Receiving Water Analyses of Proposed Marys Creek Water Reclamation Plant

October 16, 2018

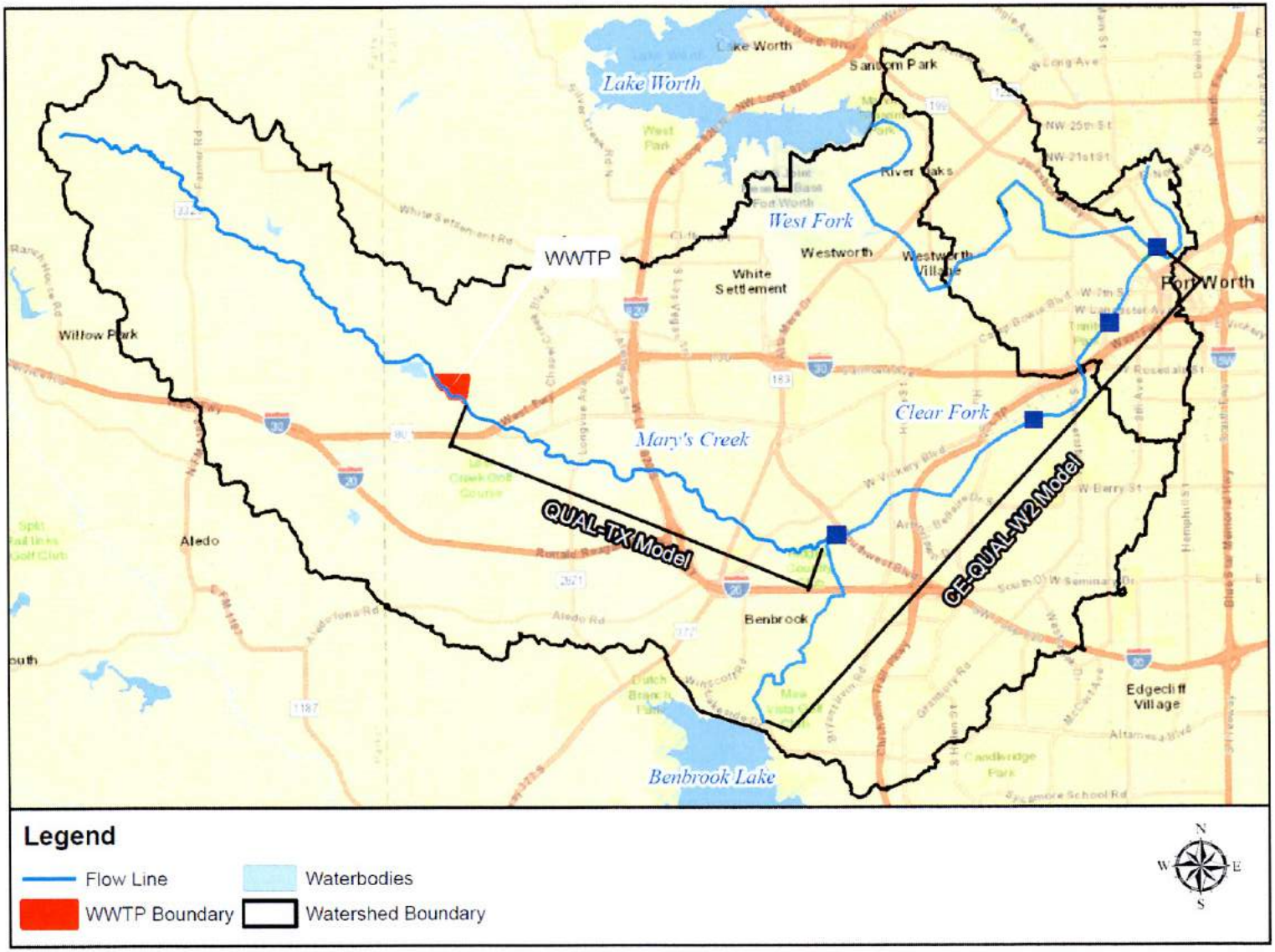
Revised February 27, 2019 (slides 40 - 54)

trwd Tarrant Regional Water District

Introduction

- The City of Fort Worth proposes to discharge treated wastewater effluent to Marys Creek about 13.2 km upstream of the confluence with the Clear Fork Trinity River from a new water reclamation facility – Marys Creek Water Reclamation Plant (MCWRP)
- Flowrates
  - 10 MGD interim phase
  - 15 MGD final phase
- Projected effluent limits
  - 5 mg/l CBOD5, 2 mg/L NH3-N, 6 mg/L DO, 1 mg/L phosphorus
- Objective of the project: evaluate impacts of MCWRP on the Clear Fork of the Trinity using the CE-QUAL-W2 model

Location Map

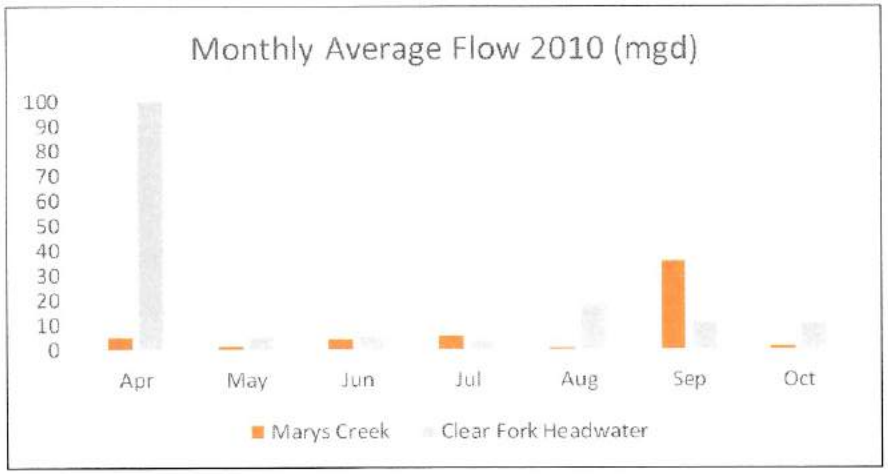


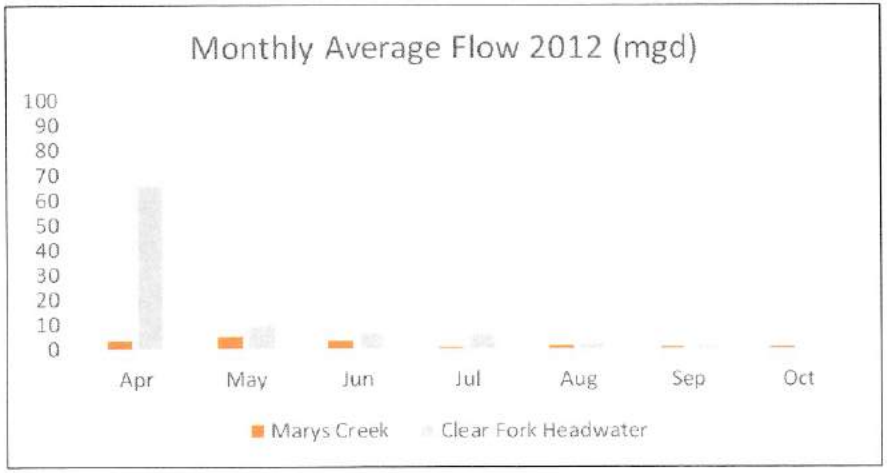
Modeling Approach

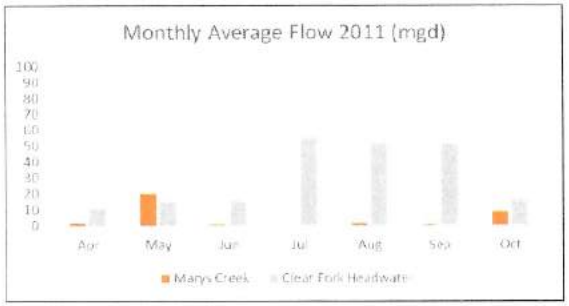
- Establish baseline condition
  - Summer 2012
- Marys Creek Assimilation Analysis
  - High nutrient assimilation
  - Low nutrient assimilation
  - Nutrient Assimilation based on TRWD tracer studies
- Clear Fork Assimilation Analysis
  - Baseline condition + WWTP discharge
  - Nutrient assimilation based on TRWD tracer studies

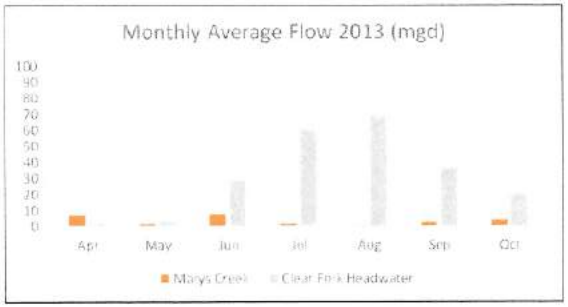
Establish Baseline

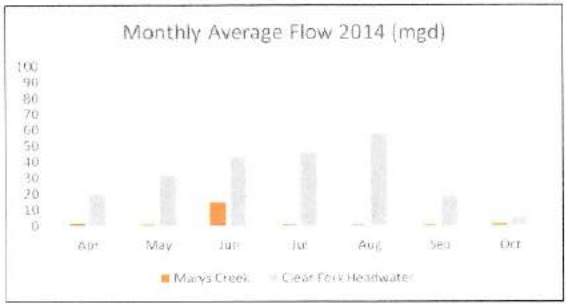
Monthly Average Flows (mgd) 2010-2014





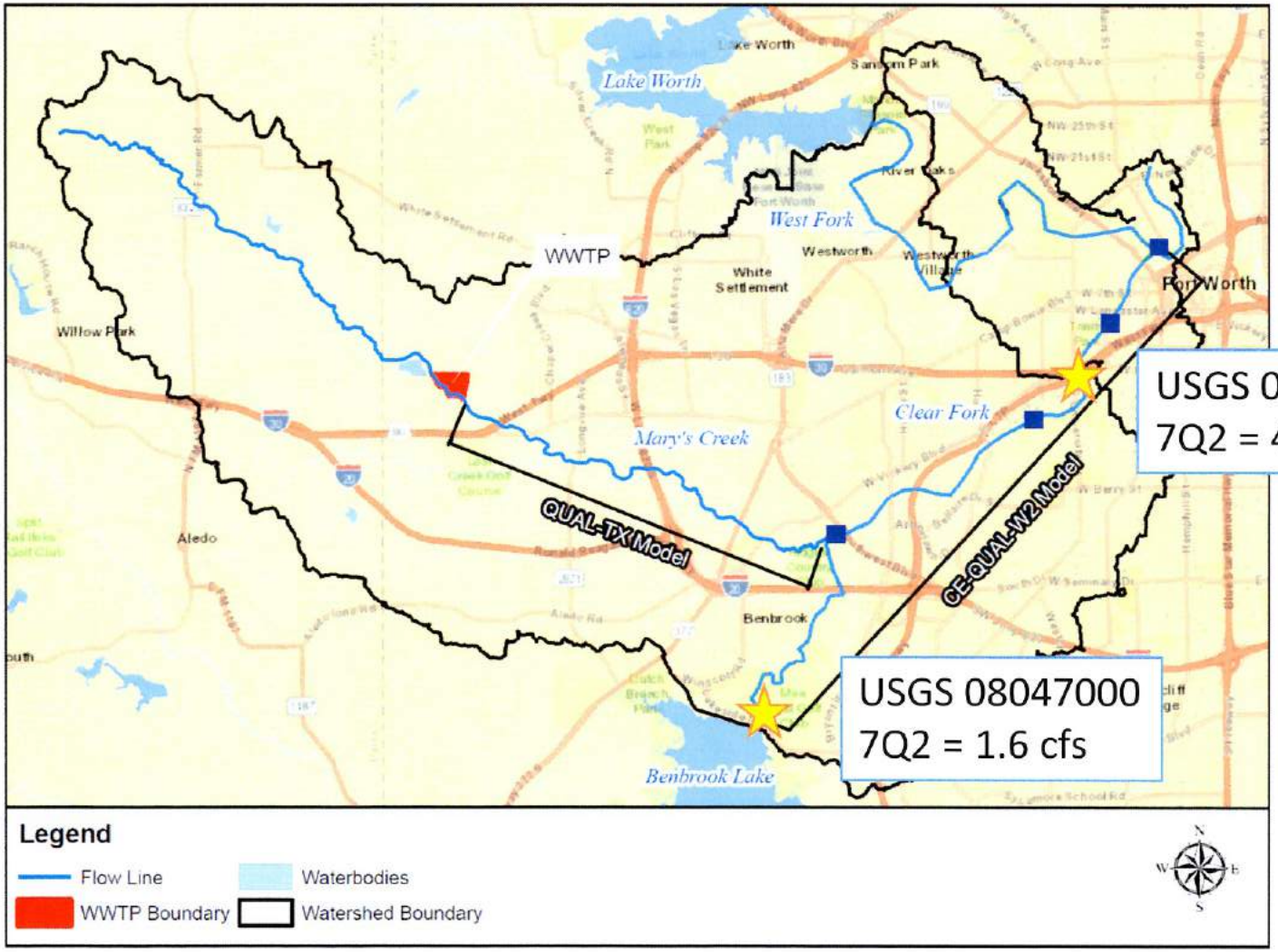




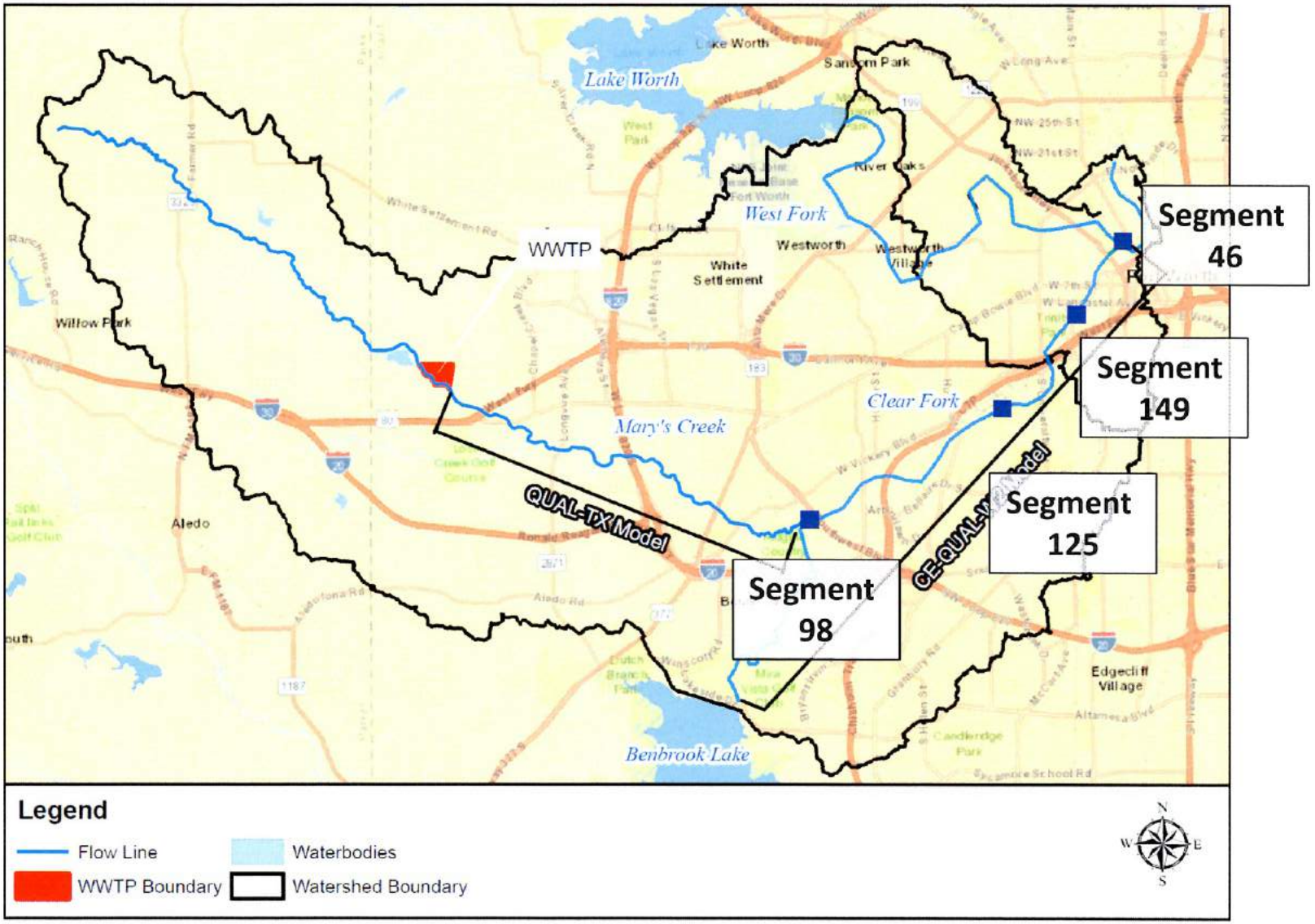


- **2010 and 2012 are candidate years for evaluating potential impacts (low flows in creeks)**
- **Summer 2012 selected for baseline condition**

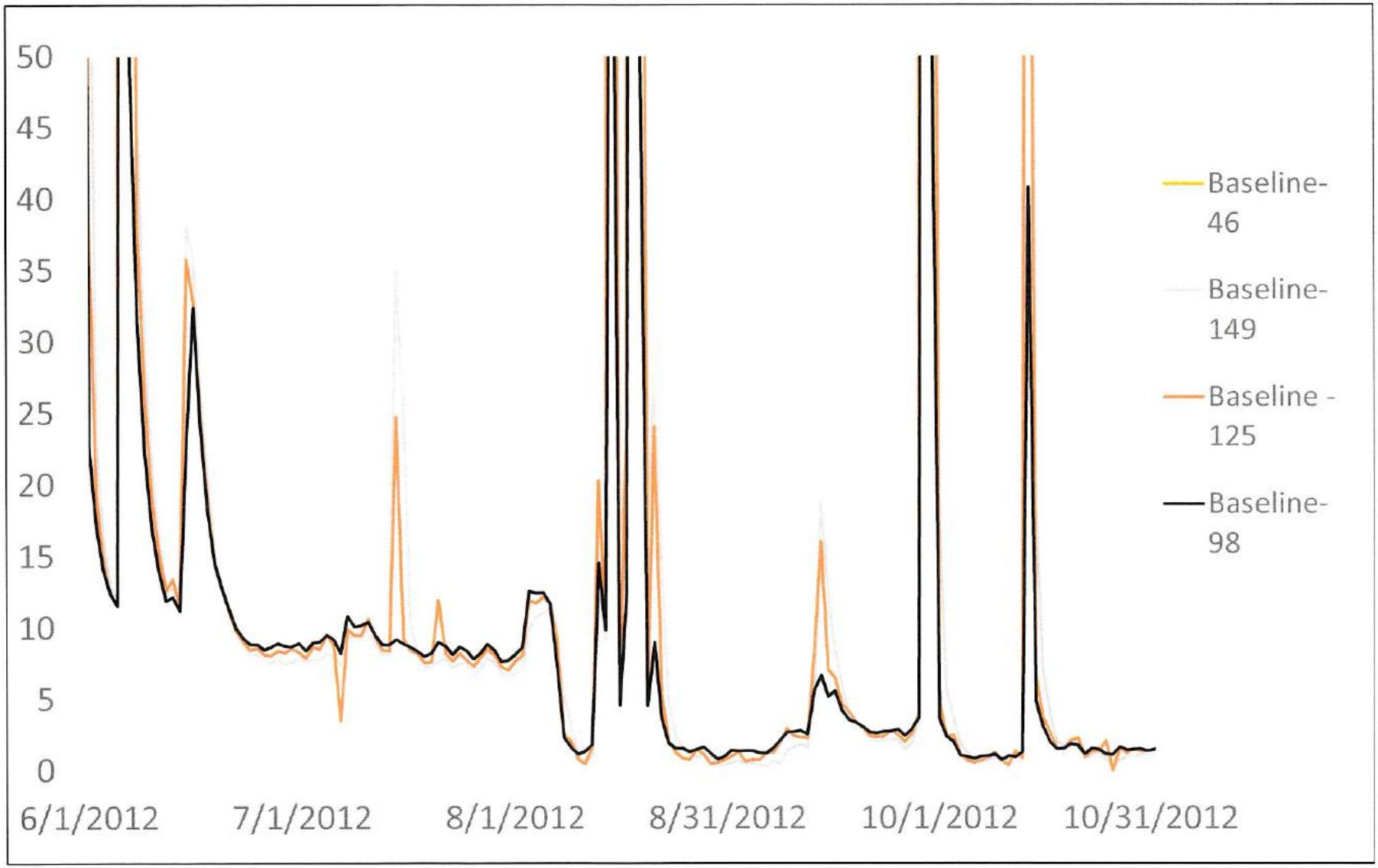
Flows – minimum 7-day, 2-year discharge (7Q2)



Location Map



Clear Fork Flow Conditions (cfs)



Marys Creek Assimilation Analysis

Marys Creek Assimilation Analysis

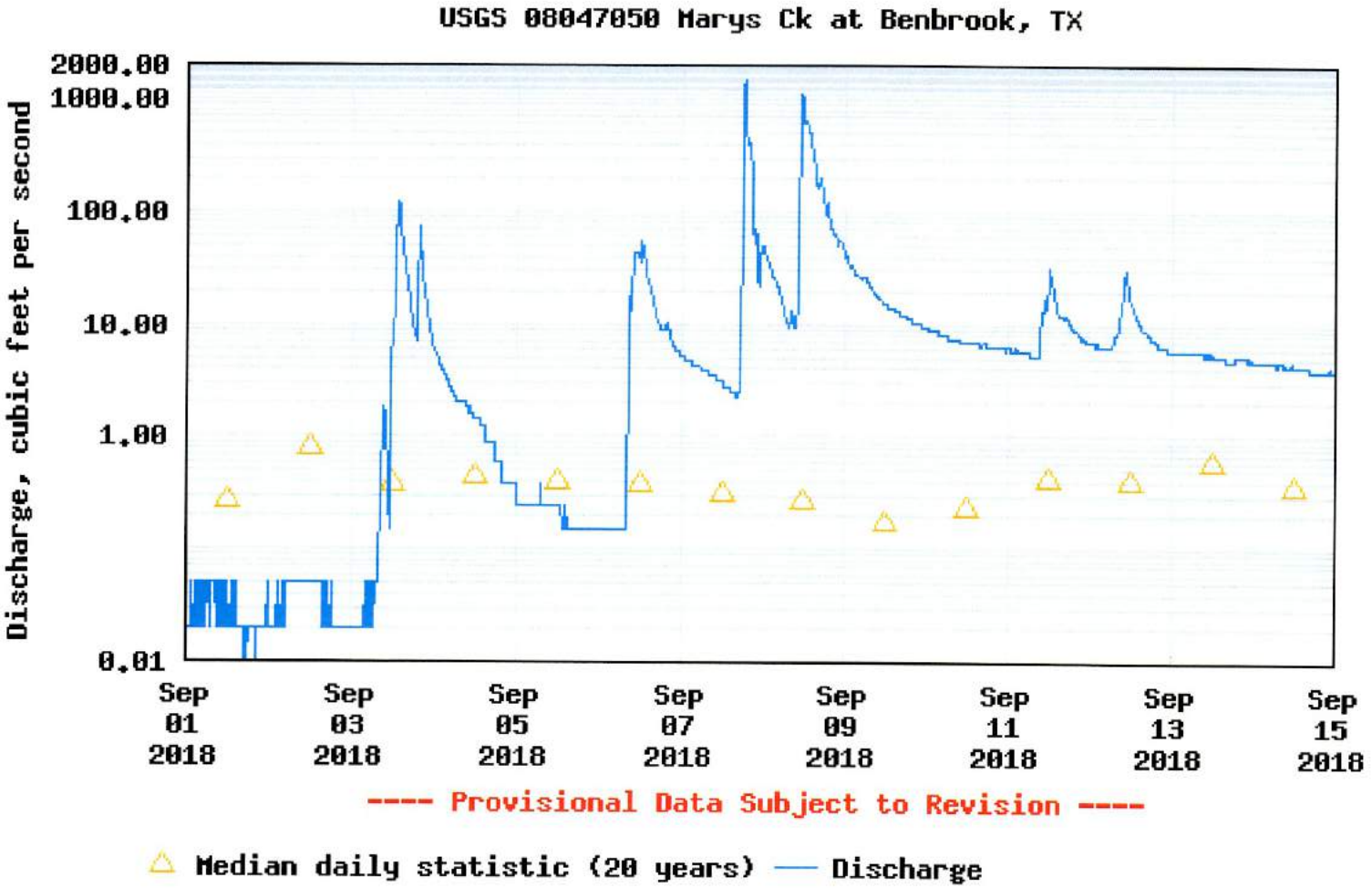
- Objective is to quantify high and low ranges of assimilation to determine end-of-reach nutrient and phytoplankton (chl-a) for Marys Creek discharge to Clear Fork given proposed WWTP discharge and range of potential in-reach assimilation.
- Methods:
  - Use existing APAI QUALTX model of Marys Creek
  - Update to reflect appropriate rate constants for nitrogen and phosphorus
  - Range of rate constant values derived from:
    1. QUALTX technical documentation and USEPA QUAL2e manual and "Rates, constants, and kinetics" report.
    2. TRWD tracer studies and measured data for similar streams.

Marys Creek Assimilation Analysis

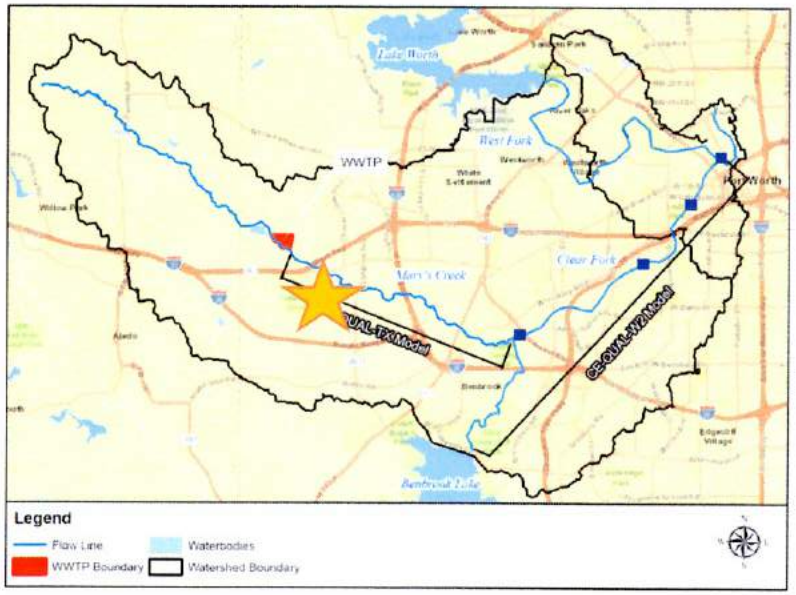
- Methods:
  - Developed 3 scenarios to bracket range of potential assimilation:
    - low assimilation rate constant scenario
    - high assimilation rate constant scenario
    - TRWD tracer study-based rate constant scenario
      - 5 regional streams with similar characteristics, 7 different conservative tracer releases + synoptic nutrient surveys (TRWD)
  - Focus on high temperature, low flow critical conditions
  - Simulations performed for 2 proposed WWTP discharge rates (10, 15 MGD) and 2 assumed WWTP TP discharge concentrations (1.0, 0.5 mg/L)
  - Algae (phytoplankton and periphyton) biomass was prescribed, rather than modeled
    - Based on site visit and photos of current system and "typical" ranges of biomass values in a stream of this size.
    - Conservative assumption of 10 ug/L made for end-of-reach for Clear Fork

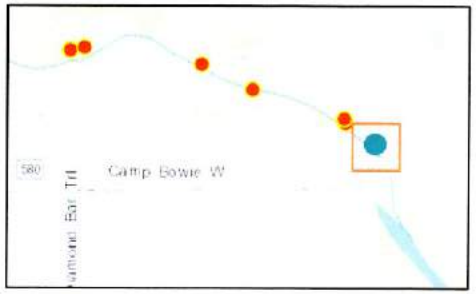
Marys Creek Field Visit - 9 /13/2018

- Flow was approximately 5 cfs

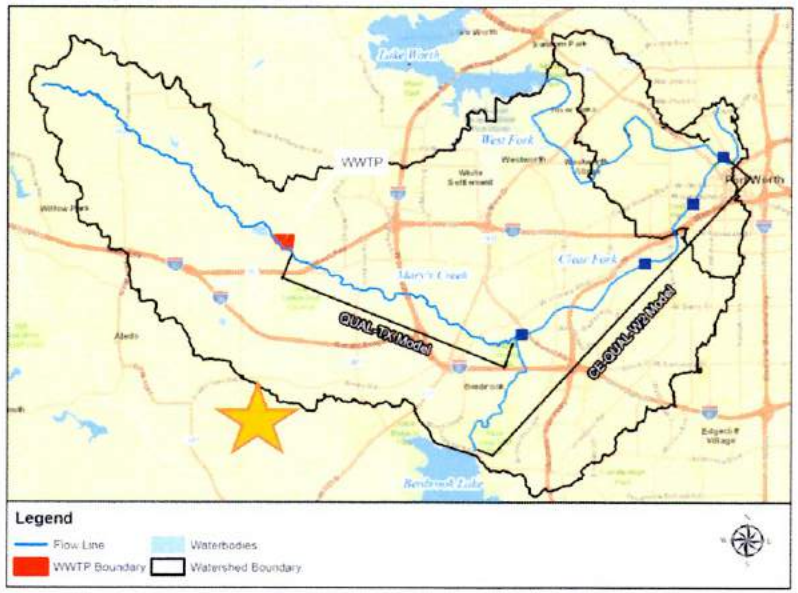


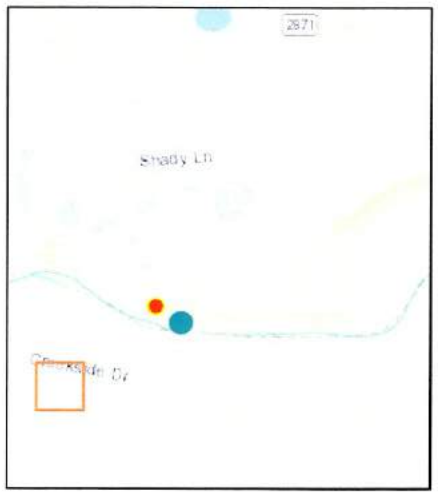
Marys Creek - North of 580

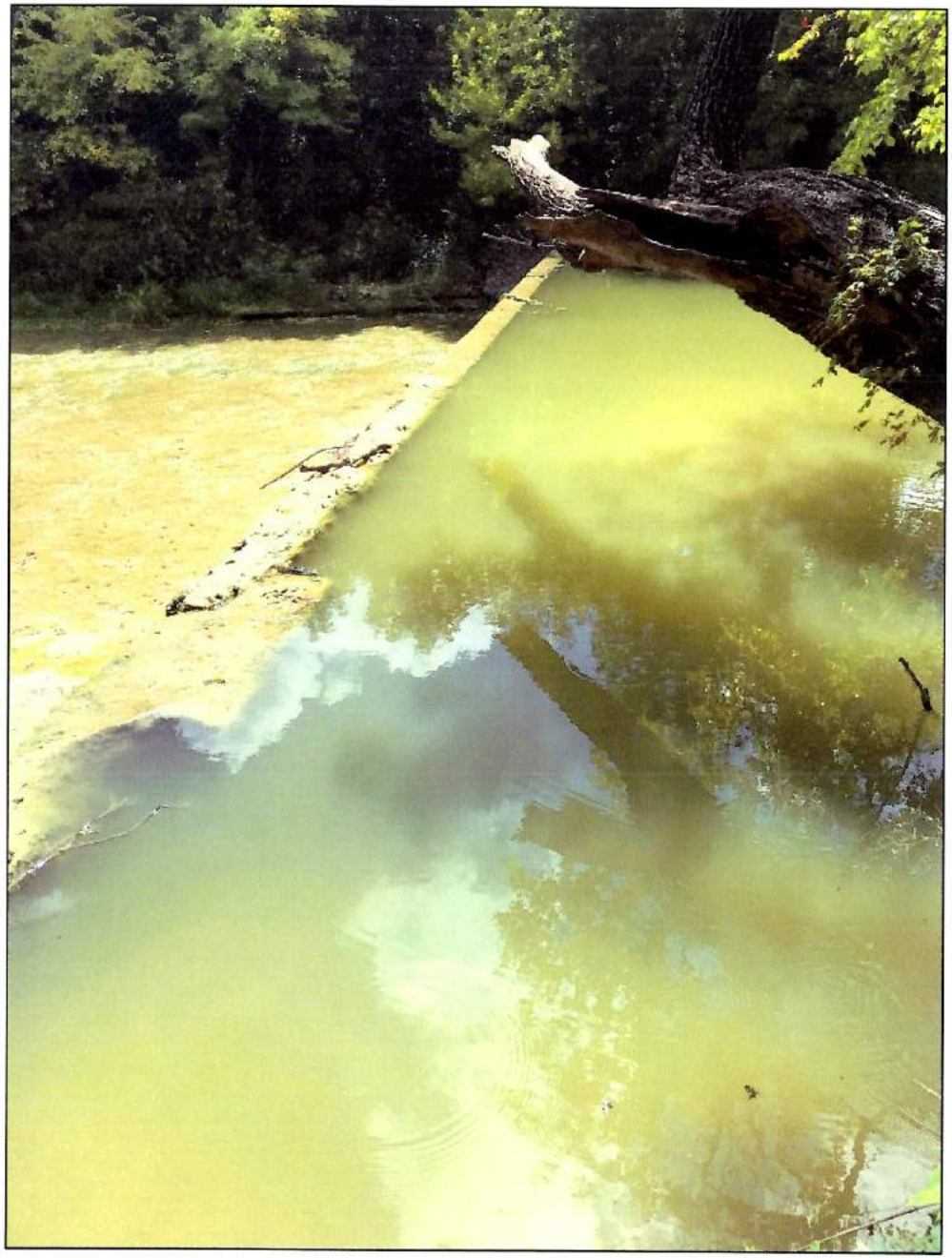




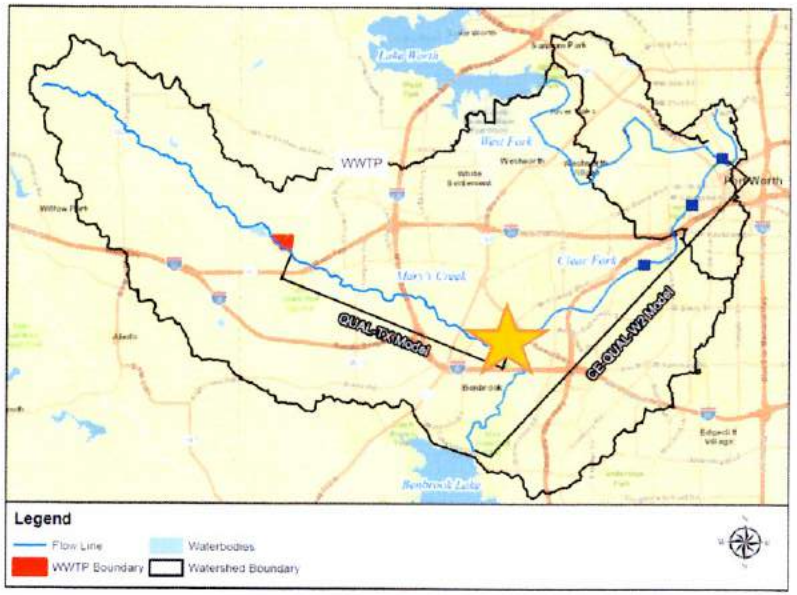
Marys Creek – West of 2871

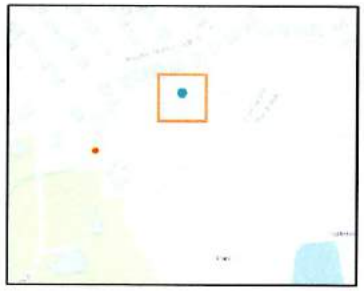


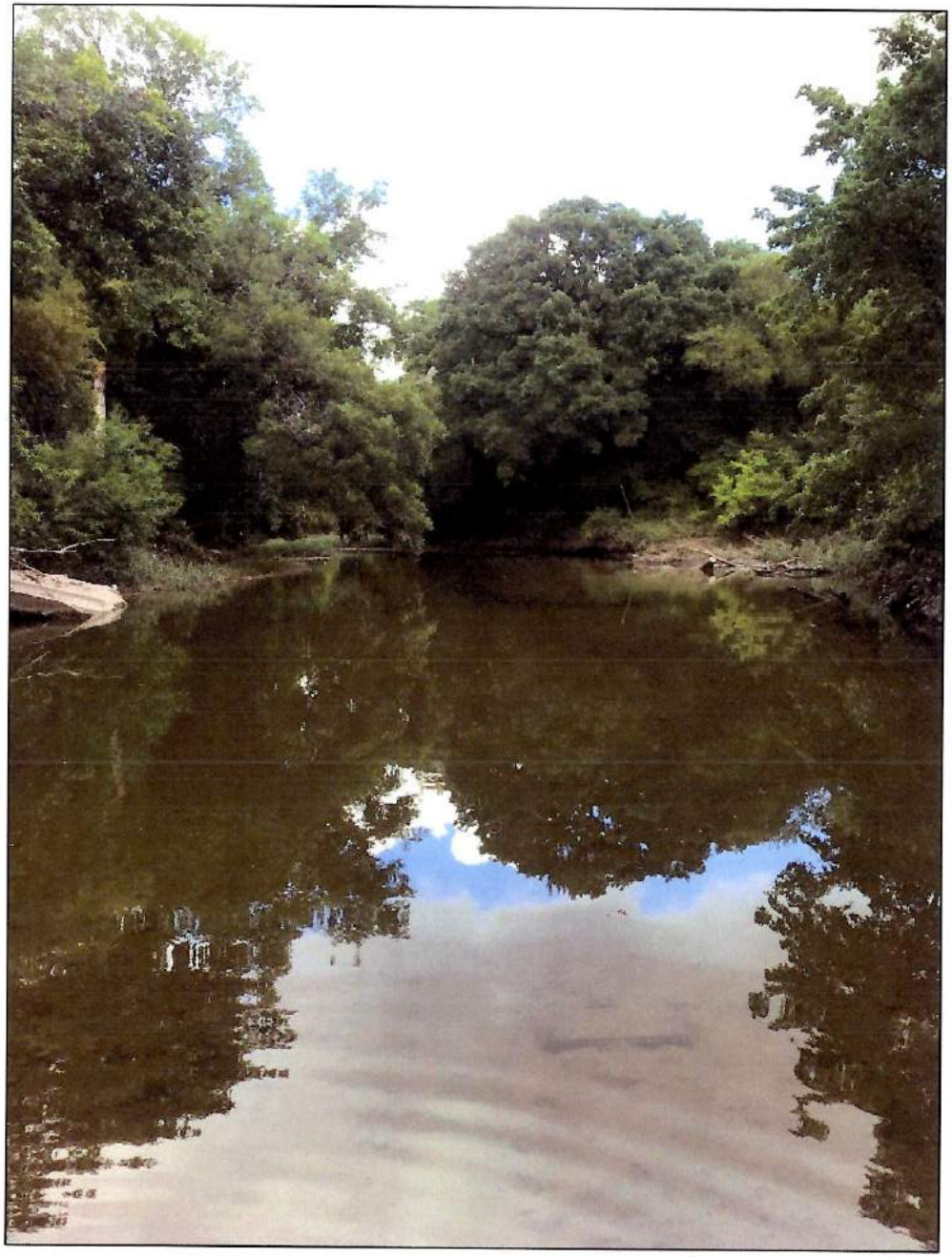




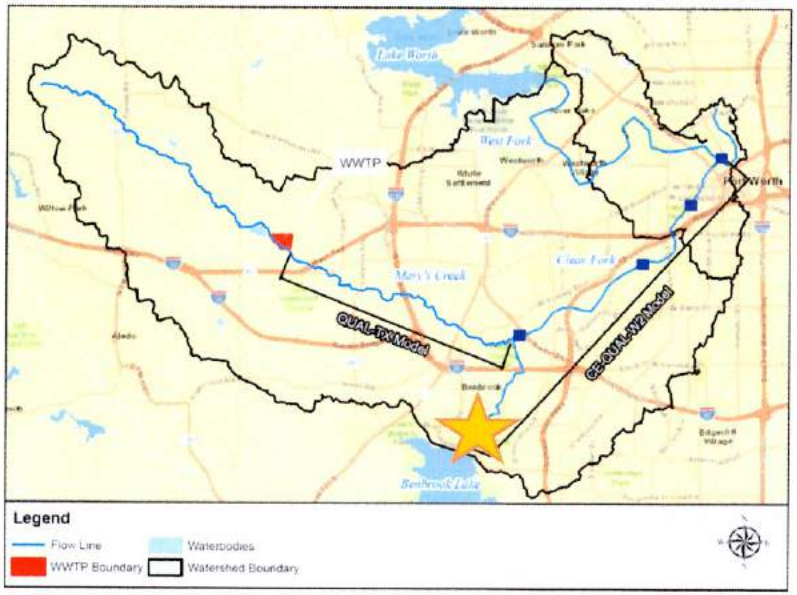
Marys Creek – Confluence

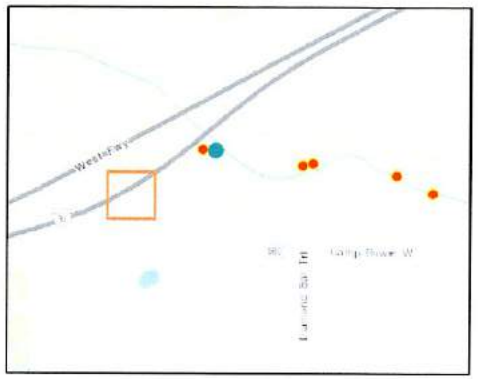


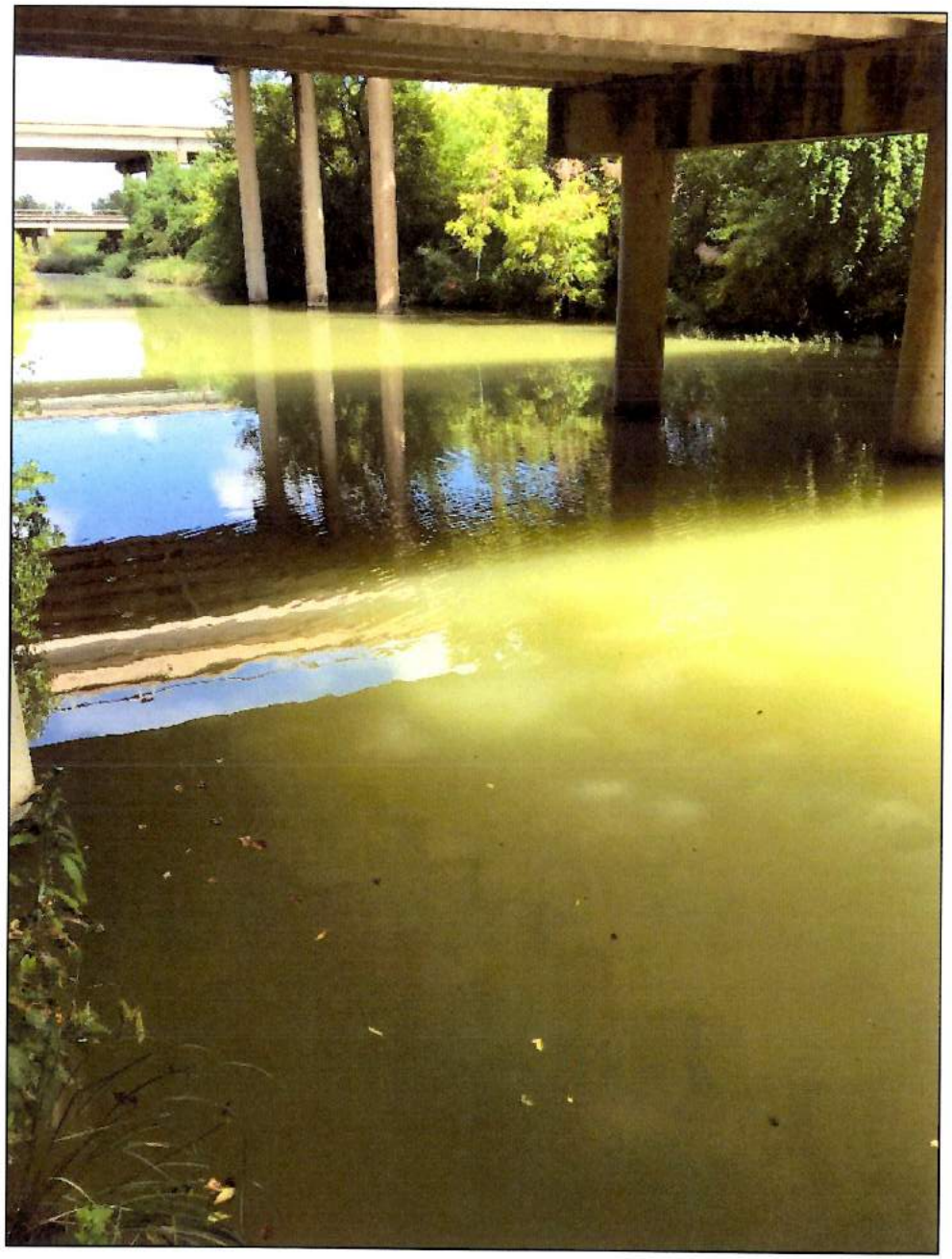




Clear Fork Downstream of Marys Creek - South of I-30







Marys Creek Assimilation Analysis

- **Model Rates and Constants:**

Parameter	Low Assimilation Value	High Assimilation Value	Regional Tracer / Synoptic Results Scenario	Source, Comment
Denitrification Oxygen Threshold	2	4	4	QUALTX
BOD1 decay rate (1/d)	0.02	1.7	1.7	QUAL2e Manual
BOD1 settling rate (1/d)	0	0.36	0.36	QUAL2e Manual
BOD2 decay rate (1/d)	0.02	1.7	1.7	QUAL2e Manual
BOD2 settling rate (1/d)	0	0.36	0.36	QUAL2e Manual
Organic N decay rate (1/d)	0.02	0.4	0.4	QUAL2e Manual
Organic N settling rate (1/d)	0.001	0.1	0.1	QUAL2e Manual
Nitrification rate (1/d)	0.1	1	0.45	QUAL2e Manual
Denitrification rate constant (1/d)	0.002	1	0.4	Rates, Constants, and Kinetics (EPA)
Organic P hydrolysis rate (1/d)	0.01	0.7	0.01	QUAL2e Manual
Organic P settling rate (1/d)	0.001	0.1	0.001	QUAL2e Manual
Phytoplankton Biomass, chl-a (ug/L)	50	80	50	QUALTX Manual
Periphyton Biomass (g D.W./m2)	0	10	50	Rates, Constants, and Kinetics (EPA)
Phytoplankton N uptake rate (mg/ug chl-a/d)	0.0025	0.0025	0.0025	QUALTX default
Phytoplankton P uptake rate (mg/ug chl-a/d)	0.0002	0.0002	0.00069	QUALTX default, tracer calibration
Periphyton N uptake rate (mg/mg DW/d)	0.0025	0.0025	0.0025	QUALTX default
Periphyton P uptake rate (mg/mg DW/d)	0.0002	0.0002	0.00069	QUALTX default, tracer calibration

Marys Creek Assimilation Analysis

- Observations:
  - Large range of nitrogen and phosphorus discharge concentrations
  - Potential for significant nitrogen assimilation
  - Tracer studies indicate high potential P removal, via uptake

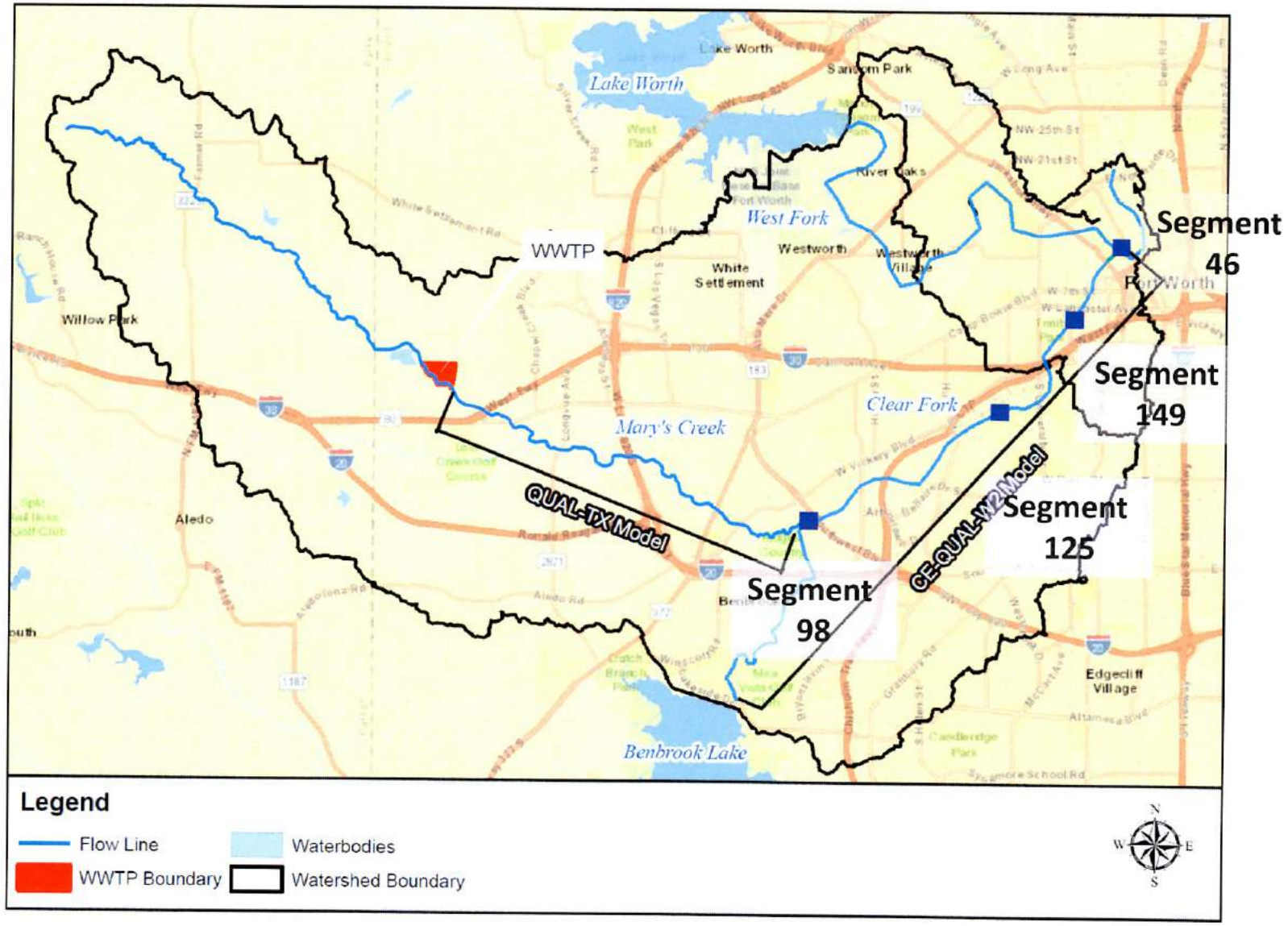
Effluent Characteristics

	(Initial)	(0.5 mg/l P)	(1 mg/l P)
DO	6	6	6
BOD1	5	5	5
ORG-N	1	1	1
NH3-N	2	2	2
NO3-N	6	6	6
BOD2	0	0	0
PO4-P	3.5	0.4	0.8
ORG-P	0.75	0.1	0.2

Scenario	MGD	NH3-N (mg/L)	NO3-N (mg/L)	Total Phosphorus (mg/L)
Low	10	1.26	6.68	0.49
	15	1.45	6.51	0.49
High	10	0.11	0.07	0.36
	15	0.23	0.77	0.40
Tracer	10	0.45	1.73	0.12
	15	0.73	2.77	0.24

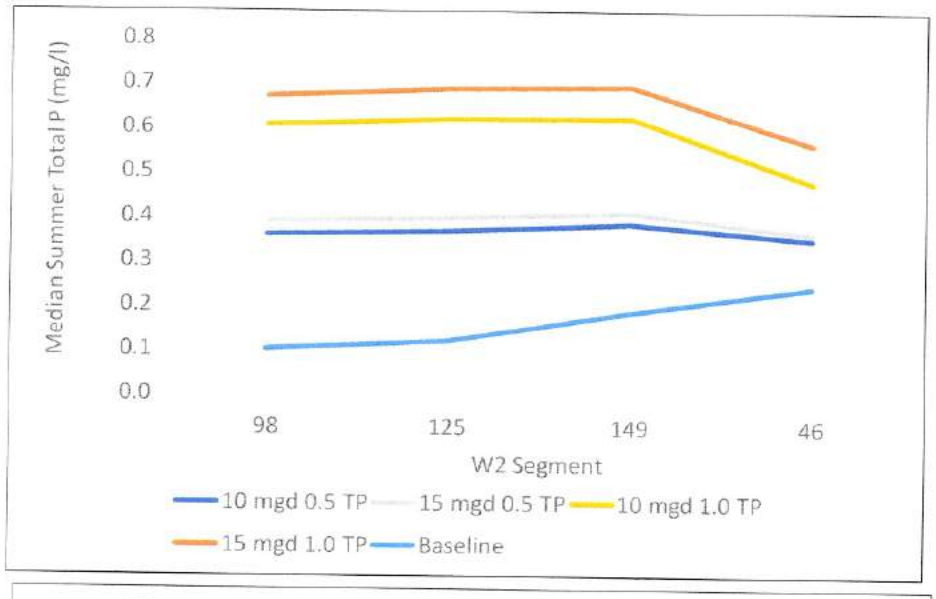
Clear Fork Assimilation Analysis

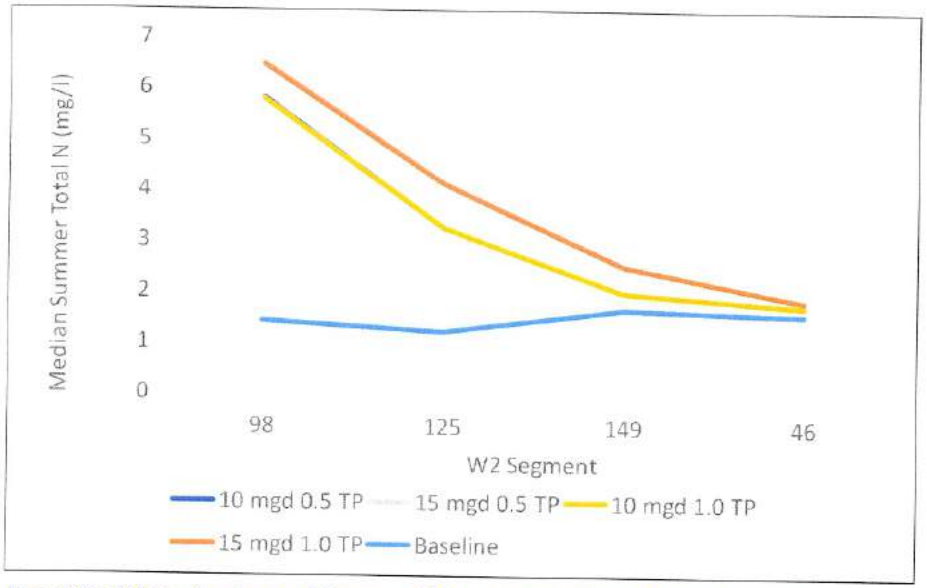
Location Map

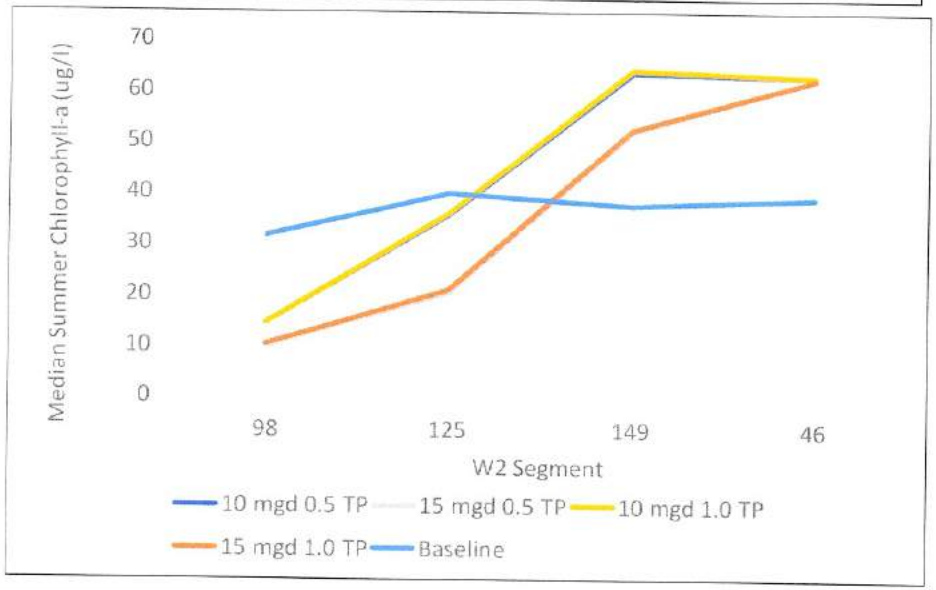


Initial Runs – No Attenuation

- Chlorophyll-a at Marys Creek confluence (98) lower assuming zero concentration from WWTP
- Downstream chlorophyll-a impacts more pronounced for 10 mgd WWTP discharge vs. 15 mgd
- Chlorophyll-a impacts are insensitive to TP concentrations at 0.5 vs. 1.0 mg/l



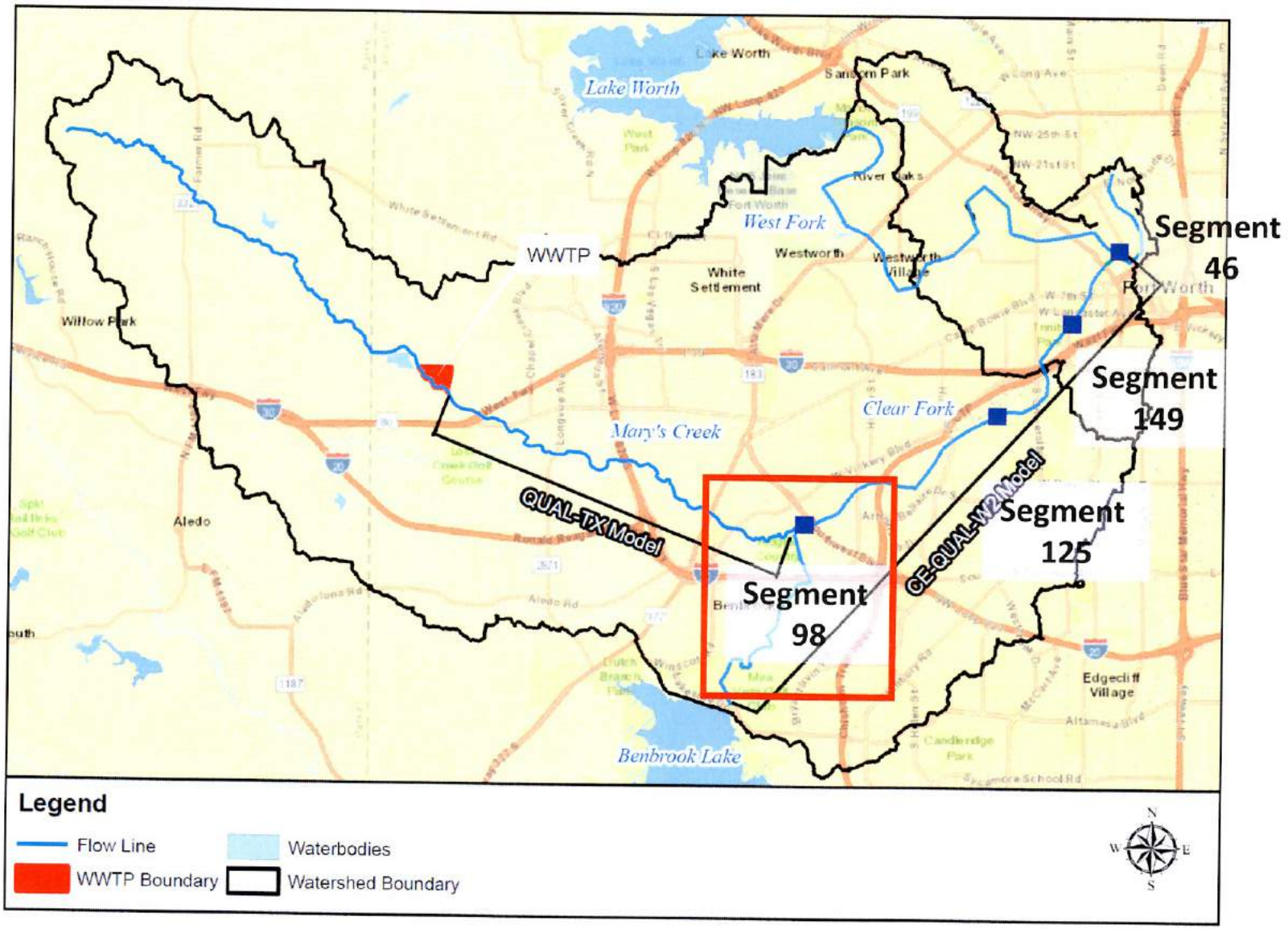




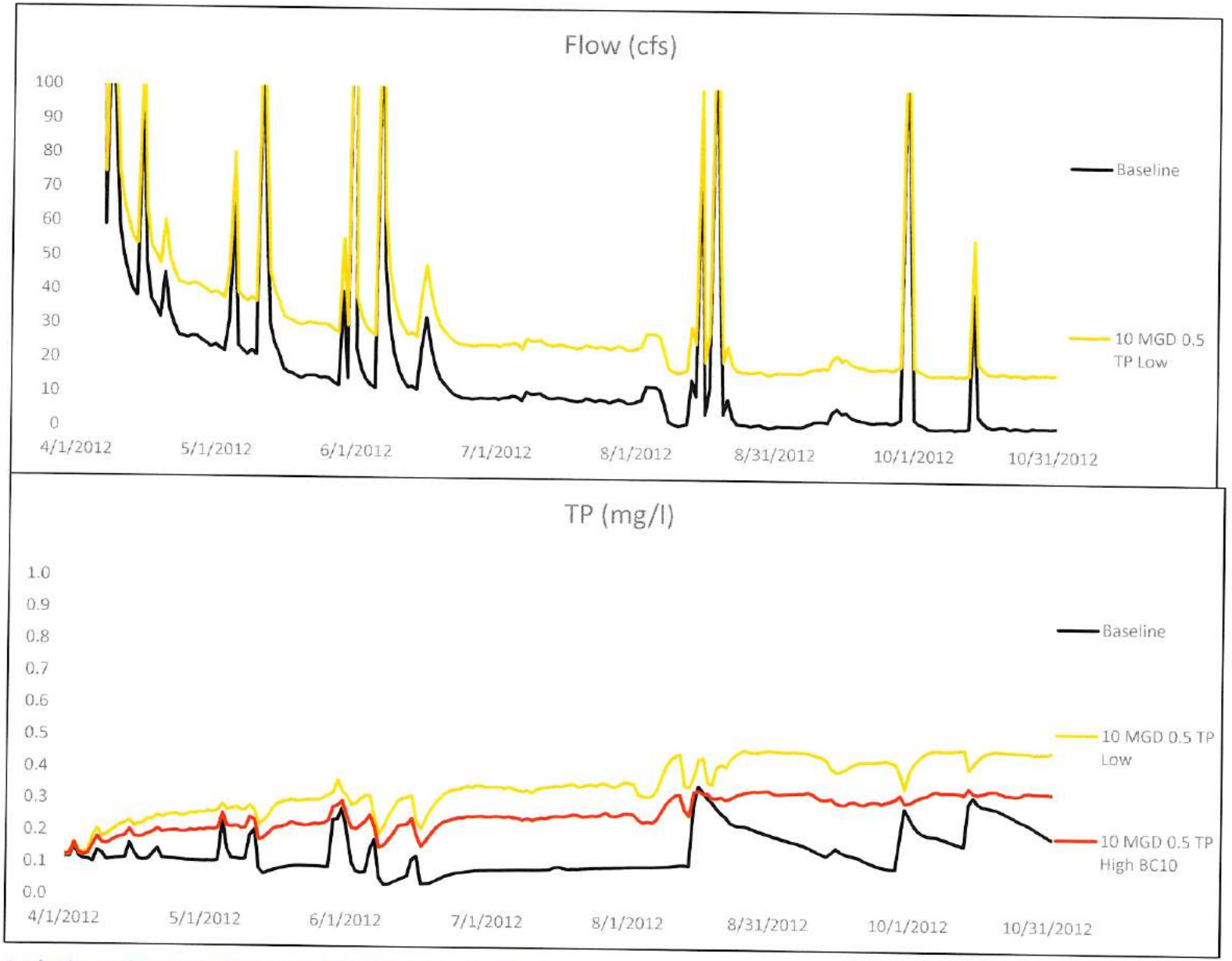
High versus Low Assimilation Model Runs

TP = 0.5 mg/L, TN = 9.0 mg/L, Flow = 10 mgd

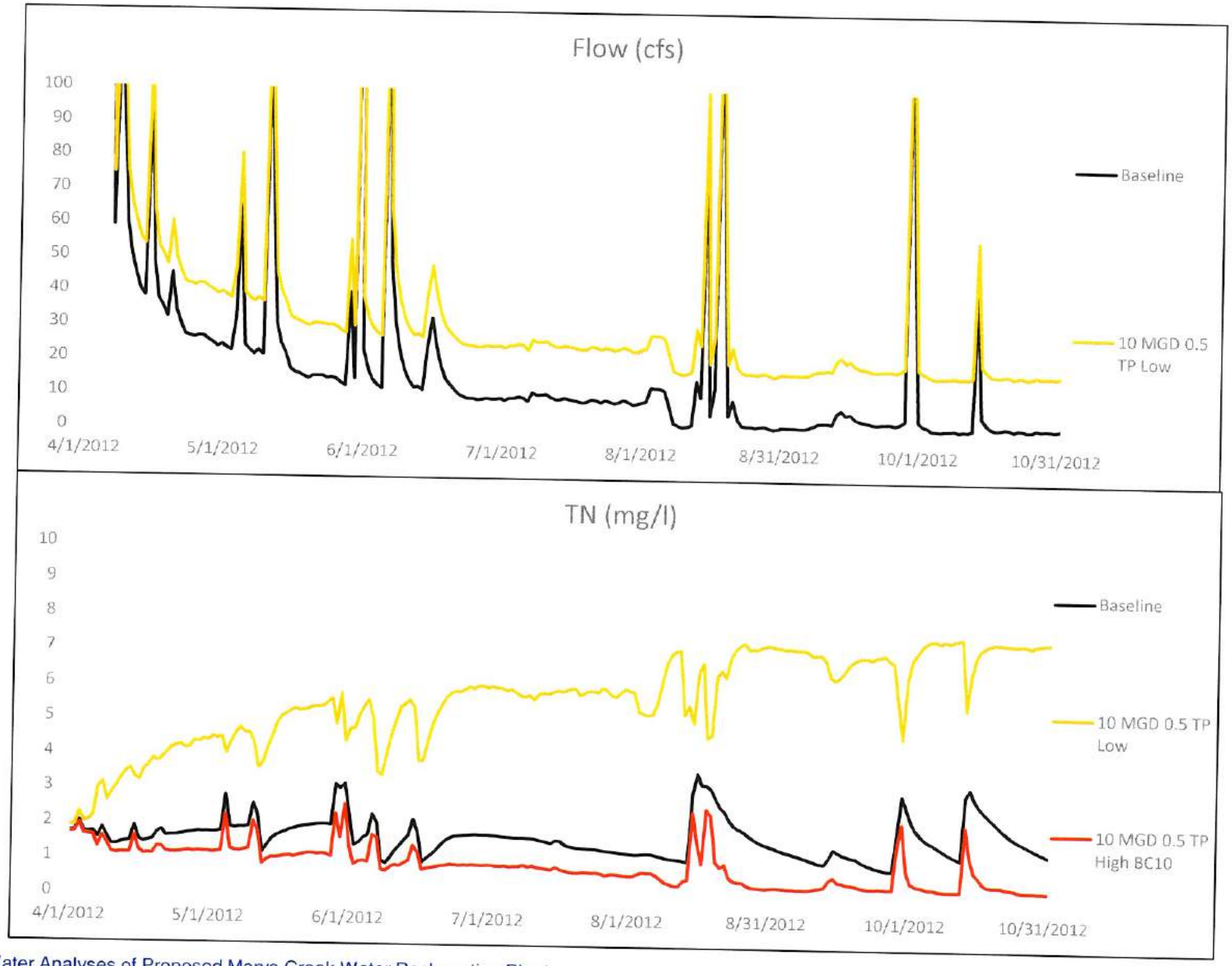
Location Map



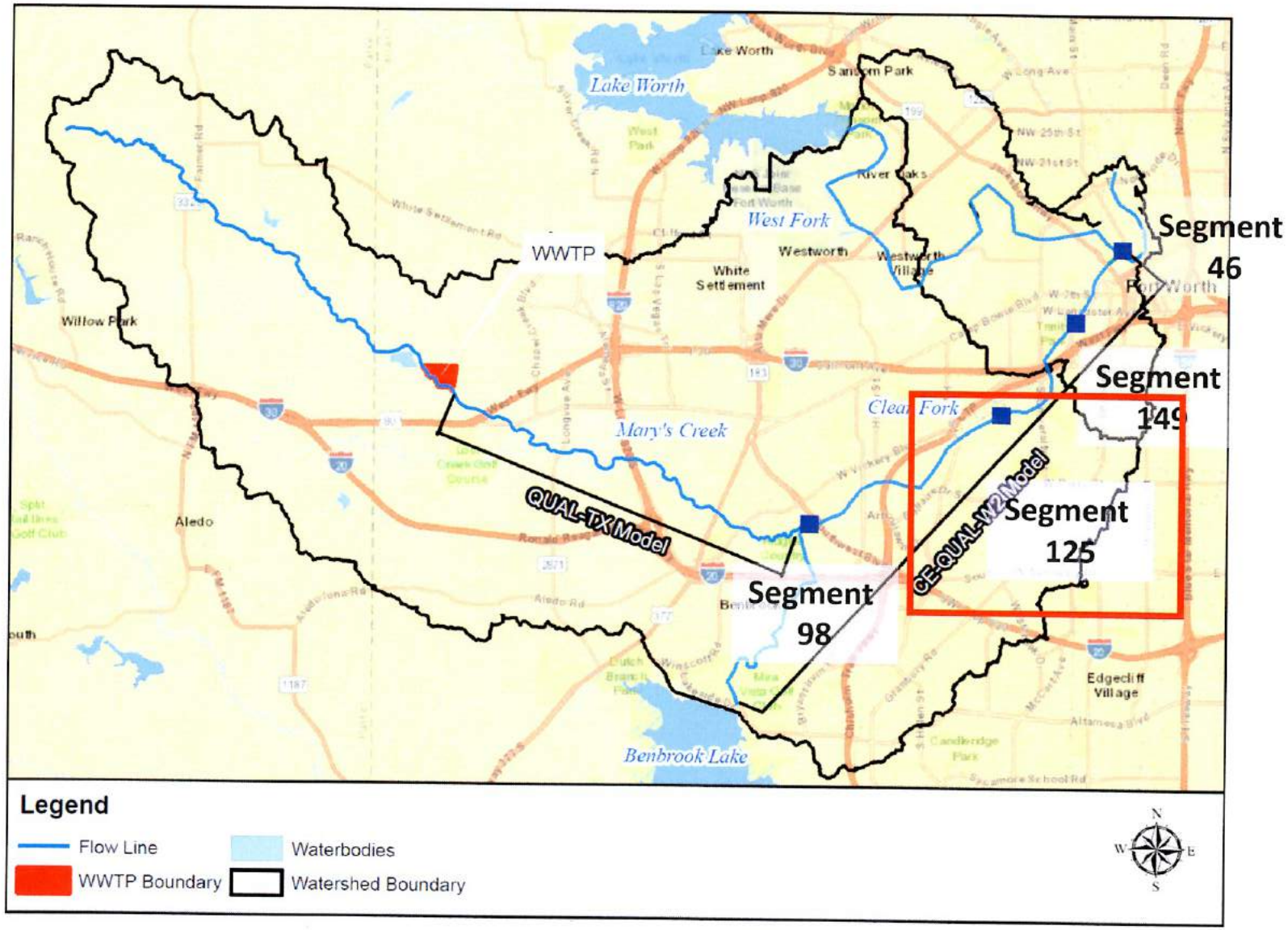
Segment 98 – Total Phosphorus



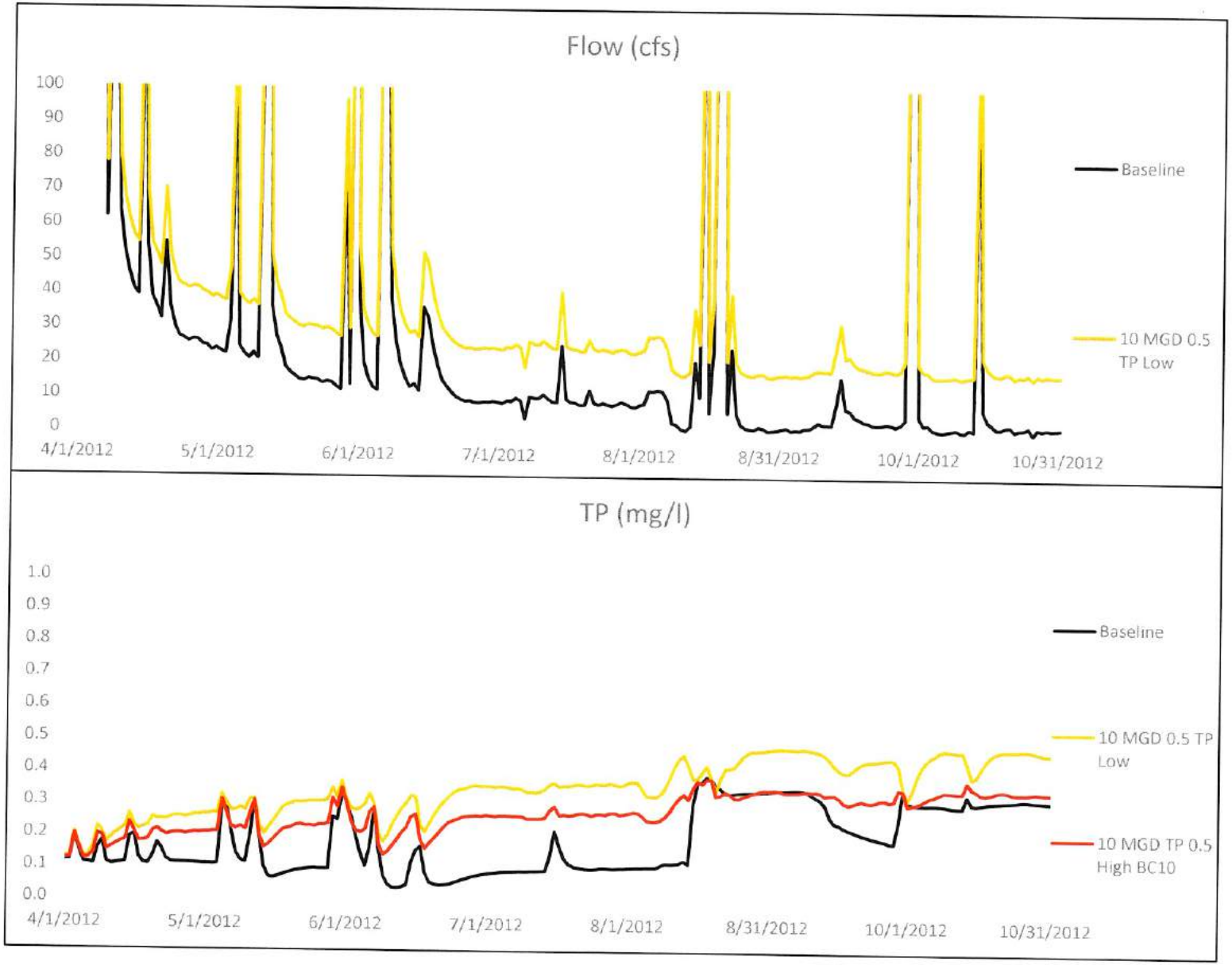
Segment 98 – Total Nitrogen



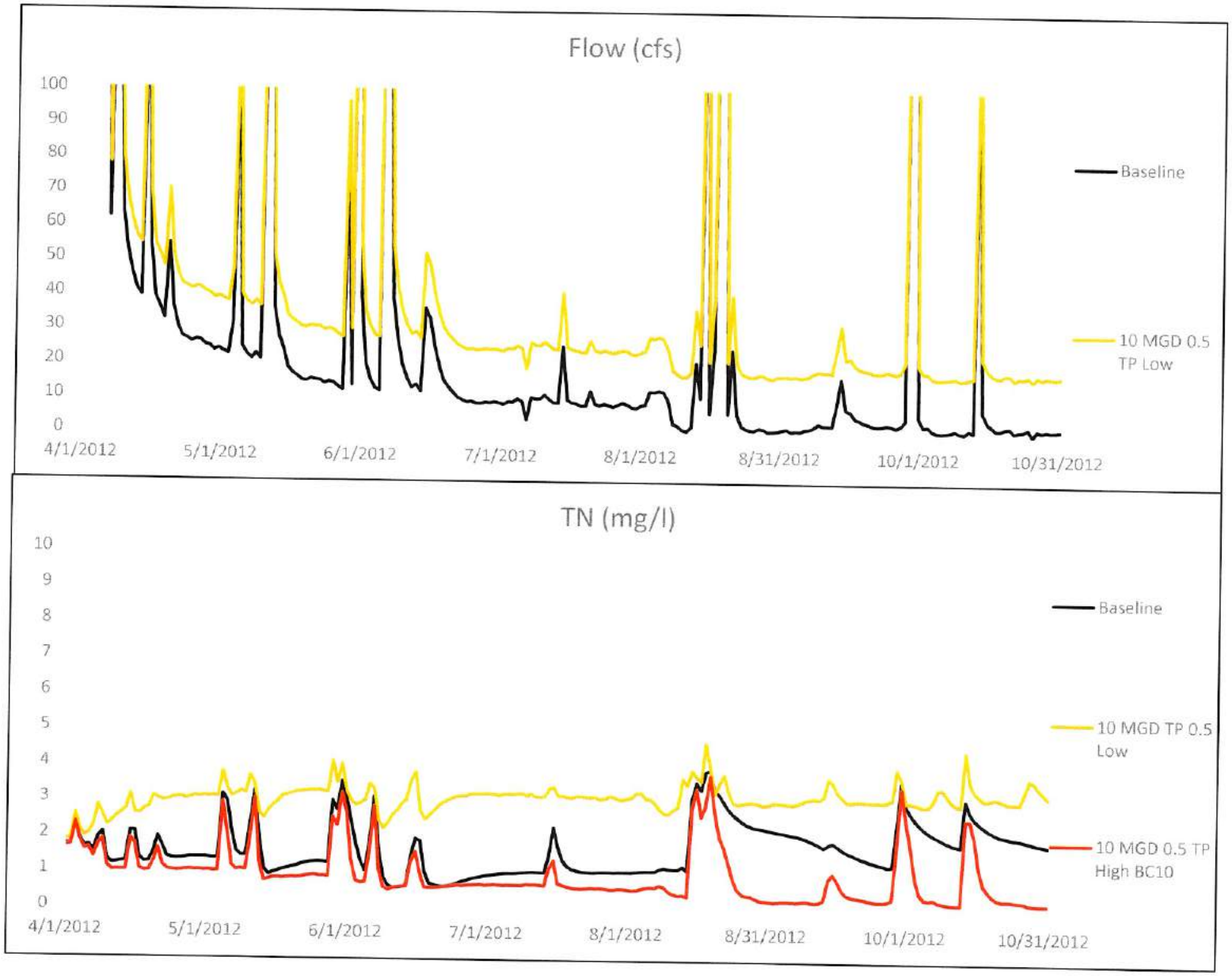
Location Map



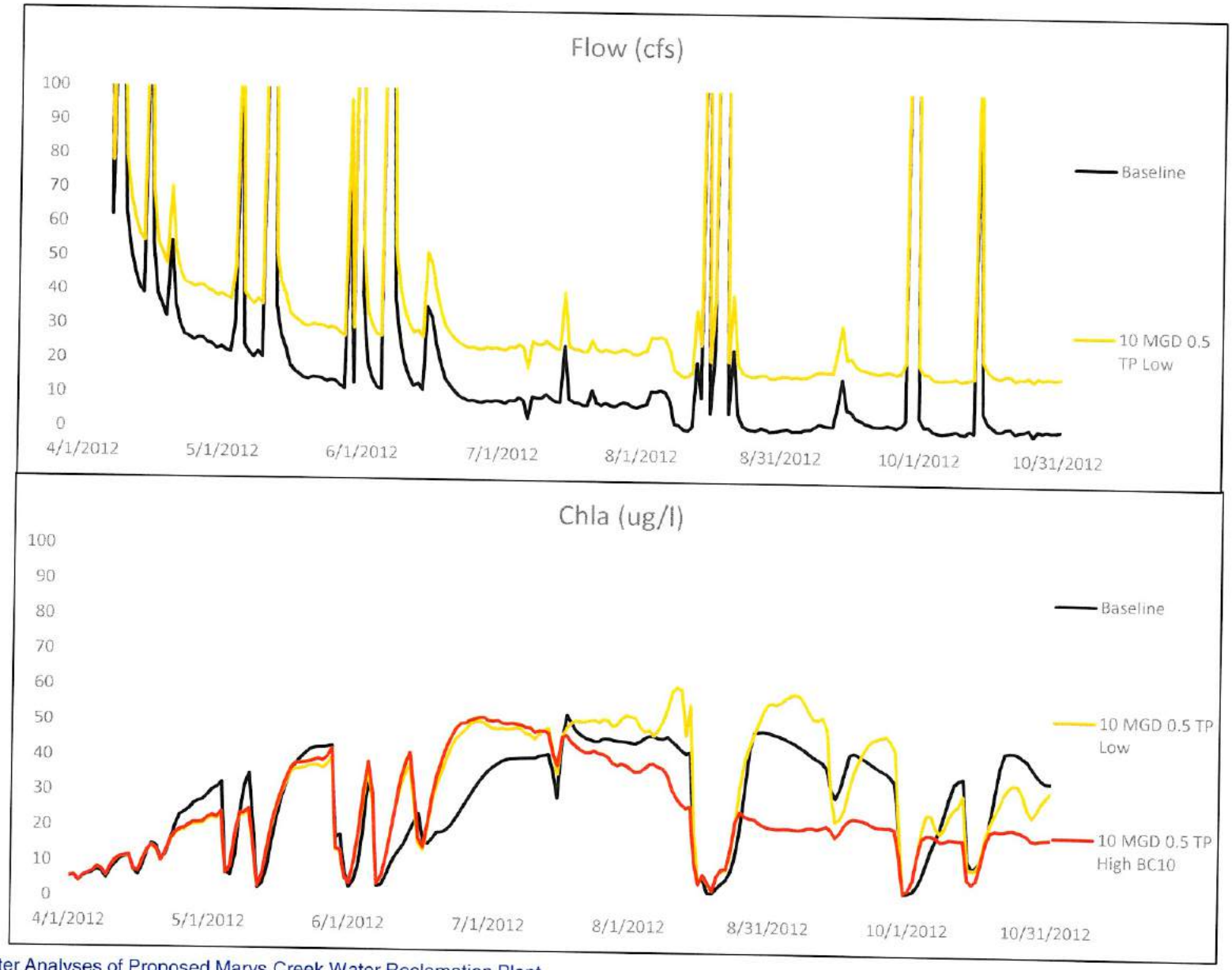
Segment 125 - Total Phosphorus



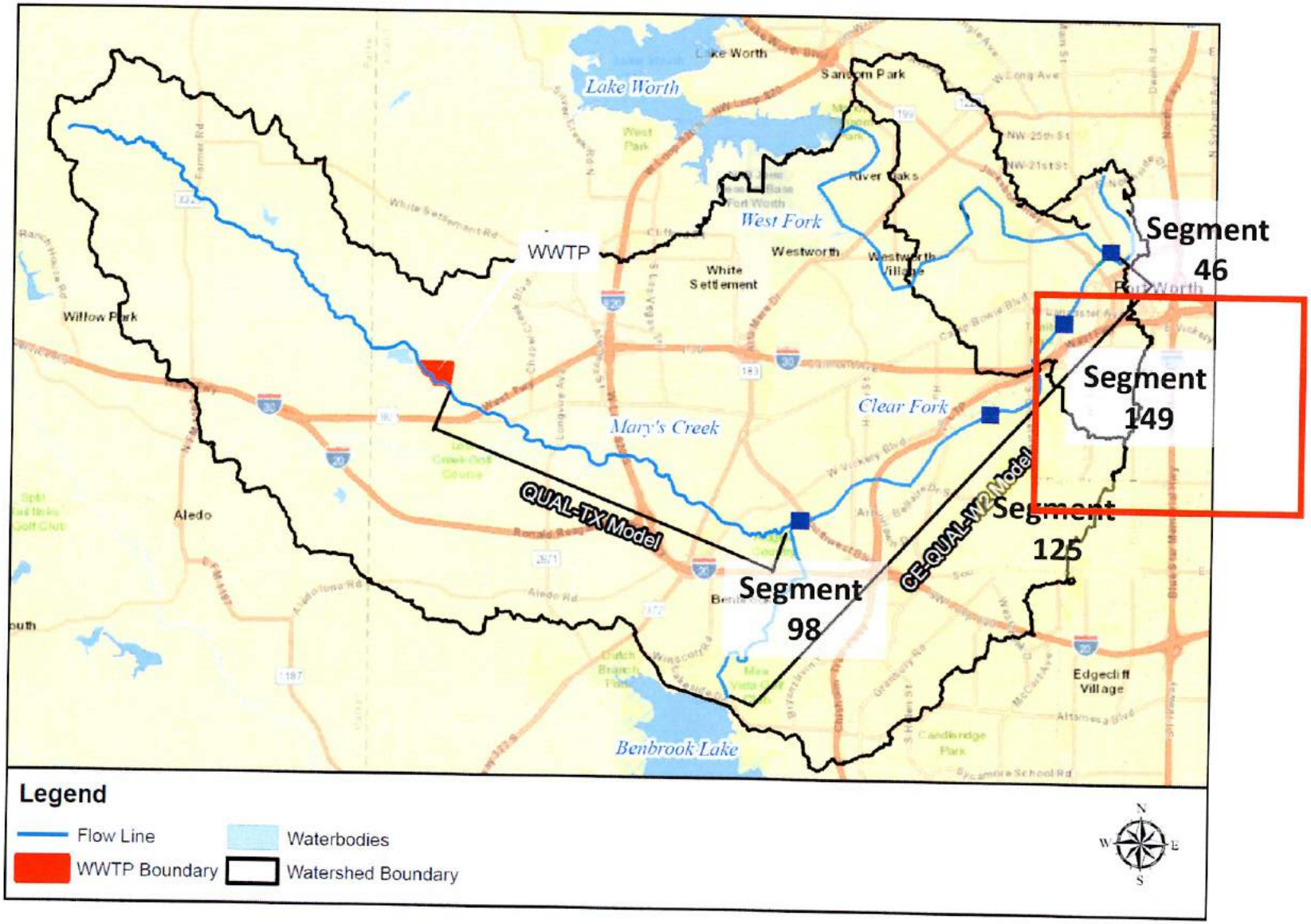
Segment 125 – Total Nitrogen



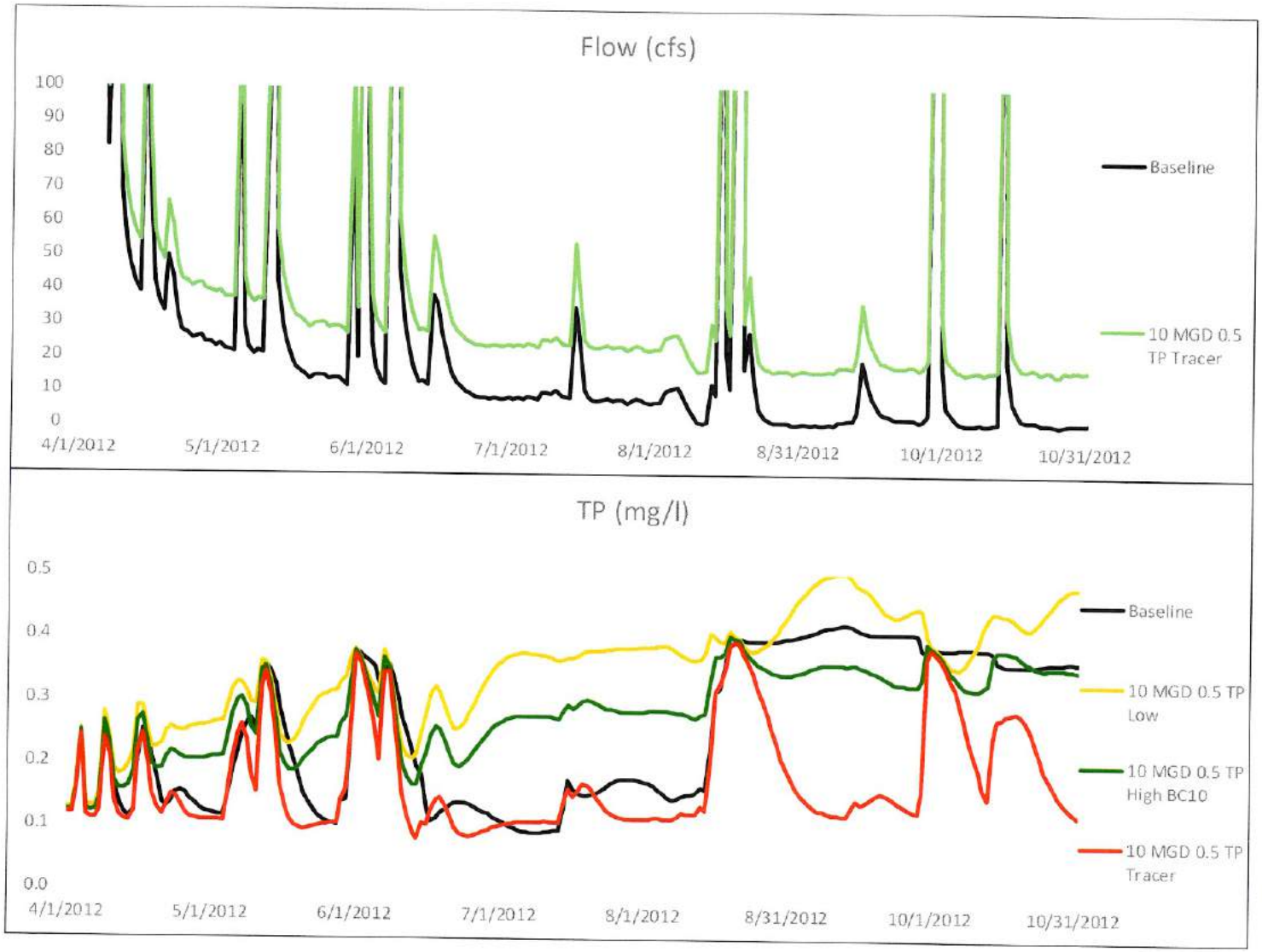
Segment 125 – Chlorophyll a



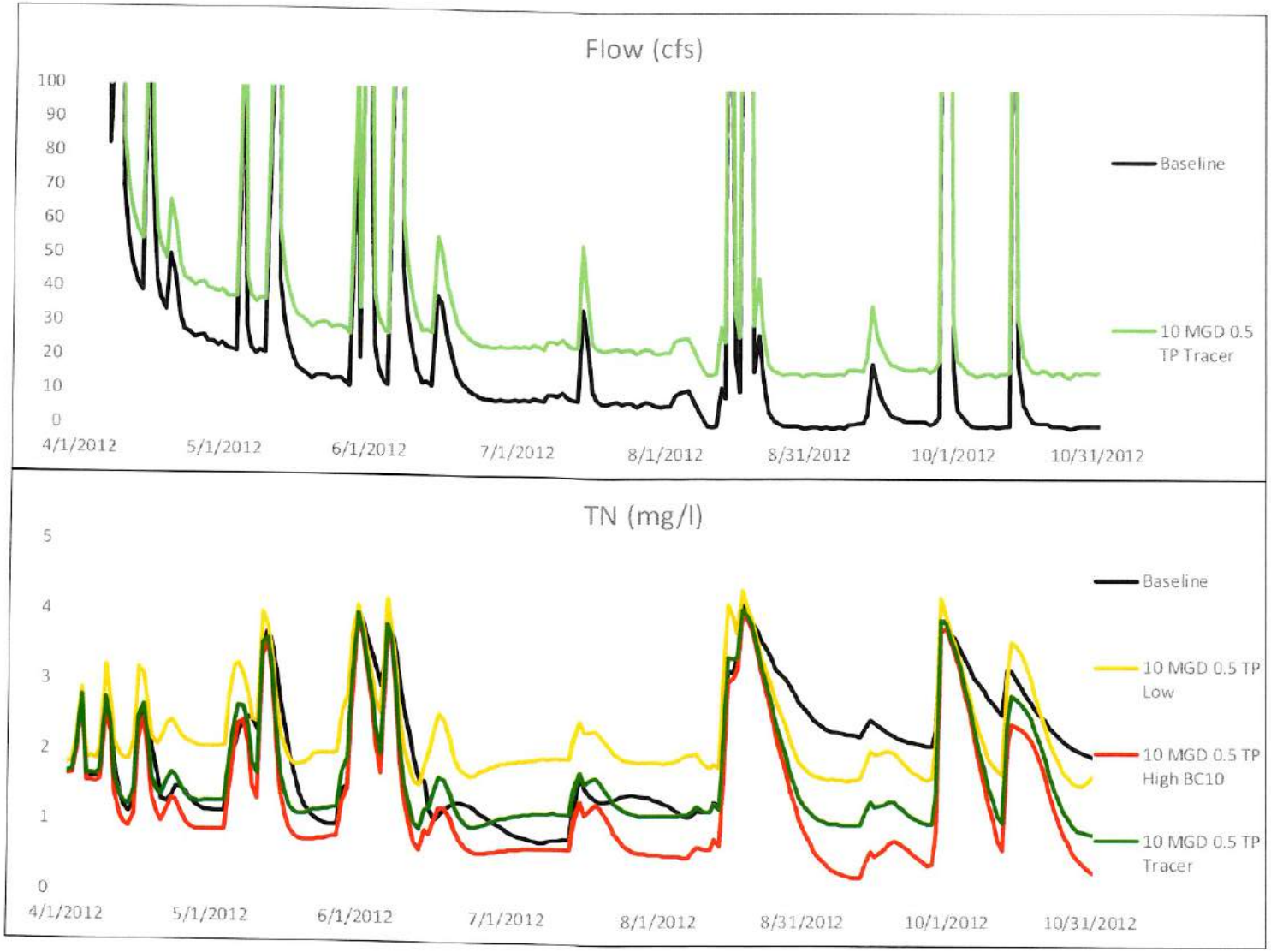
Location Map



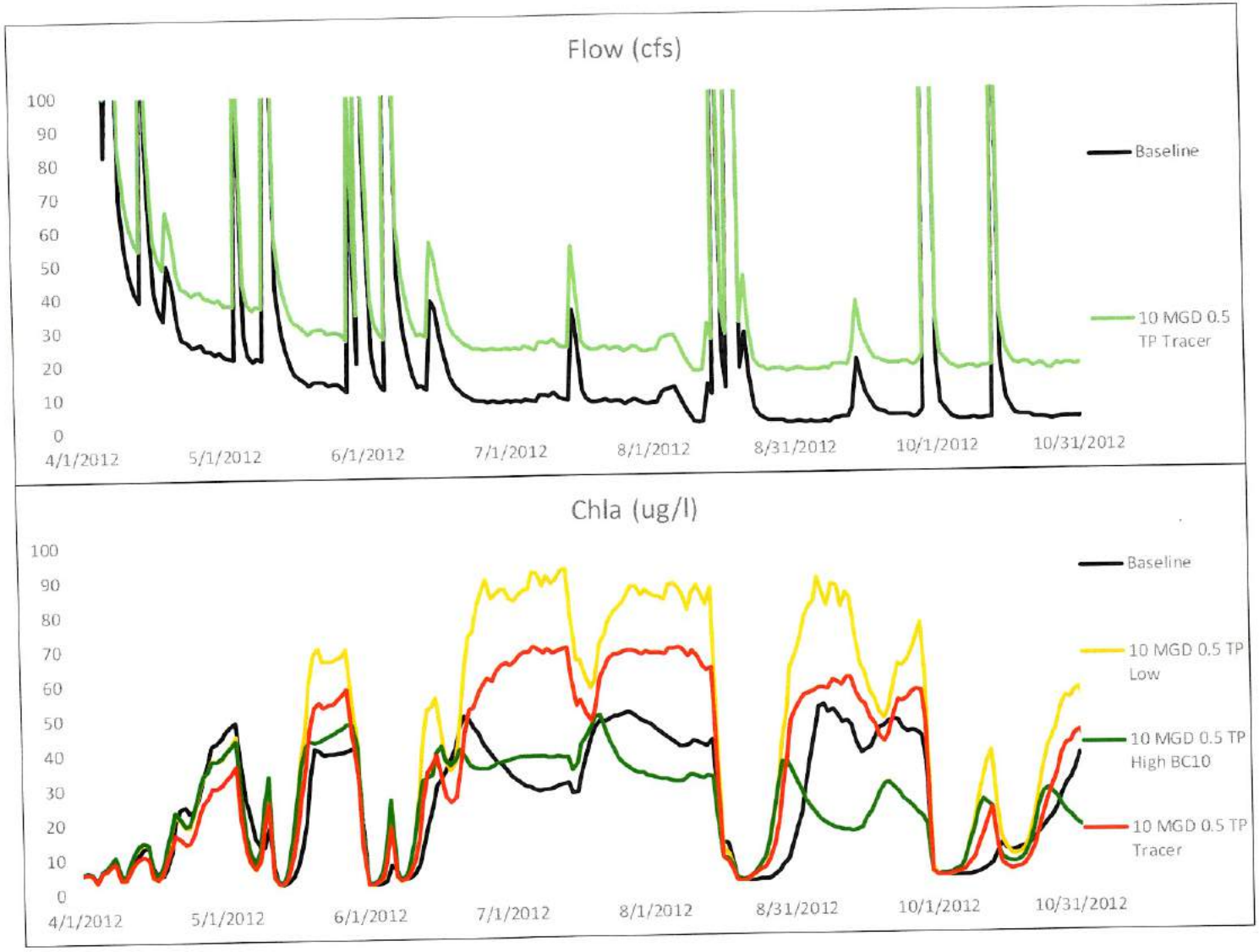
Segment 149 – Total Phosphorus



Segment 149 – Total Nitrogen



Segment 149 – Chlorophyll a



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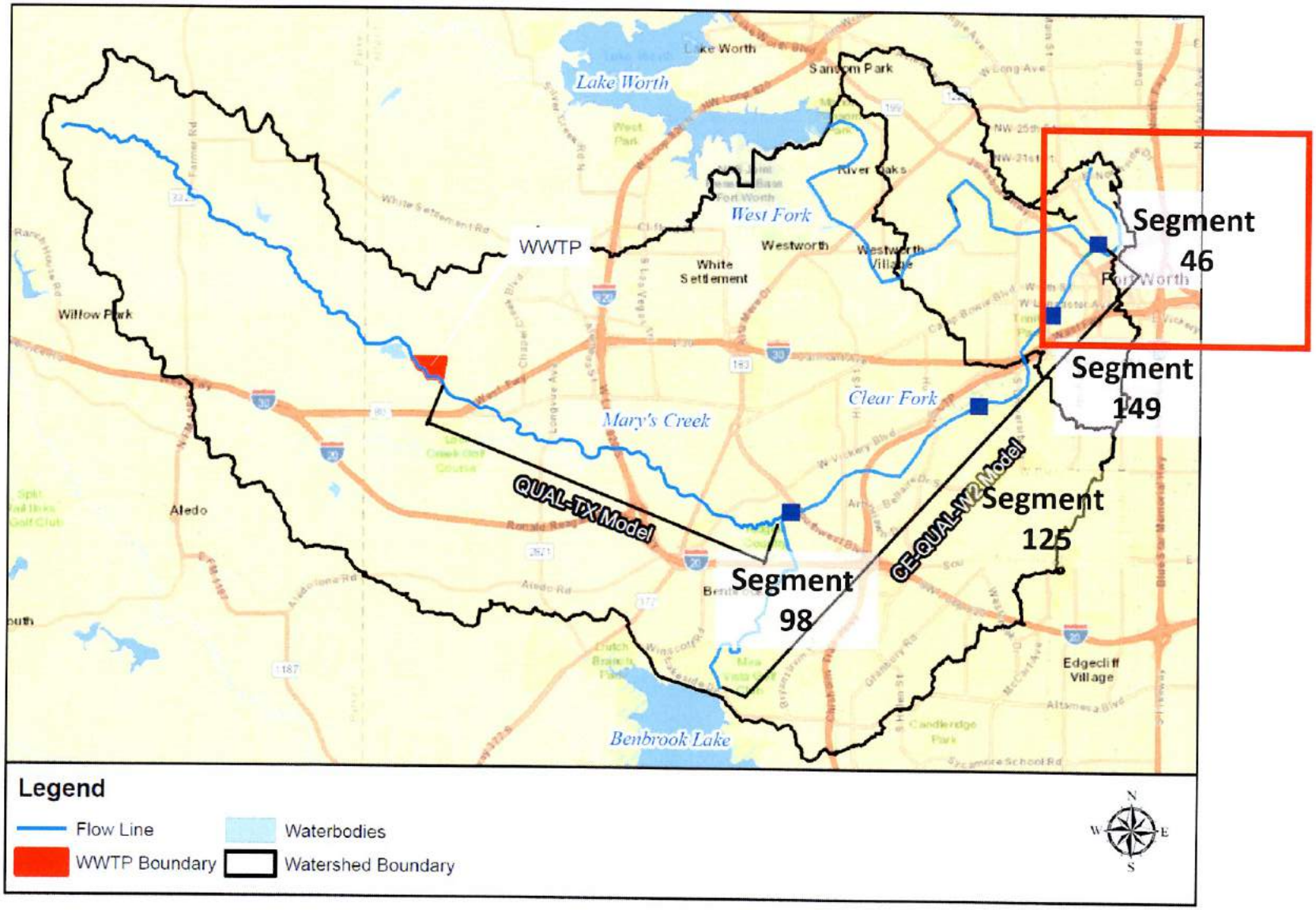
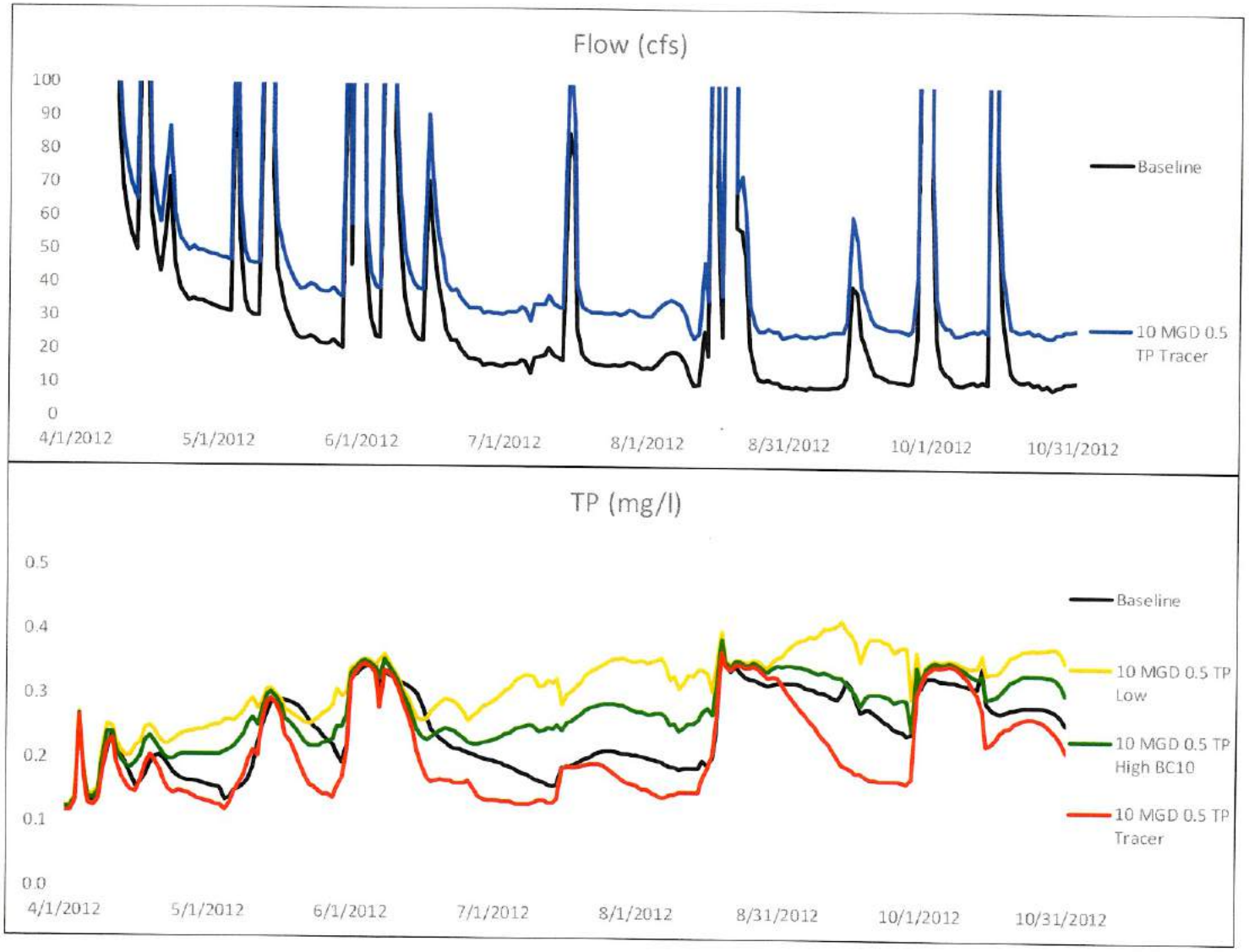
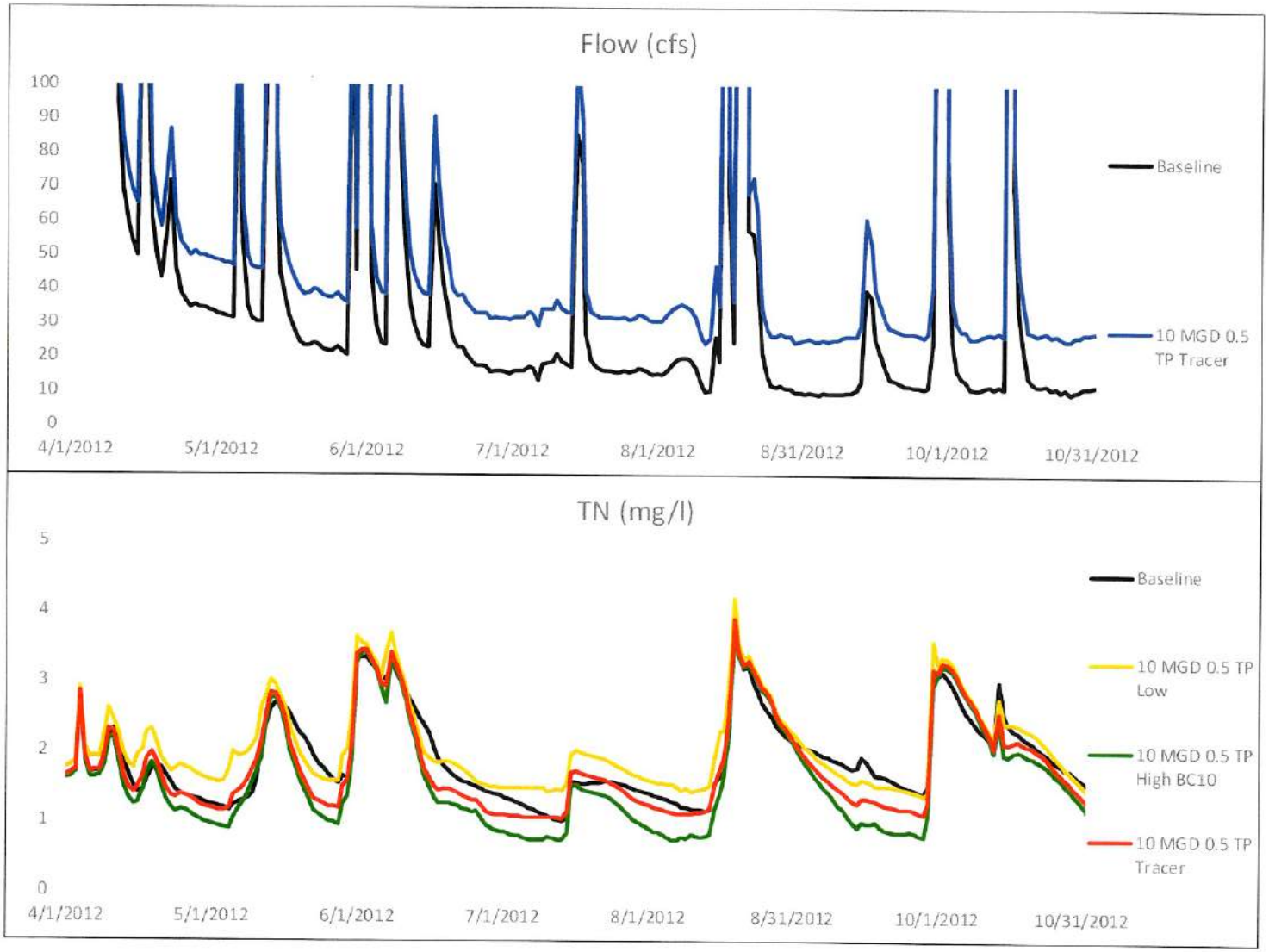


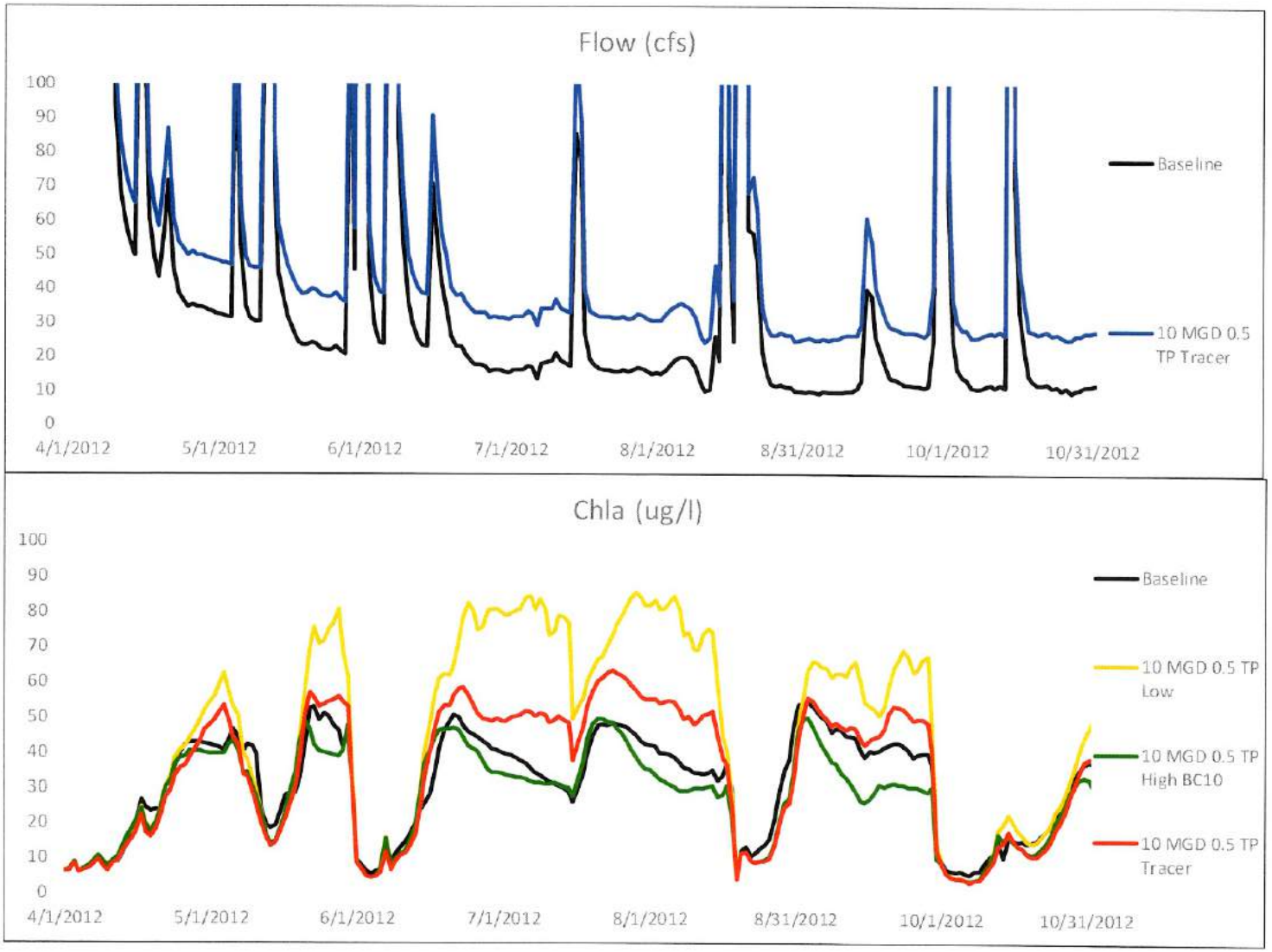
Segment 46 – Total Phosphorus



Segment 46 – Total Nitrogen



Segment 46 – Chlorophyll a

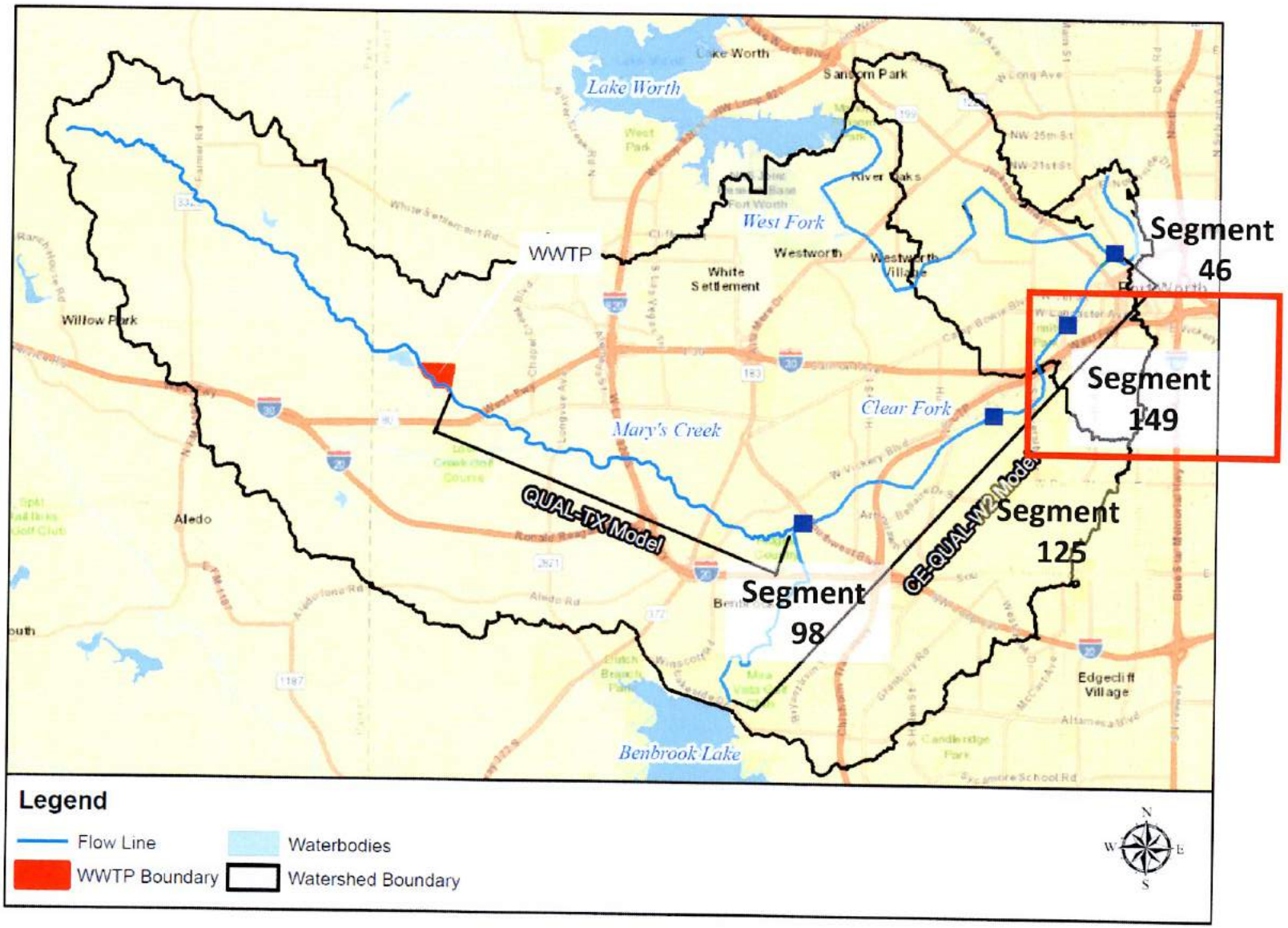


Tracer Attenuation: 10 versus 15 MGD

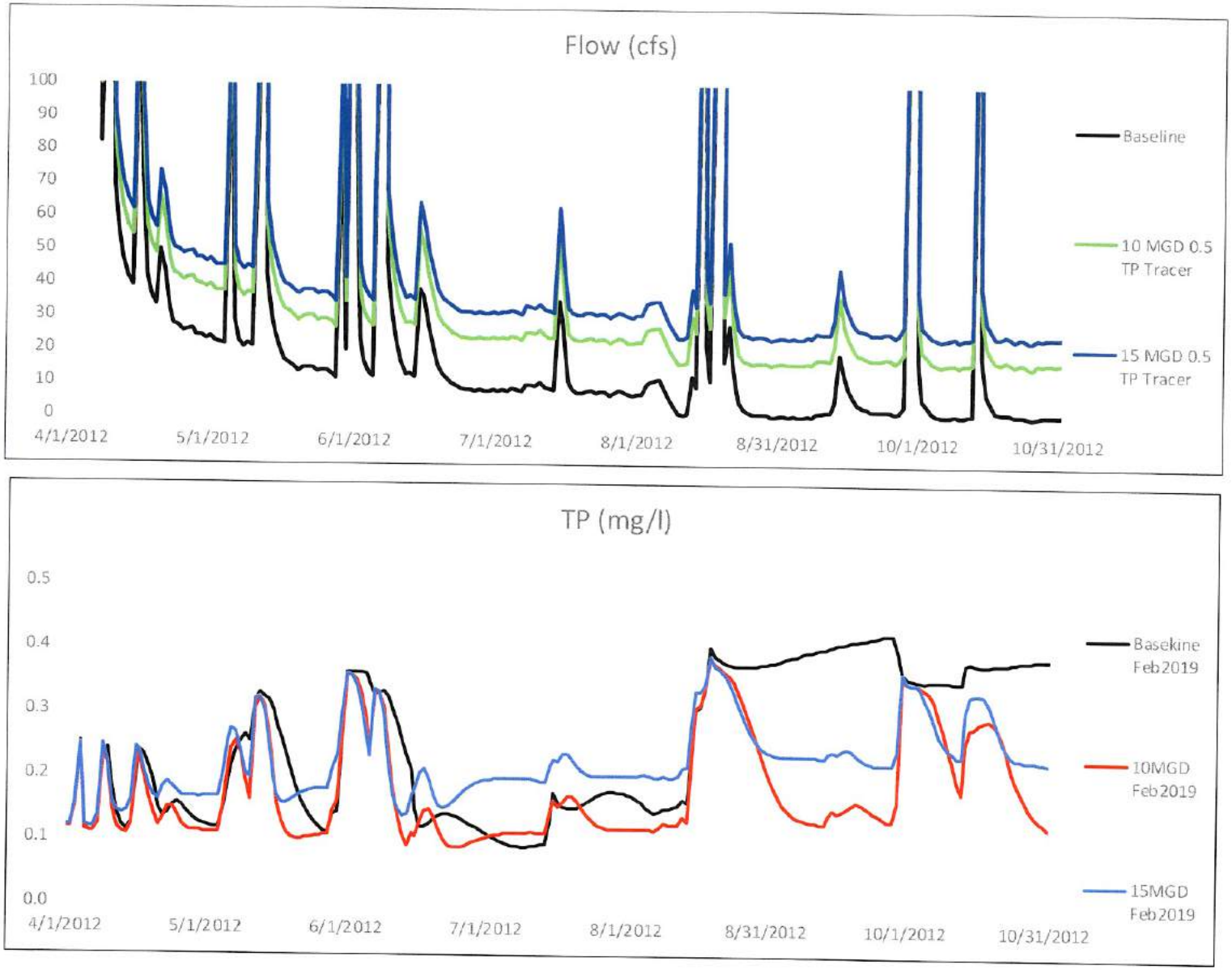
TP = 0.5, TN = 9.0, "tracer" attenuation in Marys Creek

TN/TP/Chla graphs modified for Feb 2019 final results

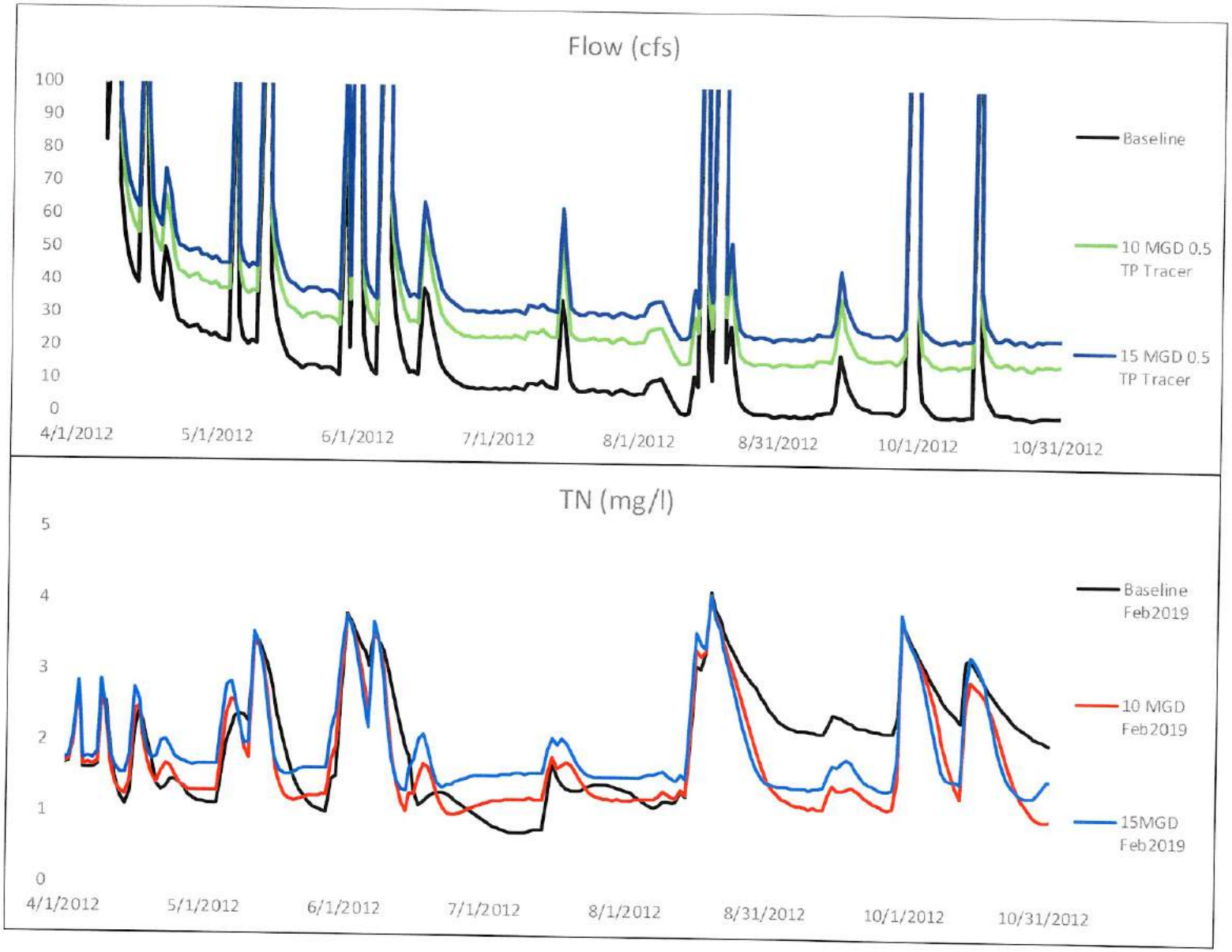
Location Map



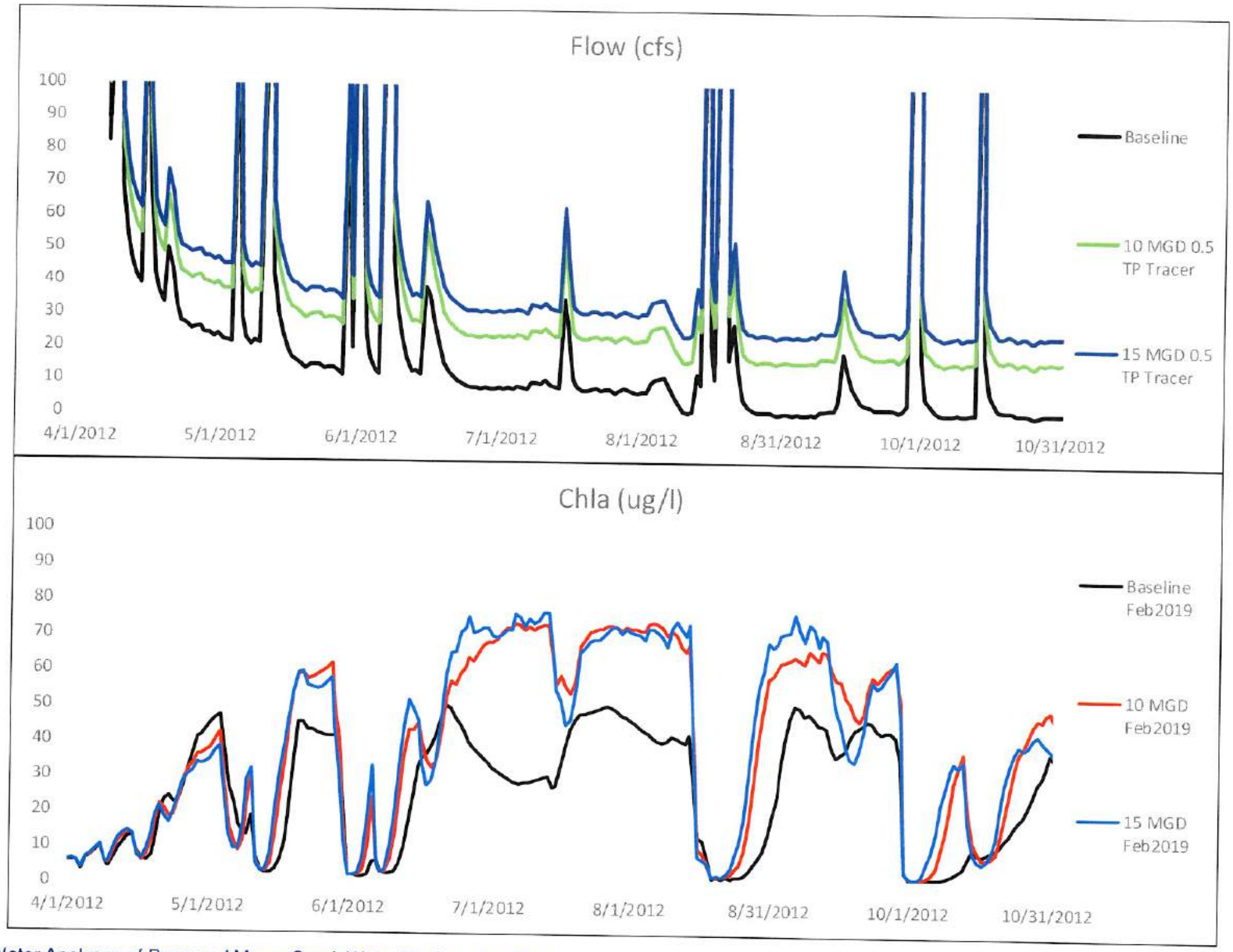
Segment 149 – Total Phosphorus



Segment 149 – Total Nitrogen



Segment 149 – Chlorophyll a



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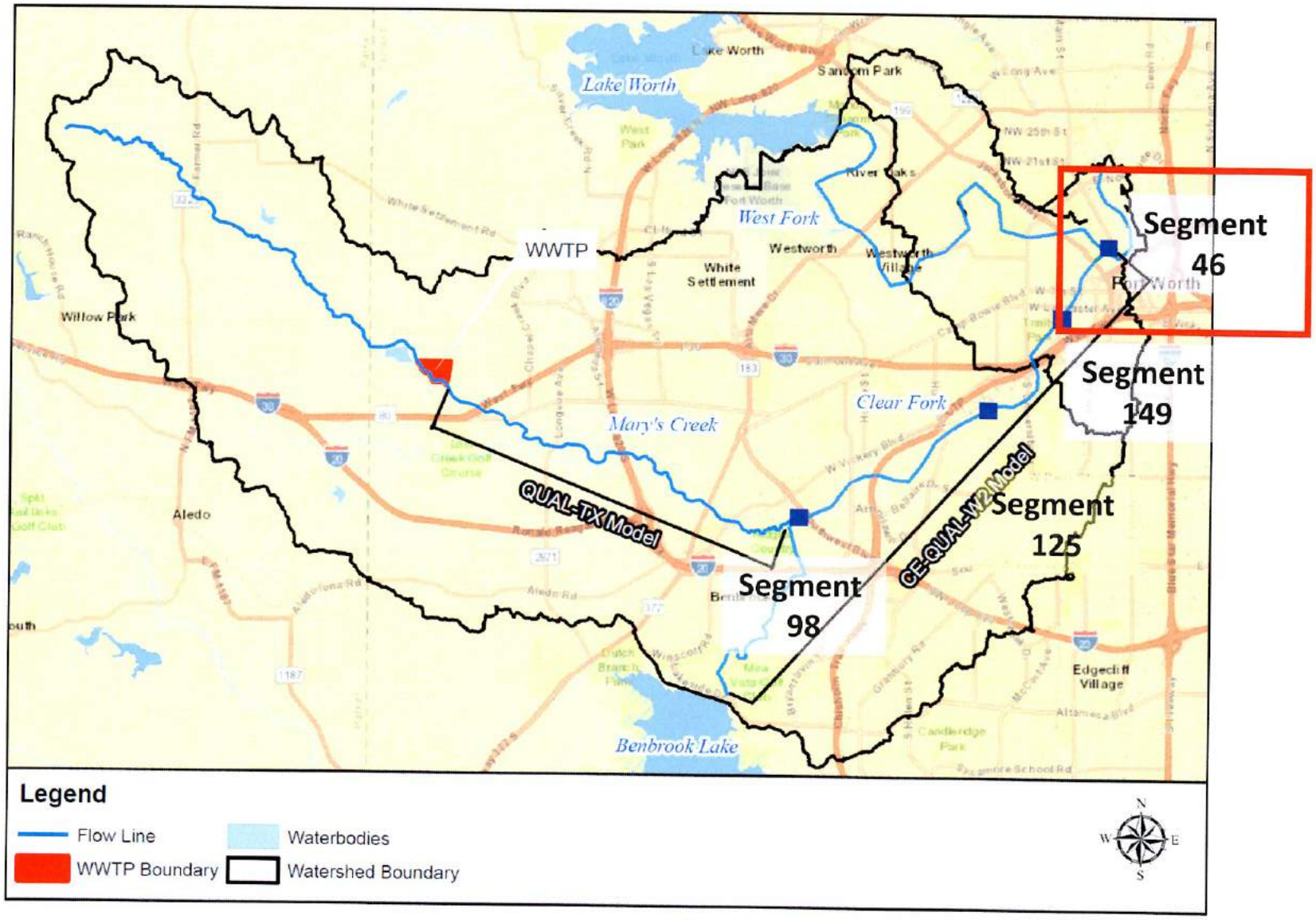

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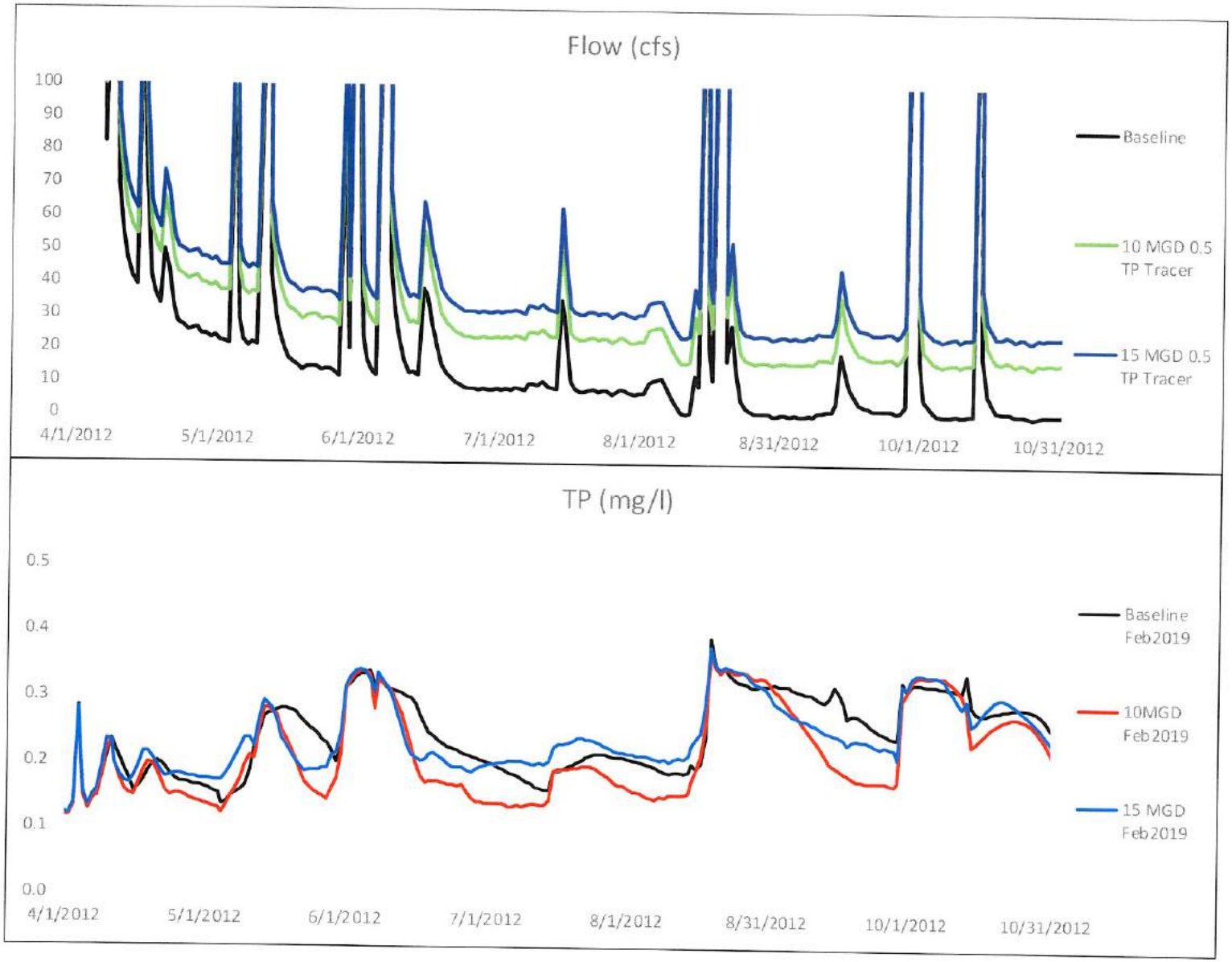
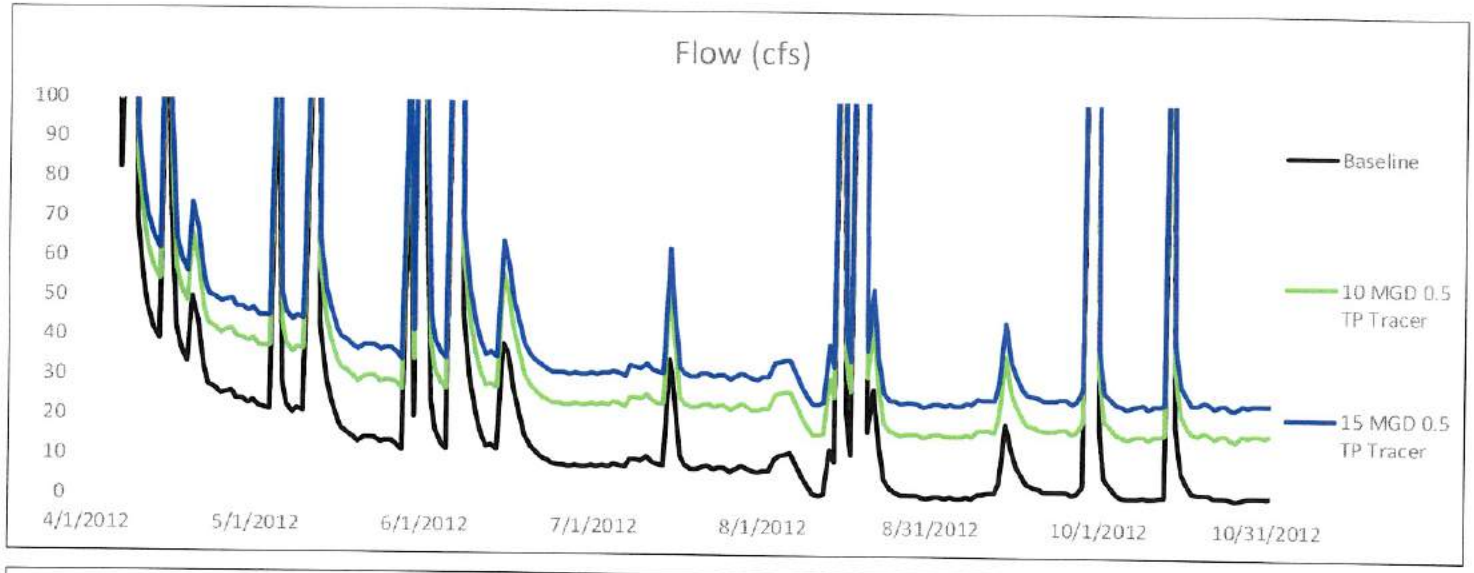
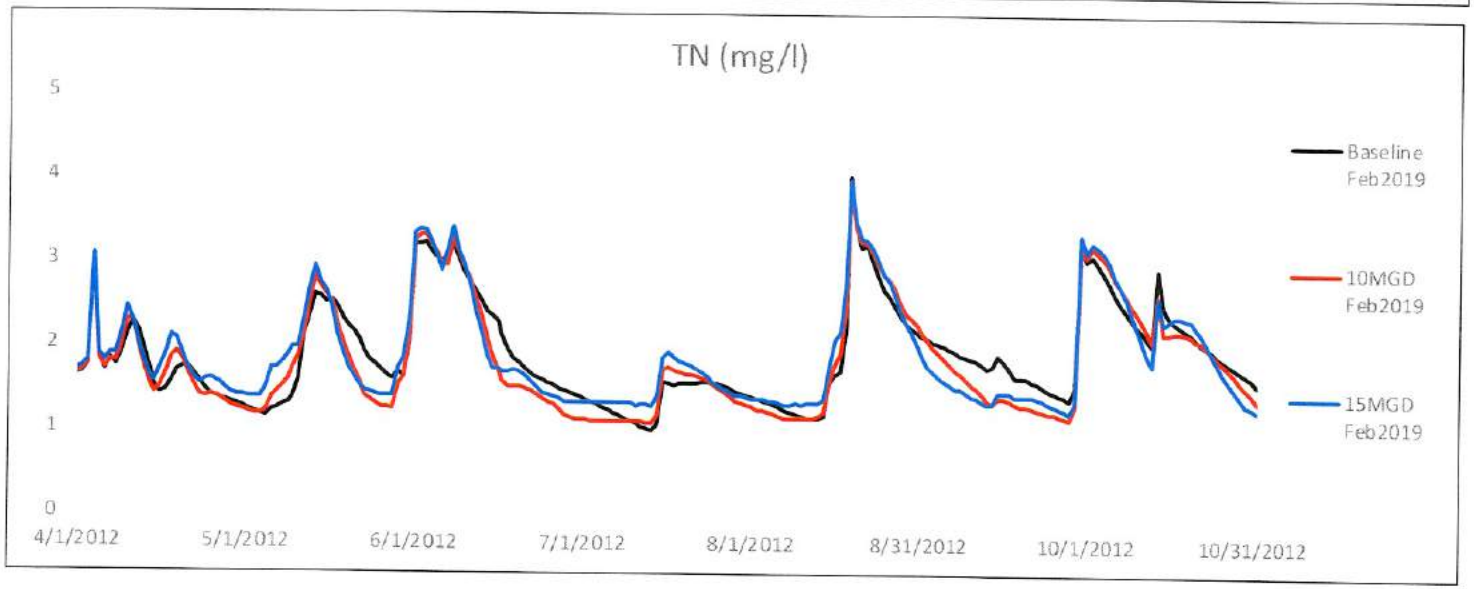
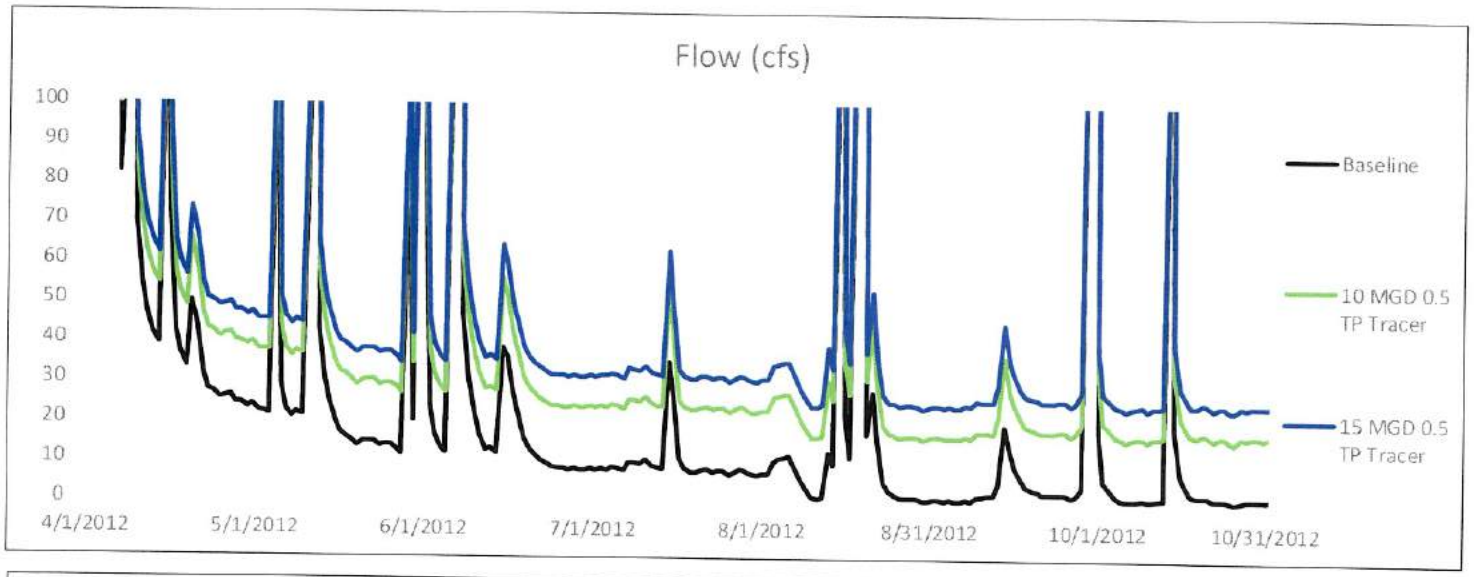


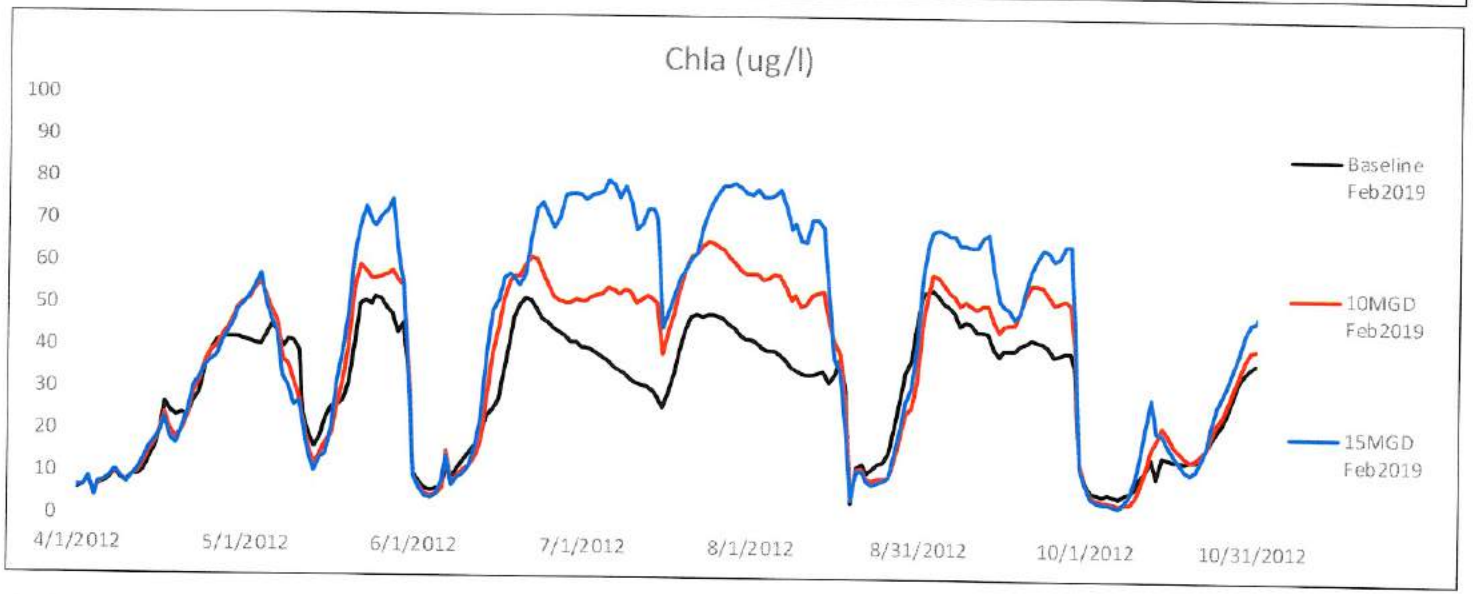
Segment 46 – Total Nitrogen





Segment 46 – Chlorophyll a

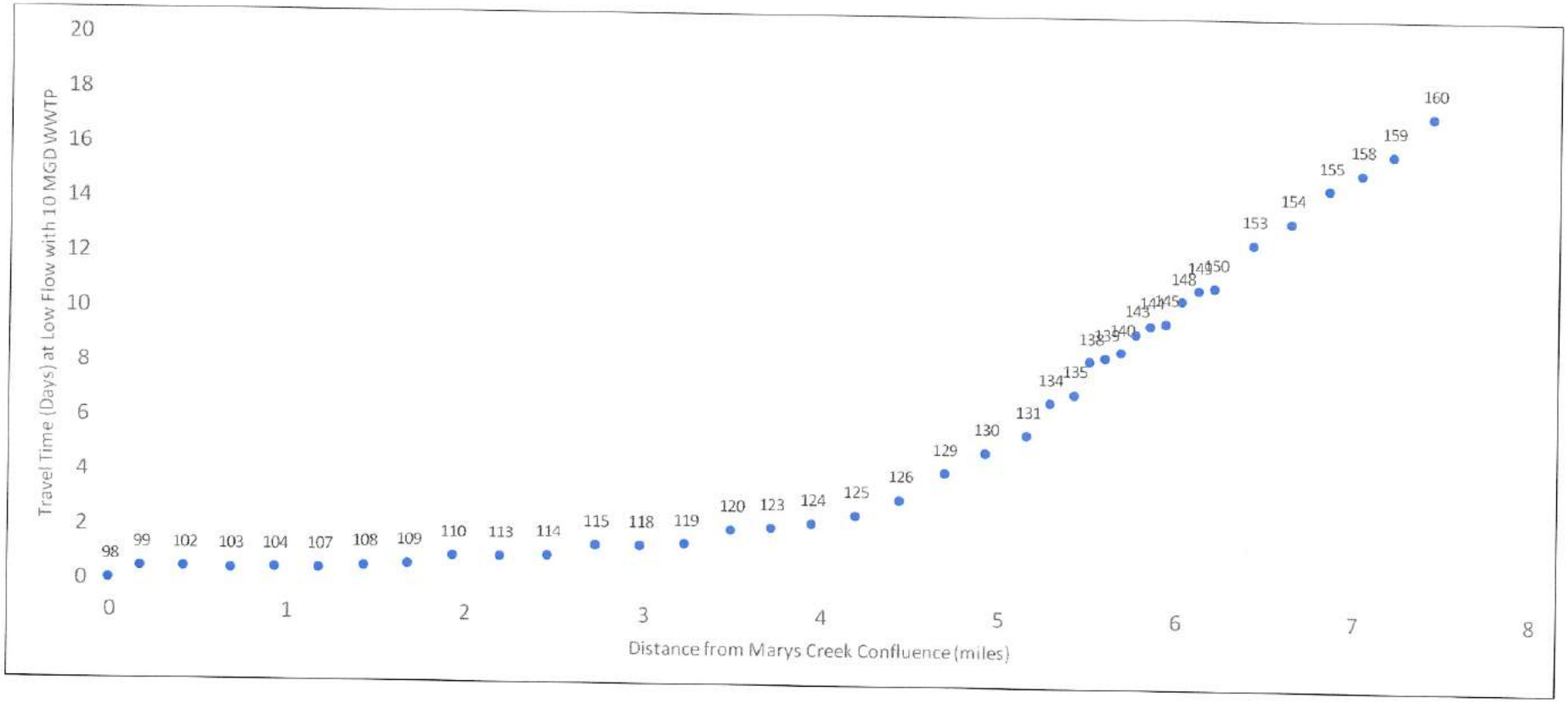




Time of Travel and Effluent Percentages

Travel Time from Marys Creek Confluence

- Period when Clear Fork flow is dominated by WWTP at 10 mgd
- Point labels are W2 segment numbers



Flow Comparisons (cfs)

Date	Scenario	Segment 149		Segment 46	
		10 MGD	15 MGD	10 MGD	15 MGD
7/1/2012	Baseline	7.9	7.9	15.3	15.3
	with WWTP	23.6	31.4	31.0	38.8
8/1/2012	Baseline	6.9	6.9	15.1	15.1
	with WWTP	22.7	30.5	30.7	38.5
8/31/2012	Baseline	0.4	0.4	9.8	9.8
	with WWTP	16.0	23.8	24.8	32.6
10/31/2012	Baseline	1.1	1.1	11.4	11.4
	with WWTP	16.5	24.3	27.0	34.7

Percentage Effluent

Date	Segment 149		Segment 46	
	10 MGD	15 MGD	10 MGD	15 MGD
7/1/2012	67%	75%	51%	61%
8/1/2012	70%	77%	51%	61%
8/31/2012	97%	98%	61%	70%
10/31/2012	93%	95%	58%	67%

Conclusions based on Dry Year (2012) Analysis

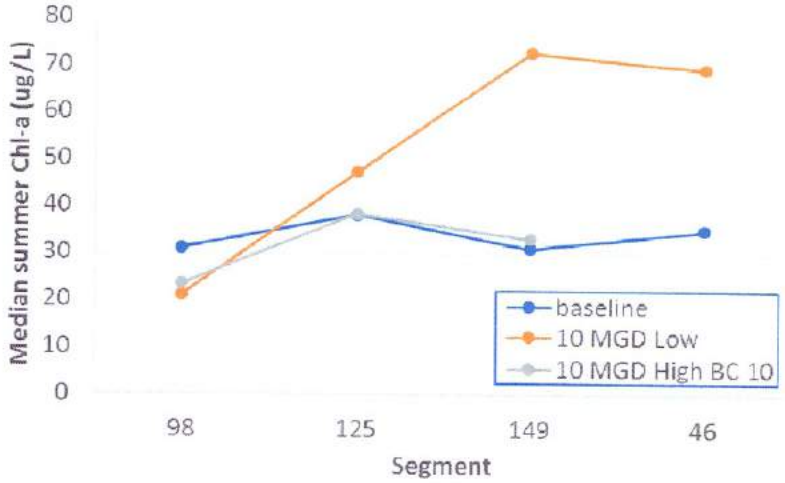
- CE-QUAL-W2 model predicts an increase in median chl-a levels at Trinity Park (Segment 149) of 27 ug/L (10 MGD discharge) during months of June – August based on TRWD's attenuation studies applied to Marys Creek
- CE-QUAL-W2 model predicts an increase in median chl-a levels at confluence of Clear Fork and West Fork (Segment 46) of 17 ug/L (10 MGD discharge) during months of June-August based on TRWD's attenuation studies applied to Marys Creek
- Chl-a concentrations at the confluence of the Clear Fork and West Fork currently do not exceed 60 ug/L "bloom level" under baseline conditions. With the addition of 10 MGD WWTP effluent, the CE-QUAL-W2 model predicts exceedances of up to 3% of the time for the entire year and 13% during months of June-August. Exceedances with 15 MGD discharge are up to 21% of the time for entire year and 53% during months of June-August.

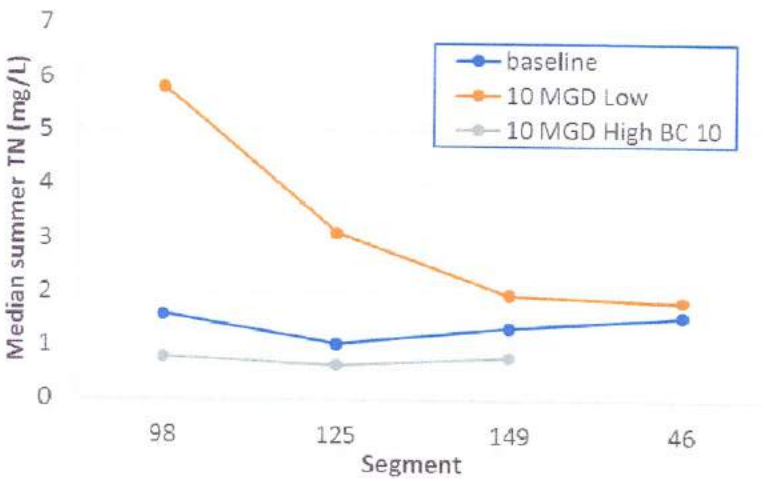
Conclusions based on Dry Year (2012) Analysis

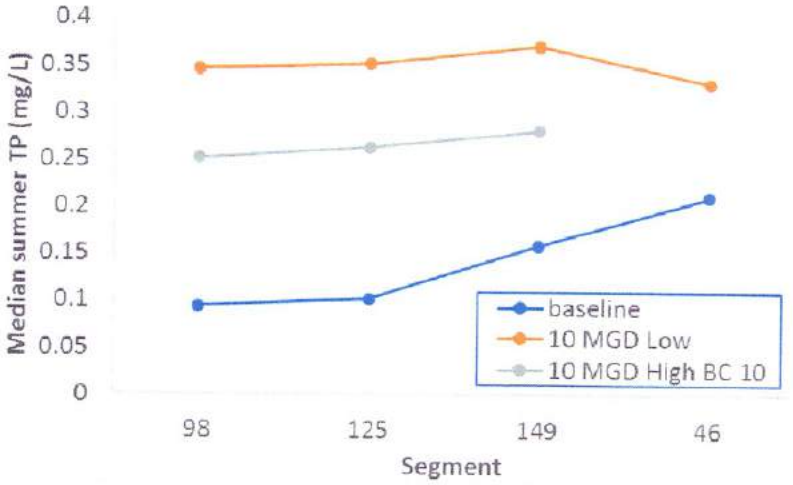
- During August low flow conditions, effluent comprises up to 98% of the streamflow on the Clear Fork and up to 70% of the streamflow at the Clear Fork and West Fork confluence
- This is the period of time that the Clear Fork and the Clear Fork and West Fork confluence experiences the highest public recreational use

Longitudinal Plots

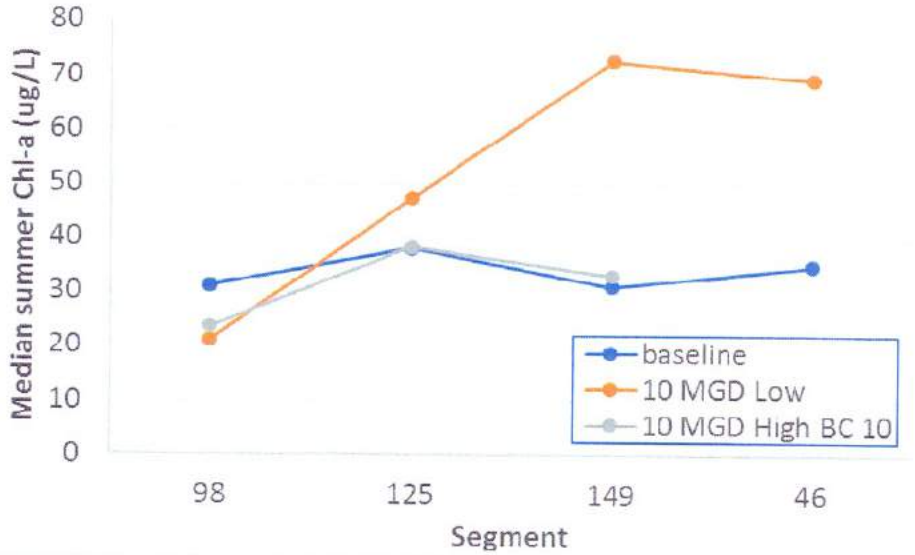
Longitudinal Plots (6/2012 – 9/2012)



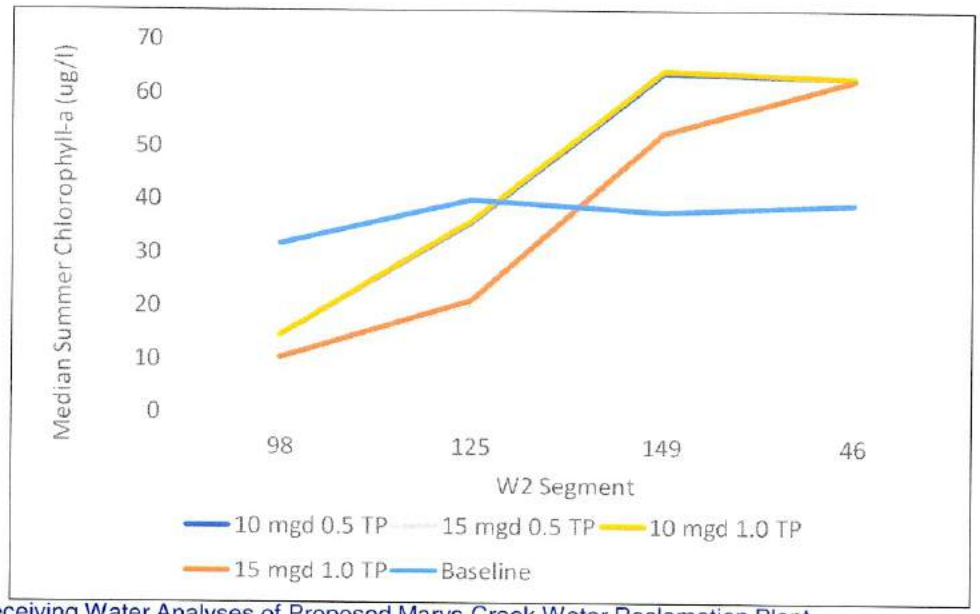




Longitudinal Plots (6/2012 – 9/2012) – Chlorophyll A



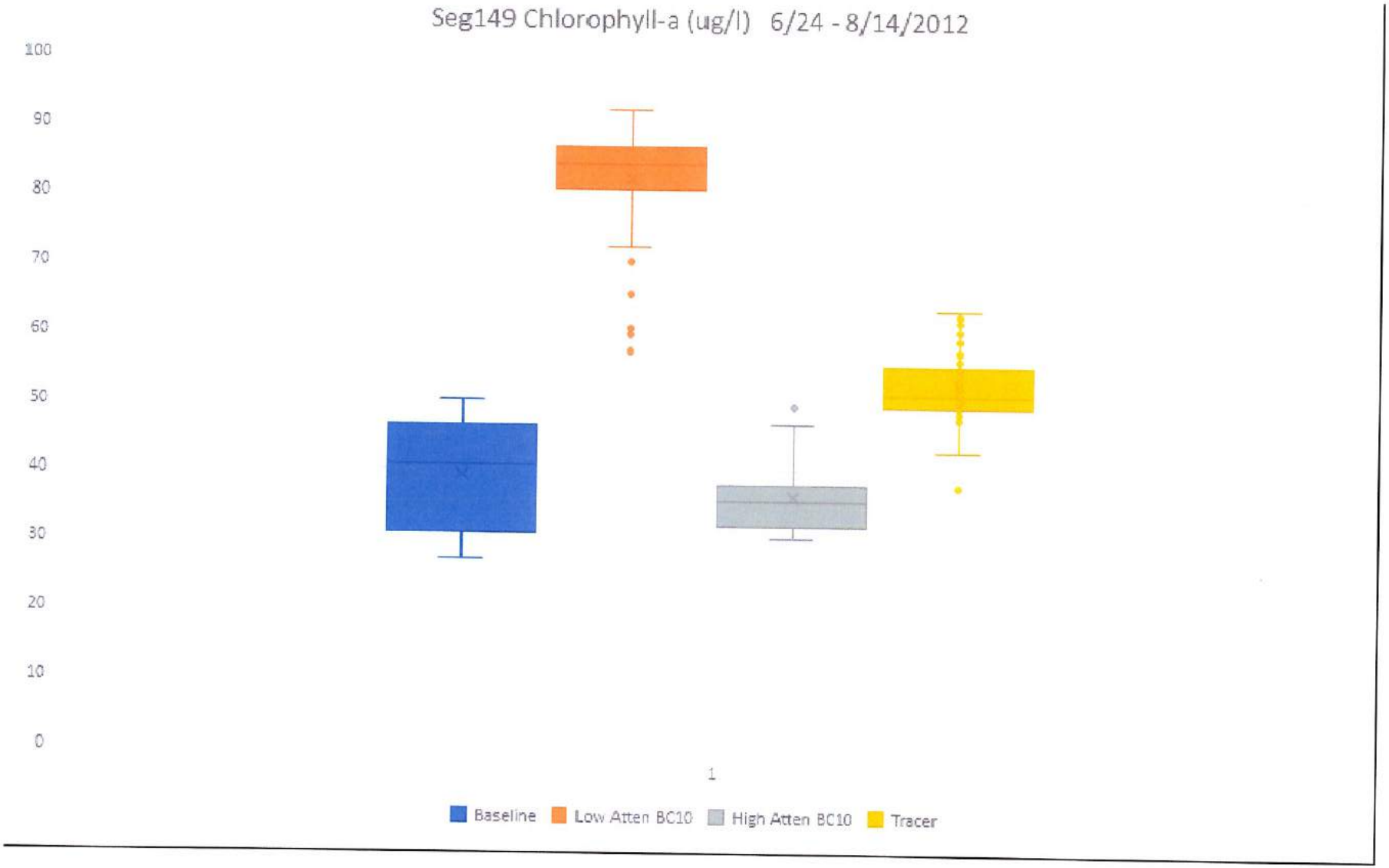
- With attenuation (0.5 mg/L TP; 10 MGD)



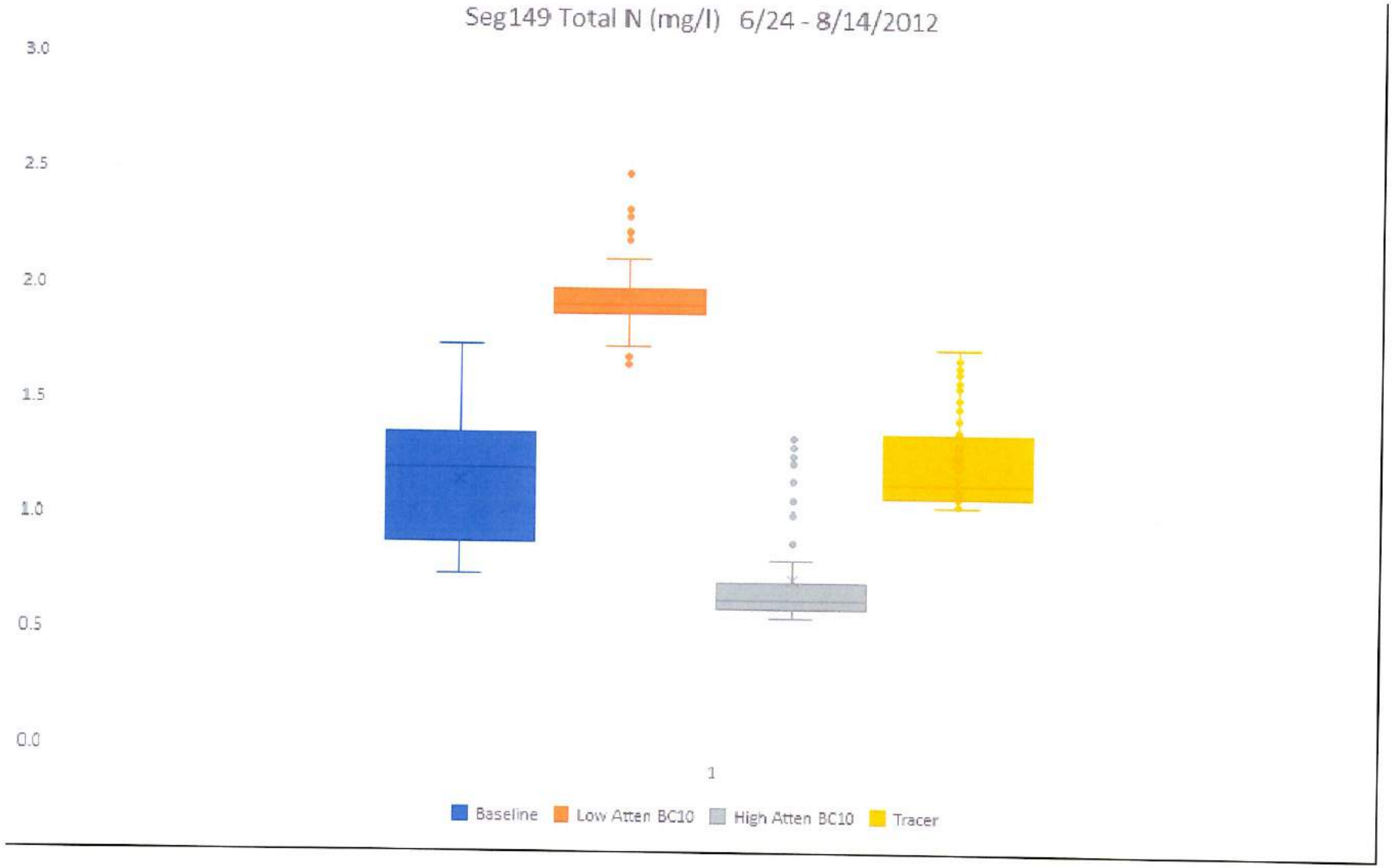
- Without attenuation (0.5 mg/L TP; 10 and 15 MGD)

Box Plots

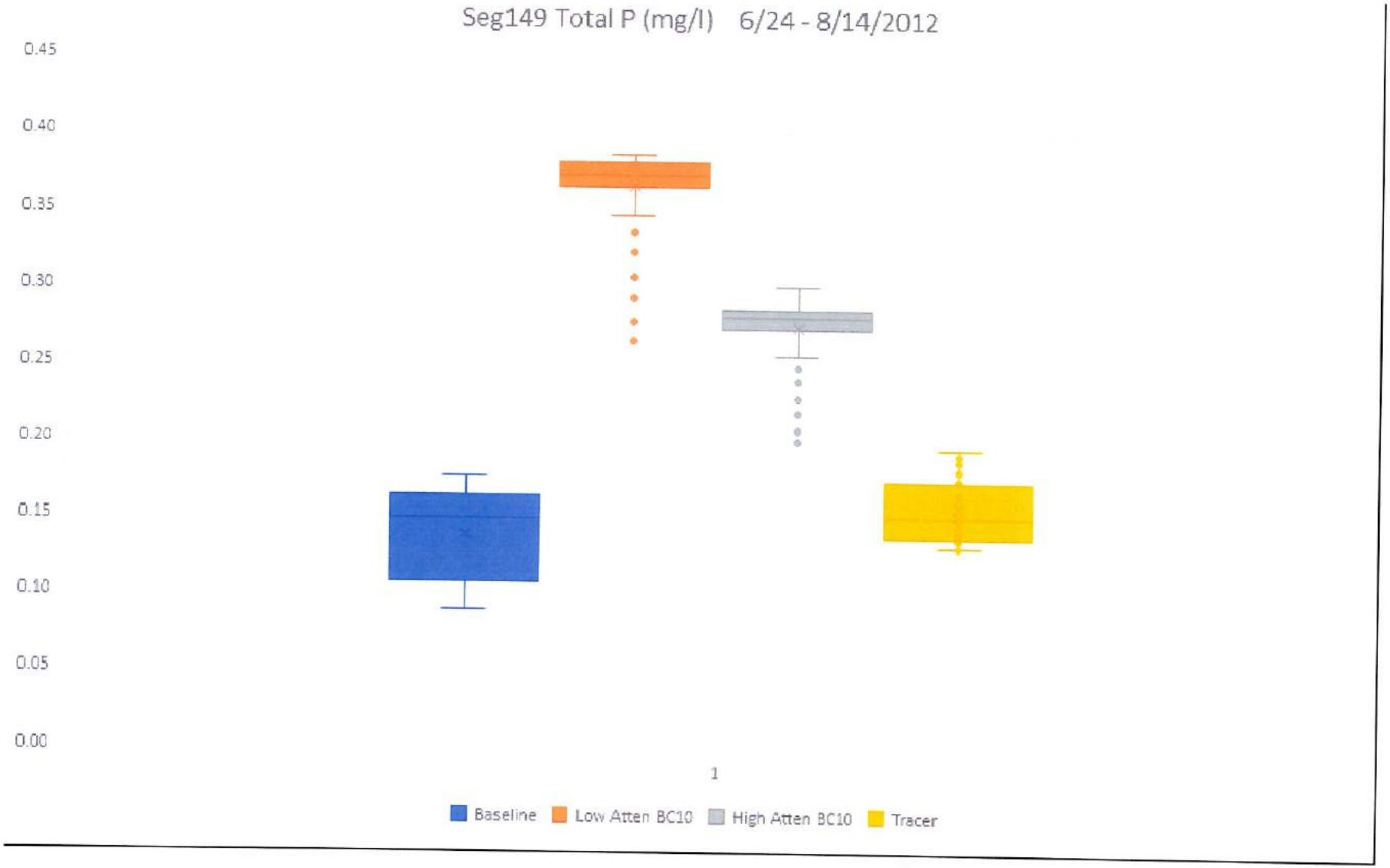
Segment 149 Chlorophyll a



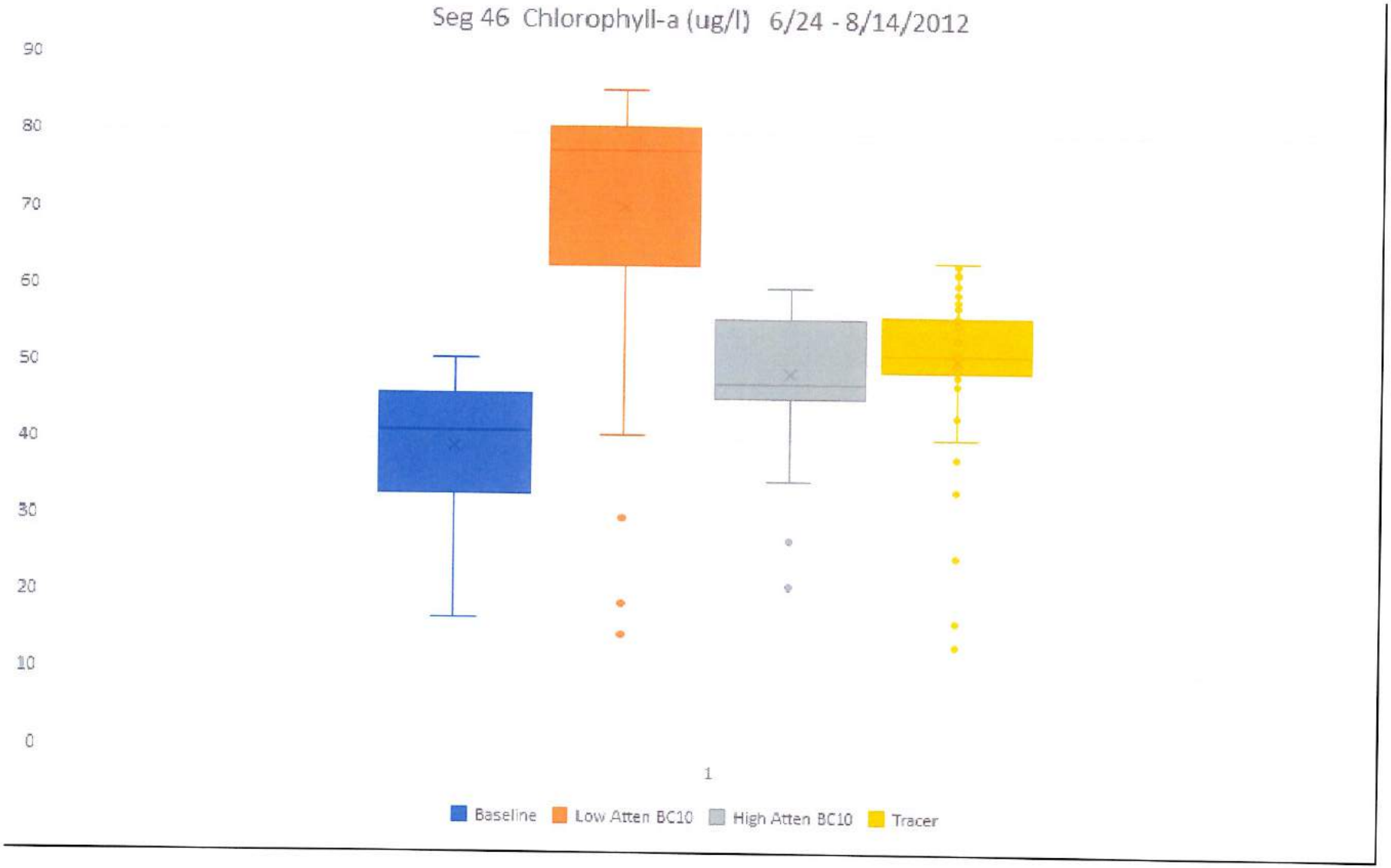
Segment 149 – Total Nitrogen



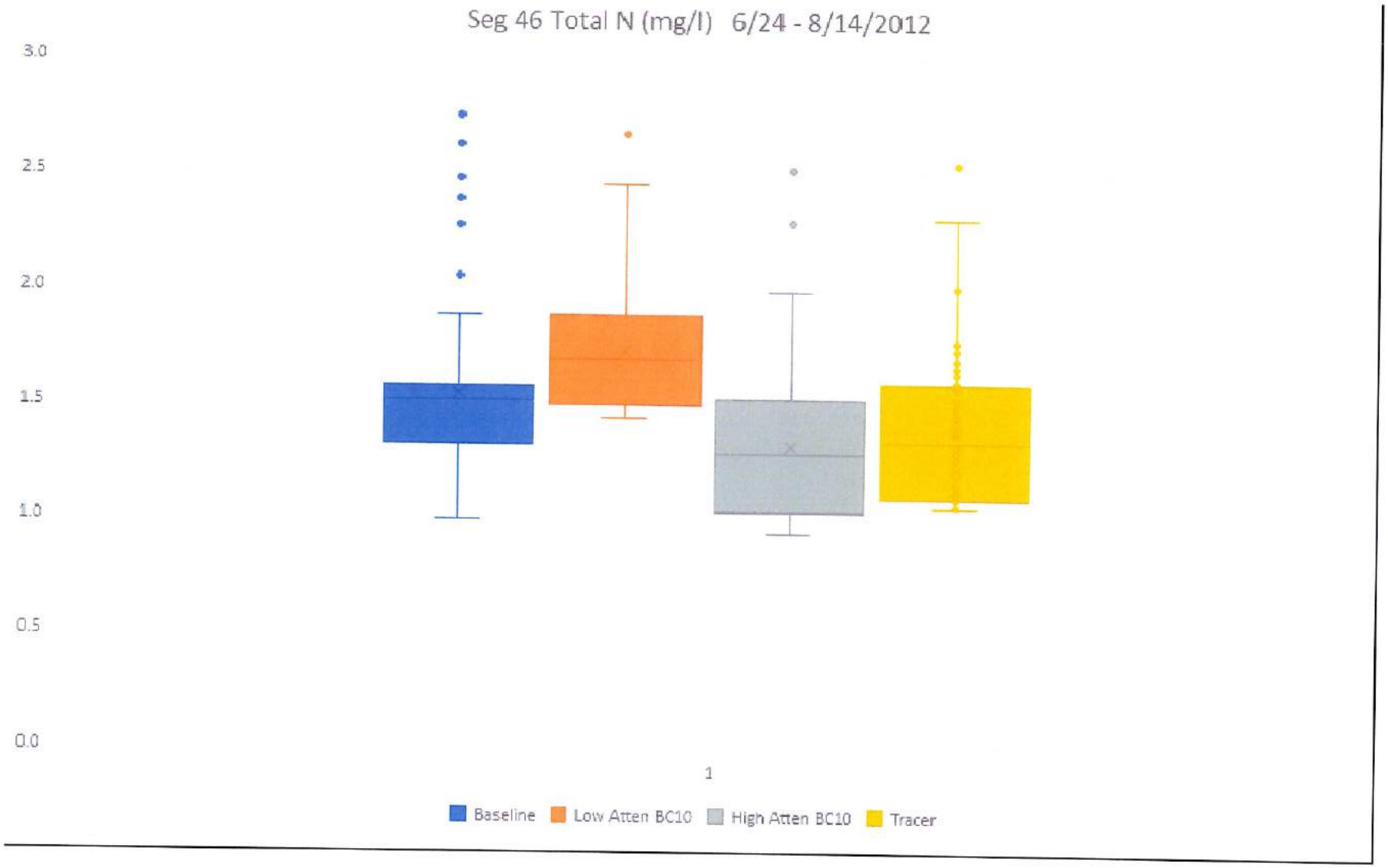
Segment 149 – Total Phosphorus



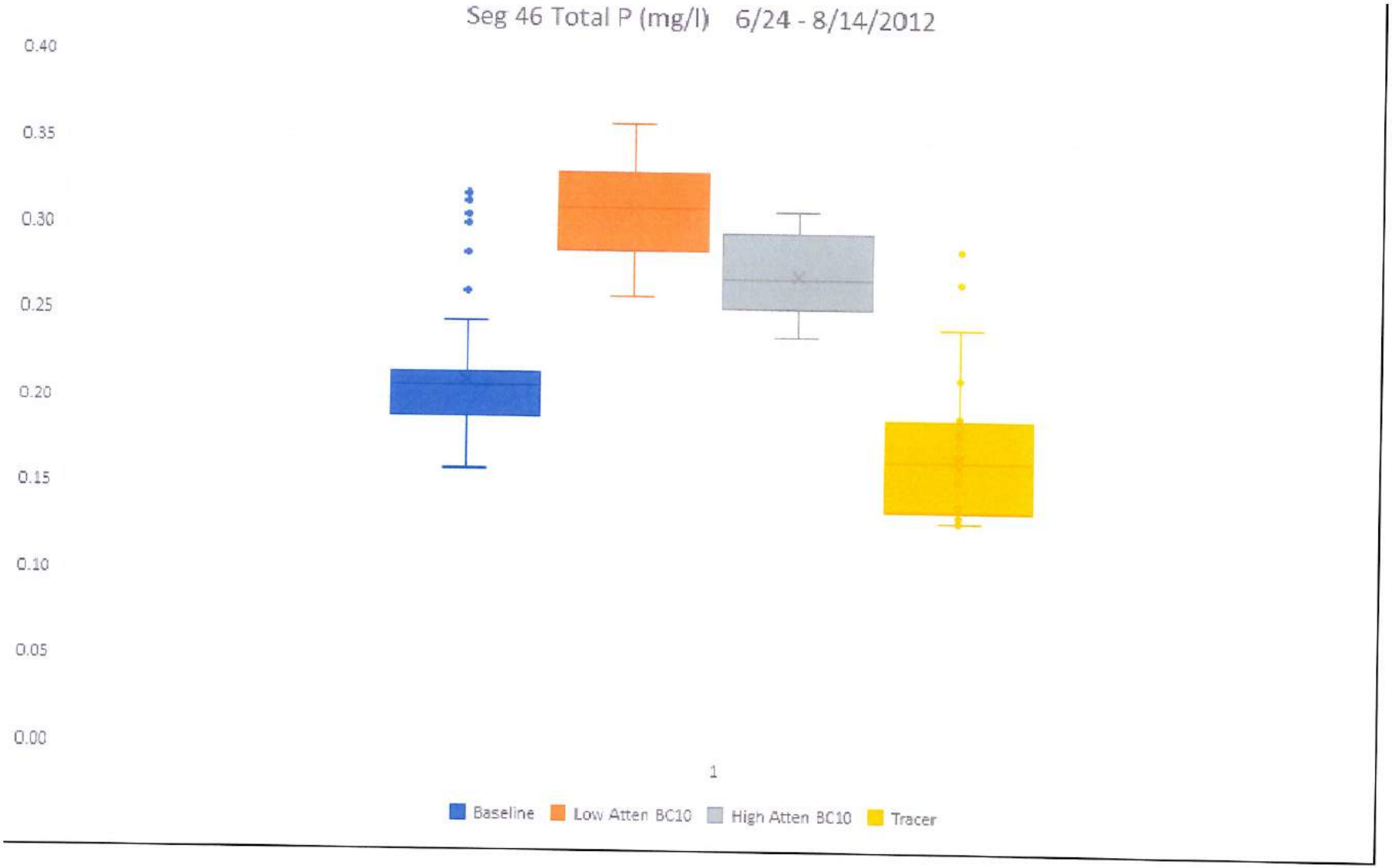
Segment 46 – Chlorophyll a



Segment 46 – Total Nitrogen



Segment 46 – Total Phosphorus



Chlorophyll A Exceedances

Segment 46 – Chlorophyll a Exceedances