Appendix A:

Modeling Report

Yellow Fever Creek

WBID: 3240E

Nutrients and Dissolved Oxygen

September 30, 2010

Region 4 serving the southeast

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1. Watershed Description

The 257-square-mile Caloosahatchee Estuary Planning Unit, which lies within Lee and Charlotte Counties, contains 13 WBIDs. Waterbodies in the planning unit include the Caloosahatchee River and Estuary; Hancock, Yellow Fever, Daughtrey, Popash, Stroud, Owl, and Trout Creeks; and numerous residential canals and drainage ditches. The principal communities are Fort Myers, Fort Myers Shores, North Fort Myers, and Cape Coral.

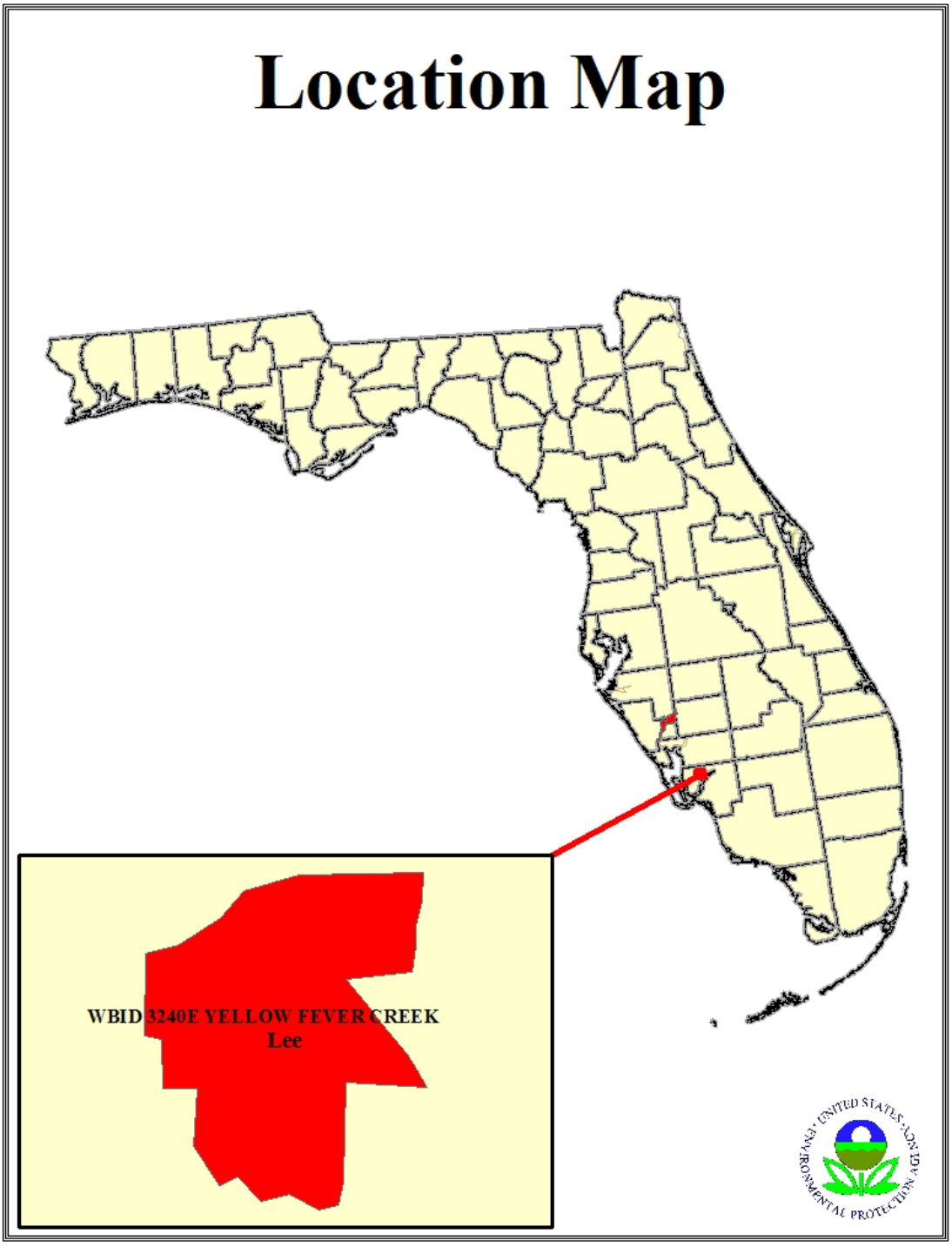

Figure 1 Location Map for Yellow Fever Creek

The landuse distribution for the Yellow Fever Creek watershed is presented in Figure 2.

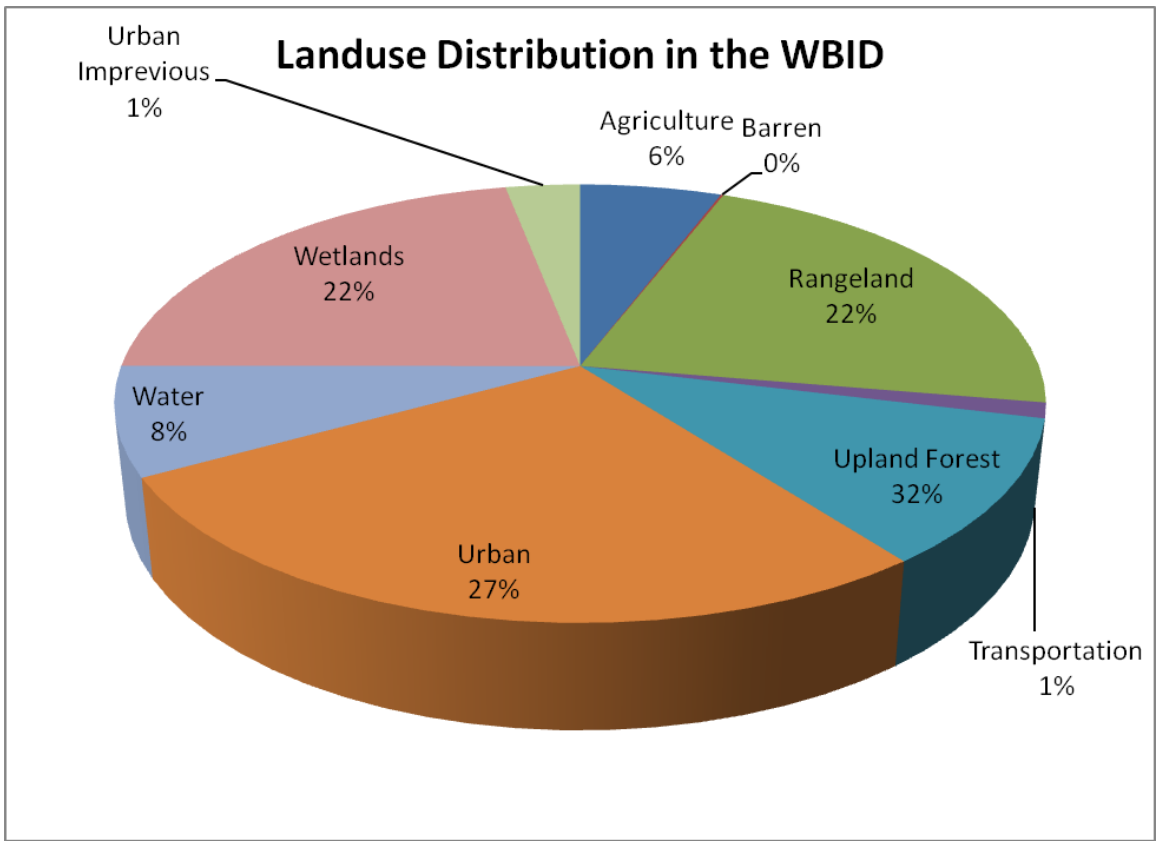

Figure 2 Landuse Distribution for Yellow Fever Creek Watershed

2. TMDL Targets

The TMDL reduction scenarios will be done to achieve a dissolved oxygen concentration of 5 mg/L in within Yellow Fever Creek or establish the natural condition.

3. Modeling Approach

A coupled watershed and 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 2009. The watershed model provides daily runoff, nutrient and BOD loadings from the Yellow Fever Creek Watersheds. The predicted results from the LSPC model are transferred forward to the receiving waterbody model Water Quality Analysis Simulation Program (WASP 7.4) (USEPA, 2009). 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.

3.1. Yellow Fever Creek Watershed Model

The goal of this watershed modeling effort is to estimate runoff (flow), nutrient (total nitrogen & total phosphorus) and BOD loads and concentrations from the upstream watersheds flowing into the Yellow Fever Creek. 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.

3.1.1. Yellow Fever Creek Watershed Delineation and Landuse

The surrounding watershed that drains directly to the Yellow Fever Creek is presented in Figure 3. This WBID was delineated into 2 LSPC sub basins to simulate the runoff and pollutant loads.

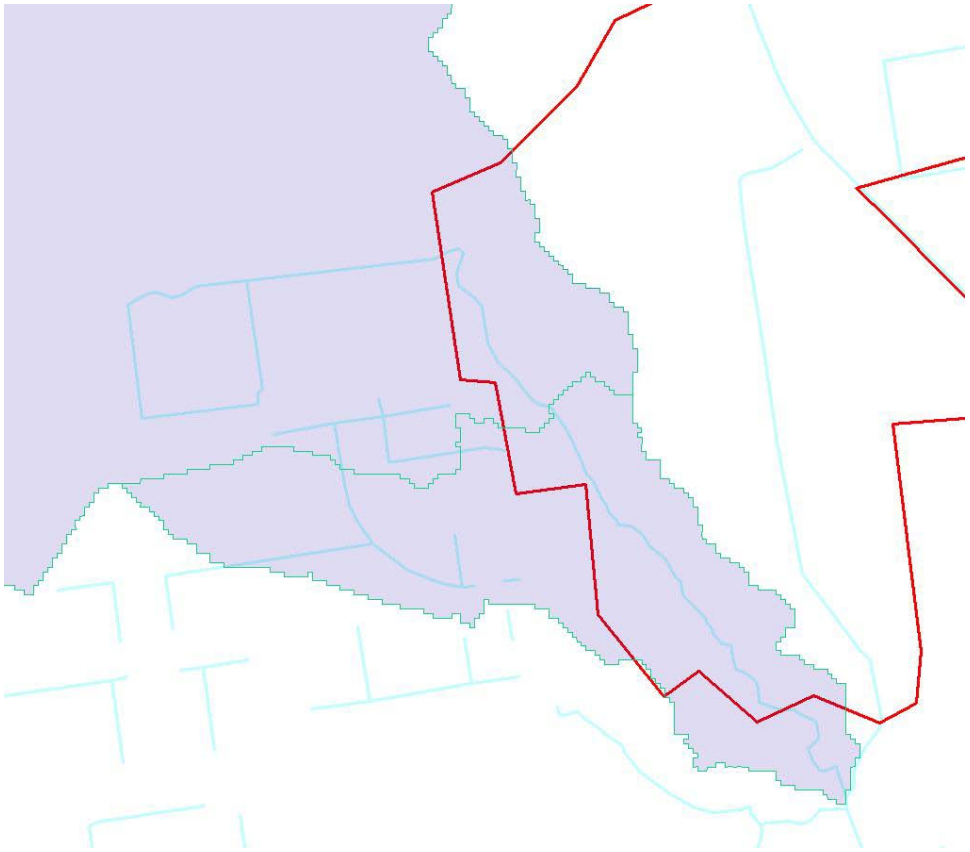

Figure 3 Yellow Fever Creek Watershed Delineation

Figure 4 illustrates the Florida Landuse Classification (Level-1) for the Yellow Fever Creek surrounding watershed.

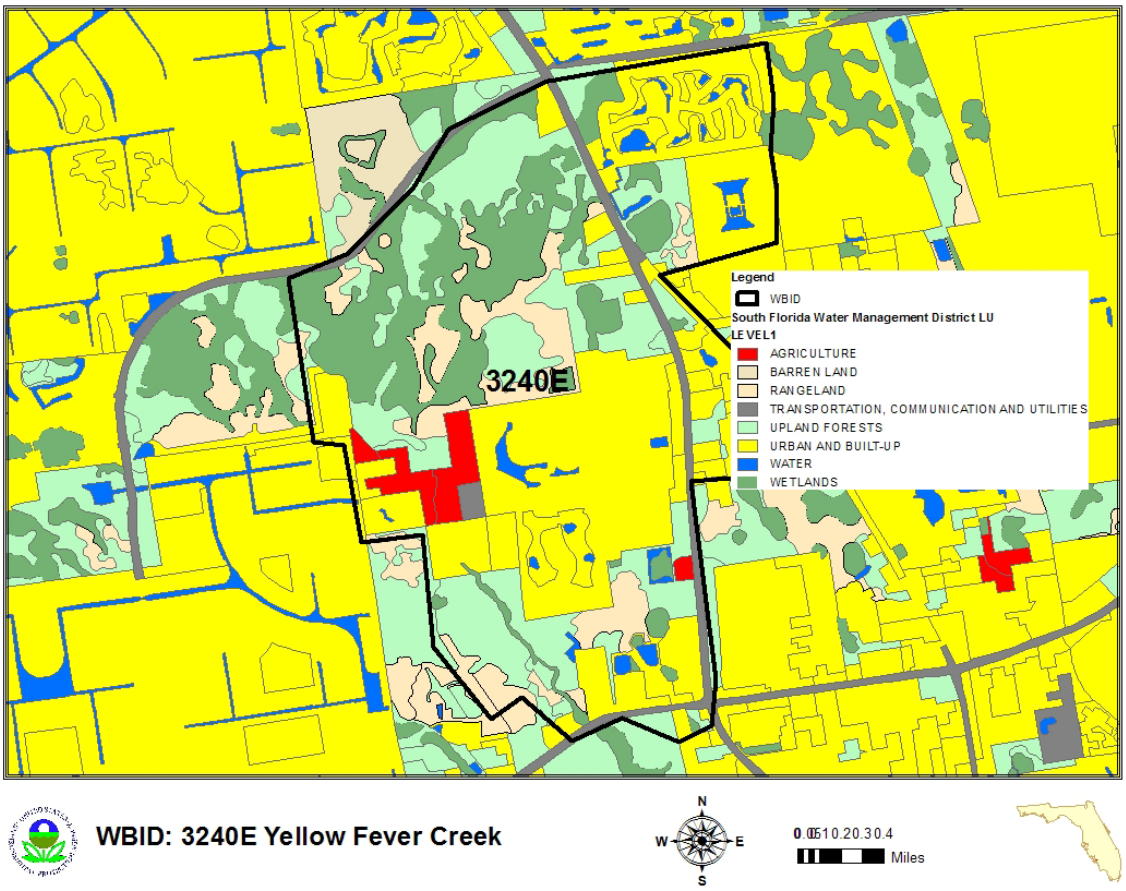

Figure 4 Yellow Fever Creek Watershed Landuse Distribution

3.2. Yellow Fever Creek Watershed Runoff

The LSPC watershed model was developed to simulate hydrologic runoff and pollutant loadings in response to recorded precipitation events for the current and natural conditions.

3.2.1. Meteorological

Rainfall and other pertinent meteorological data was obtained from the National Weather Service (NWS) WBAN station number 087397 Punta Gorda, FL.

Figure 4 provides a time series plot of daily rainfall for the simulation period.

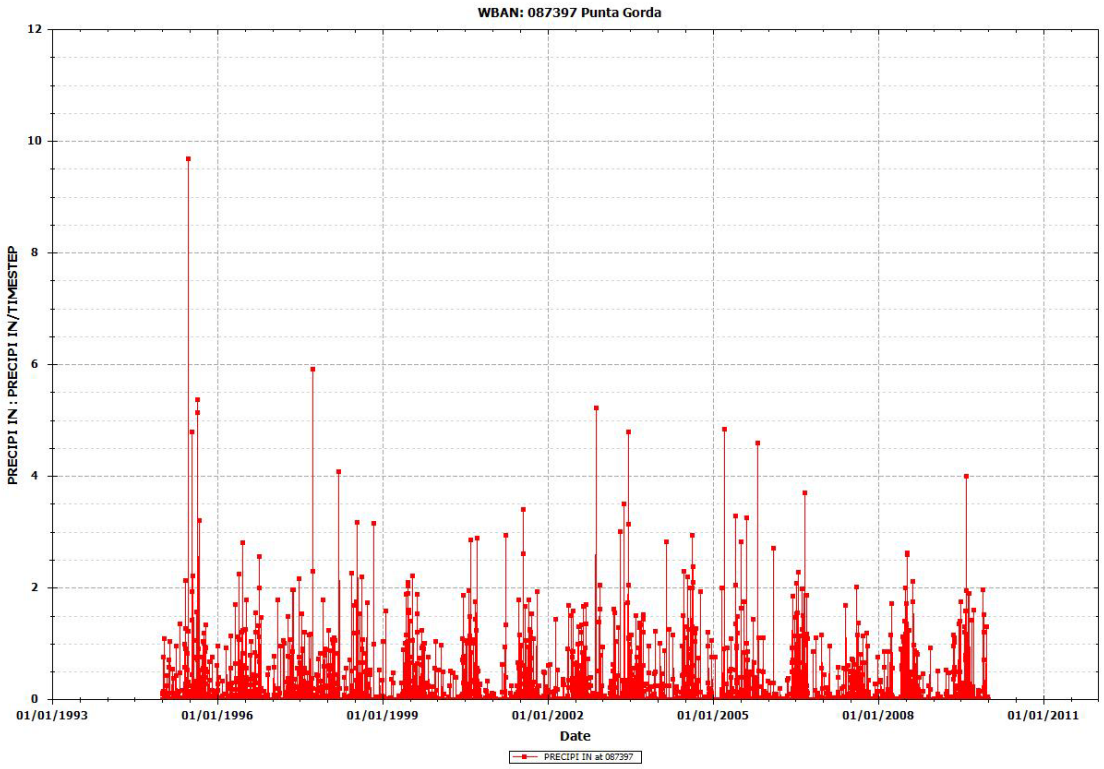

Figure 5 Rainfall for Yellow Fever Creek Watershed

Table 2 shows the annual average rainfall for each of the years simulated.

Table 1 Annual Rainfall

Year	Rain (inches)
2002	48.33
2003	53.16
2004	63.08
2005	55.94
2006	58.06
2007	51.11
2008	30.03
2009	49.35
2010	46.12

3.2.2. BOD and Nutrient Loadings

The pollutagraph was generated using event mean concentrations for total nitrogen, total phosphorus and BOD (Table 3). The initial EMC values were derived for each landuse type from Harpers Report (Harper, 1994) and then calibrated to all data available for the watershed.

Table 2 Event Mean Concentration for Landuse Classifications

Landuse	Total Nitrogen	Total Phosphorus	BOD
Agriculture	2.2	0.6	10
Barren Land	2	0.6	10
Rangeland	2.2	0.34	10
Transportation	1	0.30	10
Upland Forest	2.2	0.16	3
Urban Area	2.2	0.40	10
Water	1	0.10	3
Wetlands	1	0.4	10

BOD and nutrient watershed runoff were determined using EMCs for surface water runoff and interflow runoff and baseflow concentrations for groundwater flow. Table 4 provides the annual average total nitrogen, total phosphorus and BOD loads for the period of record 2002 through 2009. It is these loadings that the TMDL load reduction will be calculated from.

Table 3 Yellow Fever Creek Nutrient Loads (2002-2009)

	Current Condition	
Constituent	WLA (kg/yr)	LA (kg/yr)
Total Nitrogen	NA	13,676
Total Phosphorus	NA	6,497
BOD	NA	26,110

3.3. Yellow Fever Creek Water Quality Model

The Yellow Fever Creek WASP water quality model integrates the predicted flows and loads from the LSPC model to simulate water quality responses in: nitrogen, phosphorus, chlorophyll a and dissolved oxygen. A 3 segment WASP water quality model was setup to include the 3 Yellow Fever Creek sub basins.

3.3.1. 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. Widths were taken from satellite imagery and depths from the measured water quality data. Table 4 provides the basic kinetic rates used in the model.

Table 4 WASP Kinetic Rates

WASP Kinetic Parameters	Value
Global Reaeration Rate Constant @ 20 °C (per day)	1.0
Sediment Oxygen Demand (g/m2/day)	2 for stream segments
Phytoplankton Maximum Growth Rate Constant @20 °C (per day)	2
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 WASP model was calibrated to all available data from IWR 40.

Table 5 provides a comparison of predicted annual average concentrations versus the annual average concentrations of the measured data. It should be noted that only a single year of data was available from Florida's Impaired Waters Rule database version 40.

Table 5 Existing Condition Annual Average Concentrations Observed and Predicted

Constituent	Existing	Observed
Total Nitrogen (mg/L)	0.522	0.868
Total Phosphorus (mg/L)	0.22	0.233
BOD (mg/L)	1.577	2.373
DO (mg/L)	2.908	3.072
Chlorophyll a (ug/L)	4.4	6.485

Figure 6 through Figure 9 depict the calibration which compares the observed versus the predicted concentrations.

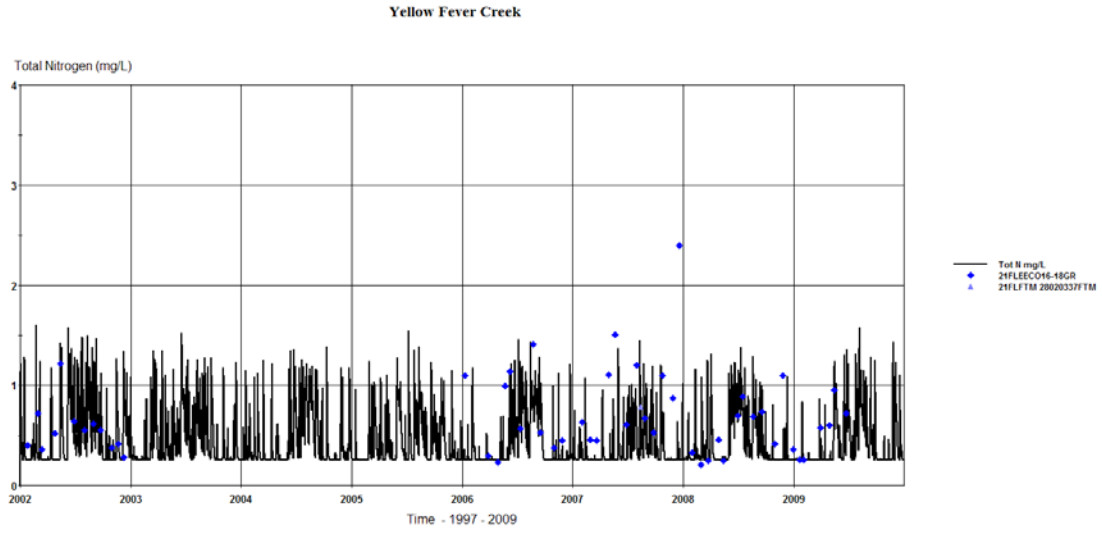

Figure 6 WASP Calibration for Total Nitrogen in Yellow Fever Creek

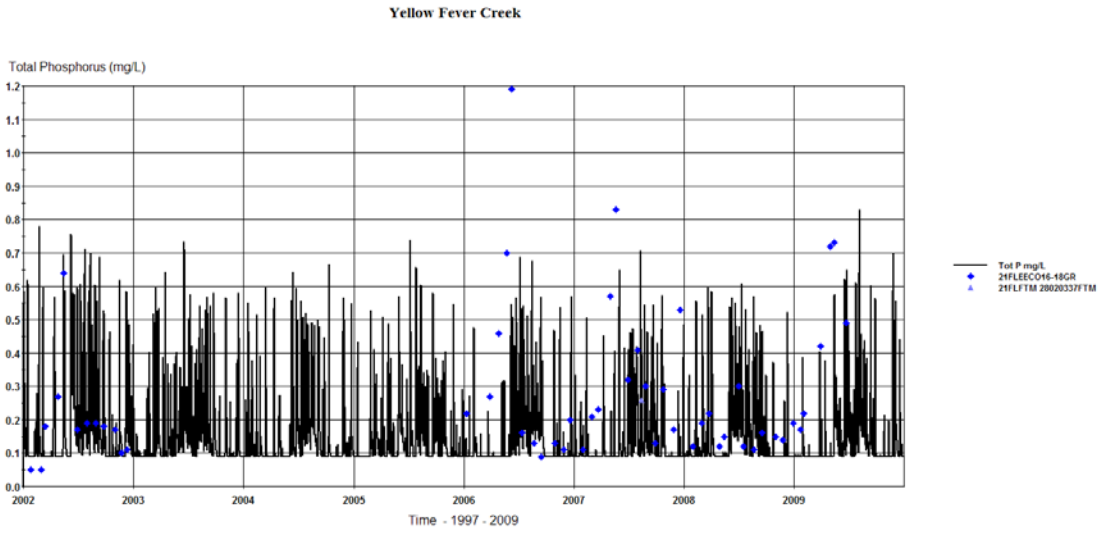

Figure 7 WASP Calibration for Total Phosphorus in Yellow Fever Creek

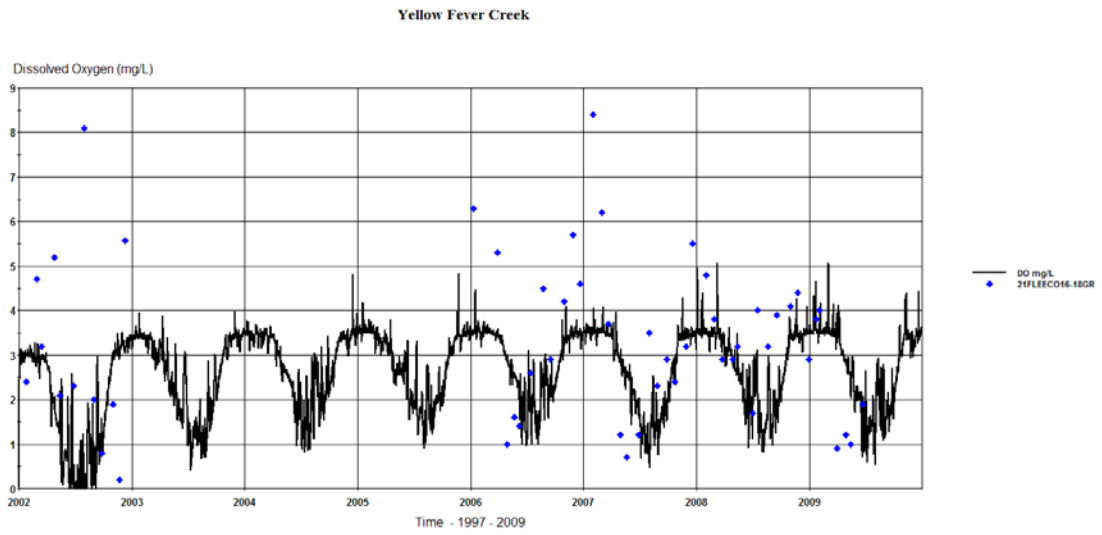

Figure 8 WASP Calibration for Dissolved Oxygen in Yellow Fever Creek

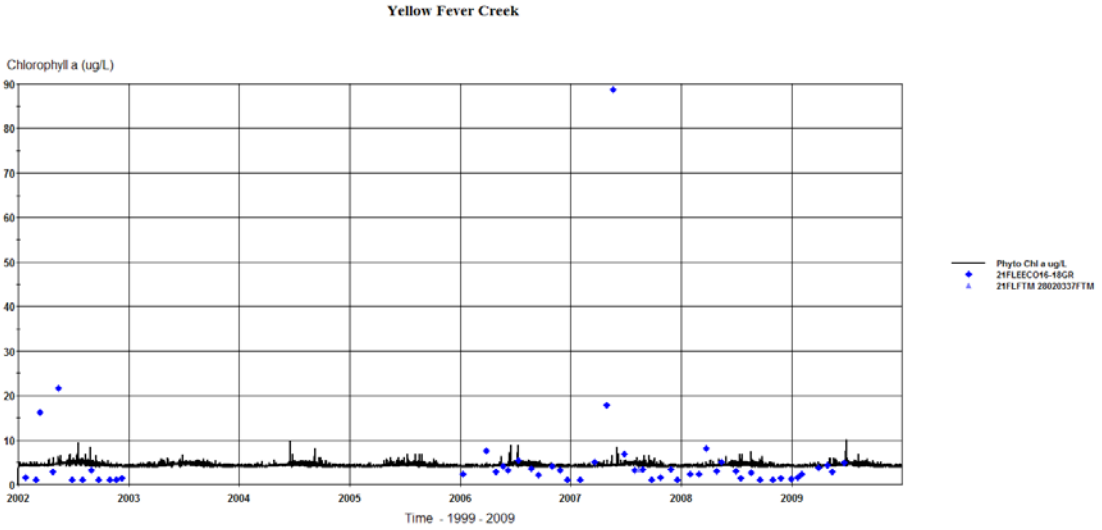

Figure 9 WASP Calibration for Chlorophyll a in Yellow Fever Creek

4. 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)

4.1. Yellow Fever Creek Watershed Natural Condition Analysis

Yellow Fever Creek sub basins and upstream landuses were changed from impacted lands to upland forest and wetlands landuses. LSPC was then used to simulate the natural condition nutrient loads (Table 8) which were inputted in to WASP model. Other than the nutrient load reductions the SOD rate was reduced to reflect the reduced loadings. Table 6 provides the annual average model predictions for total nitrogen, total phosphorus, and dissolved oxygen.

Table 6 Annual Average Loadings for Natural Condition

	Natural Condition	
Constituent	WLA (kg/yr)	LA (kg/yr)
Total Nitrogen	NA	9,587
Total Phosphorus	NA	4,014
BOD	NA	8,556

Table 7 presents the predicted annual average concentrations under natural conditions. Without the impacts of anthropogenic sources the dissolved oxygen concentration in the Yellow Fever Creek still would achieve the dissolved oxygen standard of 5 mg/l.

Table 7 Natural Condition Annual Average Model Predictions

Constituent	Natural
Total Nitrogen (mg/L)	0.426
Total Phosphorus (mg/L)	0.17
BOD (mg/L)	0.55
DO (mg/L)	4.046
Chlorophyll a (ug/L)	4.418

4.2. 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.

5. 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		MS4	LA
Constituent	WLA (kg/yr)	LA (kg/yr)	WLA (kg/yr)	LA (kg/yr)	% Reduction	% Reduction
Total Nitrogen	NA	13,676	NA	9,587	30%	30%
Total Phosphorus	NA	6,497	NA	4,014	38%	38%
BOD	NA	26,110	NA	8,556	67%	67%