Appendix A:

Modeling Report

Braden River and Cedar Creek

WBIDs: 1914 & 1926

Nutrients and Dissolved Oxygen

September 30, 2009

Region 4 serving the southeast

Table of Contents

Table of Figures

Table of Tables

1. Watershed Description

Braden River (~13.42 miles) flows in a westerly direction just above the Bill Evers Reservoir. Rattlesnake Slough (~3.72 miles) flows in an easterly direction feeding into the Braden River just above the Bill Evers Reservoir. Cedar Creek (~1.43 miles) flows in a northerly direction feeding into the Braden River approximately a half mile above the Bill Evers Reservoir.

WBID 1914 and 1926 Braden River and Cedar Creek 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 Braden River and Cedar Creek.

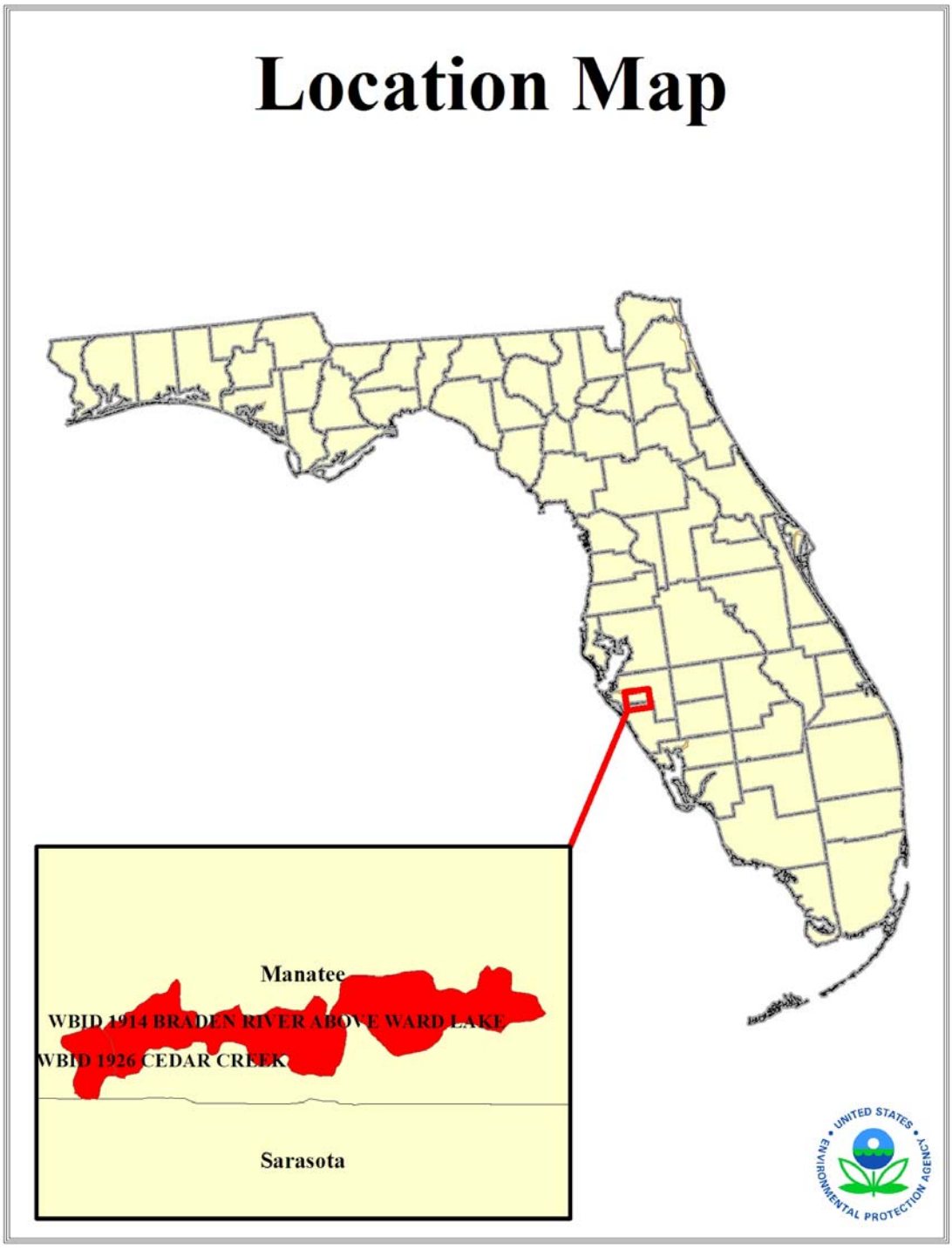

Figure 1 Location Map Braden River and Cedar Creek

The landuse distribution for the Braden River and Cedar Creek and watershed is presented in Table 1.

Table 1 Landuse Distribution in BRADEN RIVER Watershed

Land Use Name	Area (ac)	Portion of Watershed (%)
AGRICULTURE	10,739	30%
BARREN LAND	373	1%
RANGELAND	1,591	4%
TRANSPORTATION, COMMUNICATION AND UTILITIES	1,001	3%
UPLAND FORESTS	3,234	9%
URBAN AND BUILT-UP	11,463	32%
WATER	2,041	6%
WETLANDS	4,964	14%
Totals	35,405	100%

2. TMDL Targets

The TMDL target to be evaluated in this modeling report is to meet the Braden River and Cedar Creek dissolved oxygen standard of 5 mg/l..

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 2008. The watershed model provides daily runoff, nutrient and BOD loadings from the Jane Green Watersheds. The predicted results from the LSPC model are transferred forward to the receiving waterbody model Water Quality Analysis Simulation Program (WASP 7.3) (USEPA, 2007). 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, and will simulate a natural condition removing anthropogenic sources from the watershed. The WASP model will be used to determine the percent reduction in loadings that would be needed to meet water quality standards.

3.1. Braden River and Cedar 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 Braden River and Cedar 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. Braden River and Cedar Creek Watershed Delineation and Landuse

The surrounding watershed that drains directly to the Braden River and Cedar Creek is presented in Figure 2. This WBID was delineated into 7 LSPC sub basins to simulate the runoff and pollutant loads.

Figure 2 Braden River and Cedar Creek Watershed

Figure 3 illustrates the Florida Landuse Classification (Level-1) for the Braden River and Cedar Creek surrounding watershed.

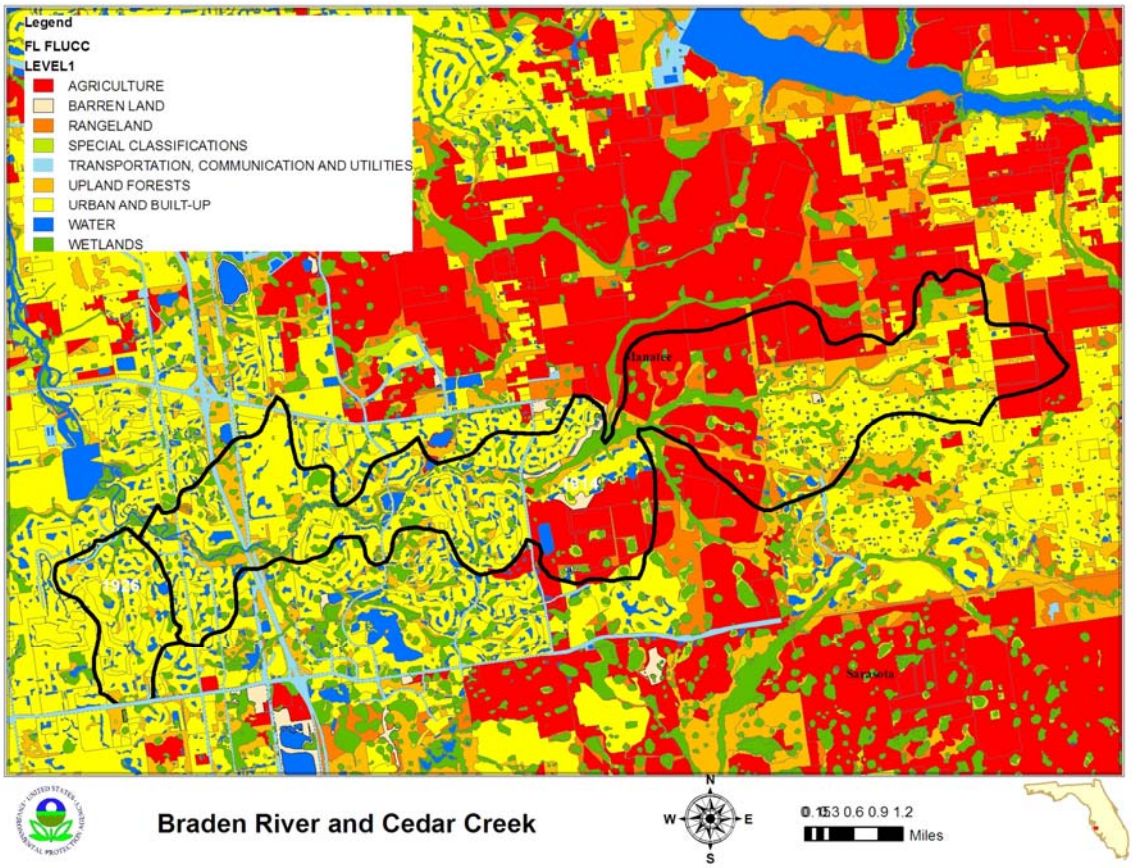

Figure 3 Braden River and Cedar Creek Watershed Landuse Distribution

3.2. Braden River and Cedar Creek Watershed Runoff

The LSPC watershed model was developed to simulate hydrologic runoff and pollutant loadings in response to recorded precipitation events.

3.2.1. Meteorological

Rainfall and other pertinent meteorological data was obtained from the National Weather Service (NWS) WBAN station number 12842**:** Tampa International Airport near Tampa, Florida.

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

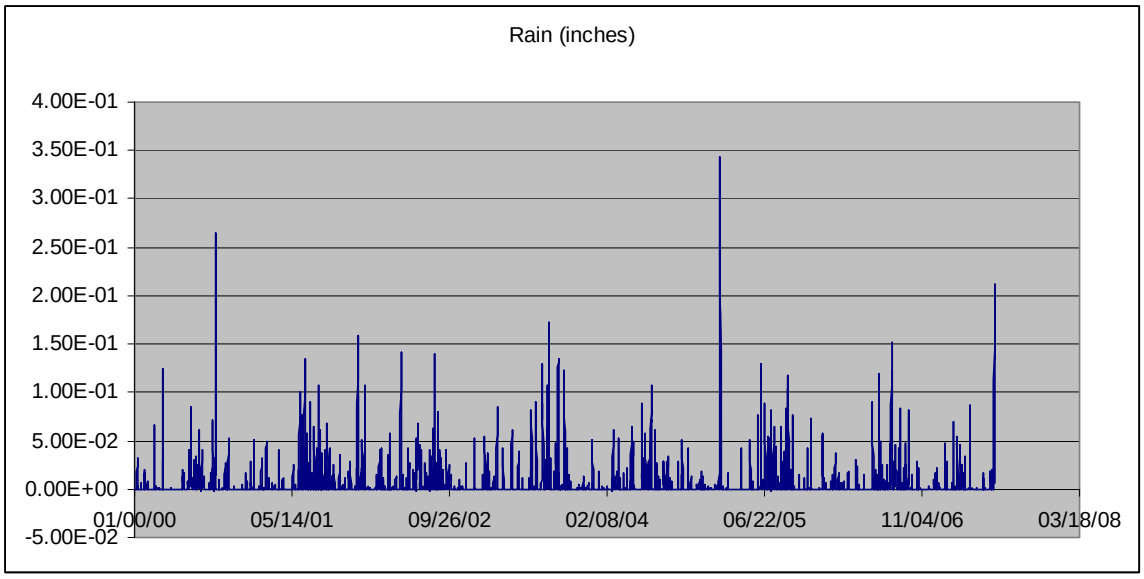

Figure 4 Rainfall for Braden River and Cedar Creek

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

Table 2 Annual Rainfall

Year	Rainfall (Inches)
2002	**38**
2002	**61**
2003	**51**
2004	**59**
2005	**39**
2006	**57**
2007	**42**
2008	**23**

3.2.2. Flow

Flows were simulated for the Braden River and Cedar Creek watershed using the watershed model and compared to the Braden River USGS gage (USGS 02300032). Flows in the Braden River and Cedar Creek watersheds were determined by the hydrology component of the LSPC watershed model. The hydrological values used to parameterize LSPC were taken from a previous application of the Hydrologic Simulation Program (FORTRAN) (HSPF) that was previously applied and calibrated for Sarasota County.

3.2.3. 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 Sarasota County modeling report (JEA 2005). Baseflow concentrations were derived from the USJR HSPF report (CDM 2007) and review of the Braden River and Cedar Creek data.

Table 3 Event Mean Concentration for Landuse Classifications

Landuse	Total Nitrogen (mg/l)	Total Phosphorus (mg/l)	BOD (mg/l)
Agriculture	4	1.1	10
Barren Land	4	1.1	10
Rangeland	2.2	0.34	10
Special Classification	2.2	0.3	10
Transporation	2.2	0.3	10
Upland Forest	1.02	0.16	3
Urban Area	1.9	0.5	10
Water	1.02	0.1	3
Wetlands	1.02	0.1	3

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 thru 2008.

Table 4 Braden River and Cedar Creek Nutrient Loads (2002-2008)

Subbasin	Total Nitrogen Load (kg/yr)	Total Phosphorus Load (kg/yr)	BOD Load (kg/yr)
Braden River Watershed	61,339	13,649	353,855
Cedar Creek Watershed	4,544	1,095	24,779
Total of Braden River and Cedar Creek Watersheds	65,884	14,744	378,634

3.3. Braden River and Cedar Creek Water Quality Model

The Braden River and Cedar 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 16 segment WASP water quality

model was setup to predict water quality in the Braden River. A separate water quality model was developed to simulate water quality in Cedar River.

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. Table 5 provides the basic kinetic rates used in the model.

Table 5 WASP Kinetic Rates

WASP Kinetic Parameters	Value
Global Reaeration Rate Constant @ 20 °C (per day)	1
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	80
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 Braden River and Cedar Creek WASP model predictions were compared to Braden River and Cedar Creek water quality data stations 21FLSJWMJGS and 21FLSJWMUSJ055.

Table 6 provides the annual average calibration summary of the comparison between the WASP Braden River and Cedar Creek segment and the Braden River and Cedar Creek Station for total nitrogen, total phosphorus, chlorophyll a and dissolved oxygen. Figure 5 through Figures 8 illustrates the comparisons of model results and data at the same location.

Table 6 Model Calibration Summary

BRADEN RIVER 21FLMANABR2	2002–2008 Data Average	2002-2008 Model Average
Total Nitrogen (mg/l)	.8	0.9
Total Phosphorus (mg/l)	0.14	0.17
DO (mg/l)	6.9	7.2
Flow (cms) USGS 02300032	1.4	1.6

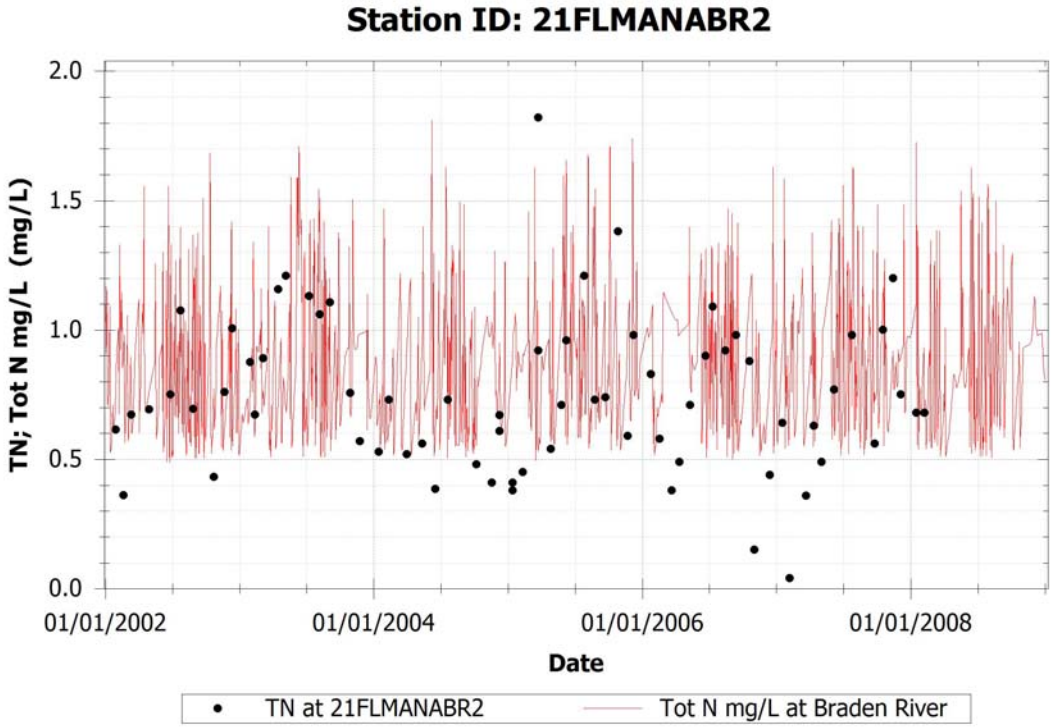

Figure 5 WASP Calibration for Total Nitrogen in Braden River and Cedar Creek

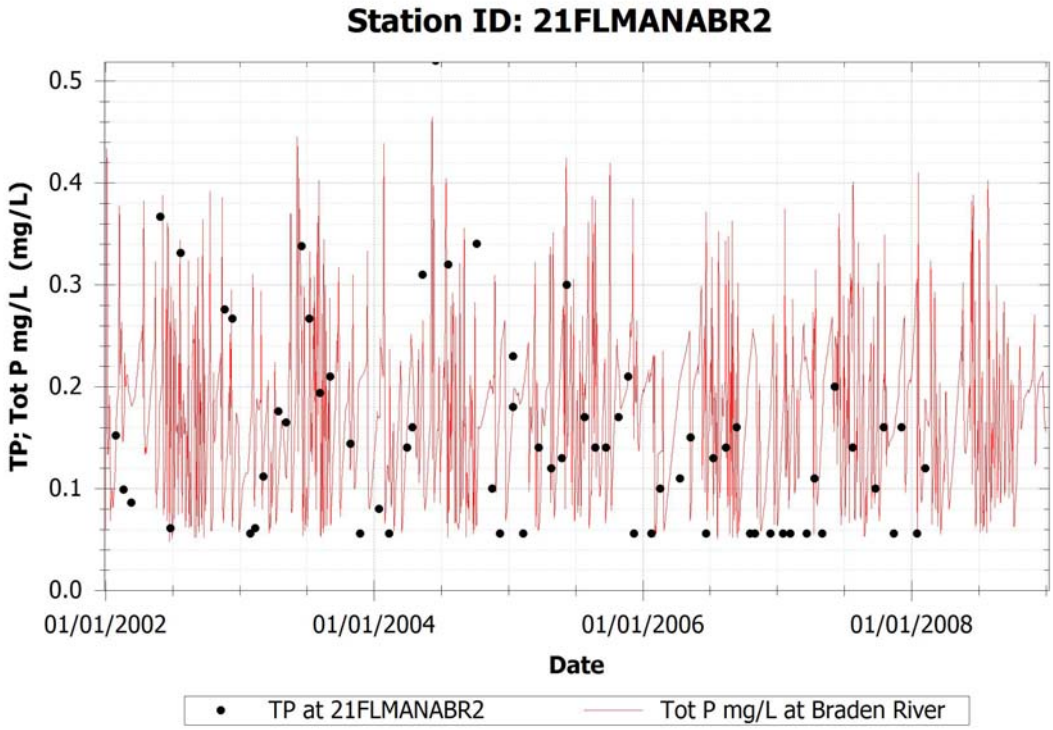

Figure 6 WASP Calibration for Total Phosphorus in Braden River and Cedar Creek

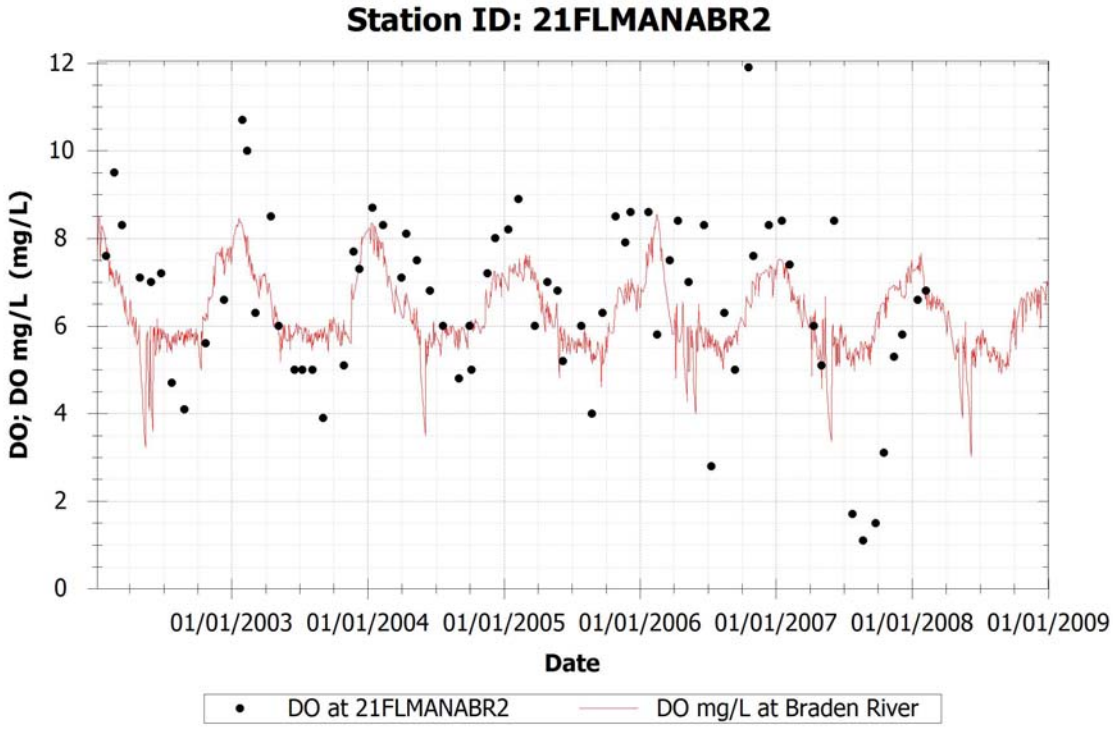

Figure 7 WASP Calibration for Dissolved Oxygen in Braden River and Cedar Creek

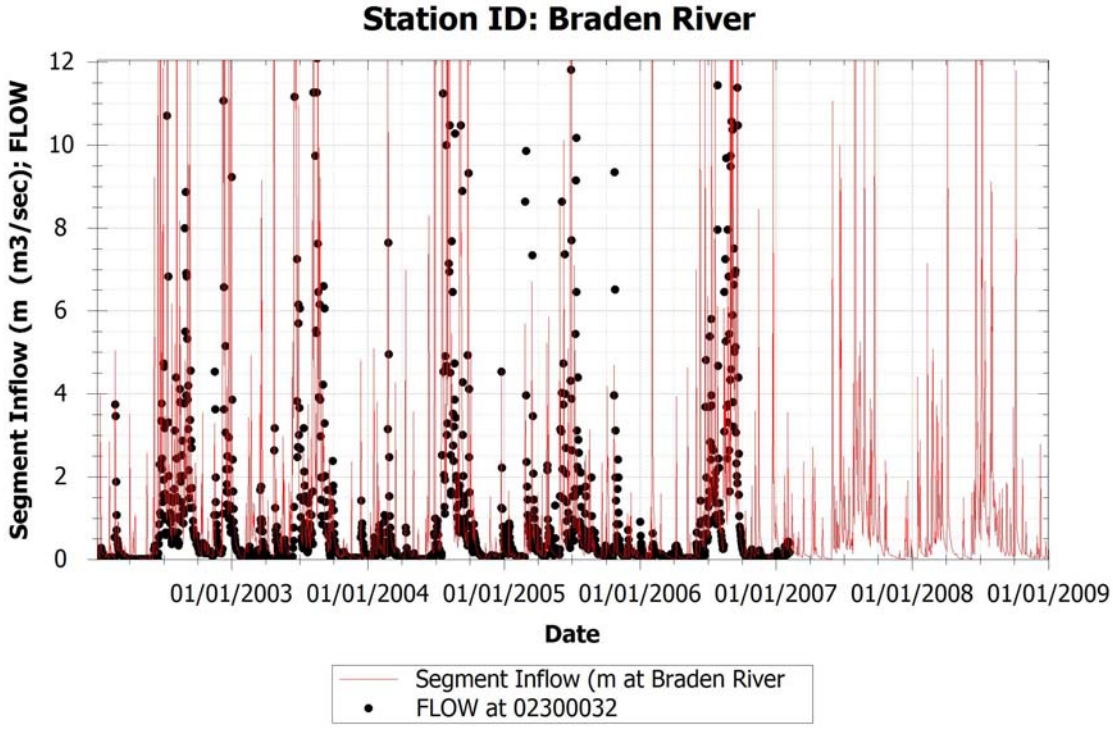

Figure 8 WASP Calibration for Flow @ USGS 02300032

Table 7 presents the annual average predictions for BOD, total nitrogen, total phosphorus and dissolved oxygen.

Table 7 Existing Condition Annual Average Model Predictions

Braden River and Cedar Creek @ 21FLMANABR2	2002-2008 Model Prediction Annual Average
BOD (mg/l)	3.5
Total Nitrogen (mg/l)	0.75
Total Phosphorus (mg/l)	0.13
DO avg (mg/l)	5.2
DO min (mg/l)	3.5

4. Modeling Scenarios

Two modeling scenarios were completed to evaluate potential nutrient reduction options. Model years 2002 thru 2008 were used, 2002 was used as model ramp up period. An initial natural condition analysis was completed to predict what Braden River and Cedar Creek chlorophyll a and dissolved oxygen levels would be if all impacted upstream lands were converted back to upland forest and wetlands. The second analysis examined the impacts of the 30% reduction scenario, which is the TMDL analysis providing the BOD, total nitrogen and total phosphorus reductions needed to meet the TMDL targets. Note the 30% reduction applies to both waterbodies.

4.1. Braden River and Cedar Creek Watershed Natural Condition Analysis

Braden River and Cedar Creek sub basins 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 better reflect the natural condition loadings. Table 9 provides the annual average model predictions for total nitrogen, total phosphorus, chlorophyll a, dissolved oxygen.

Table 8 Natural Condition Annual Average Nutrient Loads

Subbasin	Total Nitrogen Load (kg/yr)	Total Phosphorus Load (kg/yr)	BOD Load (kg/yr)
Braden River Watershed	21,630	2,831	174,892
Cedar Creek Watershed	1,272	164	10,005
Total of Braden River and Cedar Creek Watersheds	22,902	2,995	184,898

Table 9 presents the predicted annual average concentrations under natural conditions without the impacts of anthropogenic sources on the dissolved oxygen in the Braden River and Cedar Creek.

Table 9 Natural Condition Annual Average Model Predictions

Braden River and Cedar Creek	2002-2008 Model Prediction Annual Average
BOD (mg/l)	2.3
Total Nitrogen (mg/l)	0.65
Total Phosphorus (mg/l)	0.09
DO avg (mg/l)	7.2
DO minimum (mg/l)	5.8

4.2. 30 Percent Reduction Scenario

The 30 percent reduction of nutrient loads with corresponding reduction of SOD. Table 10 provides the 30% reduction annual loads and Table 11 the resultant predictions for total nitrogen, total phosphorus and dissolved oxygen and would achieve the dissolved oxygen standard of 5 mg/l.

Table 10 30% Reduction of Annual Average Nutrient Loads

Subbasin	Total Nitrogen Load (kg/yr)	Total Phosphorus Load (kg/yr)	BOD Load (kg/yr)
Braden River Watershed	30,670	6,824	176,927
Cedar Creek Watershed	2,272	548	12,389
Total of Braden River and Cedar Creek Watersheds	32,942	7,372	189,317

Table 11 30% Reduction of Annual Average Nutrient Concentrations

Braden River and Cedar Creek	2002-2008 Model Prediction Annual Average
BOD (mg/l)	2.8
Total Nitrogen (mg/l)	0.6
Total Phosphorus (mg/l)	0.08
DO avg (mg/l)	6.2
DO minimum (mg/l)	5.0

4.3. TMDL Reduction

The TMDL load reduction was set to the 30 percent reduction scenario.

Table 12 TMDL Reduction Scenario

Braden River and Cedar Creek Watersheds	**Total Nitrogen Load (kg/yr)**	**Total Phosphorus Load (kg/yr)**	**BOD Load (kg/yr)**
Existing Conditions	65,884	14,744	378,634
30% Reduction	46,119	10,321	265,044
Percent Reduction	30%	30%	30%