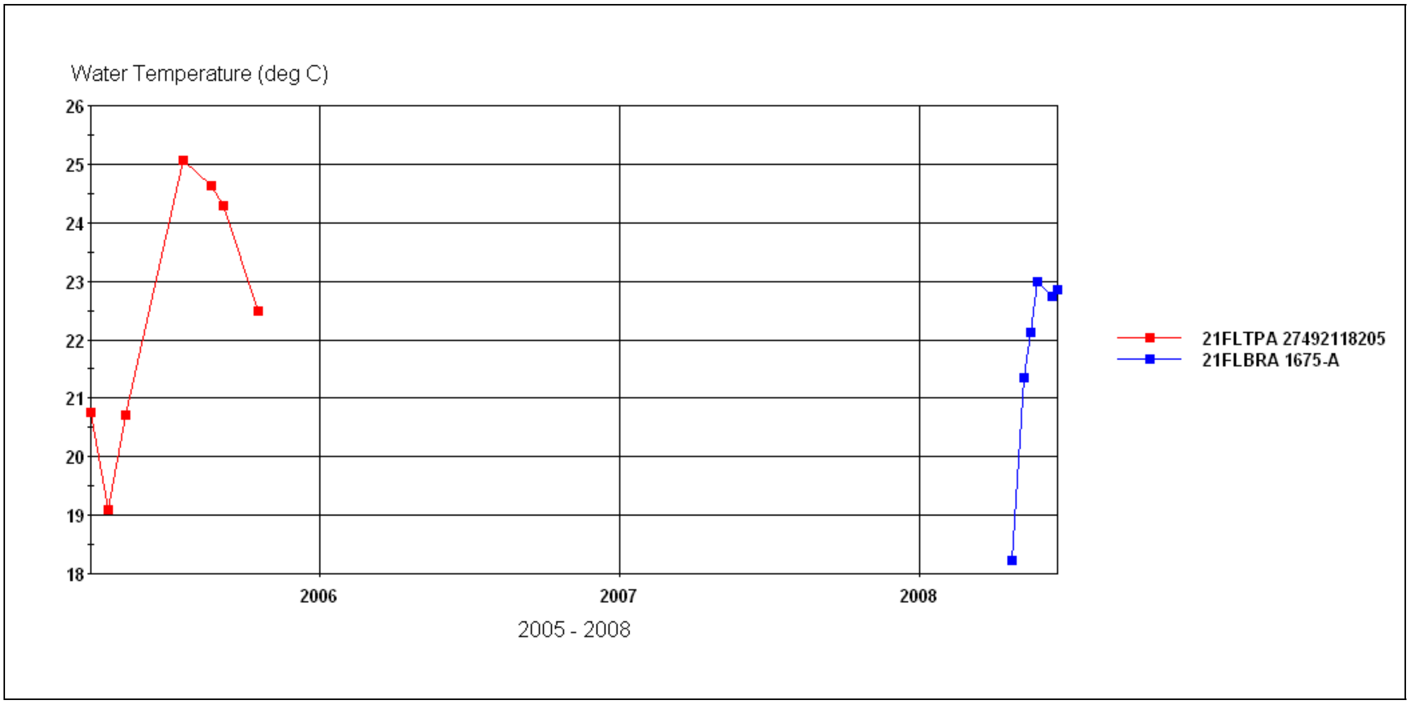


Figure 2. Water Temperature Observations in Owens Branch Segment 4 (WBID 1675).

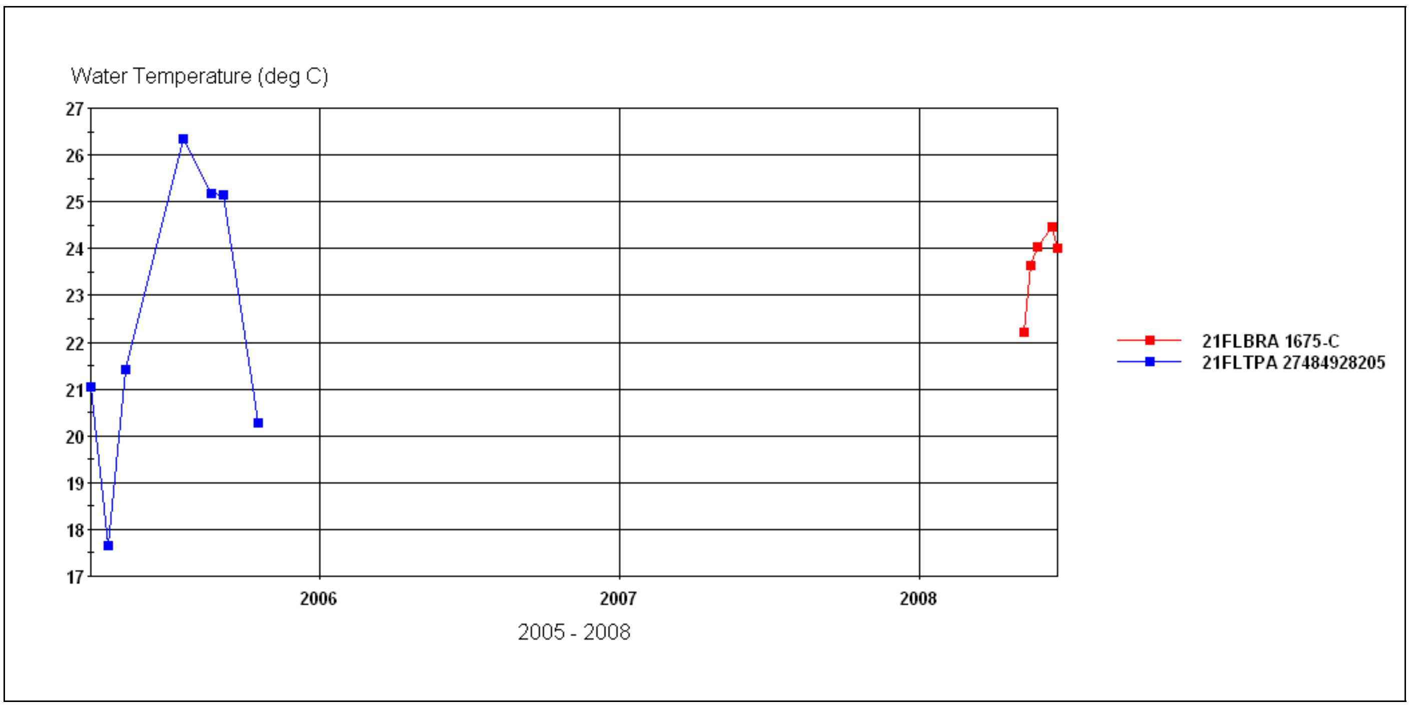


Figure 3. Water Temperature Observations in Owens Branch Segment 6 (WBID 1675).

2.2 DISSOLVED OXYGEN

Dissolved oxygen was observed in segments 2, 4, and 6. Segment 2 has the data collected at four stations, the greatest amount of records coming in 2005. The other two segments have data in 2005 and 2008, again with the best data set in 2005. Segments 4 and 6 have the lowest measurements of the three. The observations are presented in Figures 4 through 6.

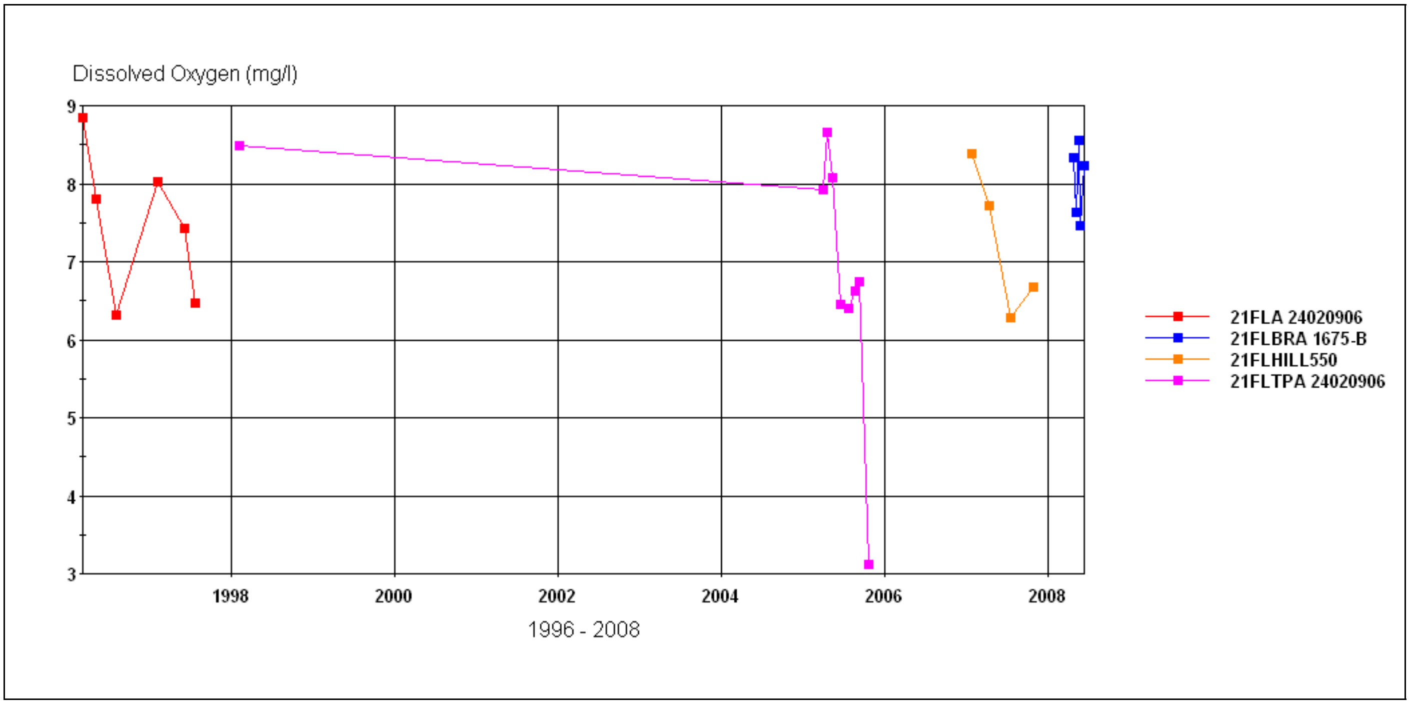


Figure 4. Dissolved Oxygen Observations in Owens Branch Segment 2 (WBID 1675).

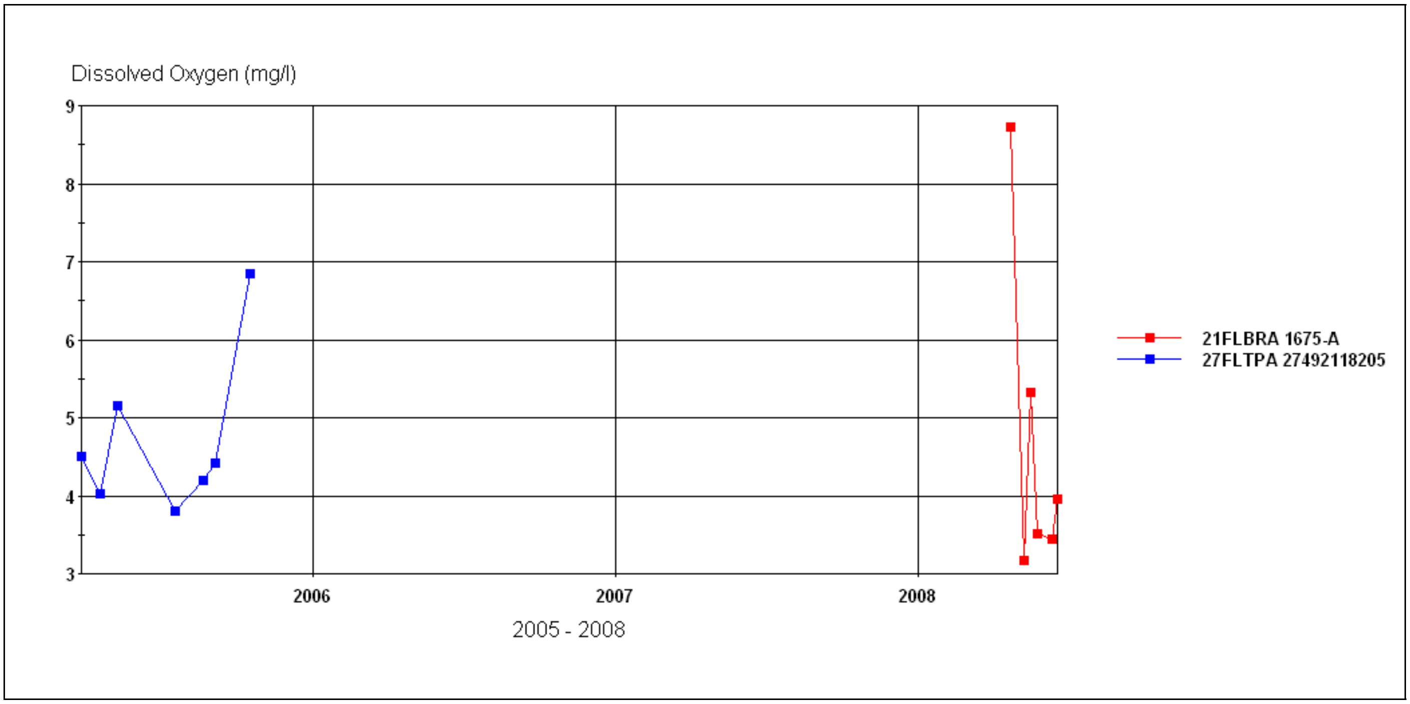


Figure 5. Dissolved Oxygen Observations in Owens Branch Segment 4 (WBID 1675).

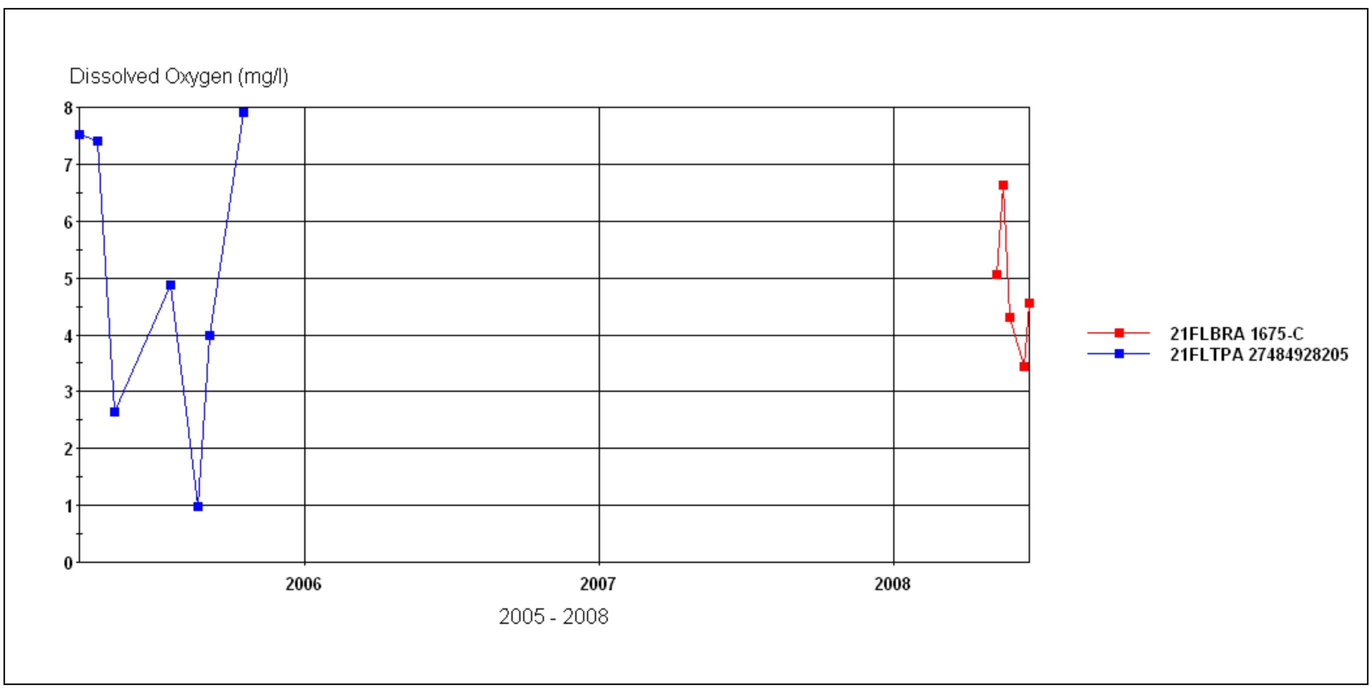


Figure 6. Dissolved Oxygen Observations in Owens Branch Segment 6 (WBID 1675).

2.3 Biochemical Oxygen Demand

Very little biochemical oxygen demand data were collected in WBID 1675. All data were collected in 1996 and 1997 (five observations), with all results being at or below the detection limit.

2.4 Nutrients

Total nitrogen, total phosphorus, and a number of their individual water quality species were collected at several stations. All of the data were collected in 2005 only, so this data will be shown in the water quality calibration plots later in this report.

3 Model Development

EPA Water Quality Simulation Analysis Program (WASP7) was used in the development of the Owens Branch Nutrient TMDL.

3.1 Model Segmentation

Model inputs needed to be developed for the WASP7 model, namely the segmentation and boundary conditions. The segments were developed using the National Hydrography Dataset (NHD), National Elevation Dataset (NED), and watershed boundary. Flows were developed by obtaining flow data from a nearby USGS gage, and then area weighting the drainage area of each segment to determine a representative flow. Each segment contained the following information:

- Segment Name
- Segment Number
- Length (m)
- Width (m)
- Depth Multiplier
- Velocity Multiplier
- Slope (m/m)
- Mannings Roughness

There were a total of six segments for Owens Branch. A schematic of the WASP7 model network is shown in Figure 7.

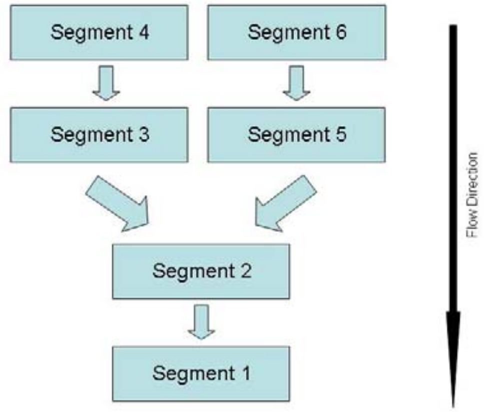


Figure 7. WASP7 Model Segment Schematic for Owens Branch.

3.2 Boundary Condition Development

Boundary conditions for nutrient concentrations were developed by land use area weighting published event mean concentrations (EMCs) to each particular segment. Data was very limited, and the event mean concentrations were sometimes much too high or too low, so it was determined that the boundaries should be set to the mean observations of the data for each water quality constituent for each individual segment. The concentrations used in each segment for each water quality constituent are defined in Tables 1 through 8.

Table 1. CBODu Concentrations for each WASP7 segment.

Segment	Segment Drainage Area (m^2)	Area Weight Factor	Concentration (mg/l)
1	293920	0.05	12
2	552212	0.09	12
3	1564609	0.25	12
4	1753081	0.28	12
5	580075	0.09	12
6	1490959	0.24	12

Table 2 Chlorophyll a Concentrations for each WASP7 segment.

Segment	Segment Drainage Area (m^2)	Area Weight Factor	Concentration (ug/l)
1	293920	0.05	2
2	552212	0.09	2
3	1564609	0.25	4
4	1753081	0.28	5
5	580075	0.09	1
6	1490959	0.24	1

Table 3. Ammonia Concentrations for each WASP7 segment.

Segment	Segment Drainage Area (m^2)	Area Weight Factor	Concentration (mg/l)
1	293920	0.05	0.047
2	552212	0.09	0.047
3	1564609	0.25	0.010
4	1753081	0.28	0.010
5	580075	0.09	0.054
6	1490959	0.24	0.054

Table 5. Nitrate Concentrations for each WASP7 segment.

Segment	Segment Drainage Area (m^2)	Area Weight Factor	Concentration (mg/l)
1	293920	0.05	1.670
2	552212	0.09	1.670
3	1564609	0.25	0.017
4	1753081	0.28	0.017
5	580075	0.09	0.075
6	1490959	0.24	0.075

Table 6. Organic Nitrogen Concentrations for each WASP7 segment.

Segment	Segment Drainage Area (m^2)	Area Weight Factor	Concentration (mg/l)
1	293920	0.05	0.848
2	552212	0.09	0.848
3	1564609	0.25	0.697
4	1753081	0.28	0.697
5	580075	0.09	1.707
6	1490959	0.24	1.707

Table 7. Orthophosphate Concentrations for each WASP7 segment.

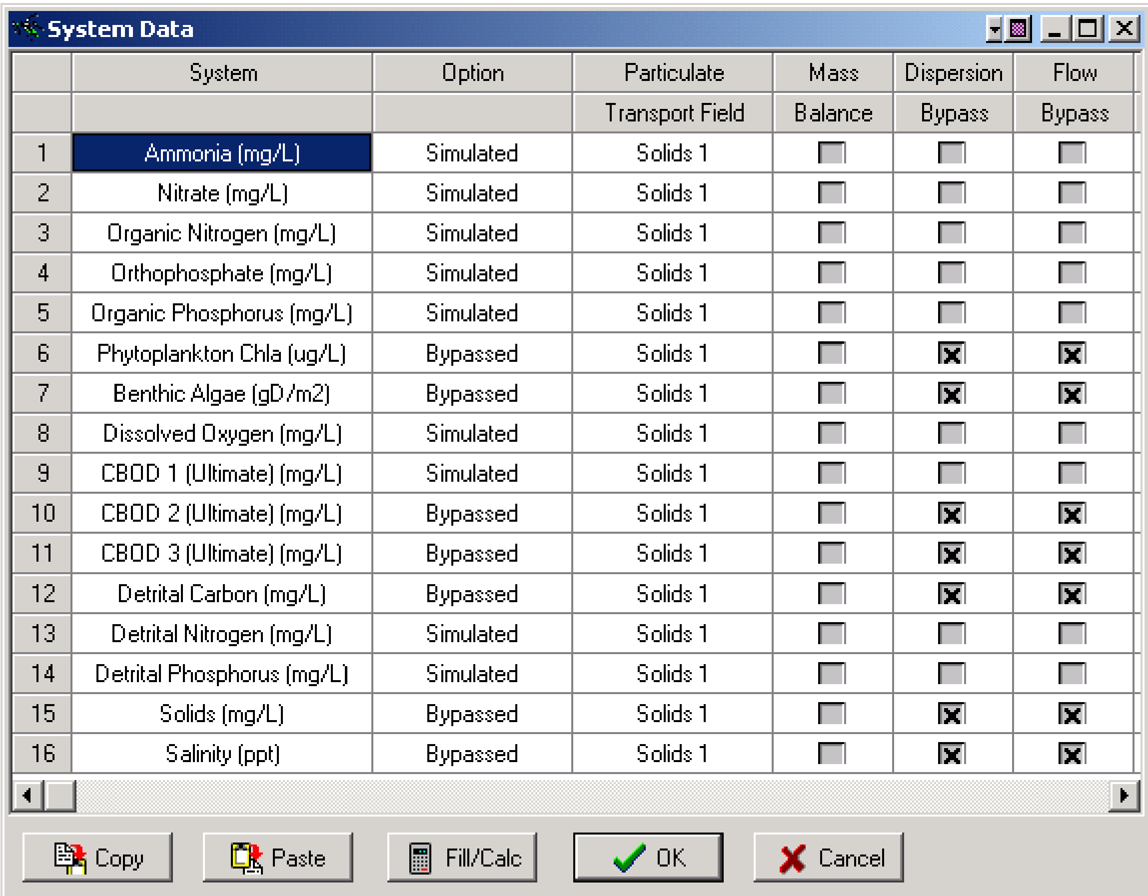
Segment	Segment Drainage Area (m^2)	Area Weight Factor	Concentration (mg/l)
1	293920	0.05	0.612
2	552212	0.09	0.612
3	1564609	0.25	0.651
4	1753081	0.28	0.651
5	580075	0.09	0.901
6	1490959	0.24	0.901

Table 8. Organic Phosphorus Concentrations for each WASP7 segment.

Segment	Segment Drainage Area (m^2)	Area Weight Factor	Concentration (mg/l)
1	293920	0.05	0.061
2	552212	0.09	0.061
3	1564609	0.25	0.122
4	1753081	0.28	0.122
5	580075	0.09	0.928
6	1490959	0.24	0.928

3.3 WASP7 Systems

WASP7 has a suite of options regarding the degree of complexity and constituent interactions. Figure 8 presents the 16 systems in WASP7 and indicates which systems are used in this application. A limited number of systems were selected to simplify the approach, yet still capture the importance of the dominant processes.

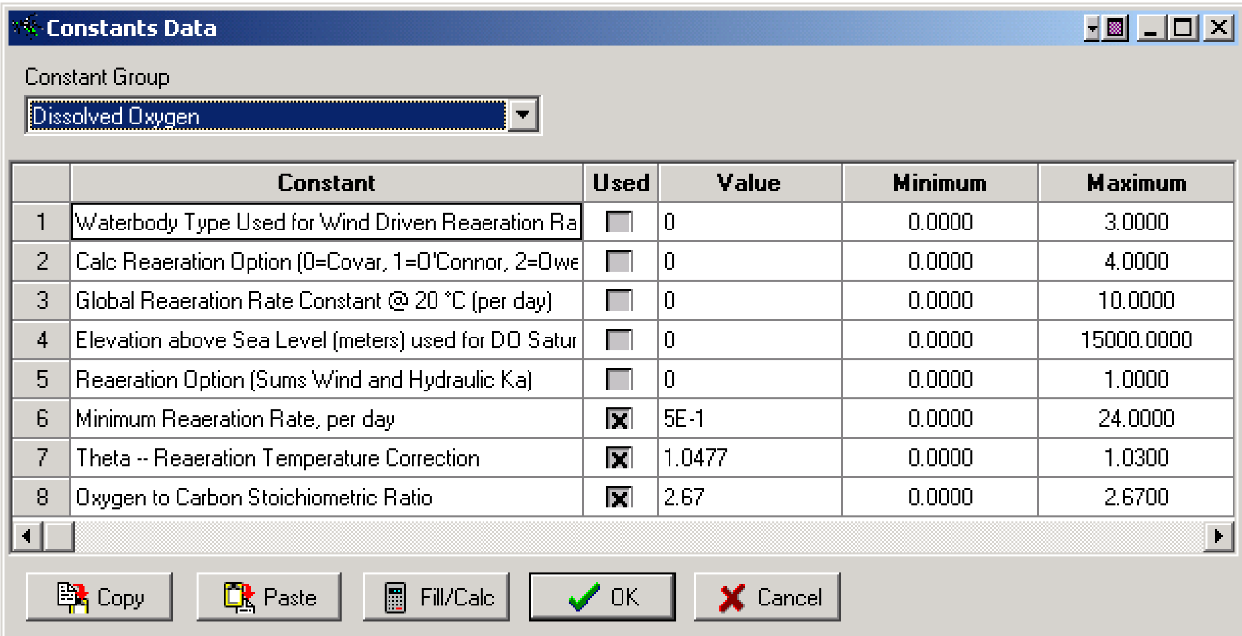


	System	Option	Particulate Transport Field	Mass Balance	Dispersion Bypass	Flow Bypass
1	Ammonia (mg/L)	Simulated	Solids 1			
2	Nitrate (mg/L)	Simulated	Solids 1			
3	Organic Nitrogen (mg/L)	Simulated	Solids 1			
4	Orthophosphate (mg/L)	Simulated	Solids 1			
5	Organic Phosphorus (mg/L)	Simulated	Solids 1			
6	Phytoplankton Chla (ug/L)	Bypassed	Solids 1		X	X
7	Benthic Algae (gD/m2)	Bypassed	Solids 1		X	X
8	Dissolved Oxygen (mg/L)	Simulated	Solids 1			
9	CBOD 1 (Ultimate) (mg/L)	Simulated	Solids 1			
10	CBOD 2 (Ultimate) (mg/L)	Bypassed	Solids 1		X	X
11	CBOD 3 (Ultimate) (mg/L)	Bypassed	Solids 1		X	X
12	Detrital Carbon (mg/L)	Bypassed	Solids 1		X	X
13	Detrital Nitrogen (mg/L)	Simulated	Solids 1			
14	Detrital Phosphorus (mg/L)	Simulated	Solids 1			
15	Solids (mg/L)	Bypassed	Solids 1		X	X
16	Salinity (ppt)	Bypassed	Solids 1		X	X

Figure 8. WASP7 Systems.

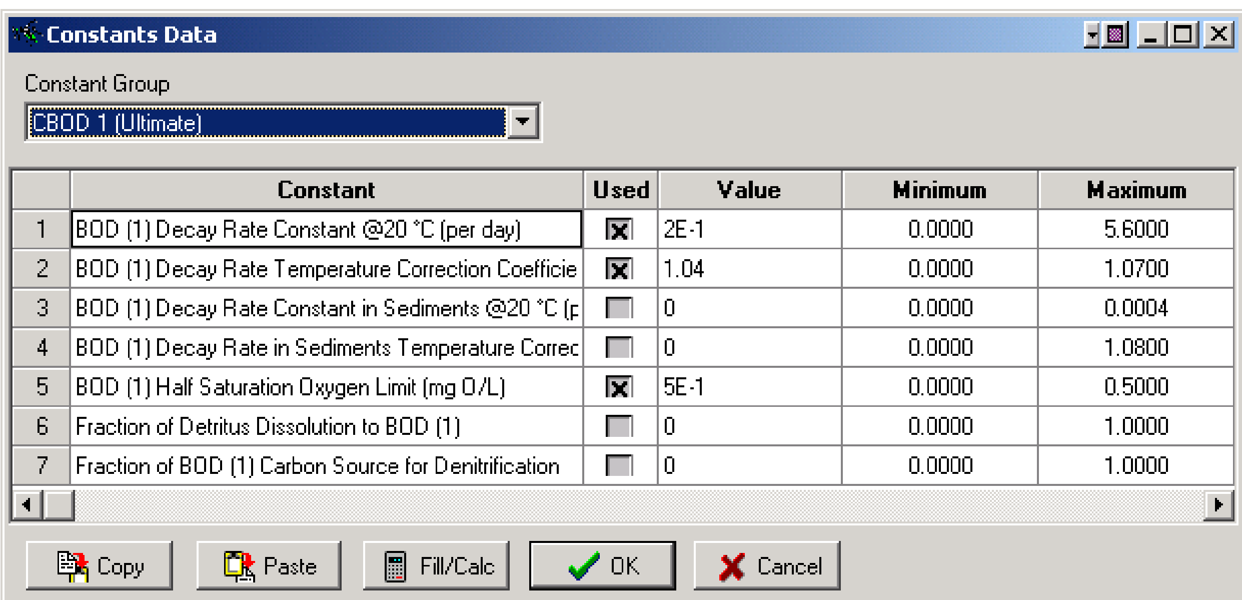
3.4 CONSTANTS

Constants were selected for the systems simulated in this application. The constants were developed from literature review and are presented in Figures 9 through 15.



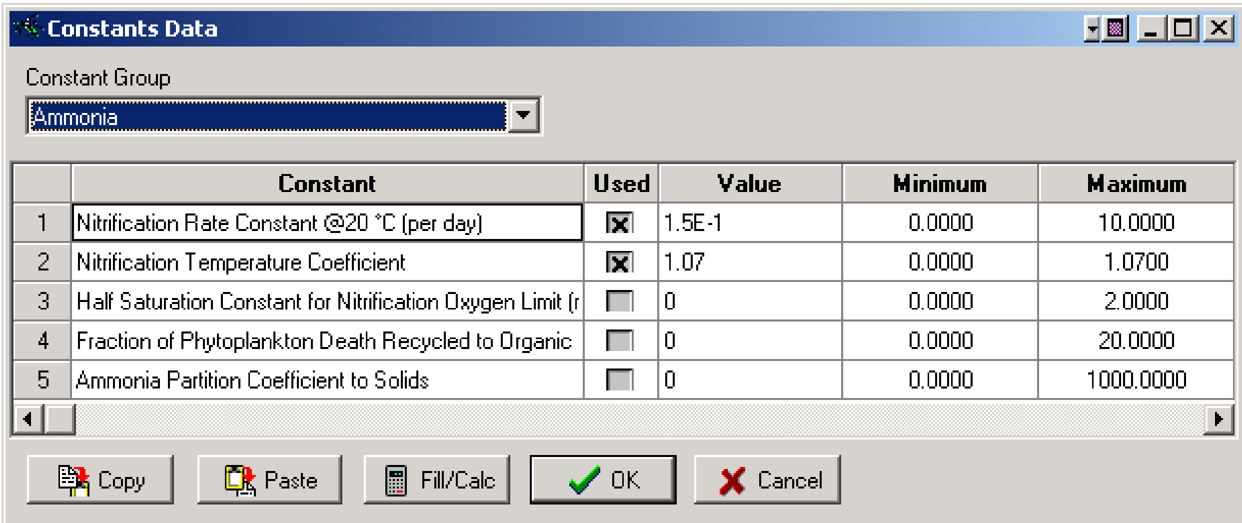
	Constant	Used	Value	Minimum	Maximum
1	Waterbody Type Used for Wind Driven Reaeration Ra		0	0.0000	3.0000
2	Calc Reaeration Option (0=Covar, 1=O'Connor, 2=Owe		0	0.0000	4.0000
3	Global Reaeration Rate Constant @ 20 °C (per day)		0	0.0000	10.0000
4	Elevation above Sea Level (meters) used for DO Satur		0	0.0000	15000.0000
5	Reaeration Option (Sums Wind and Hydraulic Ka)		0	0.0000	1.0000
6	Minimum Reaeration Rate, per day	X	5E-1	0.0000	24.0000
7	Theta -- Reaeration Temperature Correction	X	1.0477	0.0000	1.0300
8	Oxygen to Carbon Stoichiometric Ratio	X	2.67	0.0000	2.6700

Figure 9. Dissolved Oxygen Constants for WASP7.



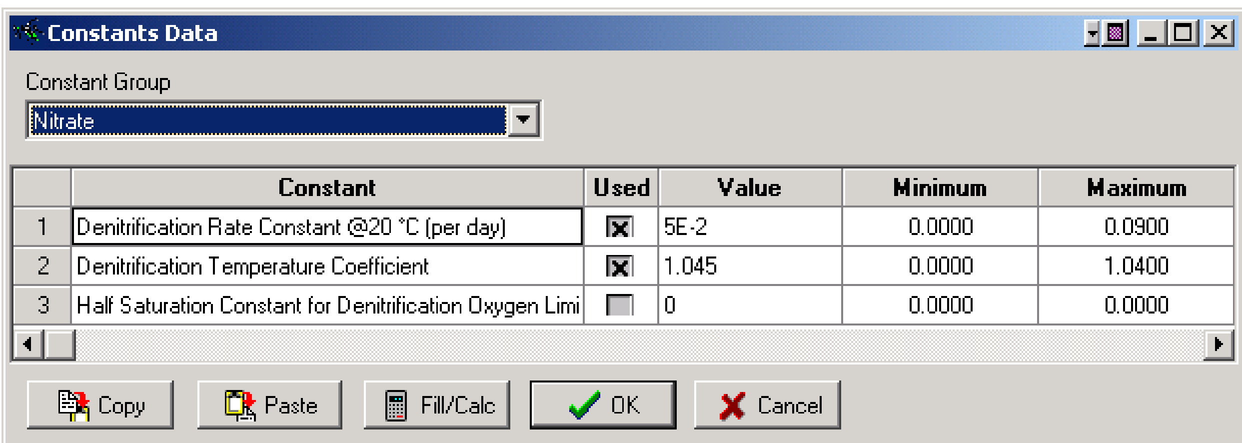
	Constant	Used	Value	Minimum	Maximum
1	BOD (1) Decay Rate Constant @20 °C (per day)	X	2E-1	0.0000	5.6000
2	BOD (1) Decay Rate Temperature Correction Coefficie	X	1.04	0.0000	1.0700
3	BOD (1) Decay Rate Constant in Sediments @20 °C (p		0	0.0000	0.0004
4	BOD (1) Decay Rate in Sediments Temperature Correc		0	0.0000	1.0800
5	BOD (1) Half Saturation Oxygen Limit (mg O/L)	X	5E-1	0.0000	0.5000
6	Fraction of Detritus Dissolution to BOD (1)		0	0.0000	1.0000
7	Fraction of BOD (1) Carbon Source for Denitrification		0	0.0000	1.0000

Figure 10. CBOD1 (Ultimate) Constants for WASP7.



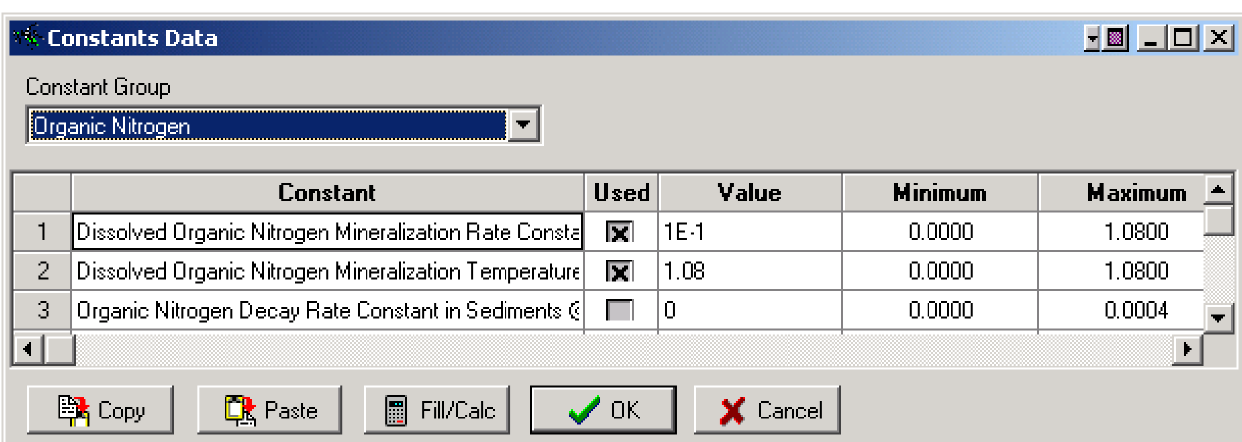
	Constant	Used	Value	Minimum	Maximum
1	Nitrification Rate Constant @20 °C (per day)	X	1.5E-1	0.0000	10.0000
2	Nitrification Temperature Coefficient	X	1.07	0.0000	1.0700
3	Half Saturation Constant for Nitrification Oxygen Limit (r		0	0.0000	2.0000
4	Fraction of Phytoplankton Death Recycled to Organic		0	0.0000	20.0000
5	Ammonia Partition Coefficient to Solids		0	0.0000	1000.0000

Figure 11. Ammonia Constants for WASP7.



	Constant	Used	Value	Minimum	Maximum
1	Denitrification Rate Constant @20 °C (per day)	X	5E-2	0.0000	0.0900
2	Denitrification Temperature Coefficient	X	1.045	0.0000	1.0400
3	Half Saturation Constant for Denitrification Oxygen Limi		0	0.0000	0.0000

Figure 12. Nitrate Constants for WASP7.



	Constant	Used	Value	Minimum	Maximum
1	Dissolved Organic Nitrogen Mineralization Rate Consta	X	1E-1	0.0000	1.0800
2	Dissolved Organic Nitrogen Mineralization Temperature	X	1.08	0.0000	1.0800
3	Organic Nitrogen Decay Rate Constant in Sediments @		0	0.0000	0.0004

Figure 13. Organic Nitrogen Constants for WASP7.

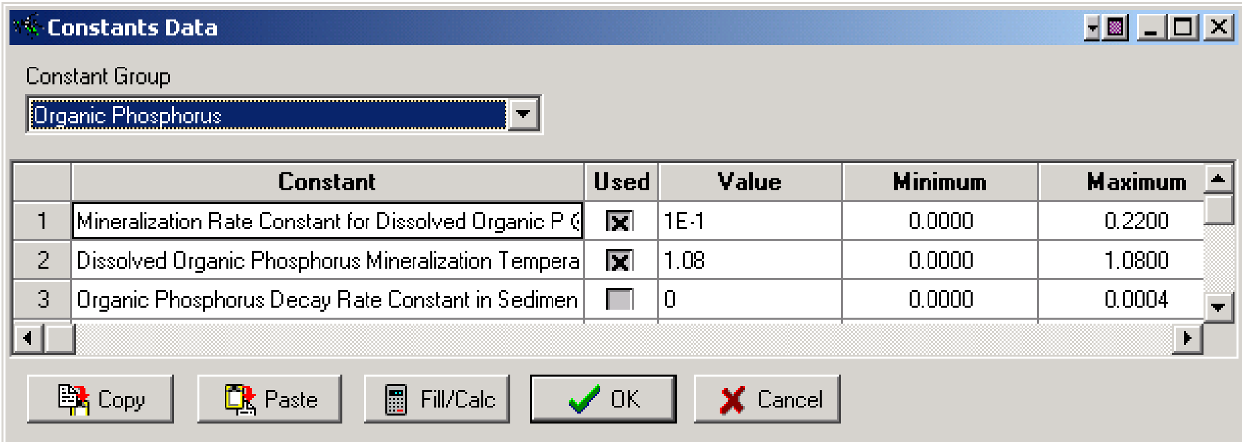


Figure 14. Organic Phosphorus Constants for WASP7.

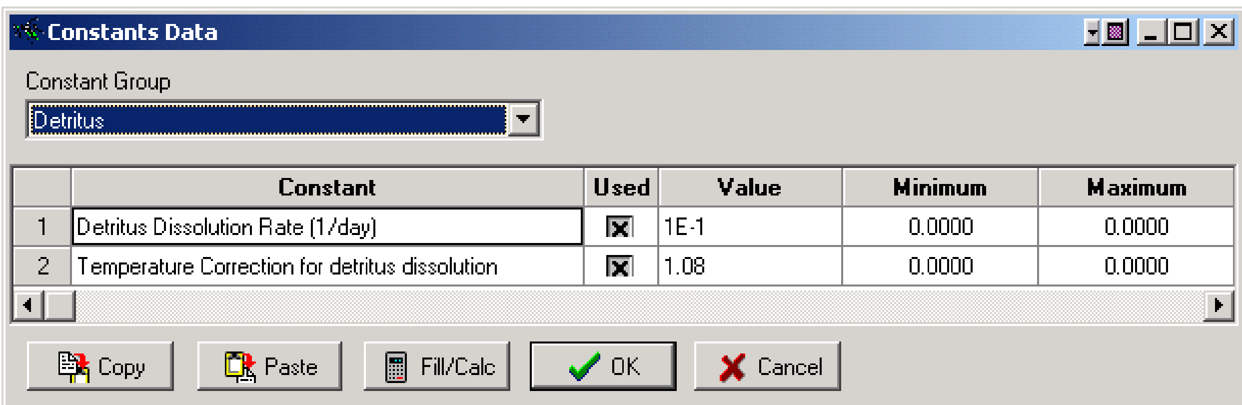


Figure 15. Detritus Constants for WASP7.

3.5 WATER TEMPERATURE AND DISSOLVED OXYGEN FORCING

Temperature was available at all stations. The limited numbers of observations at all stations meant that there could be great variability and have a potential for a timeseries that is truly not representative. It was decided that all data for all stations be combined to produce a representative sine curve. Dissolved oxygen was forced using available data at the appropriate segments to develop a time series. Table 9 shows what instream station was used as the forcing for each segment.

Table 9. Dissolved Oxygen Boundary Forcing Inputs.

Segment	Instream Station used for Dissolved Oxygen Forcing
1	21FLTPA 24020906
2	21FLTPA 24020906
3	27FLTPA 27492118205
4	27FLTPA 27492118205
5	21FLTPA 27484928205
6	21FLTPA 27484928205

3.6 SEDIMENT OXYGEN DEMAND

Sediment oxygen demand (SOD) is a main component of the Owens Branch WASP model. SOD data was developed from literature values and estimates used in other modeling applications. During initial model set-up, SOD was set using a value of 1.0 g/m^2/d. Due to an absence of SOD data a sensitivity analysis was performed to try to ascertain a range of values that may be appropriate for Owens Branch. After the sensitivity analysis and iterative calibration process, SOD was 1.25 g/m^2/d for segments one and two, and 2.0 g/m^2/d for segments 3 through 6.

4 Model Simulations

Once model input forcings and parameters were developed, the model was simulated on an iterative basis to enable calibration. The model was simulated from 1995 through 2008.

4.1 CALIBRATION

The model runs were compared to the observed data for the period of 2005, as this was selected as the critical period for the simulation. This period was identified since this period contained the only data for nutrients. Dissolved oxygen, CBOD, and temperature were calibrated at segments 2, 4, and 6. Nutrients were calibrated at segments 4 and 6. These comparisons are presented in Figures 16 through 40.

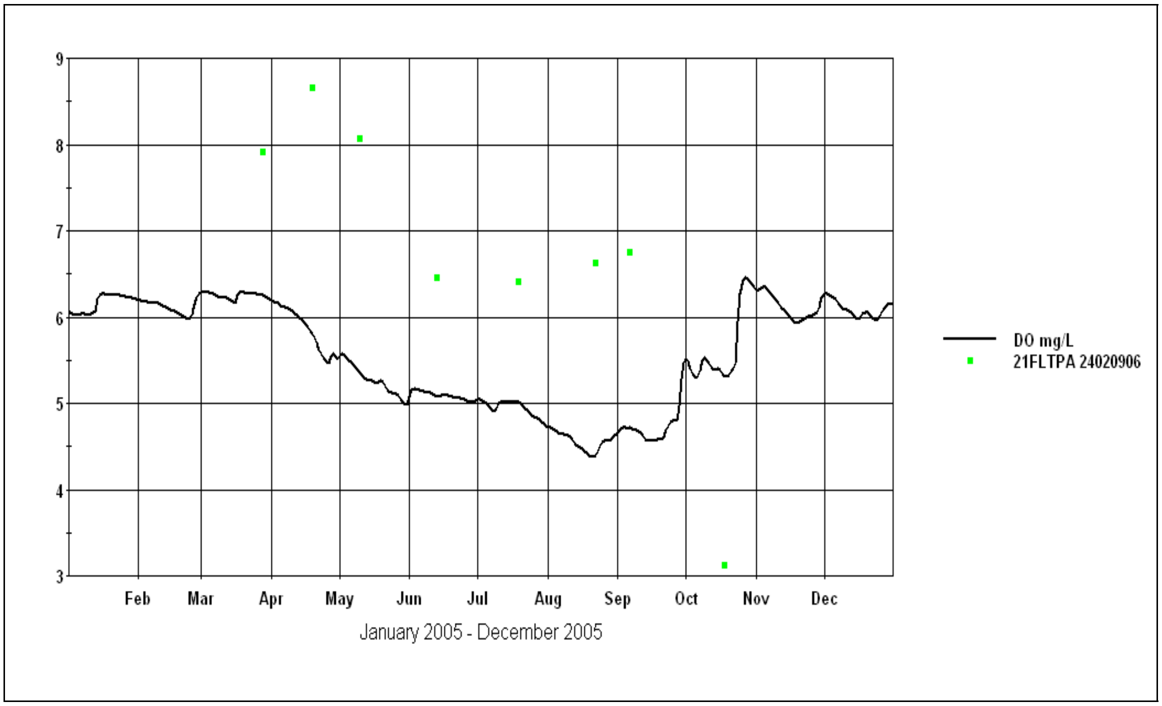


Figure 16. Segment 2 Dissolved Oxygen Calibration (2005).

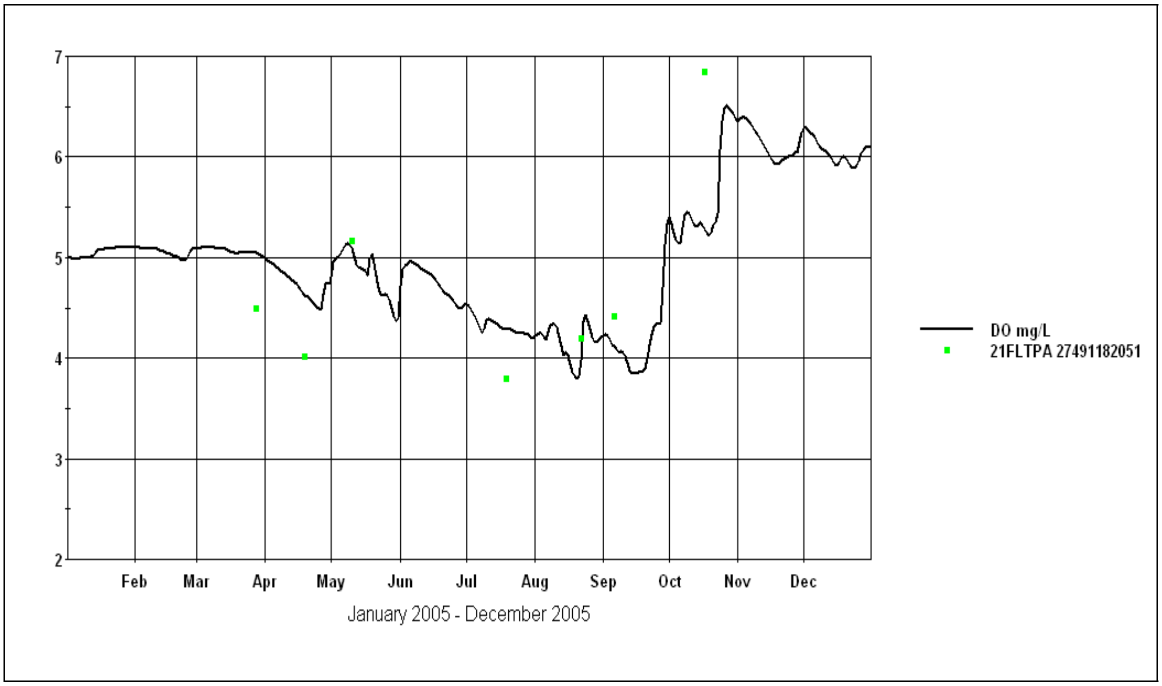


Figure 17. Segment 4 Dissolved Oxygen Calibration (2005).

Figure 18. Segment 6 Dissolved Oxygen Calibration (2005).

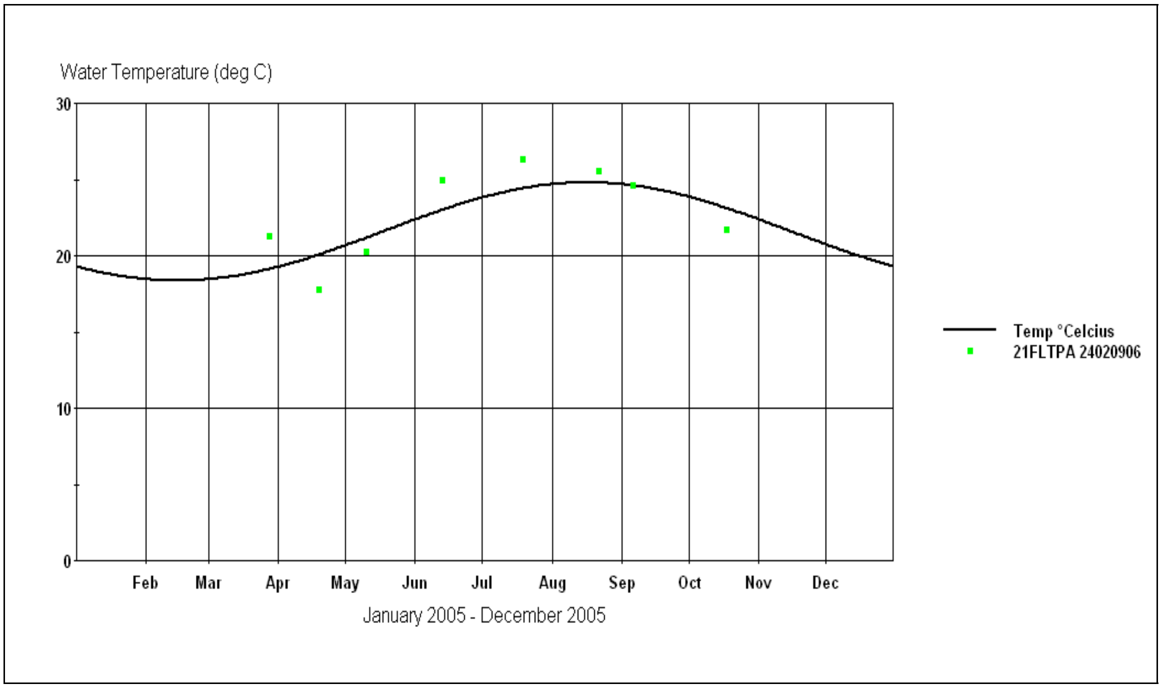


Figure 19. Segment 2 Water Temperature Calibration (2005).

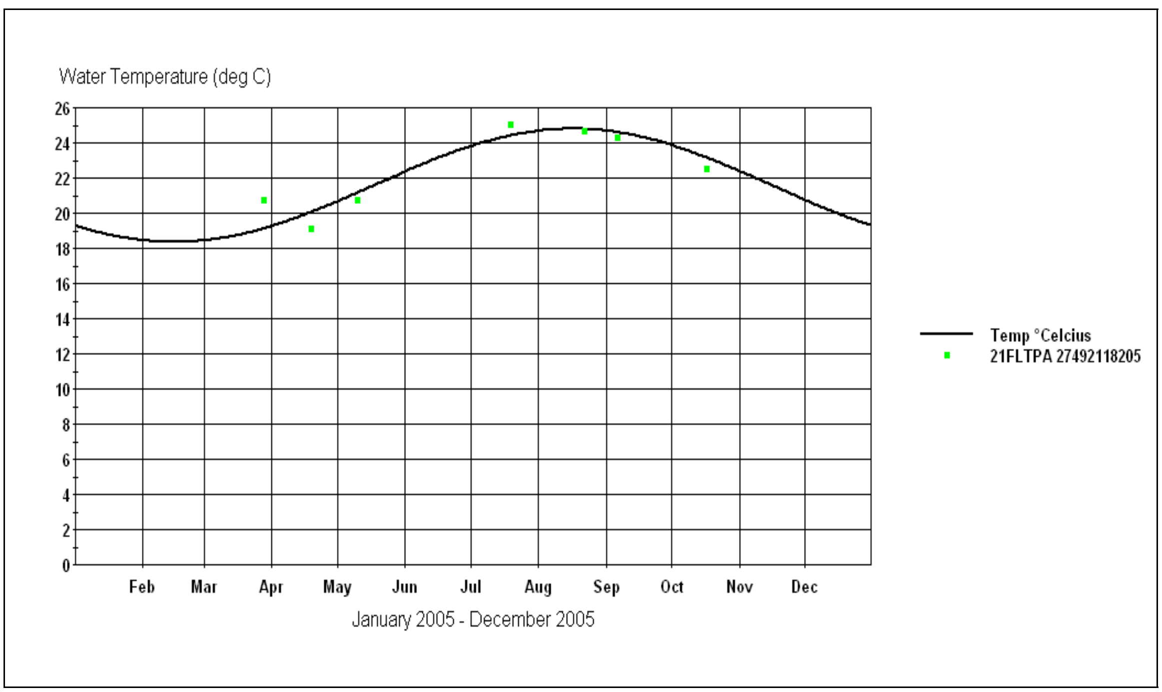


Figure 20. Segment 4 Water Temperature Calibration (2005).

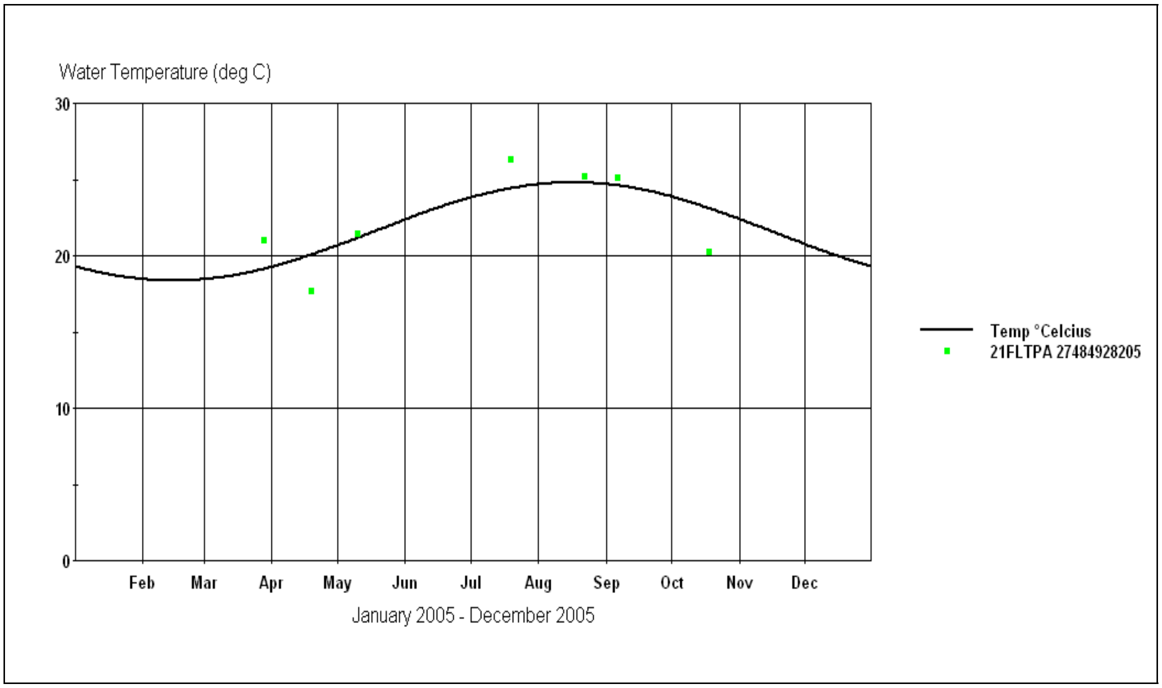


Figure 21. Segment 6 Water Temperature Calibration (2005).

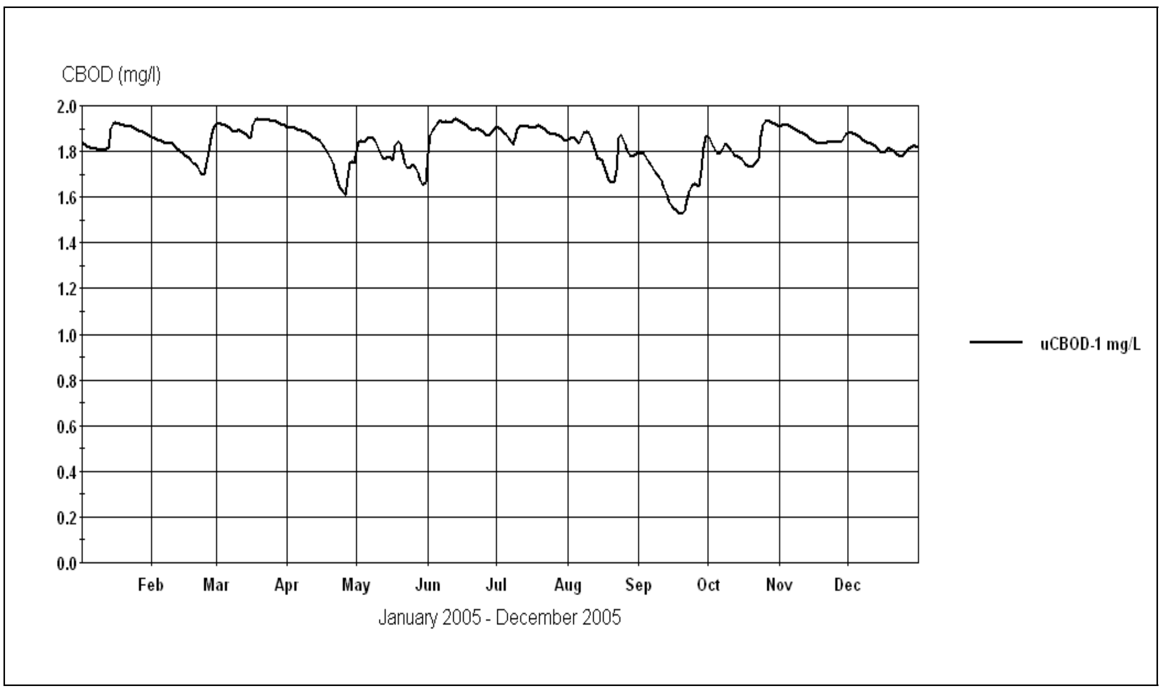


Figure 22. Segment 2 Biochemical Oxygen Demand Calibration (2005).

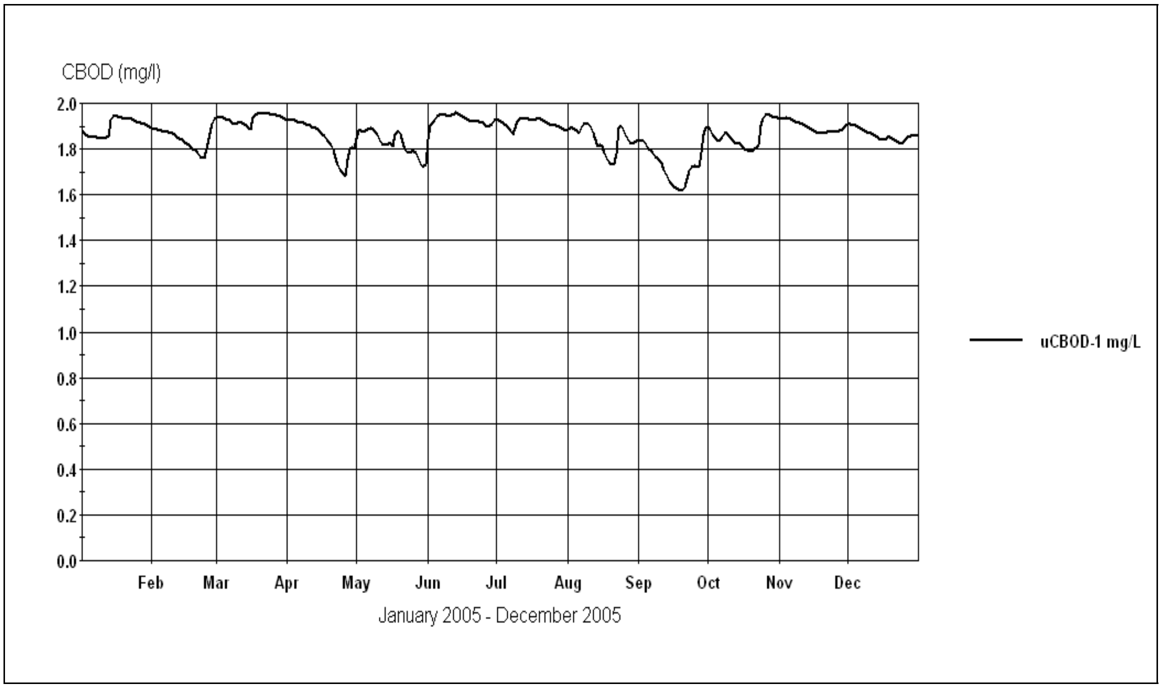


Figure 23. Segment 4 Biochemical Oxygen Demand Calibration (2005).

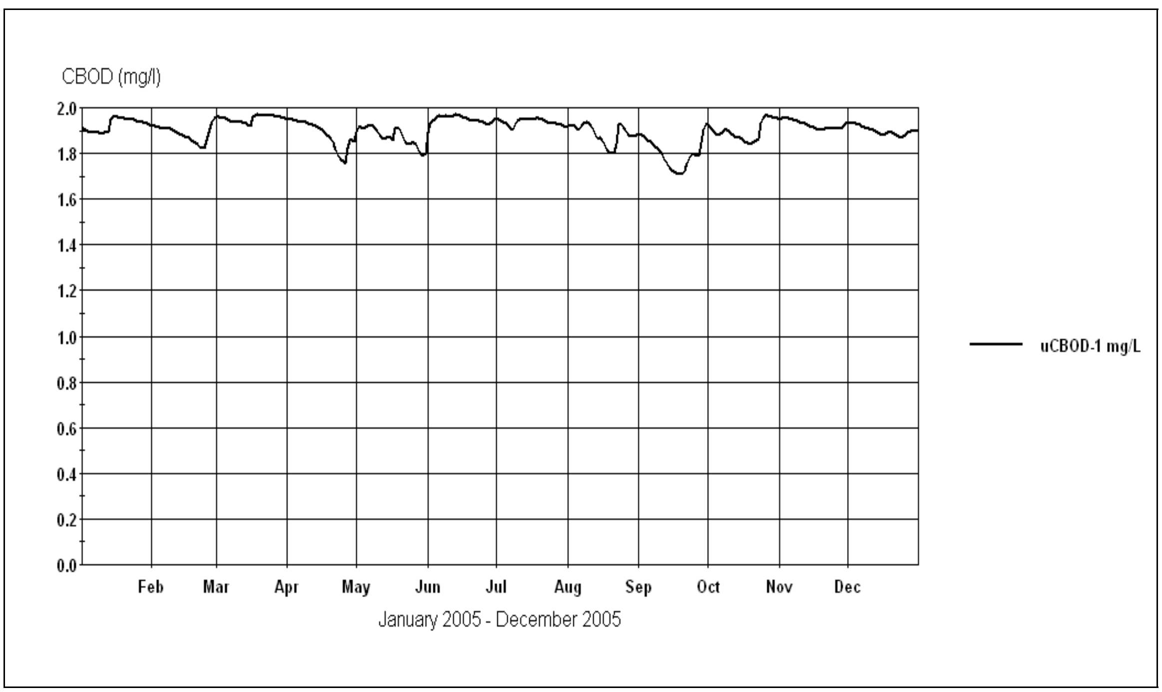


Figure 24. Segment 6 Biochemical Oxygen Demand Calibration (2005).

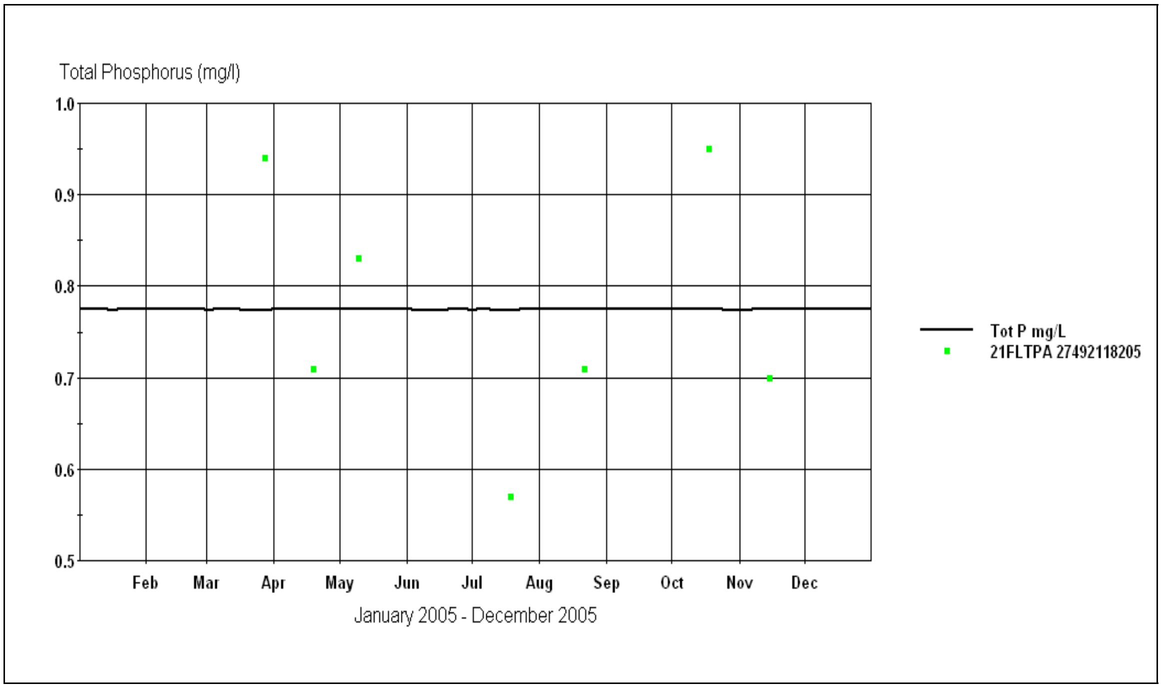


Figure 25. Segment 4 Total Phosphorus Calibration (2005).

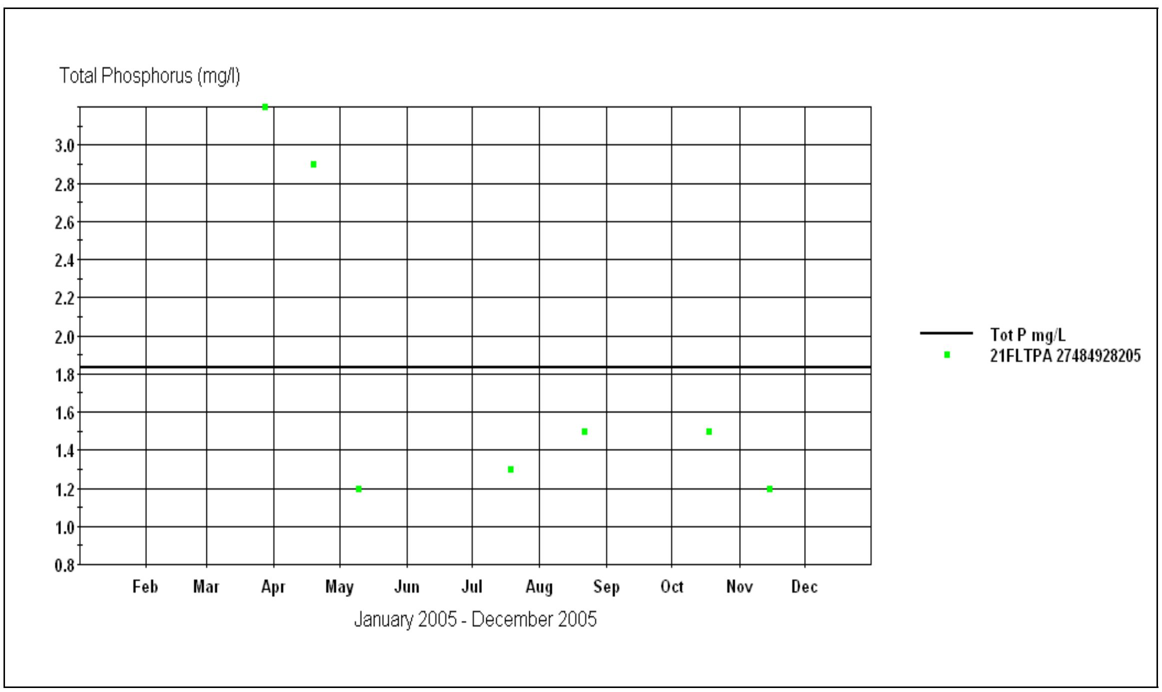


Figure 26. Segment 6 Total Phosphorus Calibration (2005).

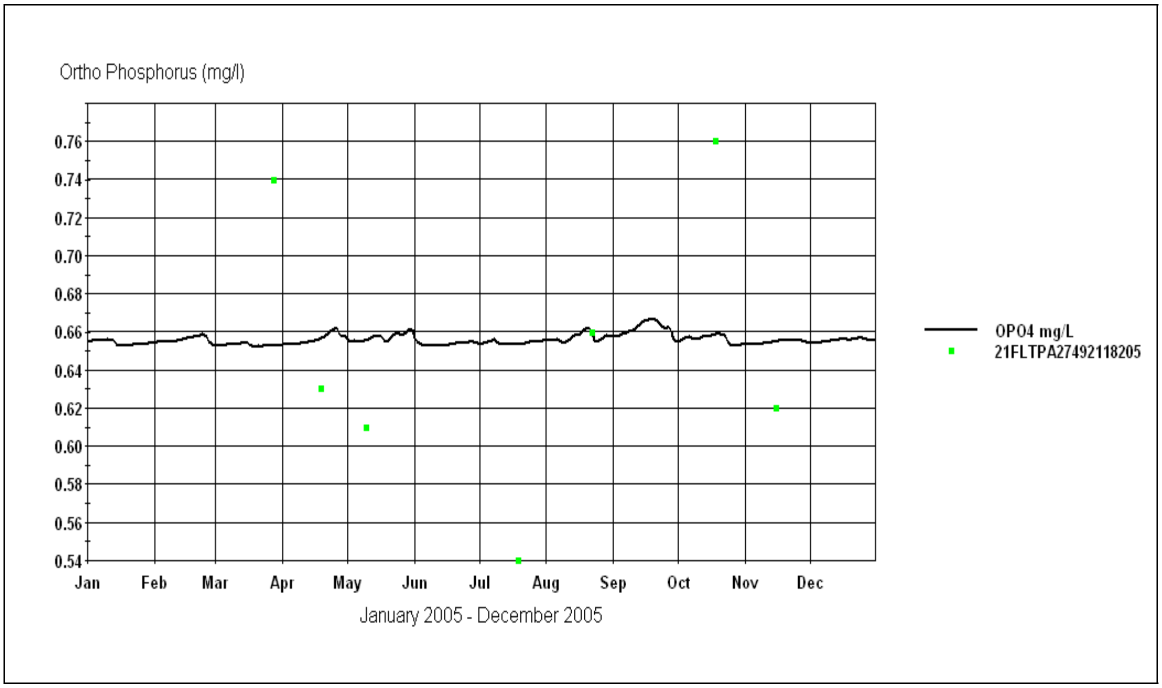


Figure 27. Segment 4 Ortho Phosphorus Calibration (2005).

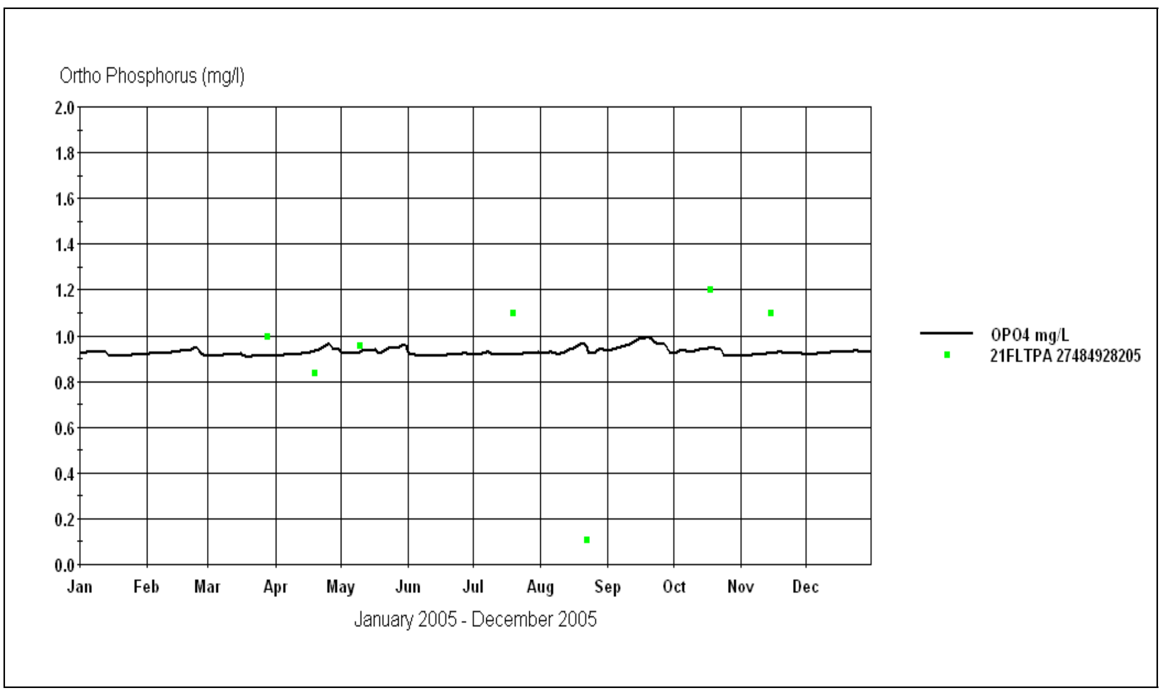


Figure 28. Segment 6 Ortho Phosphorus Calibration (2005).

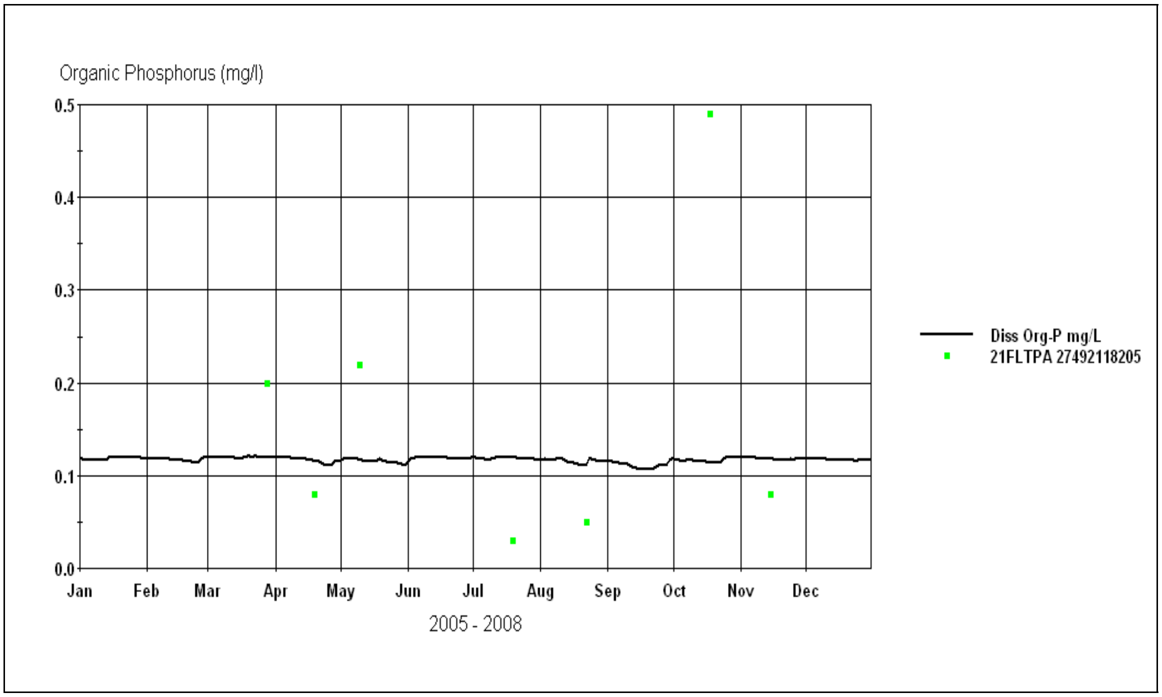


Figure 29. Segment 4 Organic Phosphorus Calibration (2005).

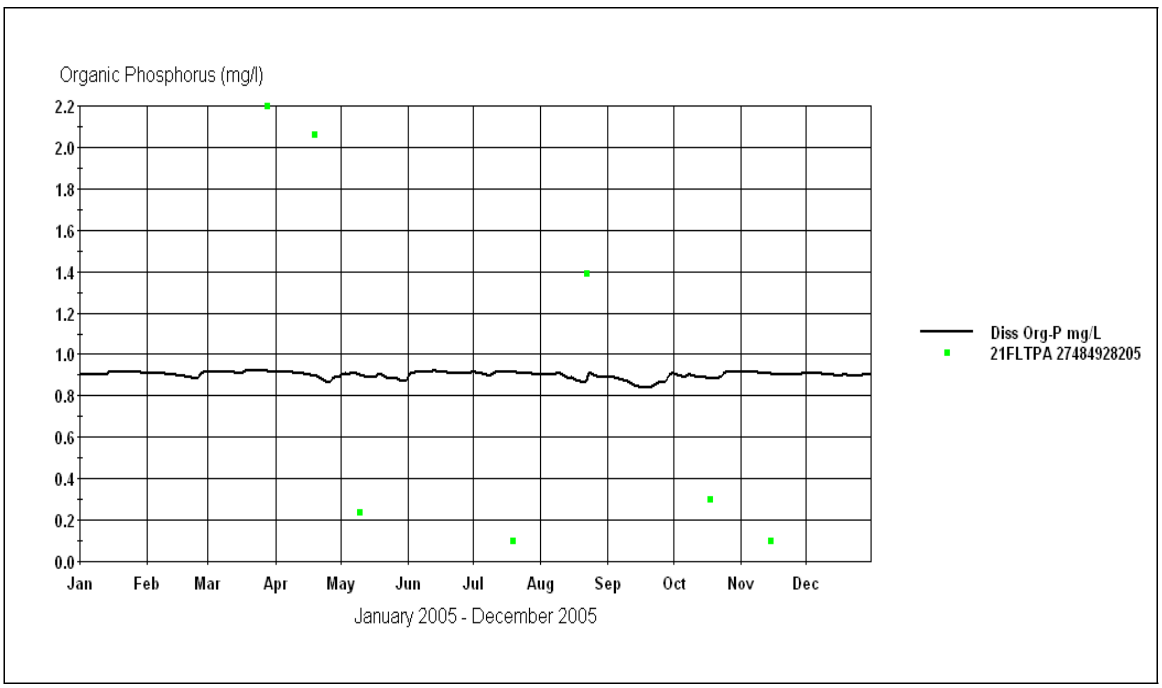


Figure 30. Segment 6 Organic Phosphorus Calibration (2005).

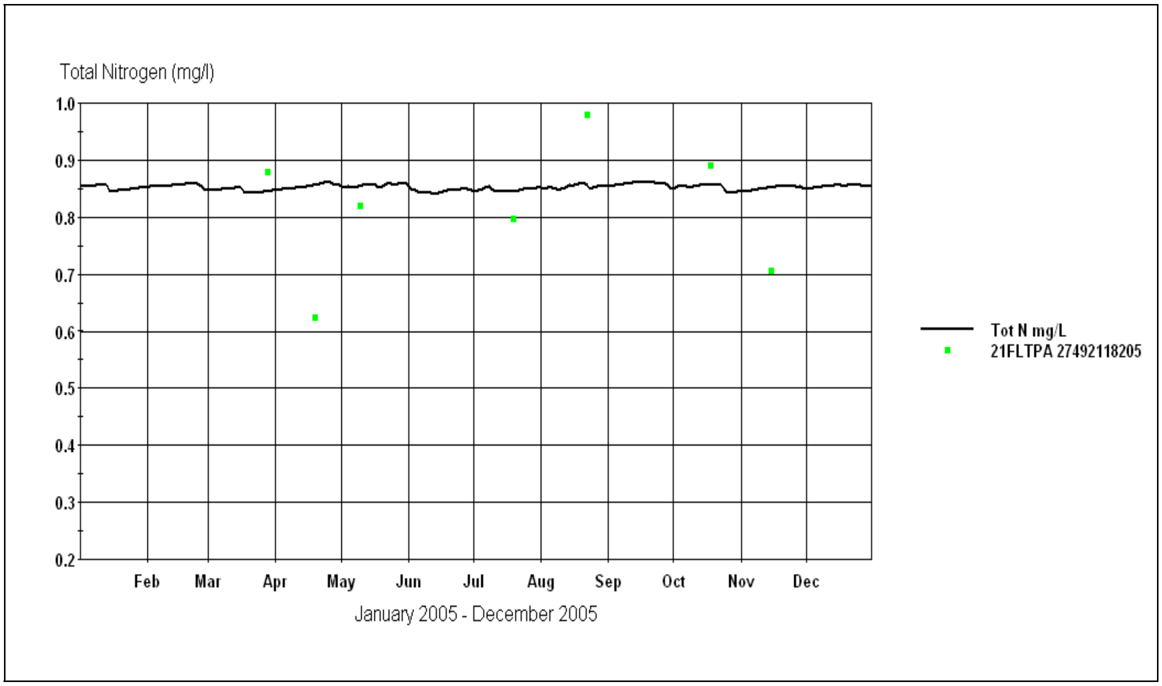


Figure 31. Segment 4 Total Nitrogen Calibration (2005).

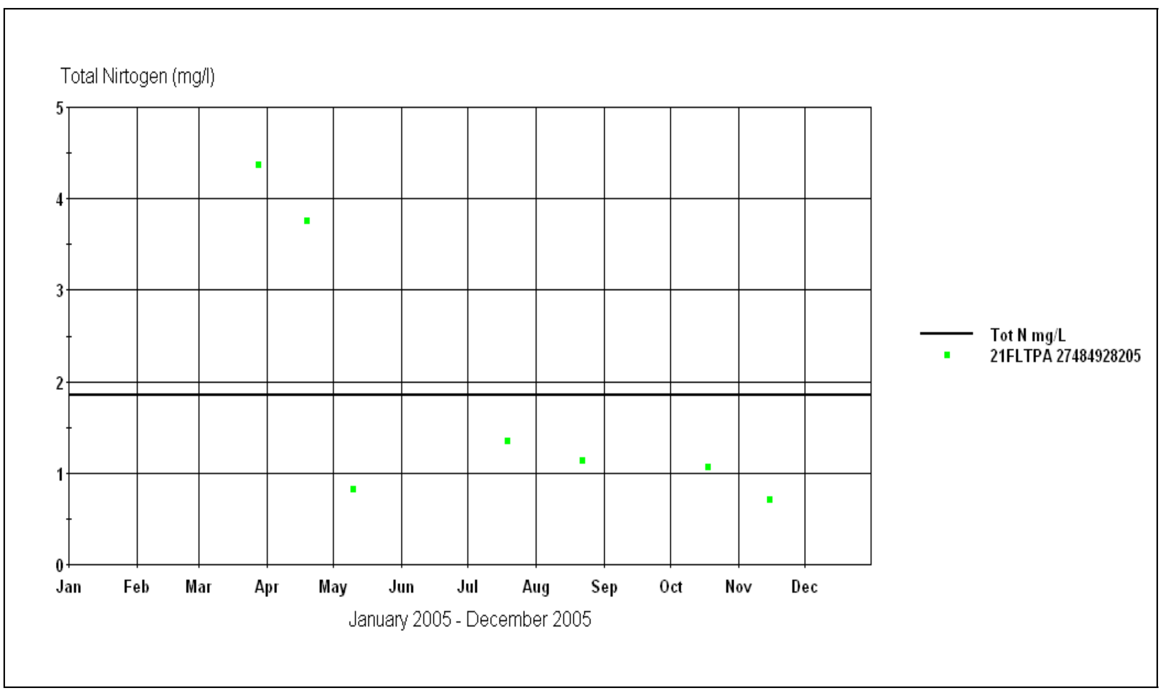


Figure 32. Segment 6 Total Nitrogen Calibration (2005).

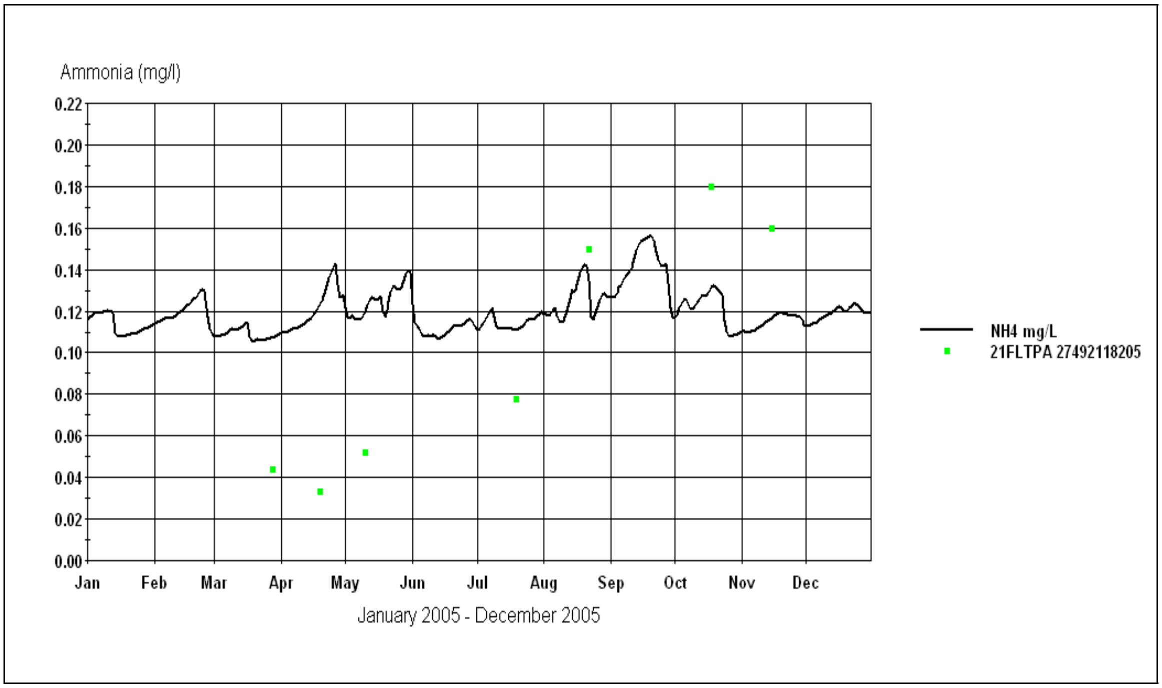


Figure 33 Segment 4 Ammonia Calibration (2005).

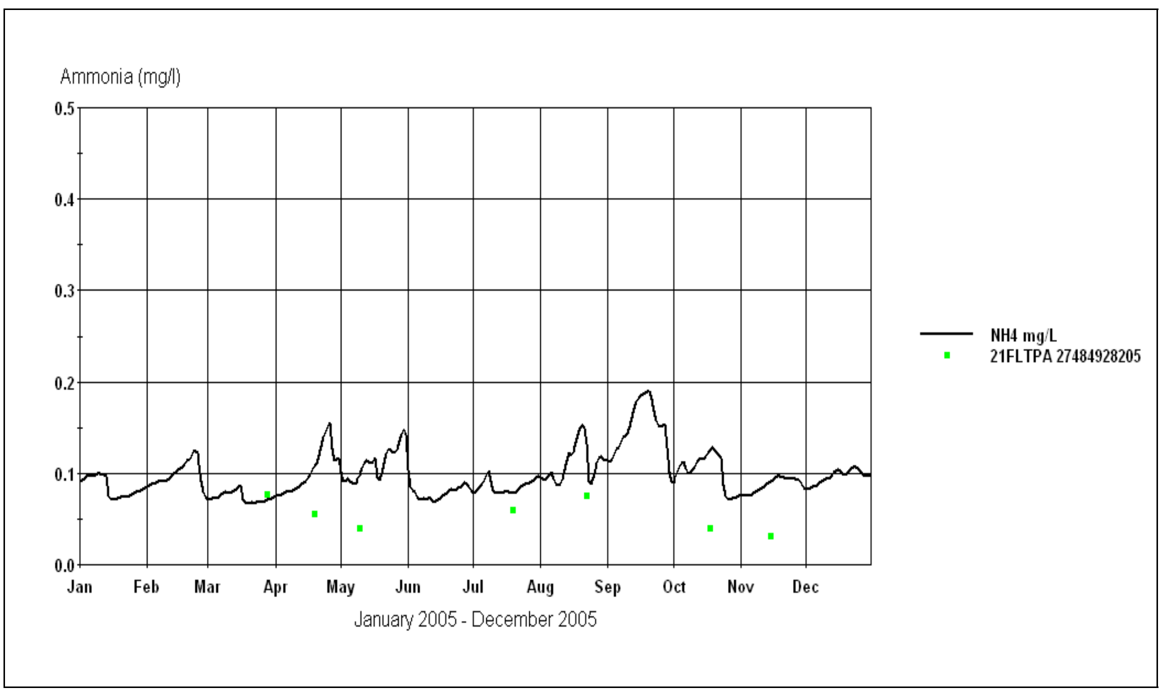


Figure 34. Segment 6 Ammonia Calibration (2005).

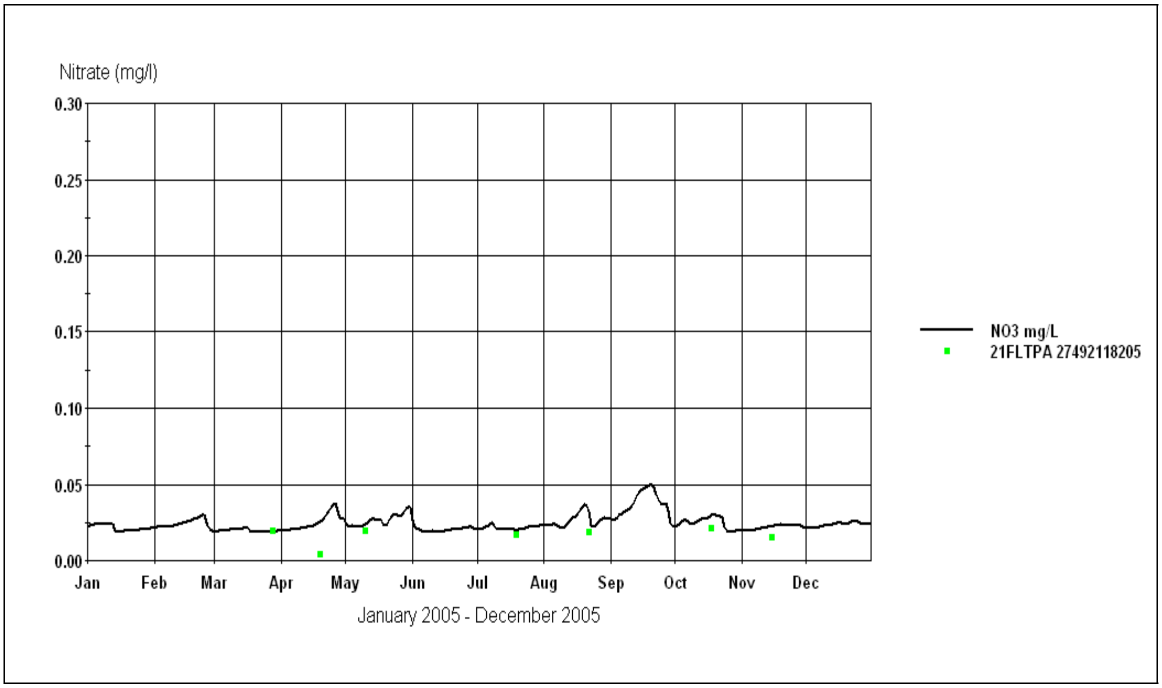


Figure 35. Segment 4 Nitrate Calibration (2005).

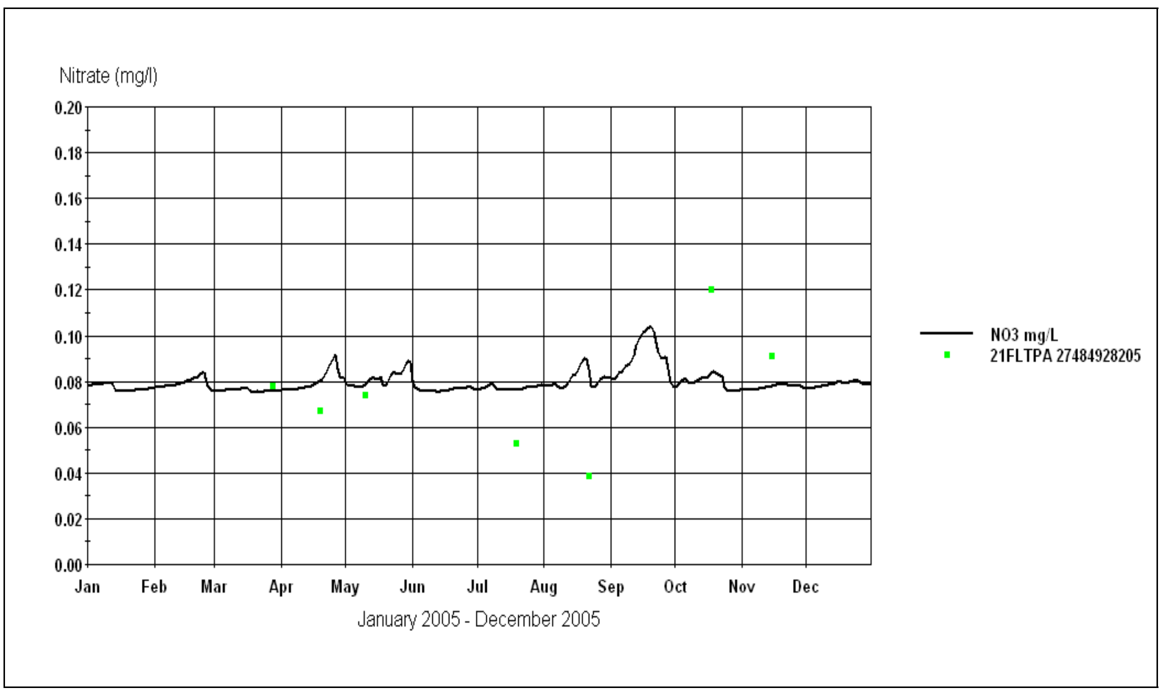


Figure 36. Segment 6 Nitrate Calibration (2005).

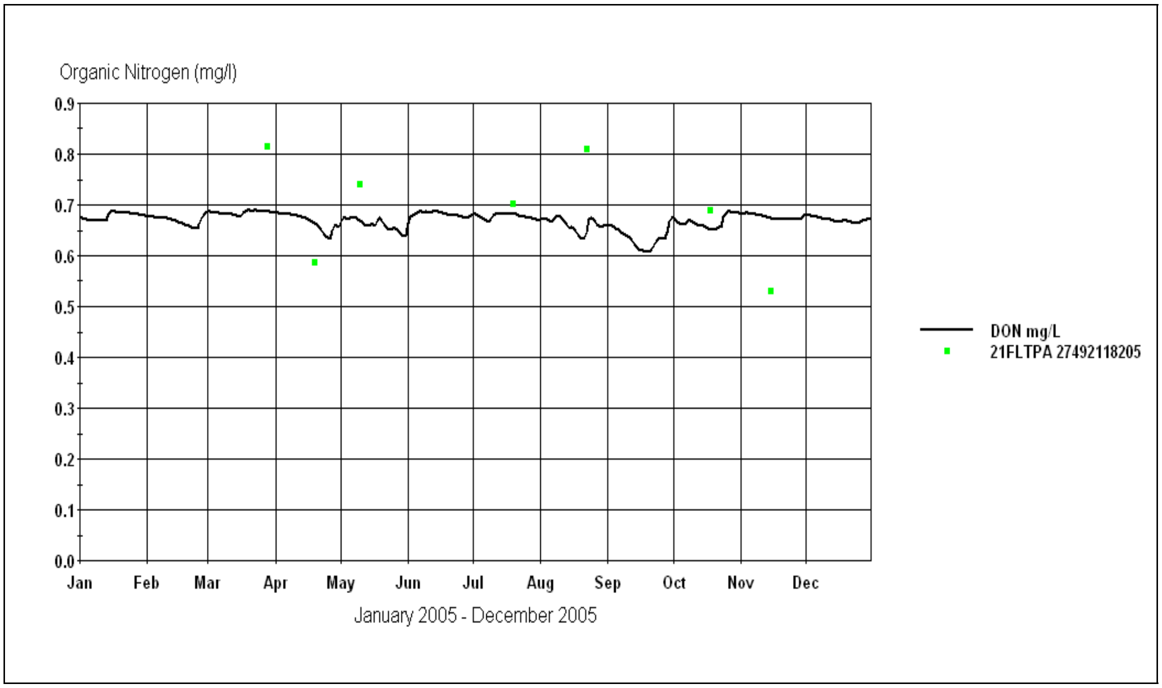


Figure 37. Segment 4 Organic Nitrogen Calibration (2005).

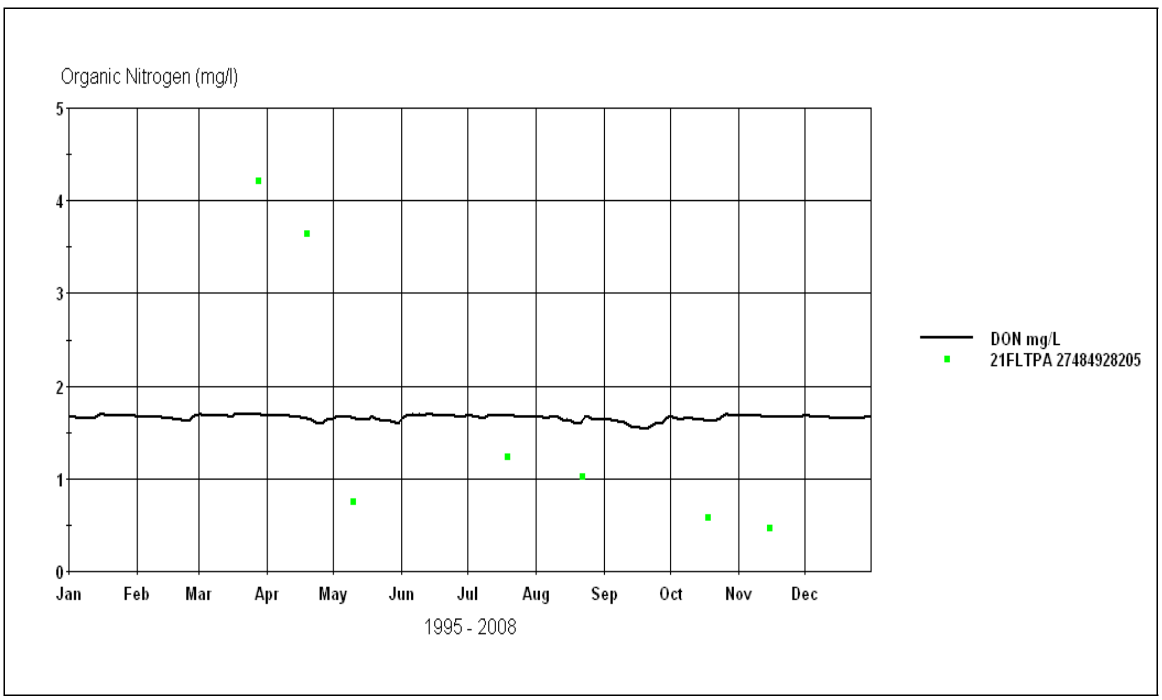


Figure 38. Segment 6 Organic Nitrogen Calibration (2005).

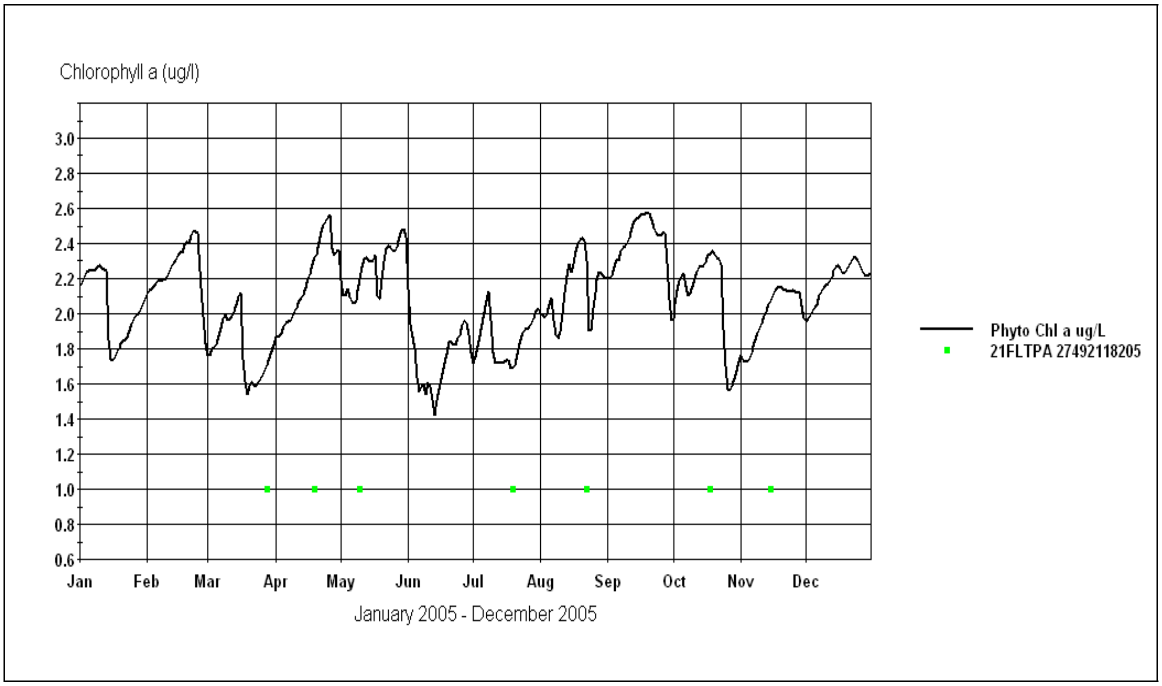


Figure 39. Segment 4 Chlorophyll a Calibration (2005).

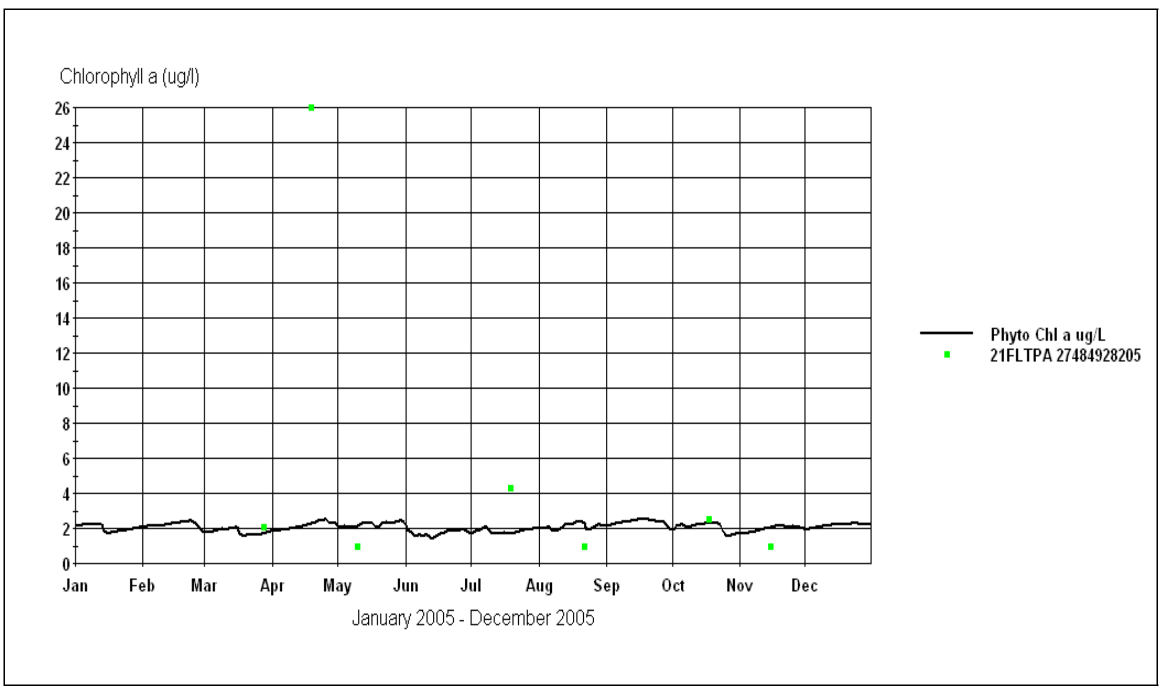


Figure 40. Segment 6 Chlorophyll a Calibration (2005).

5 SOD Spreadsheet Model

In addition to WASP7, another model was used to establish a defensible link between instream loads versus SOD. An SOD model developed by Quantitative Environmental Analysis (QEA) and modified by Dr. James Martin at Mississippi State University (MSU), was implemented to determine the relative change in SOD by altering the watershed load of CBODu and nutrients. Nutrient and CBODu parameters were input to the model, and SOD was calibrated to the exiting WASP7 model.

6 References

Martin, J.L. and S.C. McCutcheon, 1999. Hydrodynamics and Transport for Water Quality Modeling. CRC Press, Inc. Boca Raton, Florida.

EPA, 7.2. WASP manual. U.S. Environmental Protection Agency. Washington, D.C