Center for Watershed Science and Education

University of Wisconsin-Stevens Point and University of Wisconsin Extension

University of Wisconsin-Stevens Point
College of Natural Resources
800 Reserve Street • Stevens Point, WI USA 54481

Tarrant Lake Watershed Water Quality Summary Report

March 2010

Christopher Arnold, Charles Boettcher and Nancy Turyk, Center for Watershed Science and Education

University of Wisconsin Stevens Point

Watershed Description:

Tarrant Lake is located in the northeast portion of Columbia County. The surrounding surface covers approximately 140 square kilometers in size and contains 614 kilometers of streams (Figure 1). The land use in the watershed is dominated by agriculture, forests and some wetlands. The Tarrant Lake Watershed also includes the town of Cambria in addition to two ethanol plants.

Lake Description:

Tarrant Lake is a 24 acre impoundment of the North Branch of Duck Creek with a maximum depth of 2 meters and a mean depth of 1.2 meters WDNR (2005). The lake has hard water with extensive aquatic plant and algal growth and is considered entropic.

Methods: See Appendix

Background and Water Quality Results:

The water quality monitoring project as stated in the following grant was designed to add to the previously done Tarrant Lake watershed inventory, providing quantifiable data allowing for sound lake and watershed management. By quantifying the in lake and tributary water quality and combining it with watershed/land use data, watershed management can be focused on areas that are in need of best management practices the most. This grant, conducted water quality monitoring over two years providing quantifiable surface water data for the Tarrant Lake watershed, while allowing for future load analysis and lake modeling projects to be added increasing the quality of data over time for the watershed and lake. This approach reduces cost and ultimately increases the probabilities for success and efficiency for managing Tarrant Lake and the watershed.

This grant addresses the first two years of this effort. In what is being called **Phase I** (water quality monitoring), by design will be incorporated into the future phases, they include **Phase 2** (Data Modeling, Compilation and a phosphorous budget) and **Phase 3** (TMDL Development). These three phases for addressing water quality will ideally be accompanied An assessment of the aquatic plant community, especially *Potomogeton crispus* will help us to understand the role that aquatic plants are playing in the Tarrant Lake phosphorus budget.

In the summer of 2009 Columbia County began collecting and compiling water quality and discharge data in portions of the Tarrant Lake watershed. Samples and measurements were taken about every two weeks at the sites noted above and were taken between the dates of 6/3/2009 and 09/08/2010 at five tributaries sites in the Tarrant Lake watershed. Synoptic sampling was conducted on these and eight additional sites (TL06-TL13) within the watershed to get a bigger picture of the watershed (Table 1).

The Total Phosphorus **(TP)** median concentrations (Figure 4) at 3 of the 5 primary sites exceeded the proposed DNR phosphorus reference standard of 75 µg/l for wadeable streams except TL01 and TL02 which is 58 and 54 µg/, respectively (WDNR 2005). Median concentrations at TL04, 94 µg/l, were higher than the proposed standards (Figure 4). The median concentrations at TL03 and TL05 exceeded this standard (246 µg/l and 152 µg/l, respectively). In addition, TL03 exhibited great variability ranging in value from 34-813 µg/l. Also, the TP concentrations at TL03 seem to be related to stage height such that increase in stage (i.e. runoff) results in elevated TP concentrations (Figure 6). Generally, the reactive phosphorus (RP) concentrations increased with an increase in TP concentration at all sites (Figure 7).

Nitrate represents the major form of nitrogen compounds measured at all sites. The median concentrations at all sites exceeded the reference standard for algal blooms in lakes of 0.3 mg/l and ranged from 4.7 mg/l-11 mg/l (Figure 8). TL02 had the greatest variability in concentration ranging from 1.9 to 11.5 mg/l.

Total Suspended Solids or TSS concentration medians ranged from 6-20 mg/l (Figure 9). TL01 had the greatest variability with concentrations between 2 and 58 mg/l.

Chloride concentrations measured at all primary sites were all above 25 mg/l (Figure 10,11) and exceeded the regional average of 10 mg/l (Shaw et al. 2002).TL01 and TL04 exhibited high variability in concentrations ranging from 10.8-35.7 mg/l at TL03 and 25.6-35 mg/l at TL04 (Figure 10,11). The stream stage heights and chloride concentrations seem to suggest a link to groundwater particularly at TL01, TL02 and TL05 (Figure 12).

The specific conductance (SpC) measurements were elevated at all primary sites, nearly measurements exceeded 700 µmhos. The median value at TL03 was 1025 µmhos (Figure 14).

The pH measured at all primary sites ranged between from 8.7 to 7.6 (Figure15). The median value for TL01 was the highest at 8.5 most likely because it is located at the outflow of the dam. The median values for TL02, 03, 04 and 05 are 7.95, 8, 8.2 and 8.3 respectively.

The Dissolved Oxygen concentrations were measured during each sampling period. The lowest recorded value was 5.09 mg/l (Figure16).

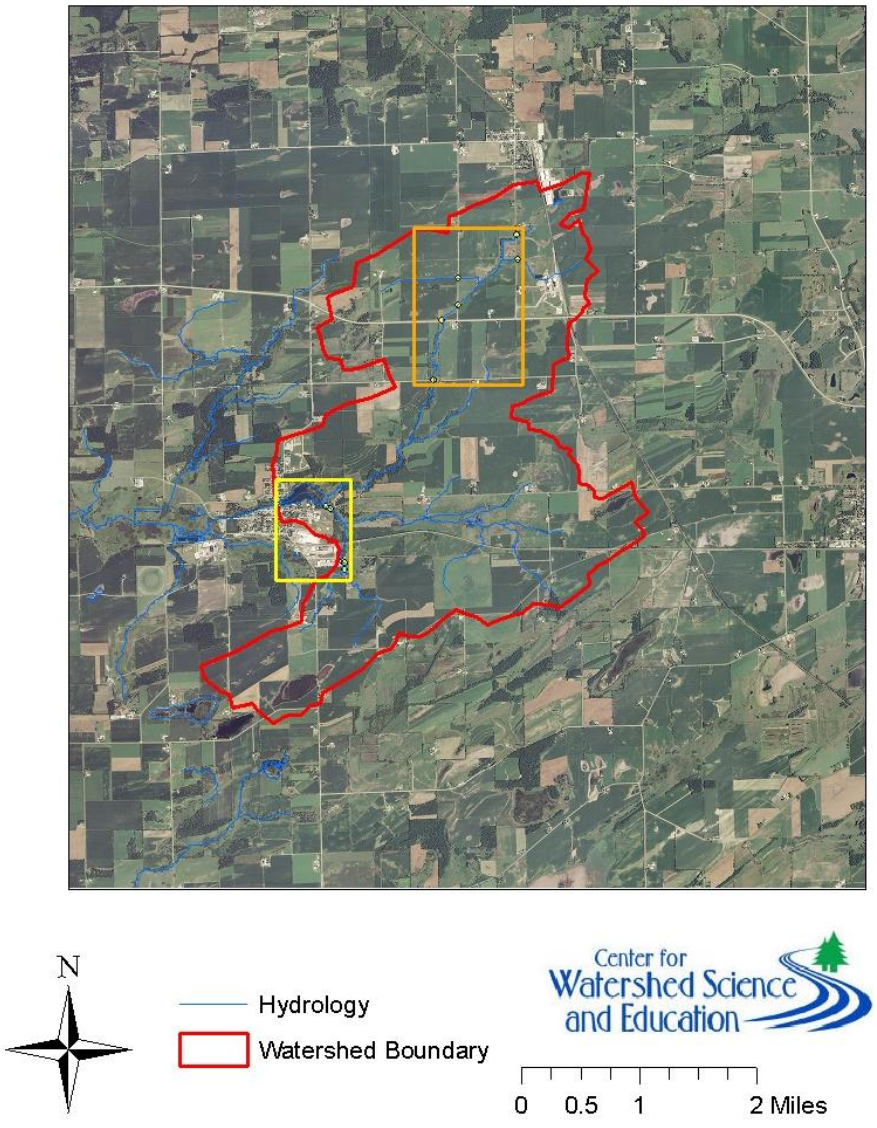

Figure 1: Map of Tarrant Lake Watershed and Tributary Sampling Site Regions highlighted in yellow and orange.

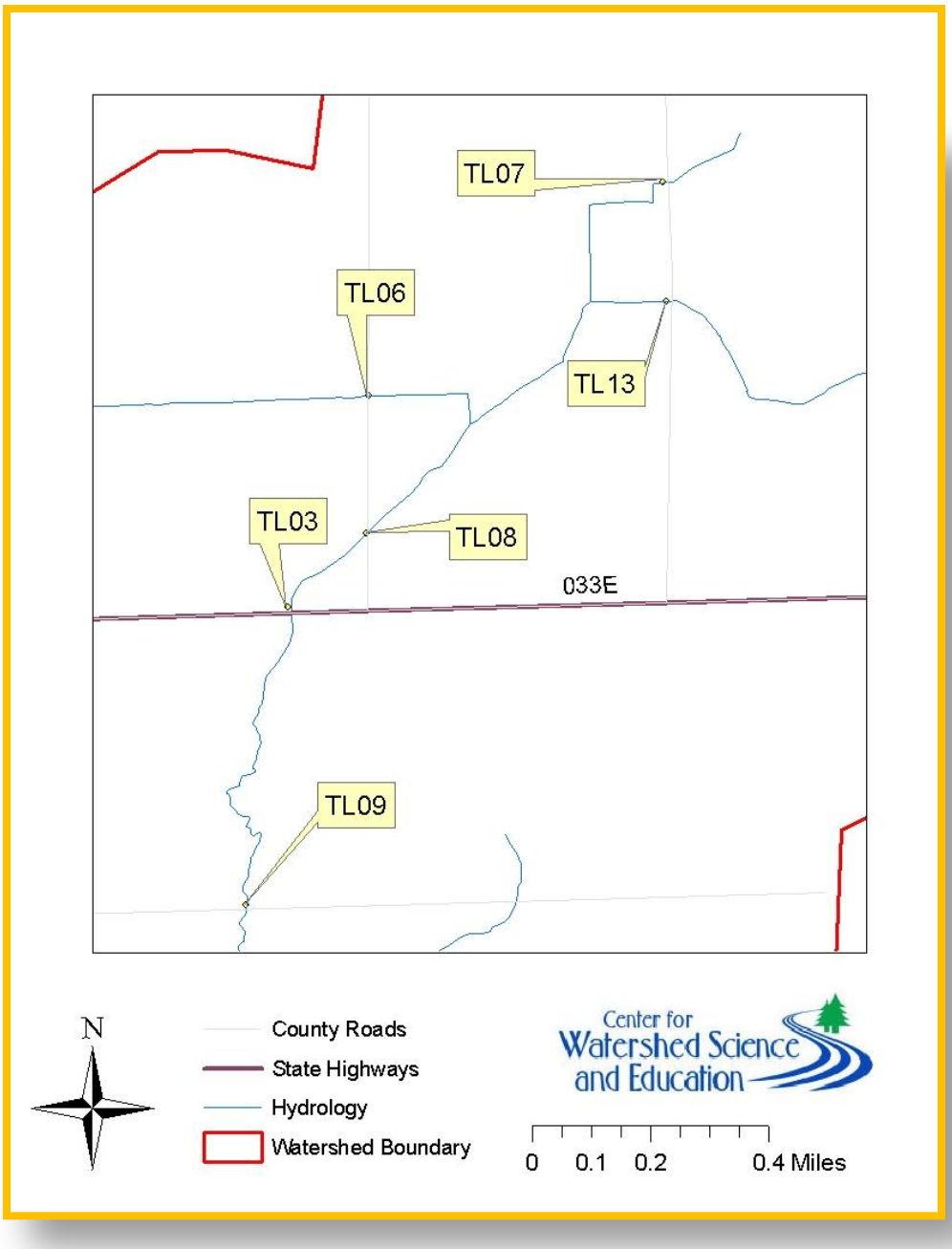

Figure 2: Locations of Sampling Sites within the Northern or Orange Outlined Region from figure 1.

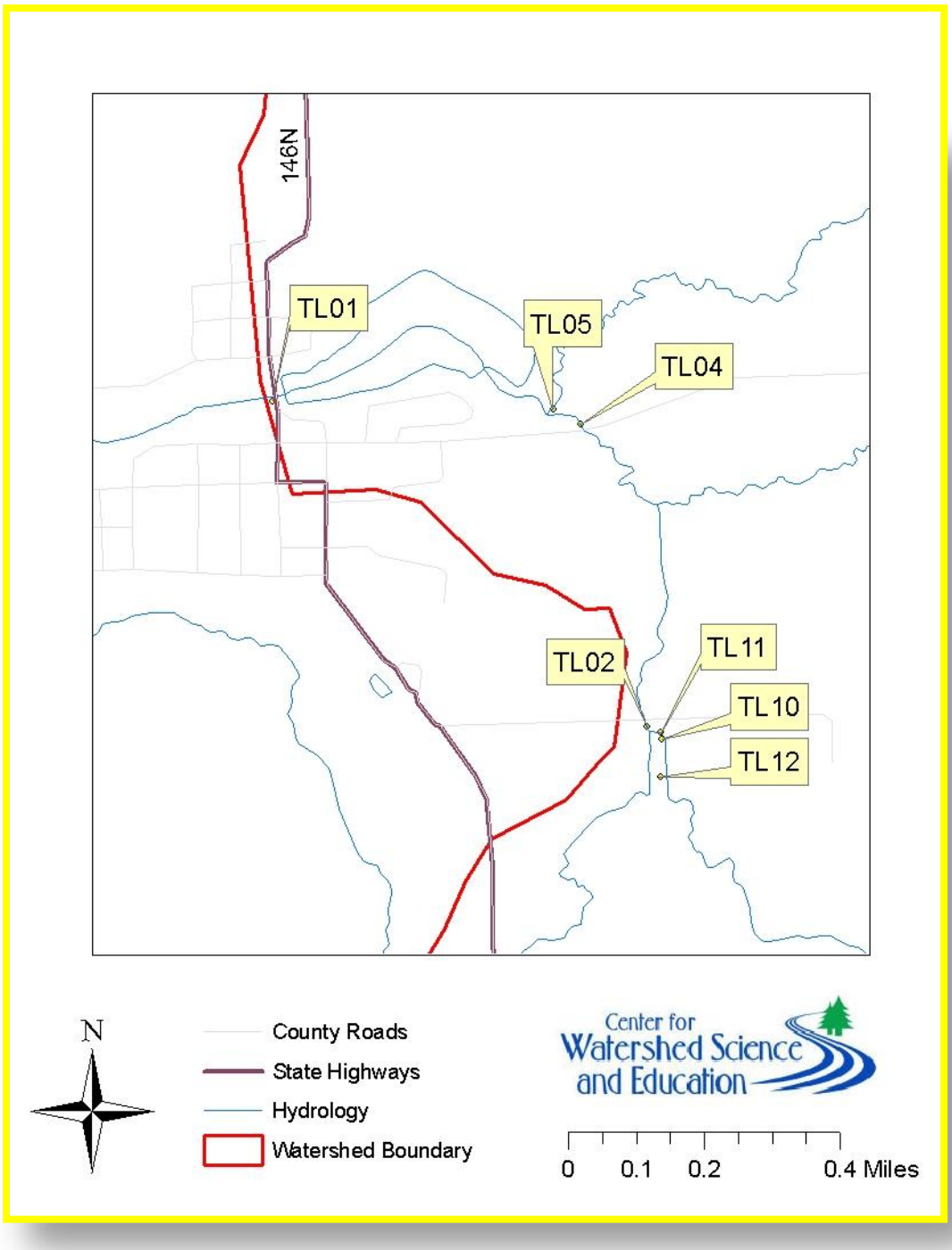

Figure 3: Location of Sampling Sites within the Southern or Yellow Outlined Region from figure 1.

Table 1. Sampling Site Locations in the Tarrant Lake Watershed

Site	Tributary Name	Adjacent Roadway
TL01	North Branch of Duck Creek (Outflow)	State Highway 146
TL02	Unnamed	Costello Drive
TL03	North Branch of Duck Creek	State Highway 33
TL04	Unnamed	County Road P
TL05	North Branch of Duck Creek	County Road P
TL06	Unnamed	Sterk Road
TL07	North Branch of Duck Creek	County Road EF
TL08	North Branch of Duck Creek	Sterk Road
TL09	North Branch of Duck Creek	Vaughn Road
TL10	Unnamed	Costello Drive
TL11	Unnamed	Costello Drive
TL12	Unnamed	Costello Drive
TL13	Unnamed	County Road EF

Discharge Data Results:

Discharge and staff gauge measures were collected beginning in the summer of 2009 and spring to fall in 2010. In total, twenty-three of these measurements have been taken for each site although some flows were too low for an accurate discharge to be measured. Several of the points should be tested as outliers.

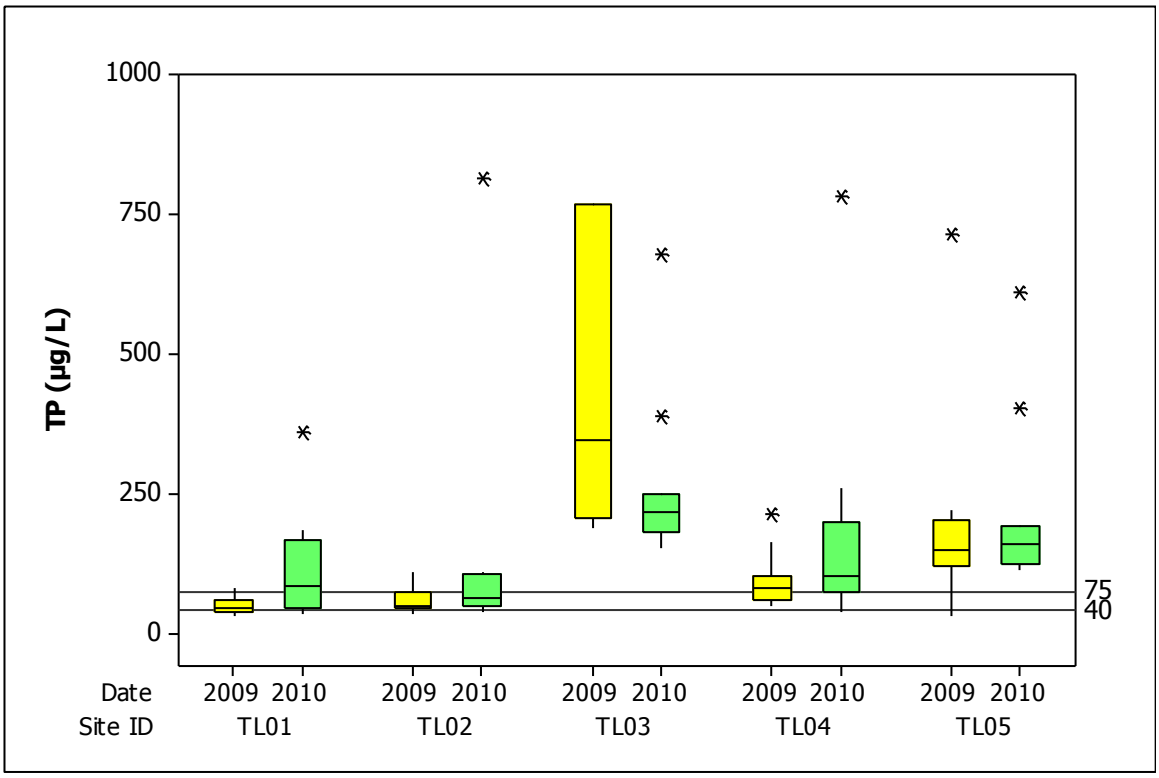

Figure 4: Range of total phosphorus concentrations measured at primary sampling sites. The horizontal line represents the reference standard of 75 µg/l for wadable streams and 40 µg/l for impoundments.

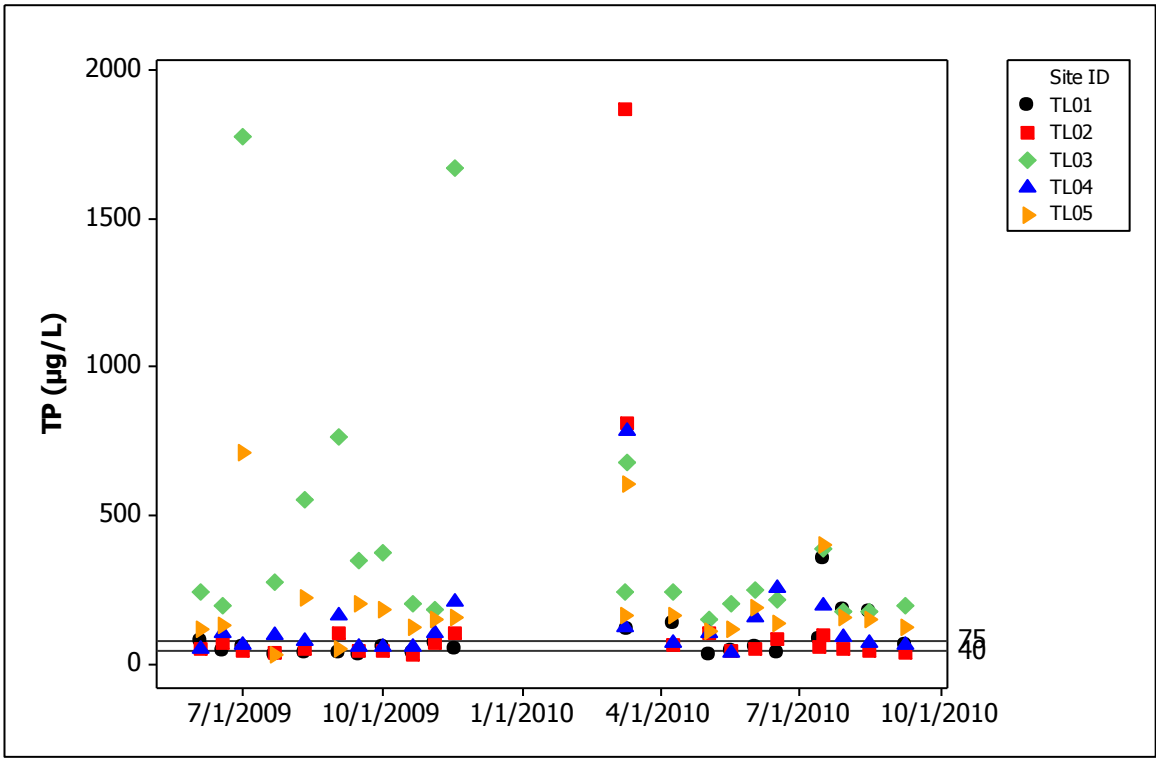

Figure 5: Total phosphorus concentration measured at primary sampling sites by date. The horizontal line represents the reference standard of 75 µg/l for wadable streams and 40 µg/l for impoundments.

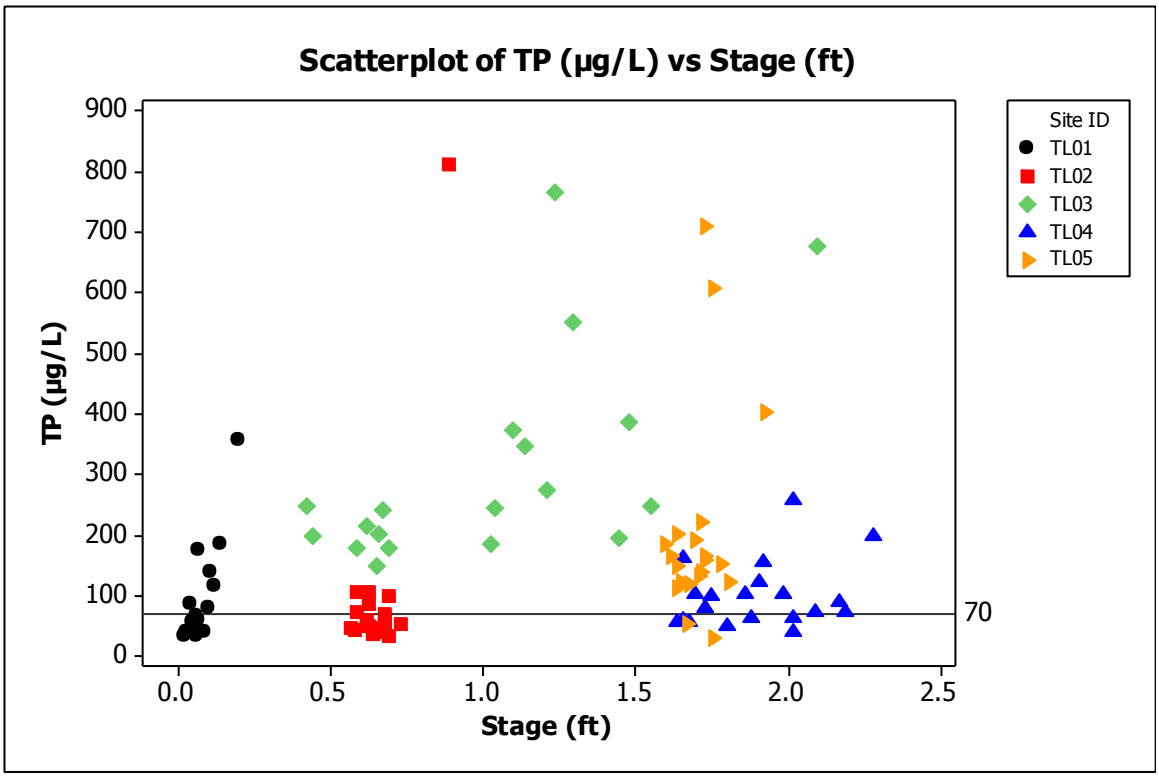

Figure 6: Total phosphorus concentration vs. by stage height. The horizontal line represents the reference standard of 70 µg/l.

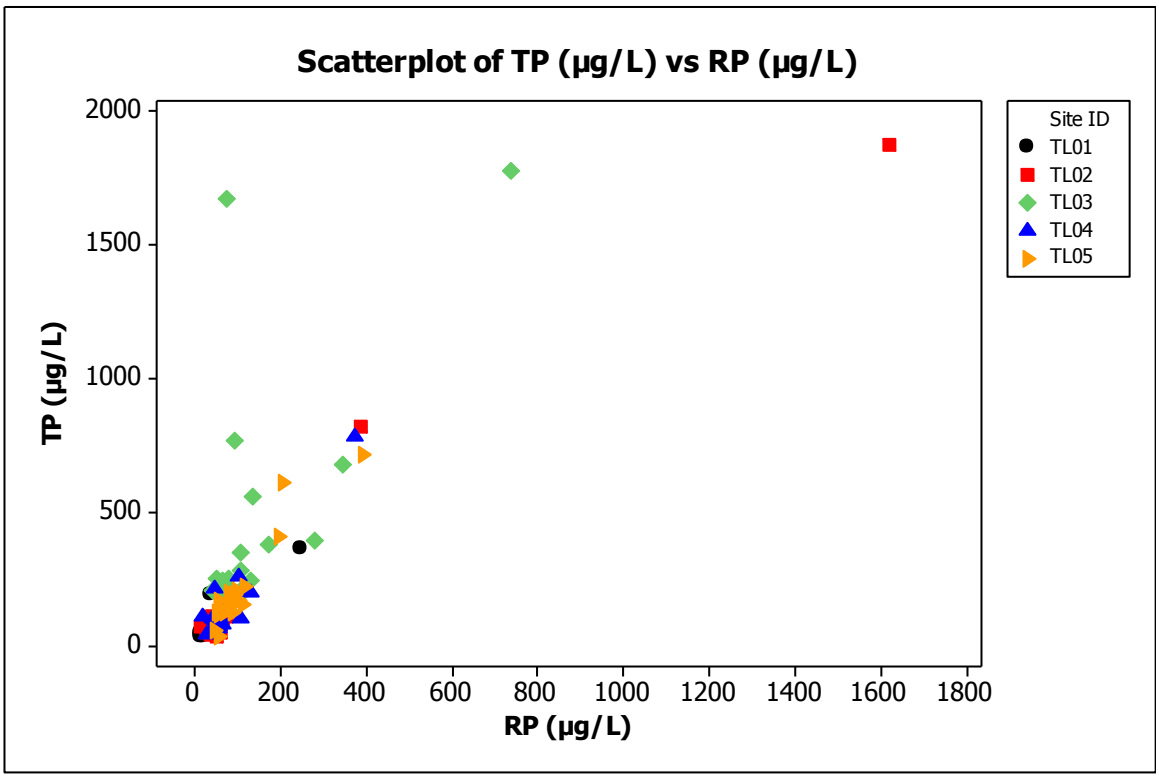

Figure 7: Total phosphorus plotted against soluble reactive phosphorus measured at each of the primary sites.

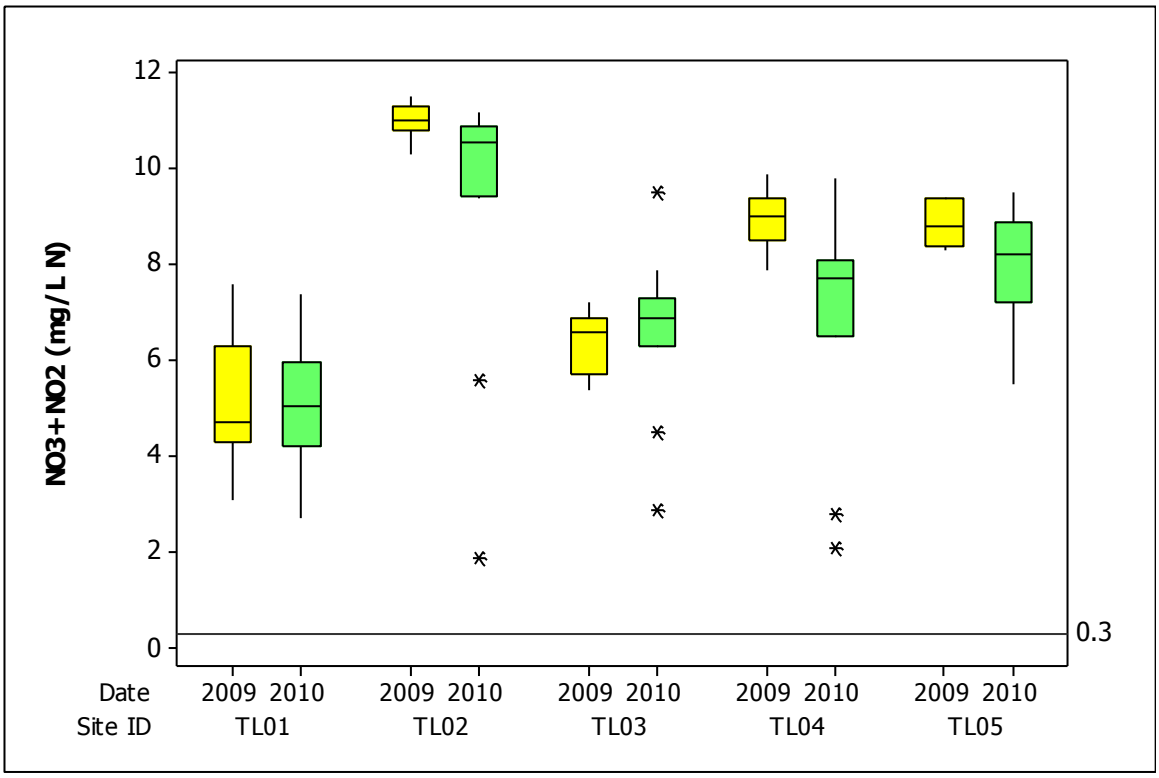

Figure 8: The range of nitrate concentrations measured at all primary sites. The horizontal line represents the reference standard for algal blooms in lakes of 0.3 mg/l.

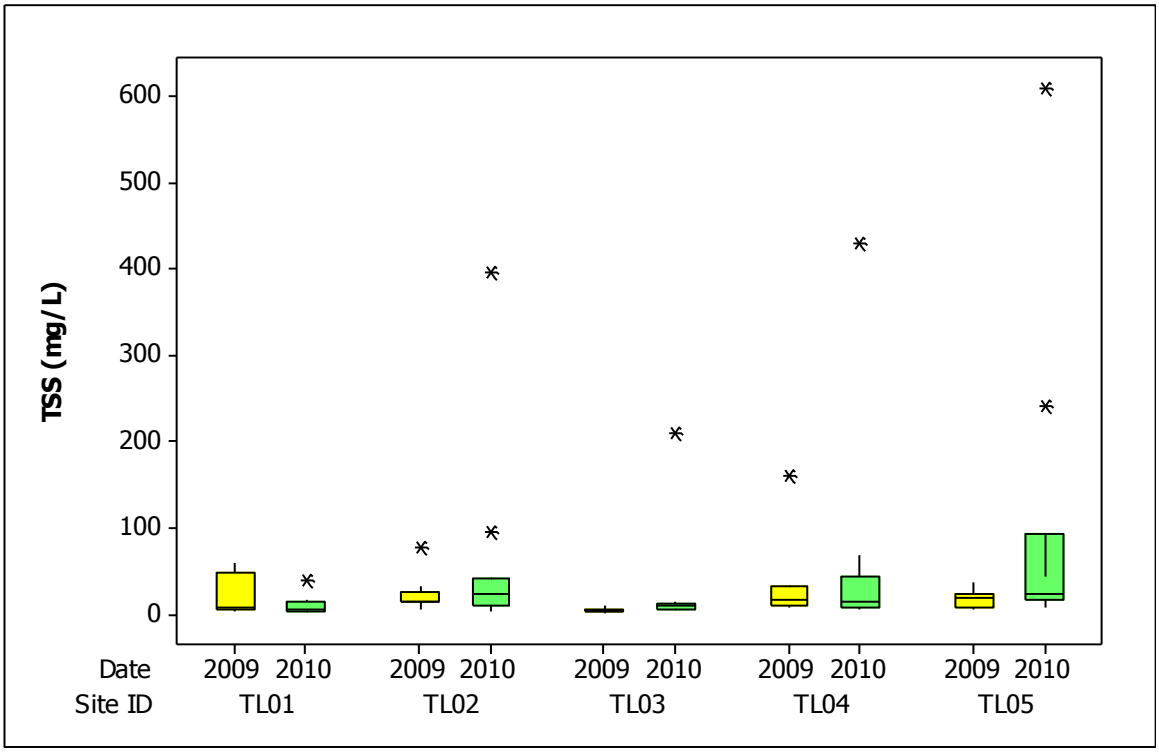

Figure 9: The range of total suspended solid concentrations measured at all primary sites.

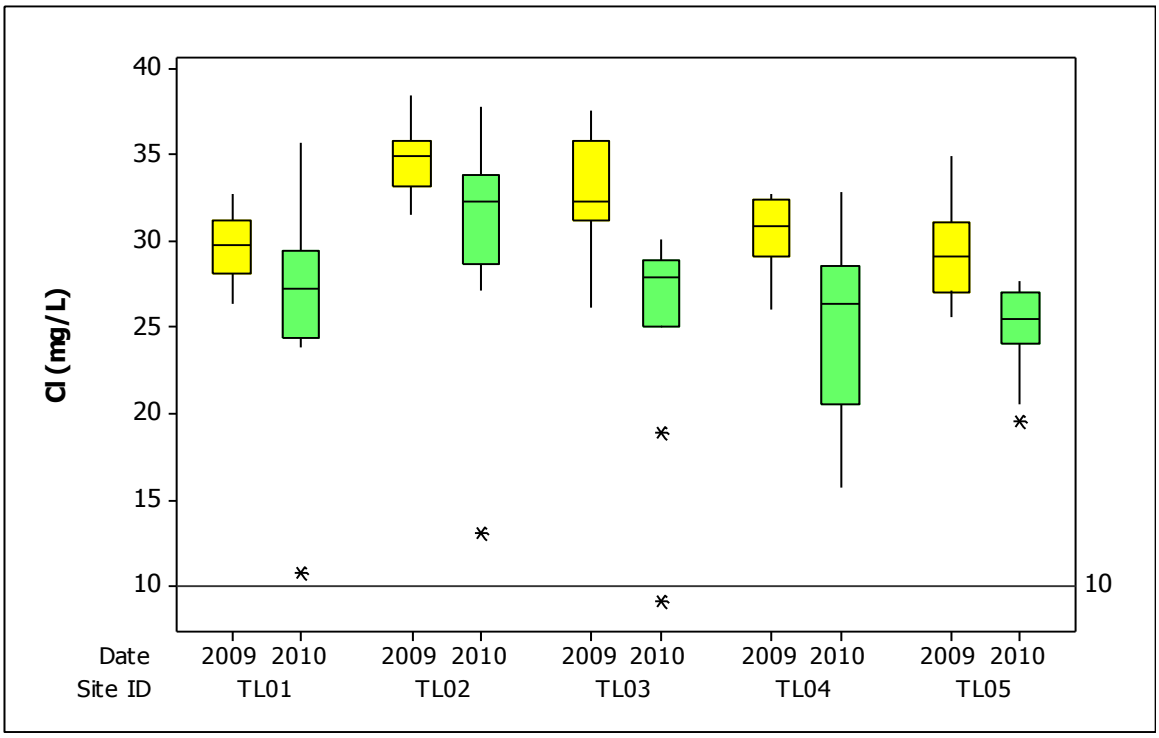

Figure 10: Range of Chloride concentrations measured at primary sampling sites. The horizontal line represents the regional average of 10 mg/.

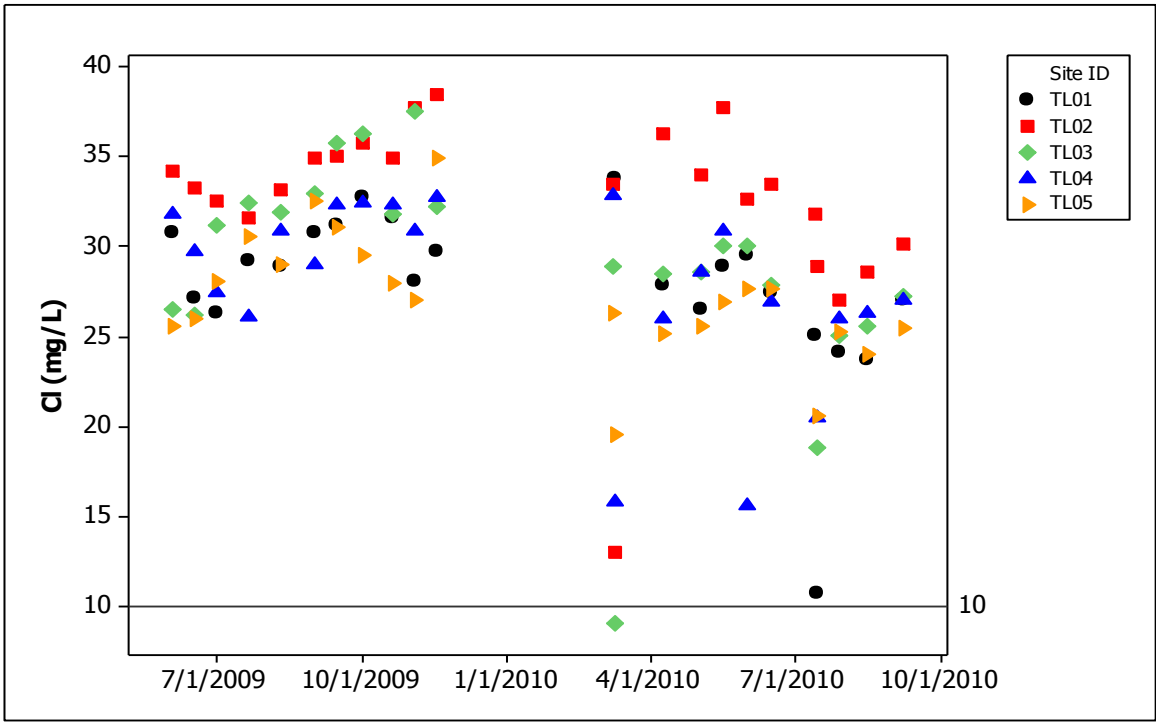

Figure 11: Chloride concentrations measured at primary sampling sites by date. The horizontal line represents the regional average of 10 mg/.

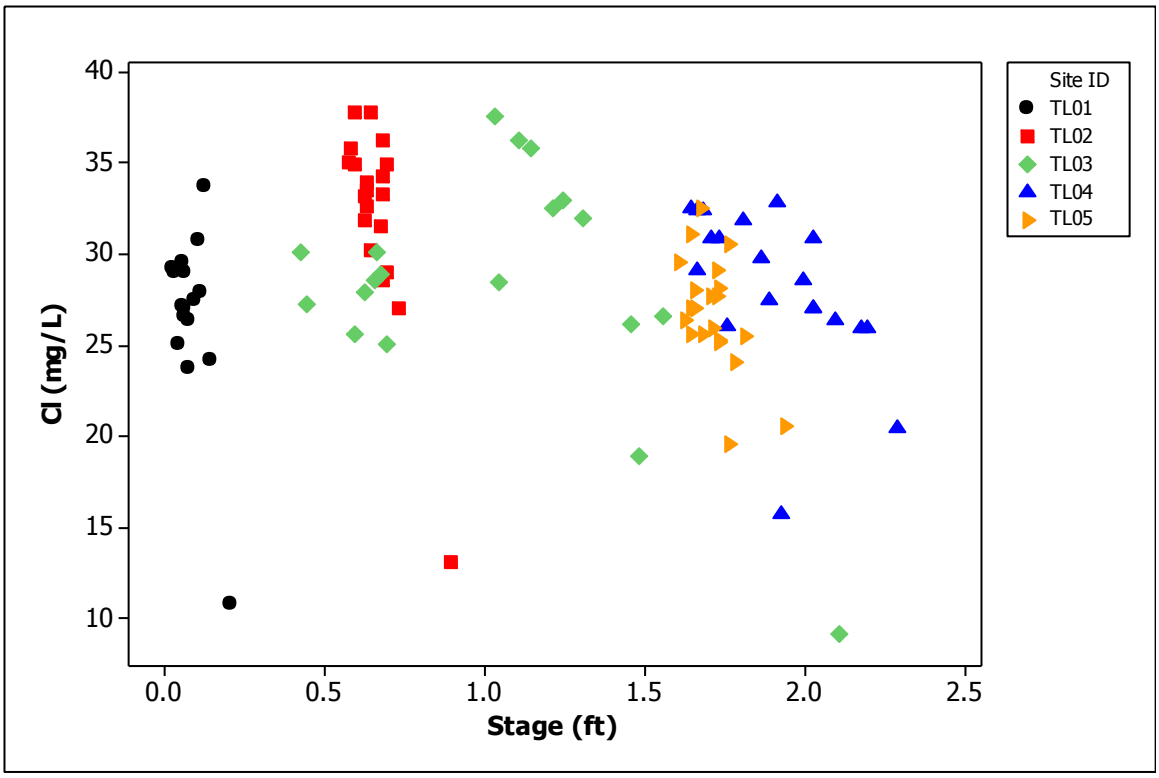

Figure 12: Chloride concentrations and stage height measured at primary sampling sites.

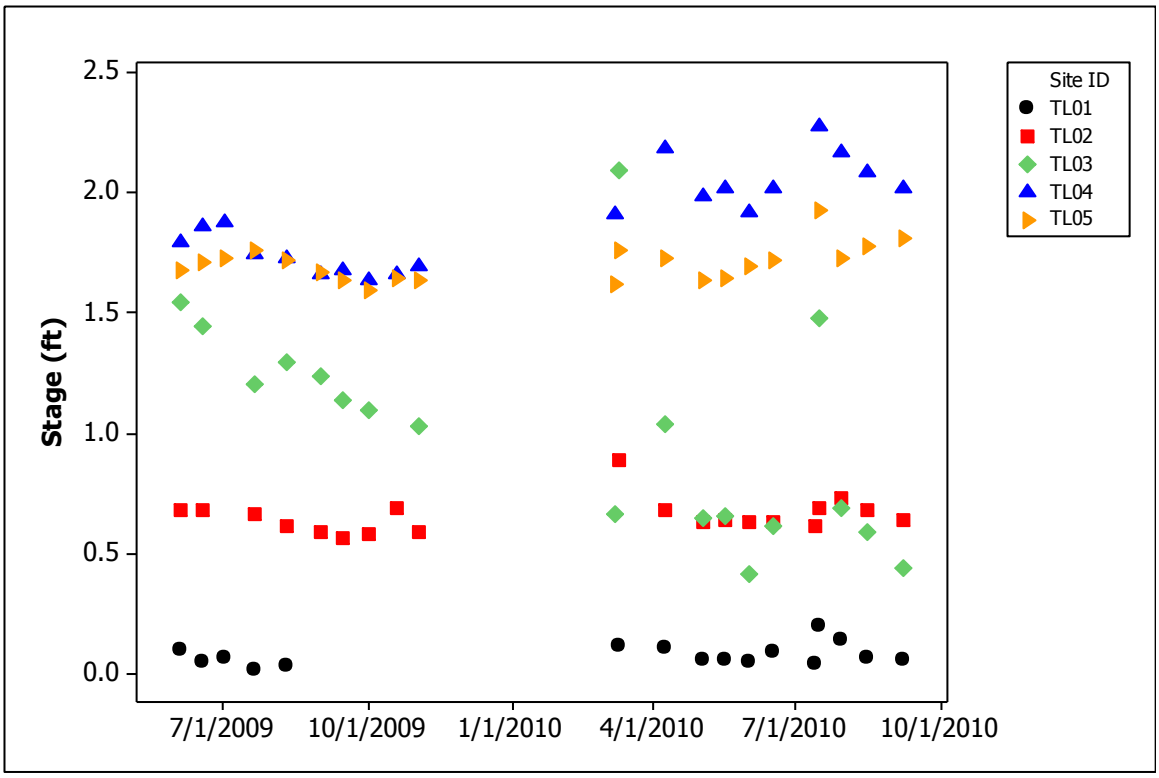

Figure 13: Stage height measured at primary sampling sites by date.

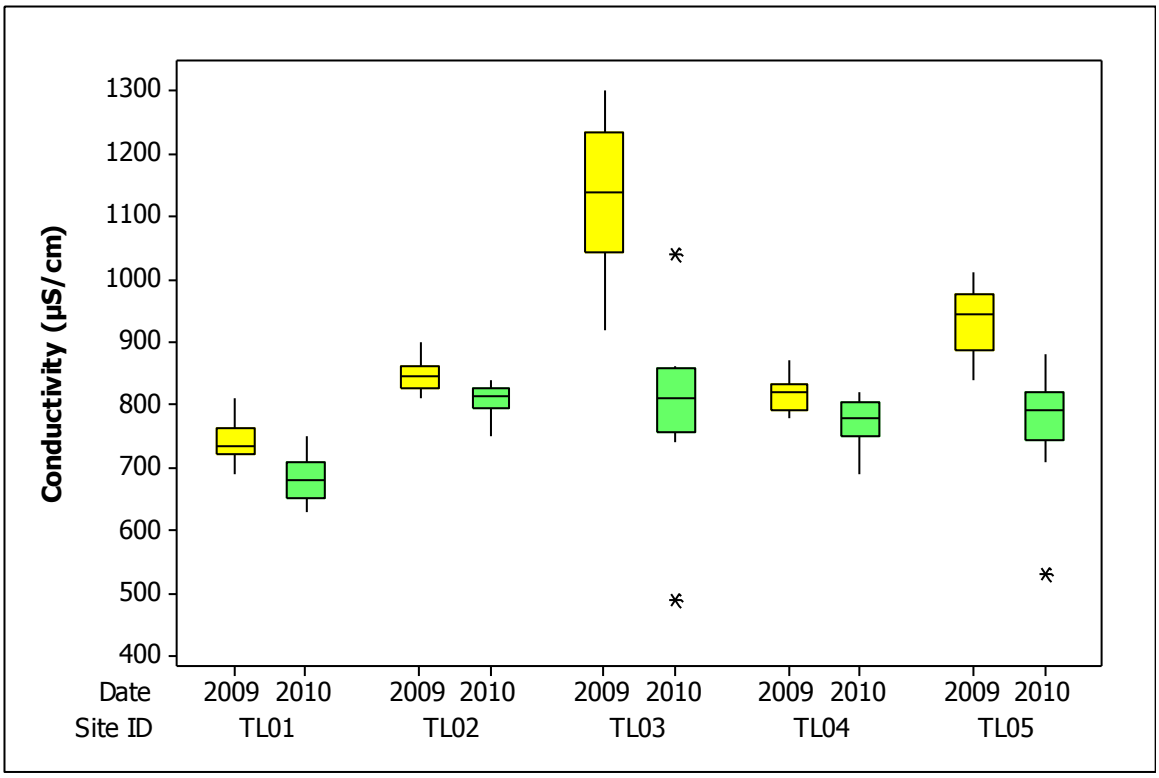

Figure 14: Range of specific conductance measured at primary sampling sites

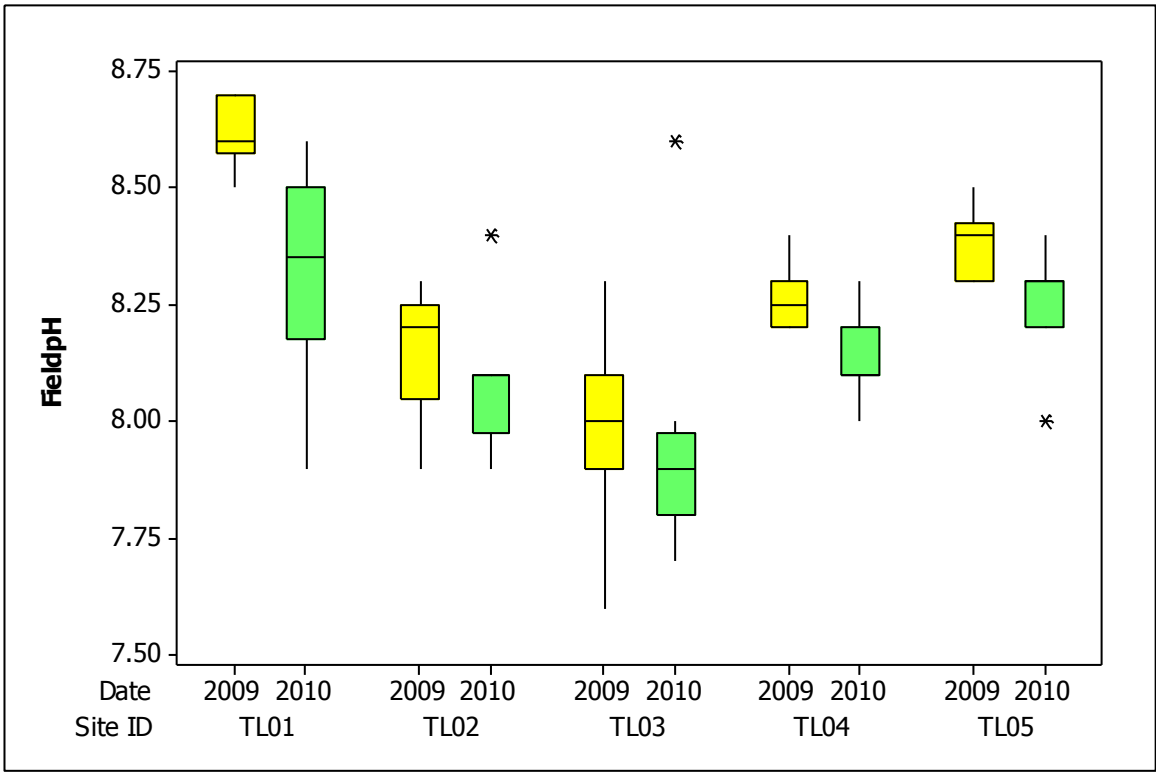

Figure15: Range of pH values measured at primary sampling sites

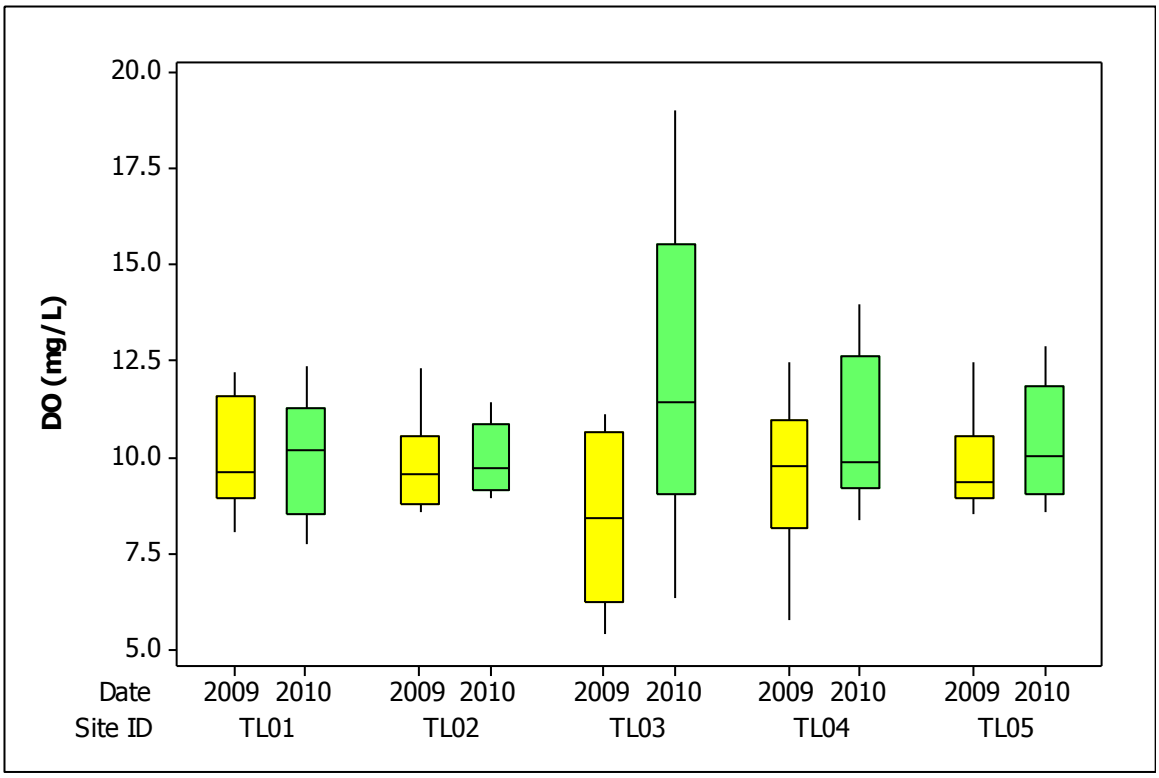

Figure 16: Range of dissolved oxygen concentrations measured at each primary sampling site.

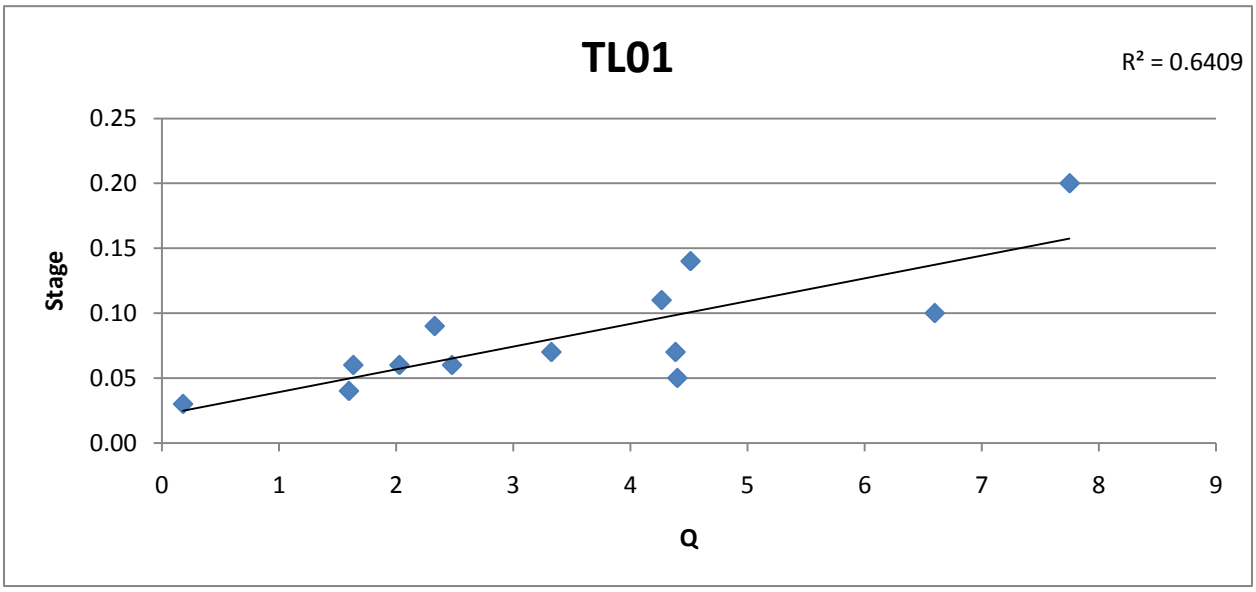

Figure 17: The rating curve for TL01

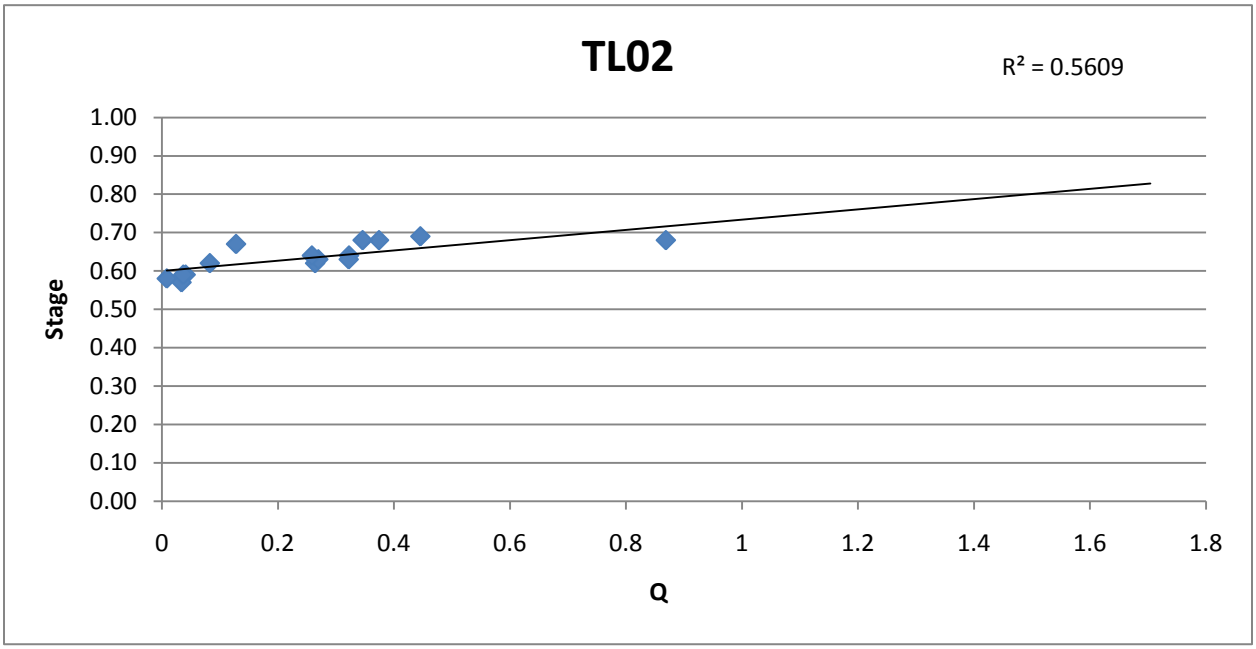

Figure 18: The rating curve for TL02

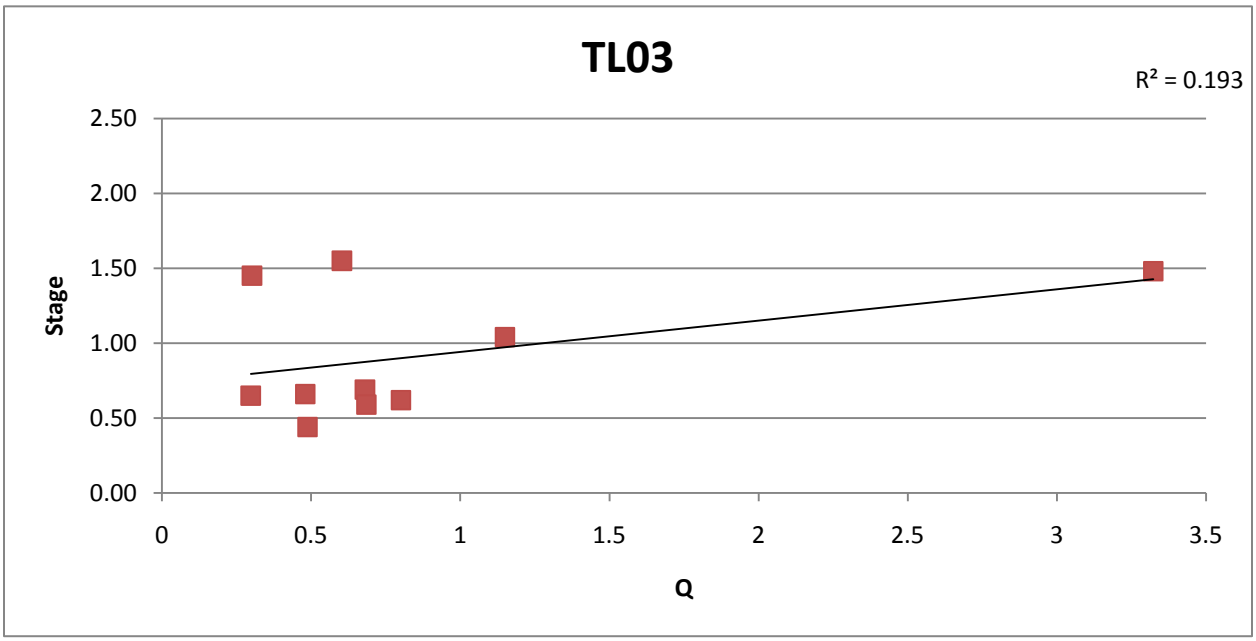

Figure19: The rating curve for TL03

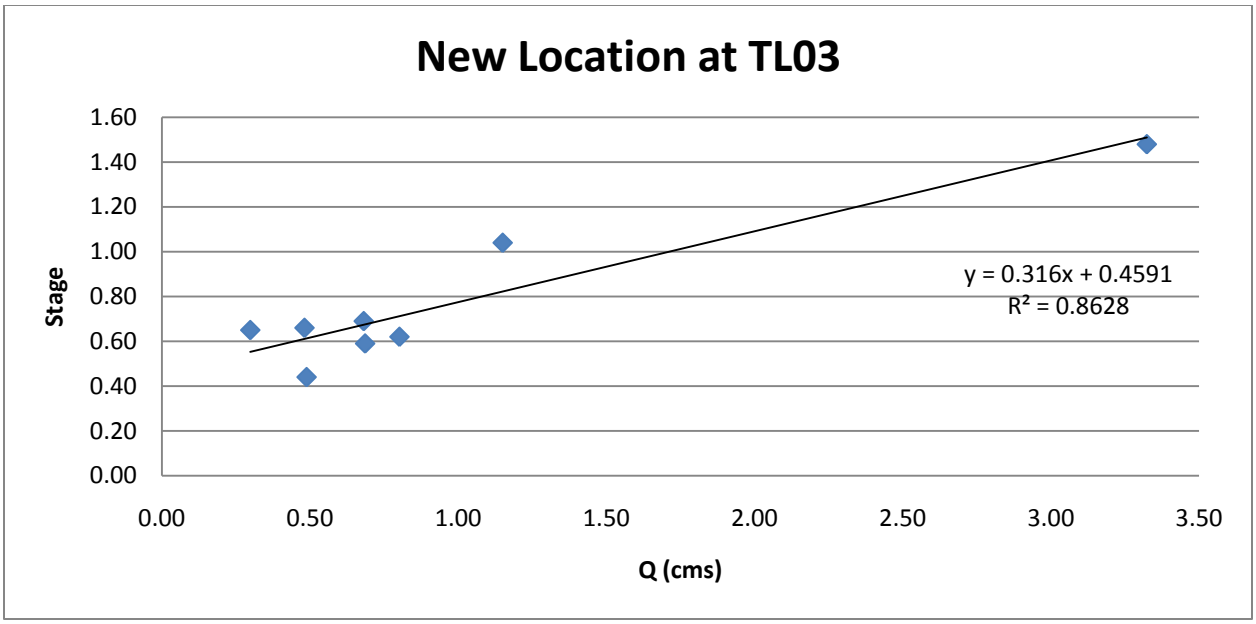

Figure 20: The rating curve for TL03 after moving location within tributary.

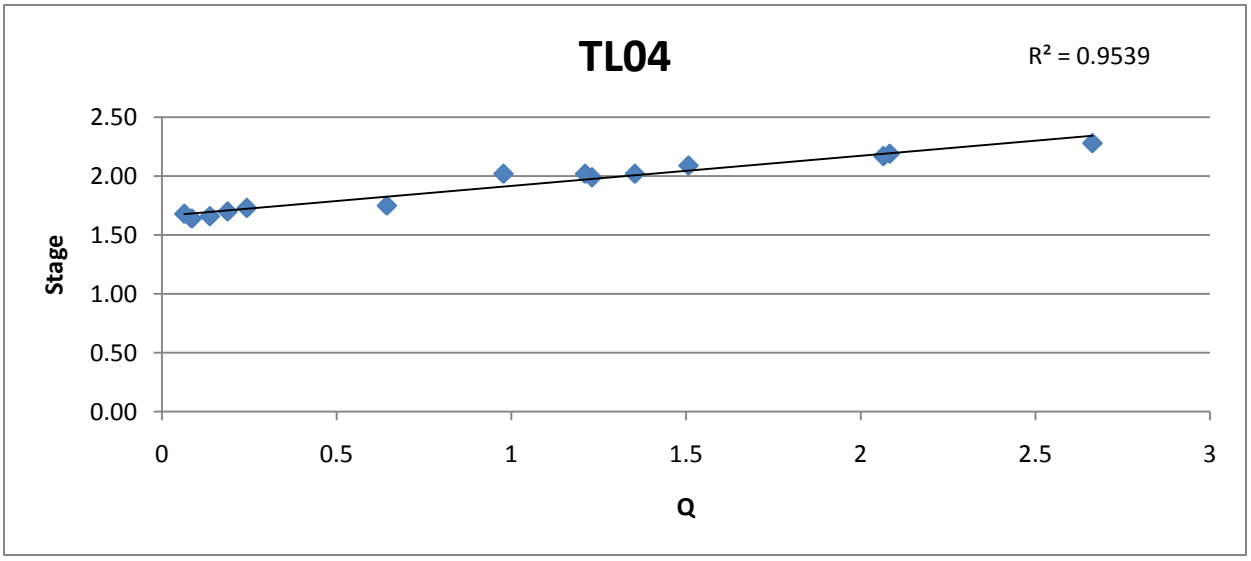

Figure 21: The rating curve for TL04

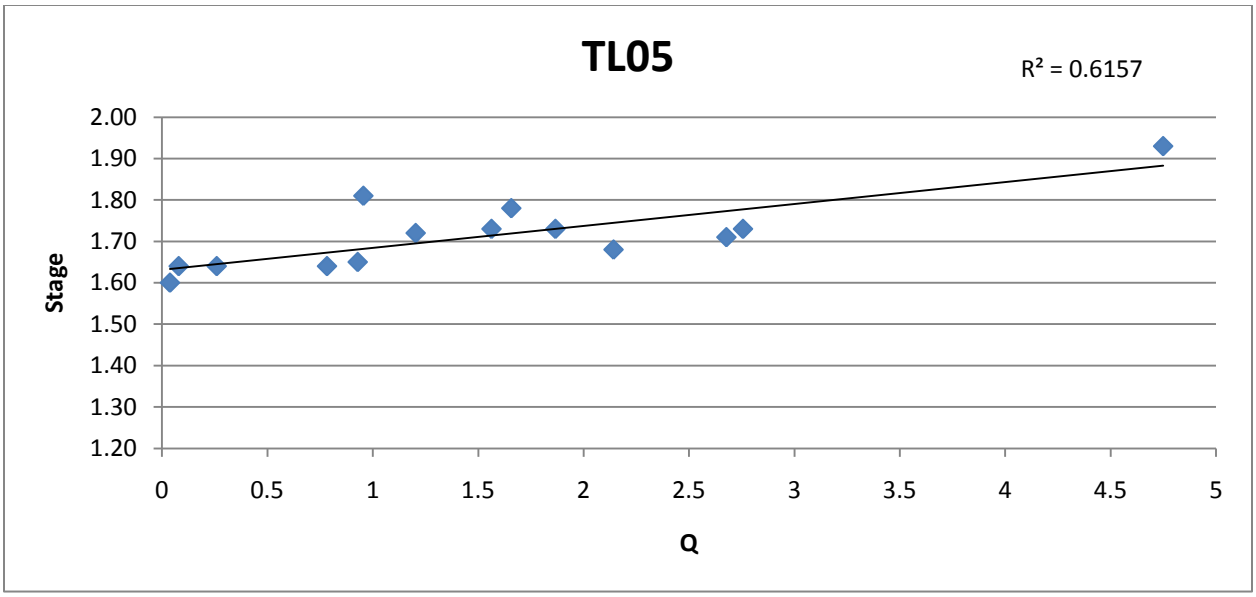

Figure 22: The rating curve for TL05

Appendix:

Watershed Sampling Methods: To understand how the watershed influences water quality in Tarrant Lake, water monitoring was performed at 5 tributaries (TL01-TL05). Tributary nutrient concentrations and water flow rates were measured. Stream flow was measured with pressure transducers, staff gauges, and stream flow measurements. Water samples were collected for lab analysis throughout the year and during a variety of flow conditions. Samples were collected during low flow (base flow) using the grab method and during high flow using siphon samplers. The siphon samplers were set at varying depths in each tributary to collect samples during different points in a storm or snow melt event. The arrangement of siphon samplers was intended to explore if and how nutrient concentrations varied with stream flow intensity related to precipitation and runoff. A synoptic sampling procedure was used to collect additional high flow samples at locations upstream of the normal monitoring sites. These samples allowed us to evaluate how land use changes from the upper to lower reaches of sub-watersheds affected water quality in the streams. A scaling procedure was used to estimate nutrient concentrations and flow in the unmonitored tributaries. Nutrient loads and flows from adjacent watersheds with similar land use and relief characteristics were scaled by area to the unmonitored watershed of interest. Samples were shipped on ice to the state-certified Water and Environmental Analysis Lab on the UWSP campus for lab analysis of NO_2+NO_3-N, NH_4, TKN, SRP, Total P, Cl, and TSS. Dissolved oxygen, pH, specific conductance, and temperature were recorded using a Hydrolab during base flow sampling. During synoptic sampling water samples were also analyzed for various ions including: arsenic, calcium, copper, iron, sulfates, potassium, magnesium, manganese, sodium, phosphorus, lead, and zinc.

Lake Sampling Methods: The Columbia County Land and Water Conservation Department conducted in-lake water quality monitoring during the spring through the fall of 2009. Lake water quality data was collected at the deep point of the basin. Profiles of temperature (Figure23,24), dissolved oxygen (Figure), pH, specific conductance, and water clarity were collected 4 times on 5/19/2009, 6/26/2009, 8/19/2009, 10/15/2009, 4/19/2010, 7/6/2010, 7/28/2010, 8/17/2010, 9/14/2010, and 11/1/2010. Dissolved oxygen, pH, specific conductance, and temperature were recorded using a Hydrolab, and a

Secchi disk was used to determine water clarity. During the summer season water quality samples were collected 2 times in 2009 and 5 times in 2010 and analyzed for total phosphorus and chlorophyll a (an indicator of algae) and are recorded in Table 2. The phosphorus samples were preserved using H_2SO_4 and the chlorophyll a samples were field filtered with 934-AH filters and stored in whirl packs covered in aluminum foil. The samples were collected using a 4 foot integrative sampler. In addition a fall overturn sample was collected 1 foot into the water column on 10/15/2009 and 4/19/2010, once again analyzed for nitrates, total nitrogen and organic nitrogen, chlorides, pH, specific conductance, alkalinity, total and calcium hardness, ammonium, total and reactive phosphorus, sulfates, potassium, sodium, turbidity and color and is recorded in Table 3. All water quality samples were kept on ice during transport to the lab. Water chemistry analysis was performed at the state certified UWSP Water and Environmental Analysis Lab.

Table 2: Total Phosphorus and Chlorophyll a readings on Tarrant Lake for 6/26/2009 and 8/19/2009

Date	TP (µg/L)	Chlora
11/1/2010	96.00	5.00
9/14/2010	49.00	13.00
8/17/2010	169.00	39.00
7/6/2010	216.00	1.00
7/28/2010	206.00	31.00
8/19/2009	60.00	26.00
6/26/2009	54.00	8.00

Table 3: Fall Overturn water quality data collected for Tarrant Lake on 10/15/2009 and 4/19/2010

Date	4/19/2010	10/15/2009
NO3+NO2 (N) (mg/l)	5.50	0.30
Cl (mg/l)	28.00	24.10
NH4 (mg/l)	0.01	0.01
TKN (mg/l)	0.91	0.97
TP (ug/l)	39.00	48.00
RP (ug/l)	5.00	46.00
conductivity (umhos)	628.00	503.00
pH	8.55	8.55
Alk (g CaCo3)	276.00	236.00
T Hard (mg/l)	371.00	268.00
Ca Hard (mg/l)	193.00	125.00
SO4 (mg/l)	42.76	25.64
K (mg/l)	3.40	3.80
Na (mg/l)	11.80	7.10
Turb (NTU)	3.00	3.10
Color (CU)	16.00	26.50

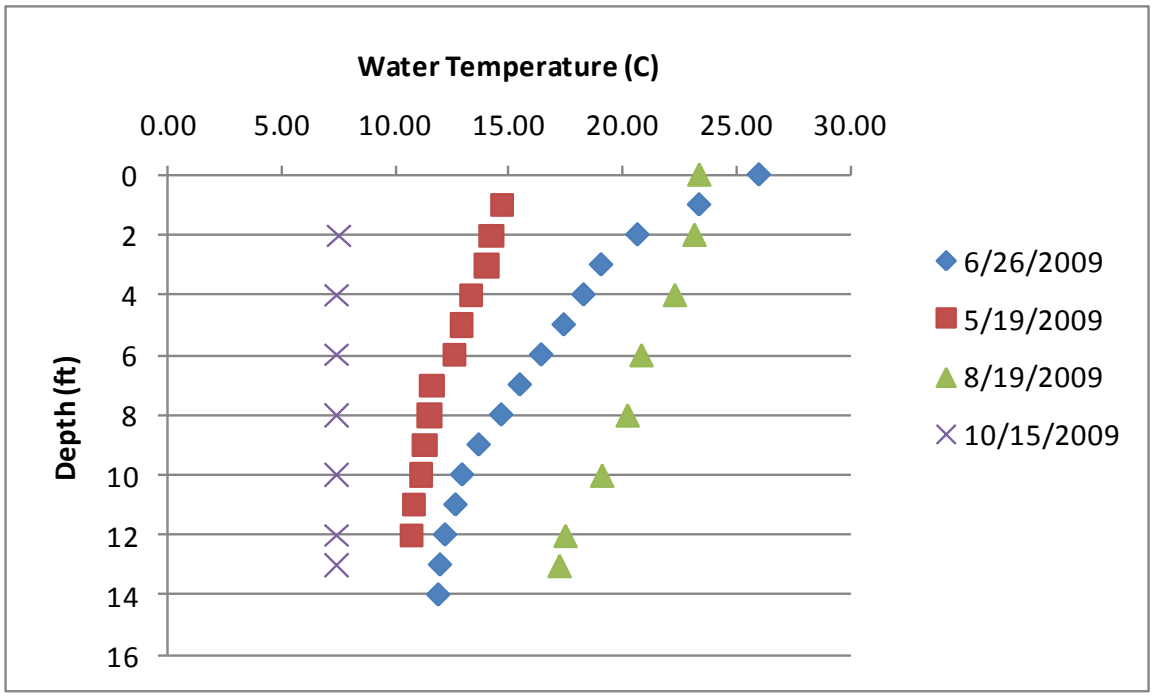

Figure 23: The temperature profile measured on Tarrant Lake by date

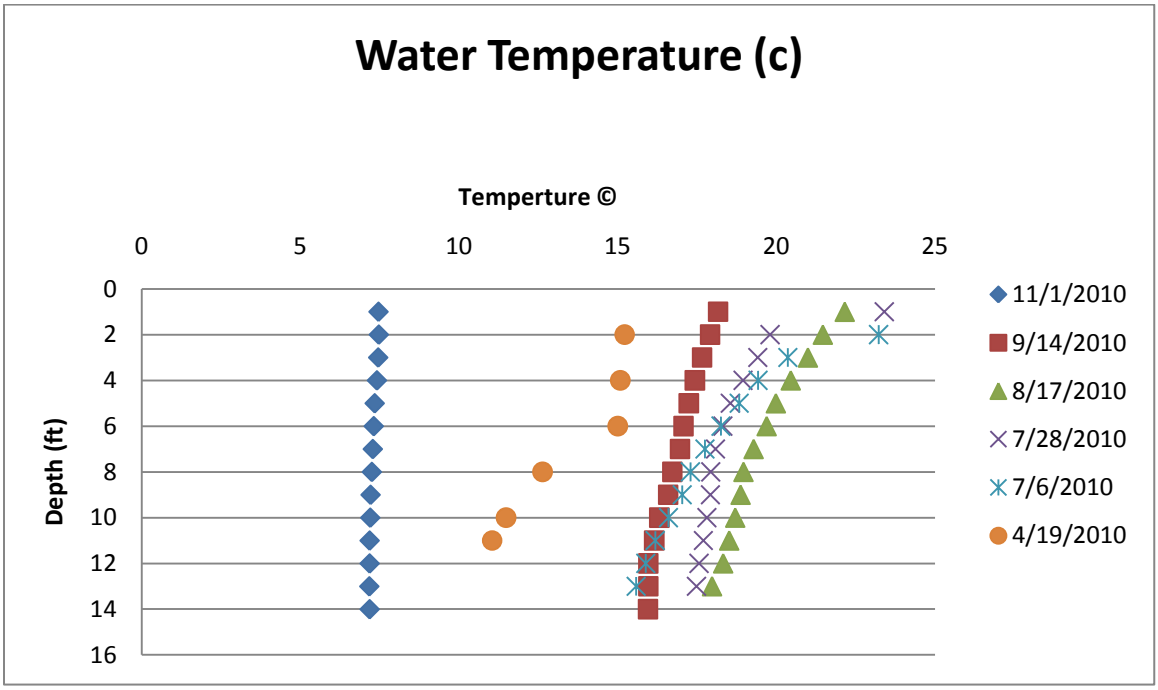

Figure 24: The temperature profile measured on Tarrant Lake by date

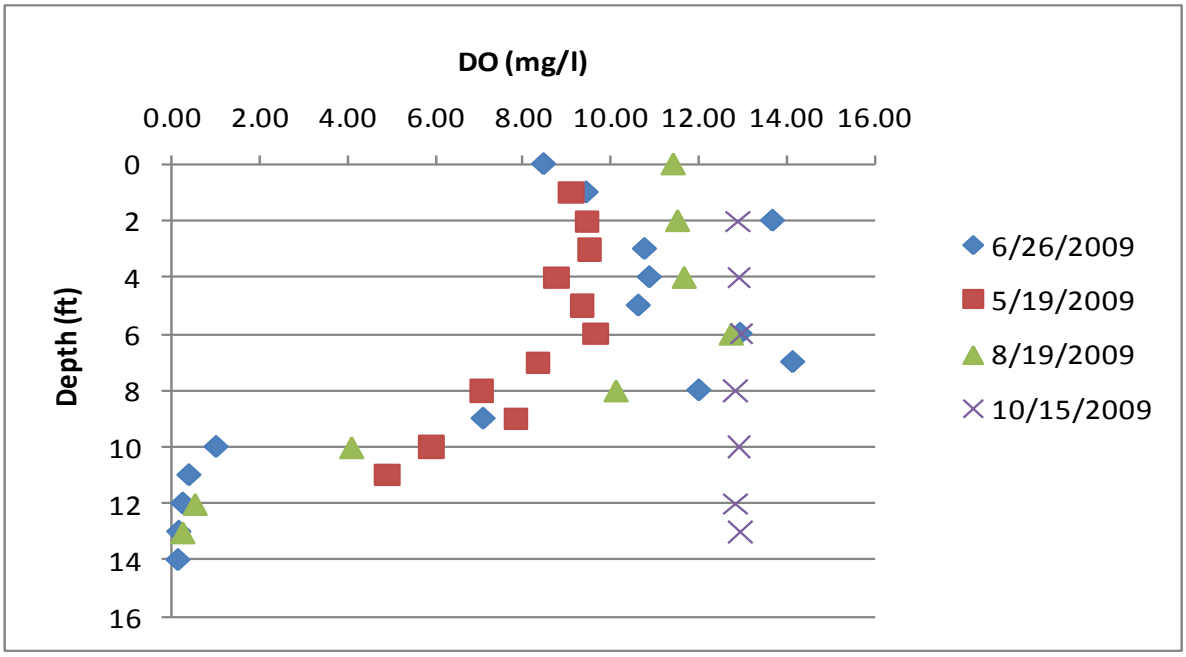

Figure 25: The dissolved oxygen profile measured at Tarrant Lake by date

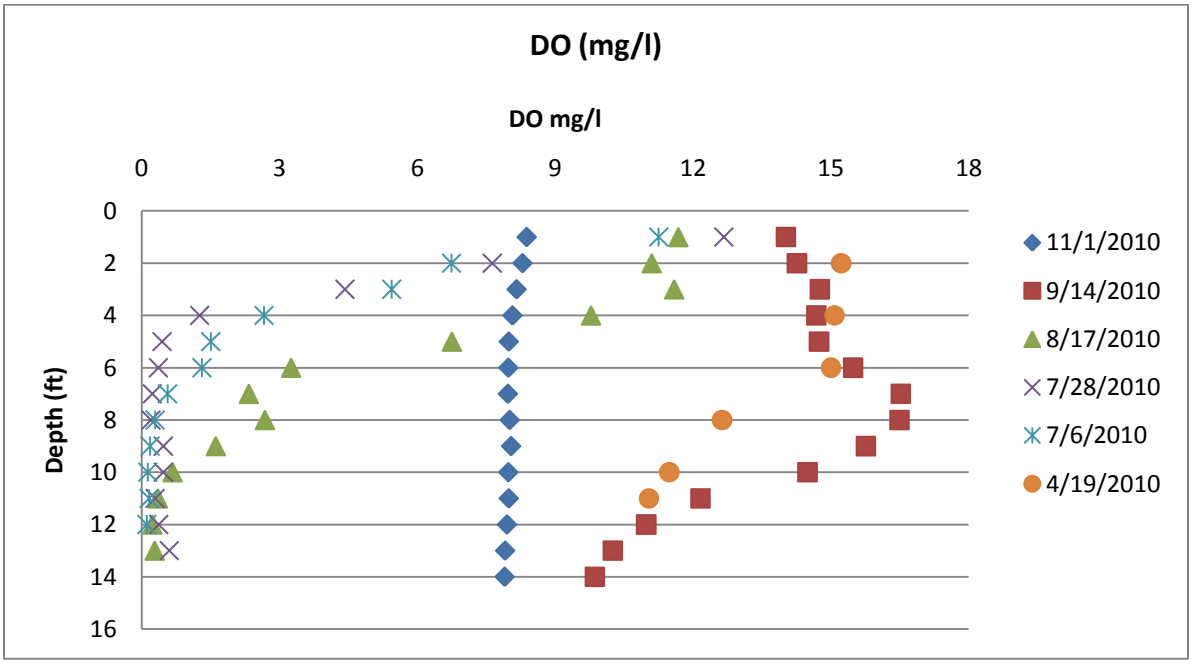

Figure 26: The dissolved oxygen profile measured at Tarrant Lake by date

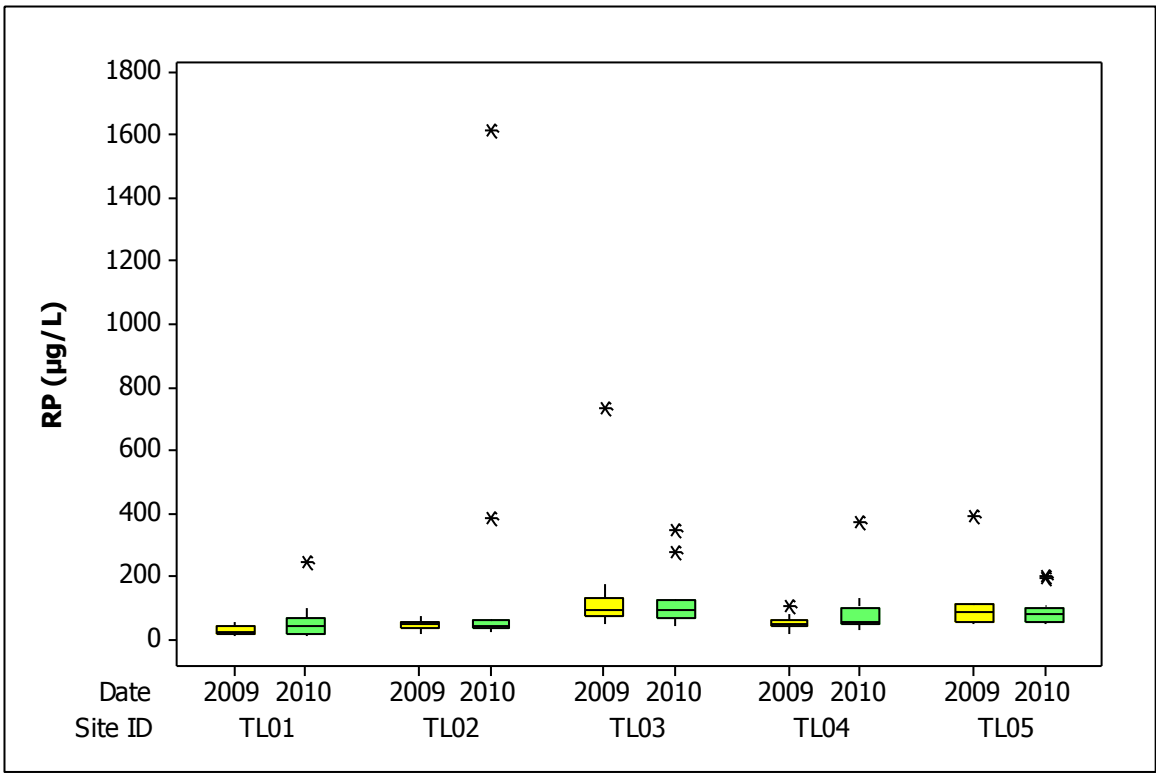

Figure 27: Range of soluble reactive phosphorus concentrations measured at each primary sampling site.

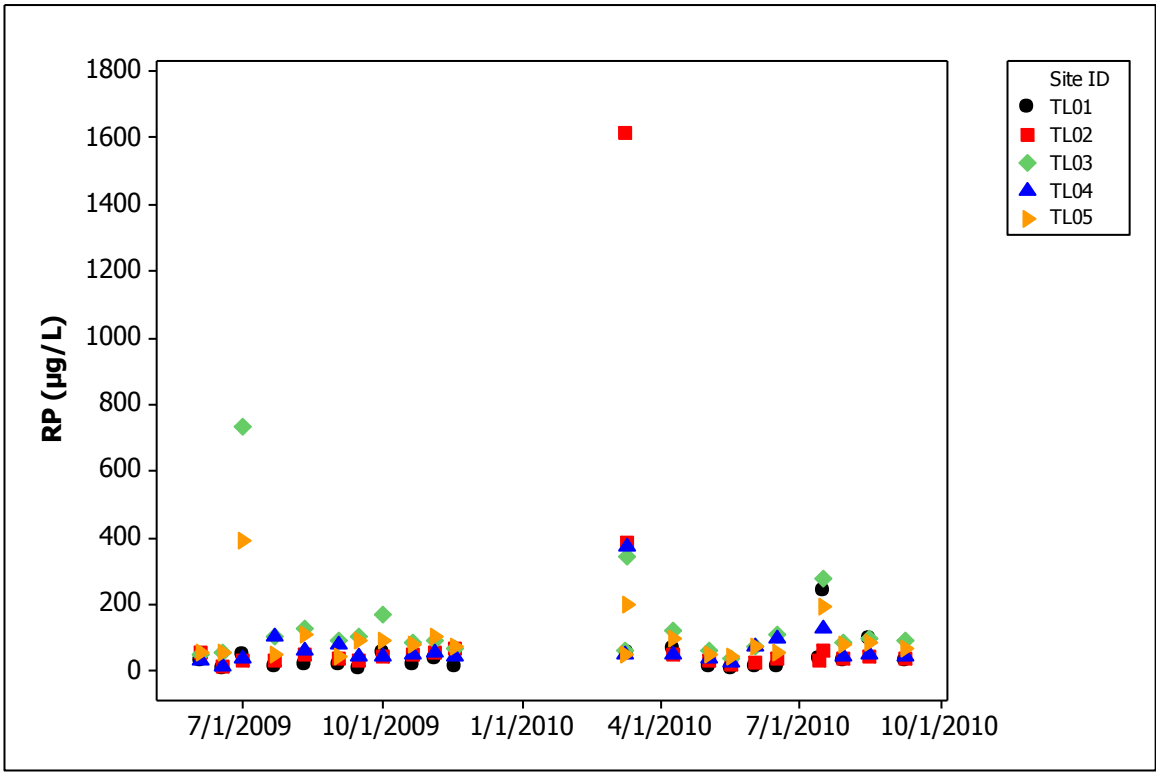

Figure 28: Soluble reactive phosphorus concentrations measured at primary sampling sites by date.

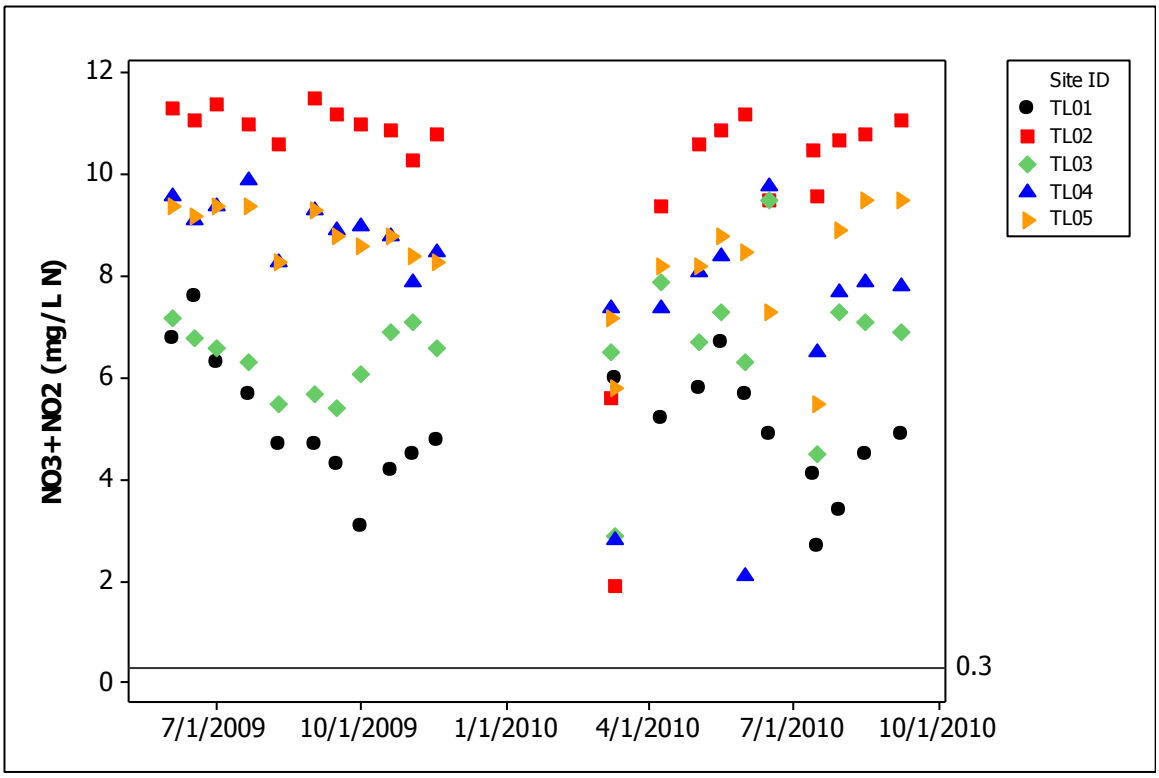

Figure 29: Nitrate concentrations measured at primary sampling sites by date. The horizontal line represents the reference standard for algal blooms in lakes of 0.3 mg/l.

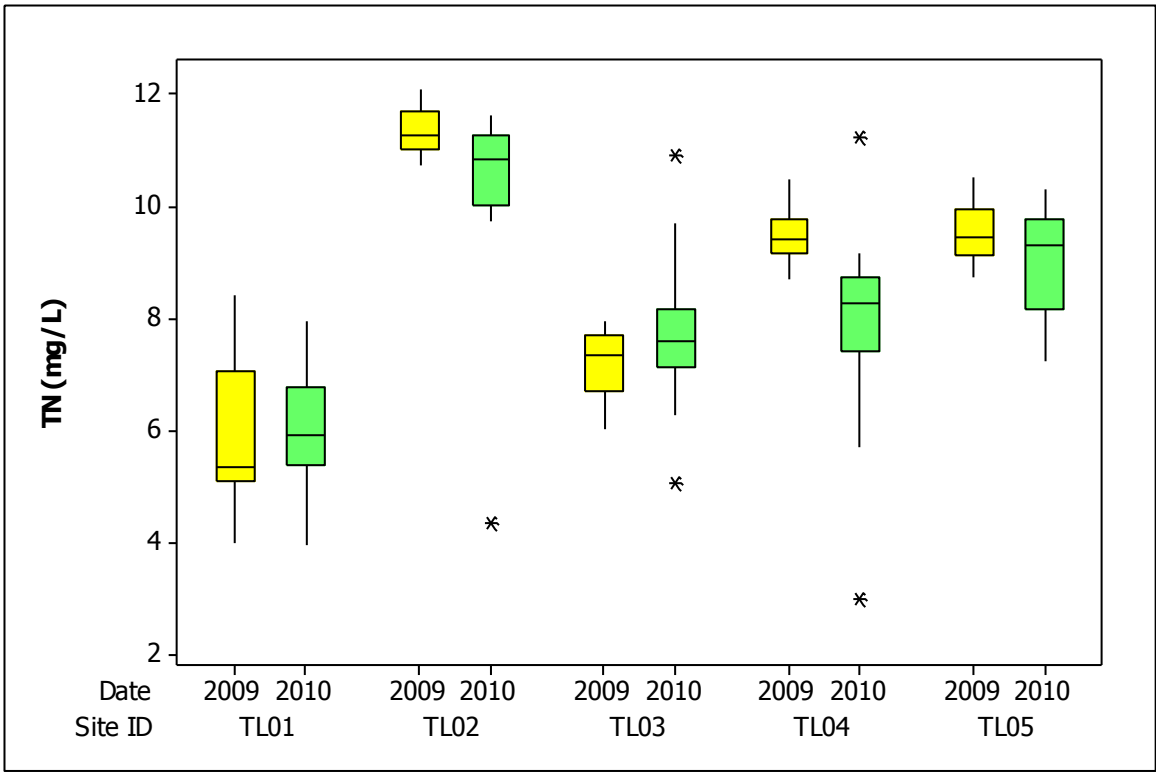

Figure 30: Range of total nitrogen concentrations measured at primary sampling sites.

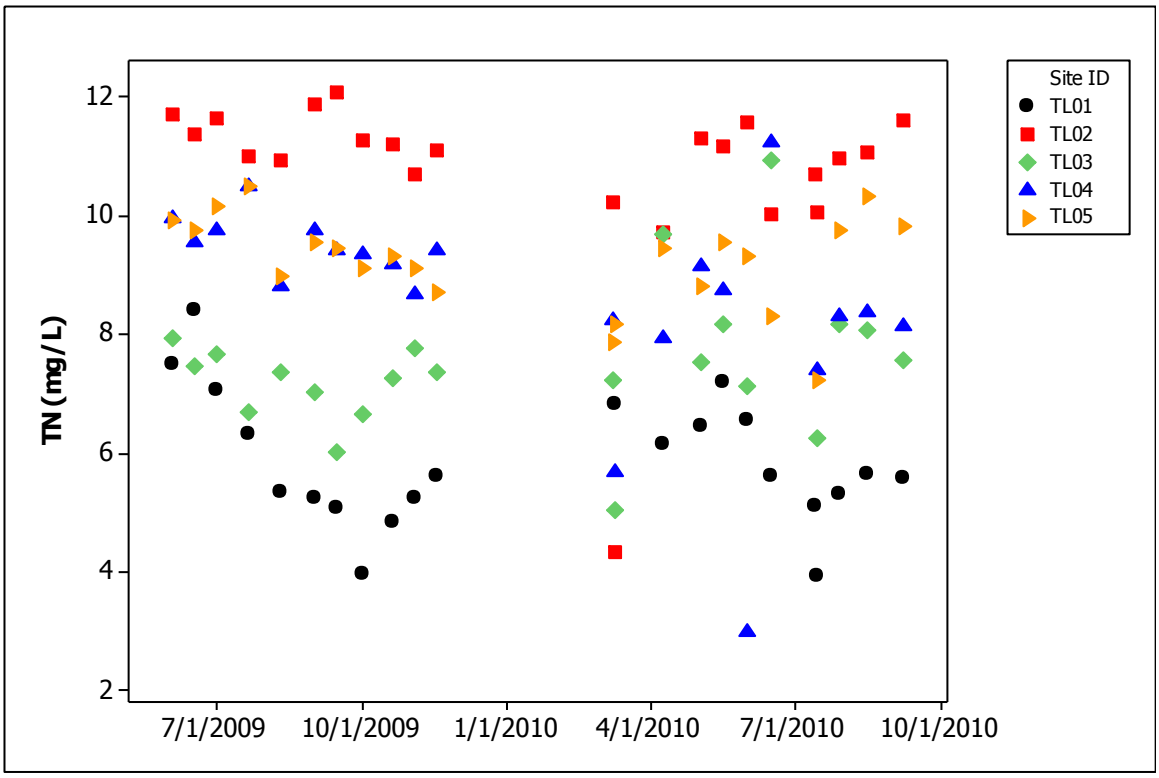

Figure 31: Total nitrogen concentrations measured at primary sampling sites by date.

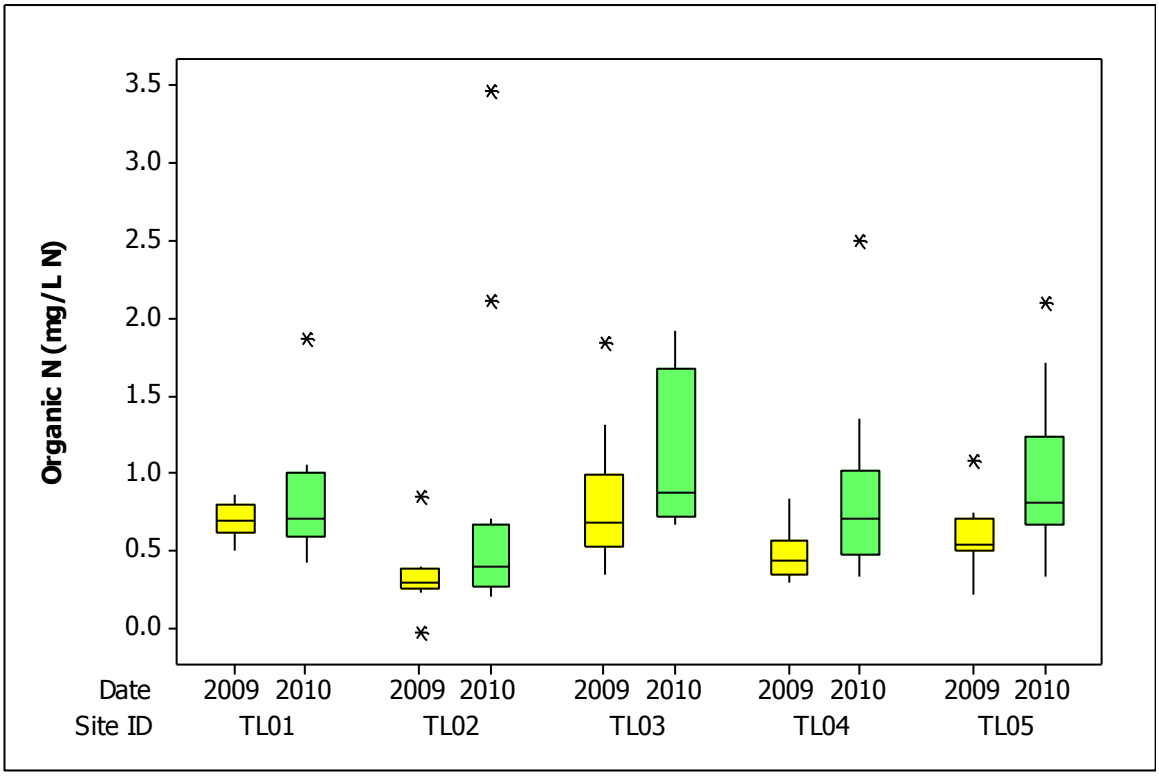

Figure 32: Range of organic nitrogen concentrations measured at primary sampling sites.

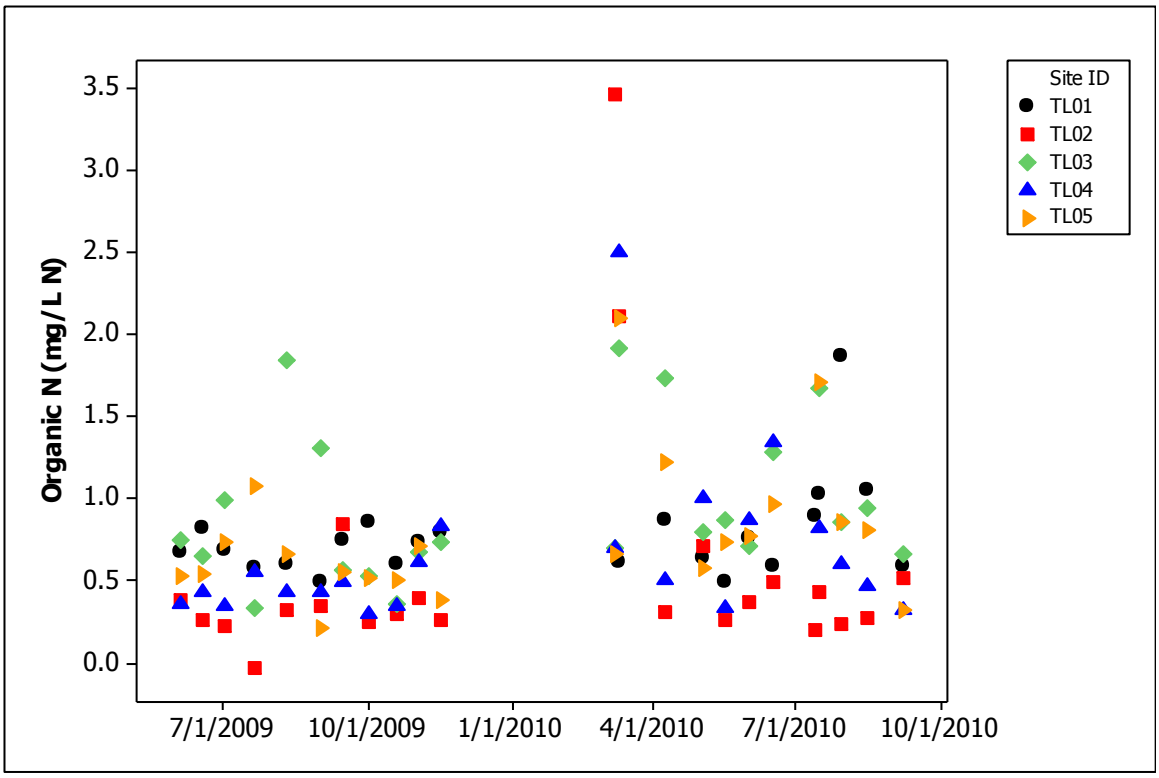

Figure 33: Organic nitrogen concentrations measured at primary sampling sites by date.

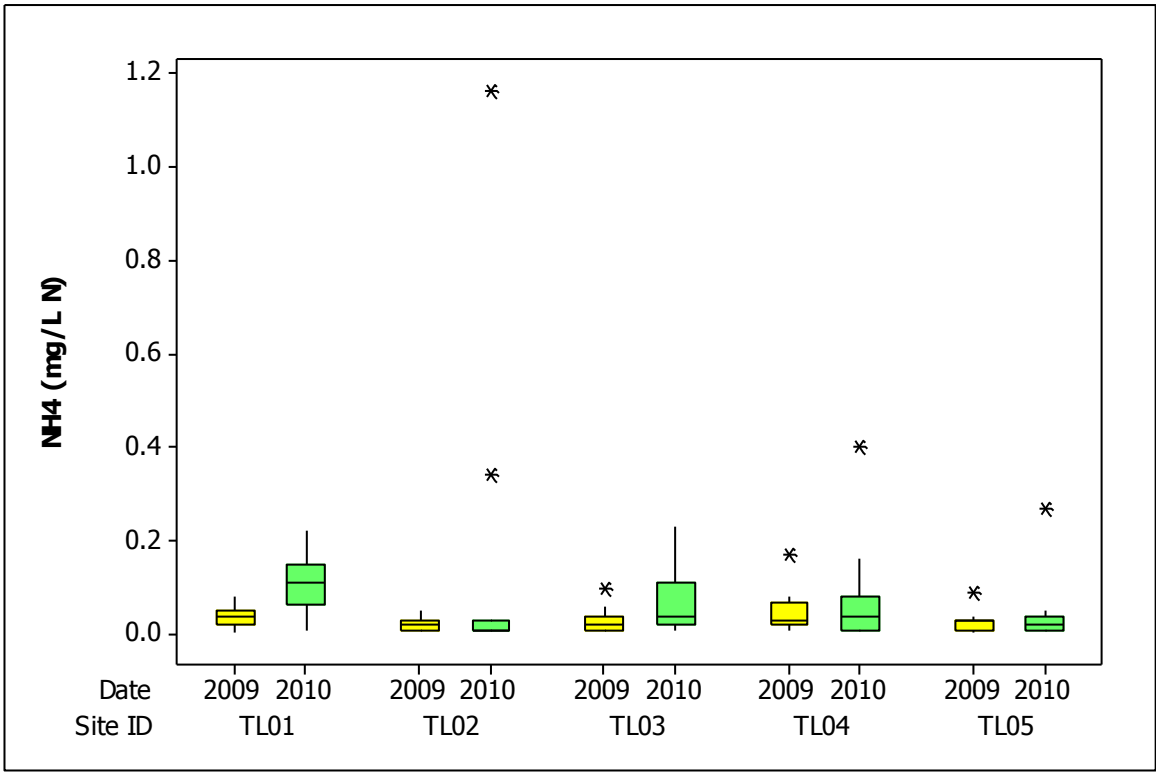

Figure 34: Range of ammonium concentrations measured at primary samplings sites.

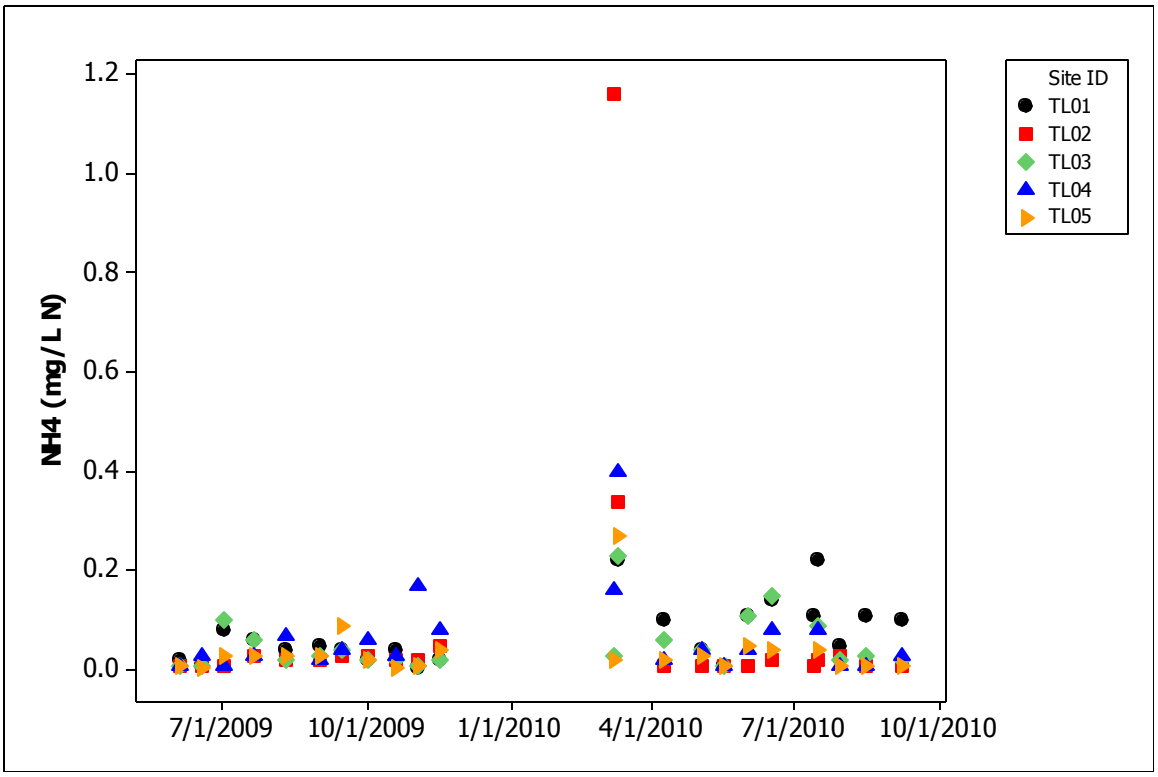

Figure 35: Ammonium concentrations measured at primary sampling sites by date.

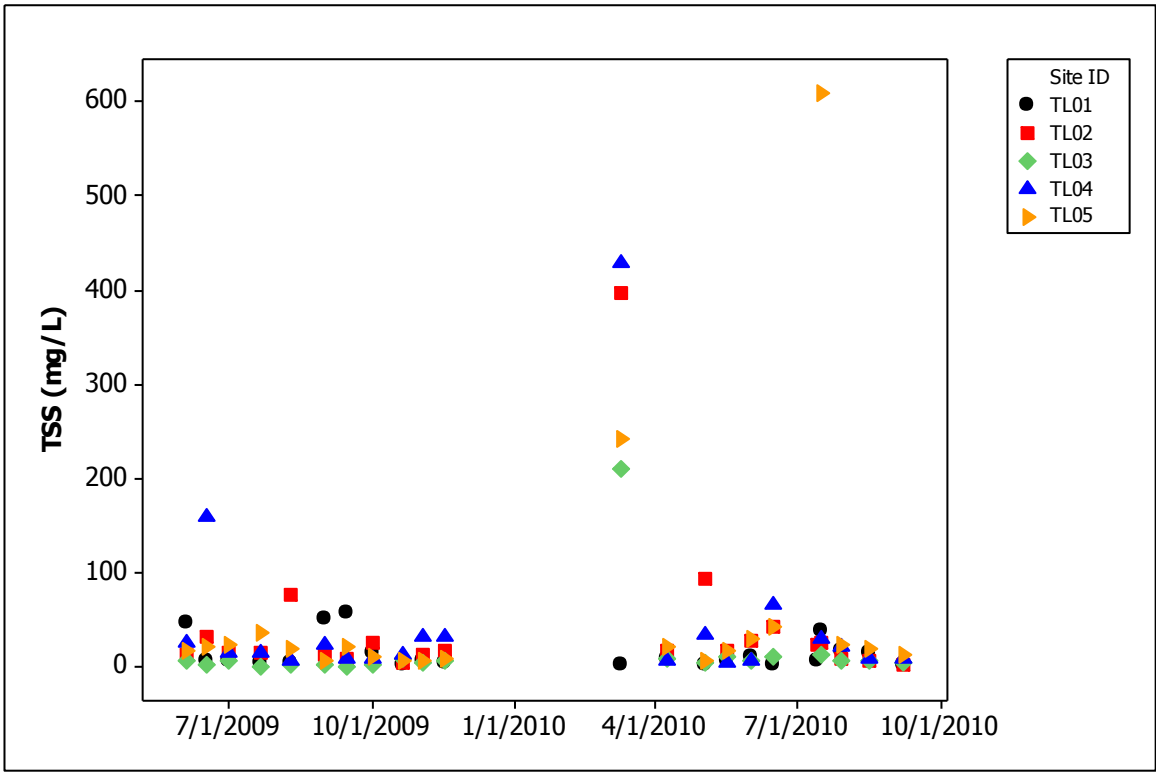

Figure 36: Total suspended solids concentrations measured at primary sampling sites by date.

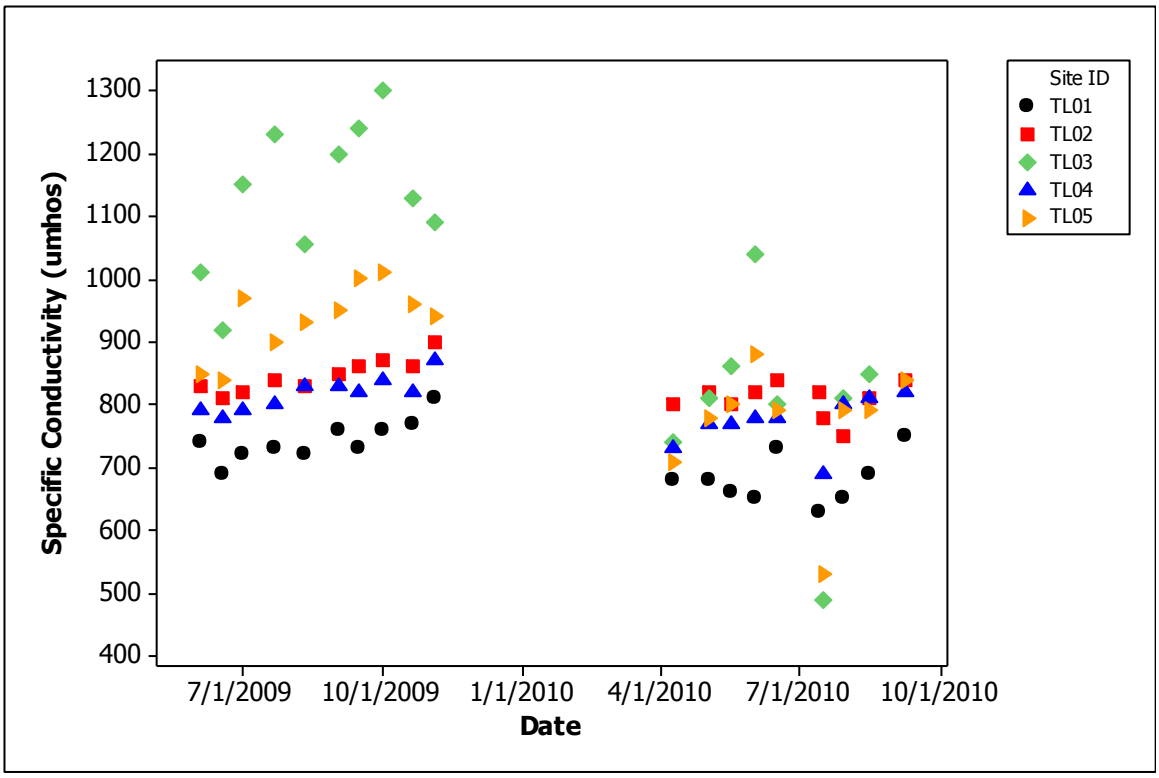

Figure 37: Specific conductance measurements at primary sampling sites by date.

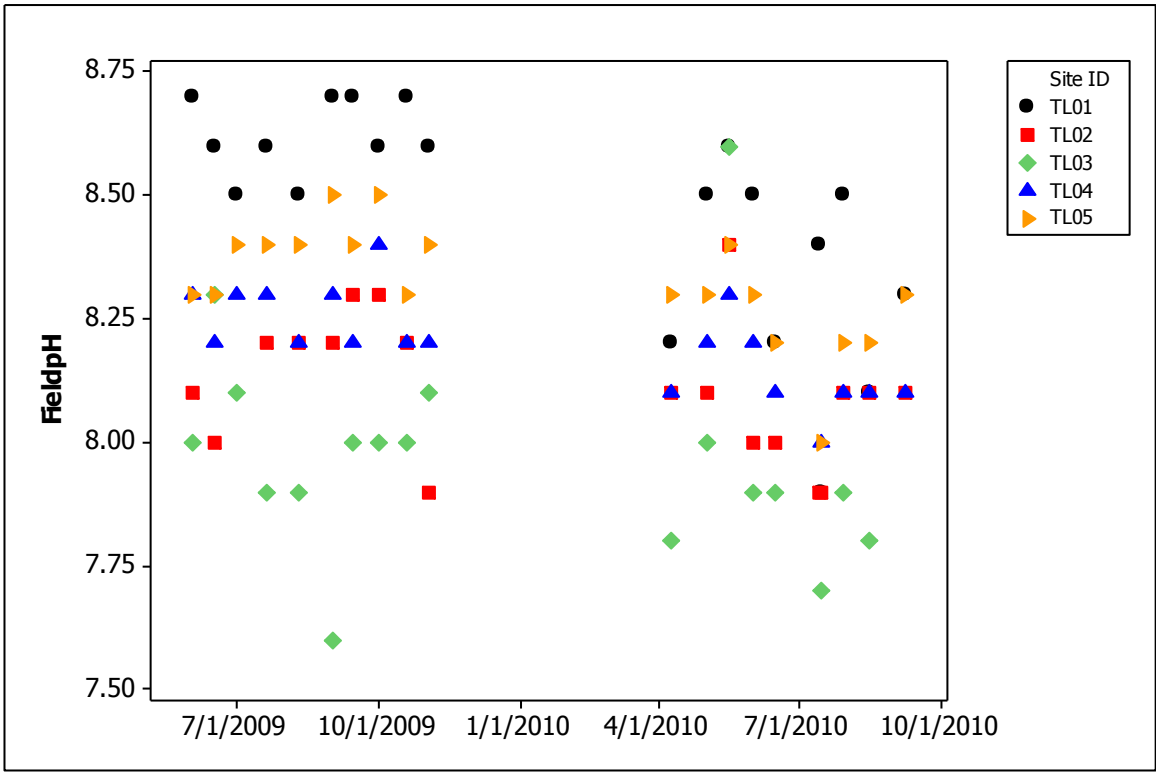

Figure 38: Measurements of pH from primary sampling sites by date.

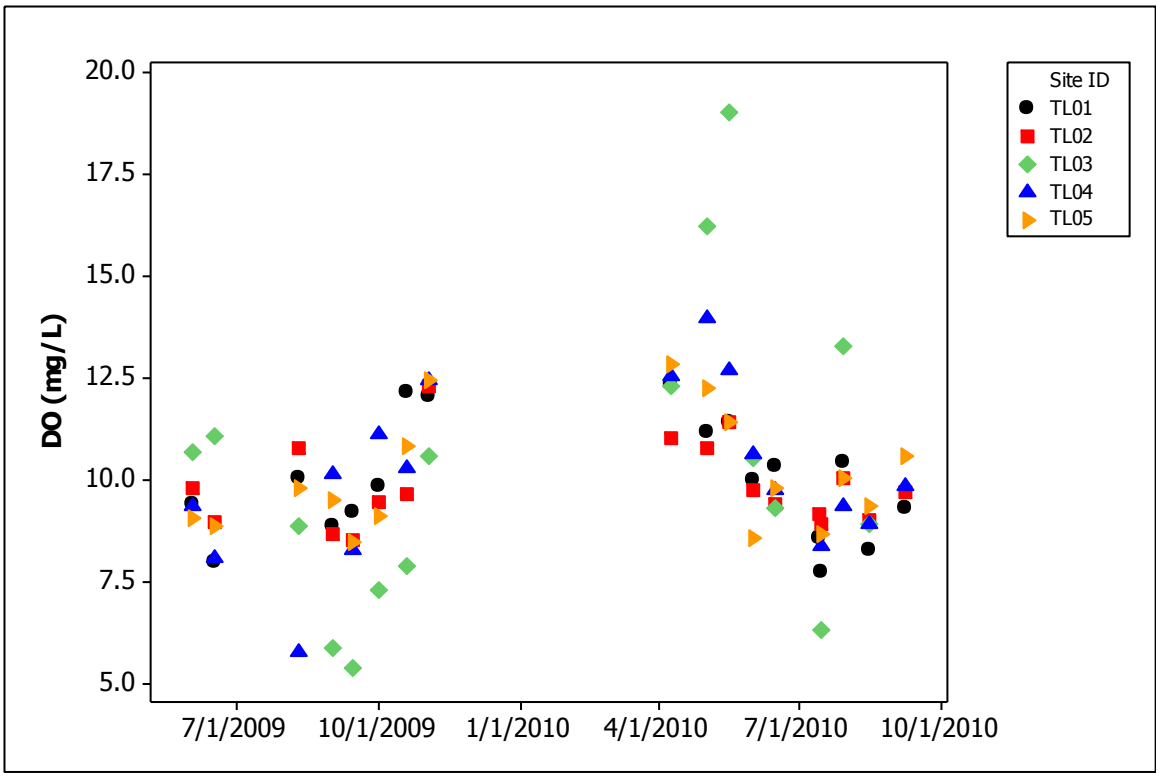

Figure 39: Dissolved oxygen concentrations measured at primary sampling sites by date.

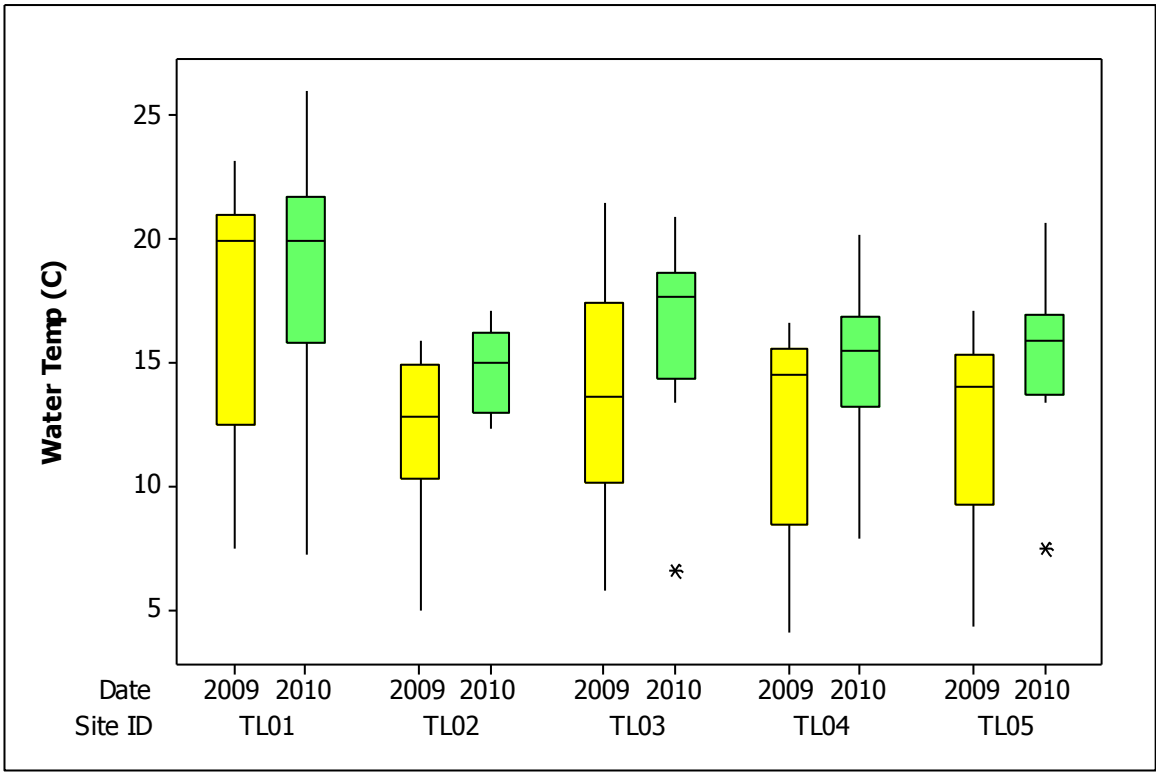

Figure 40: Range of water temperature measurements at the primary sampling sites.

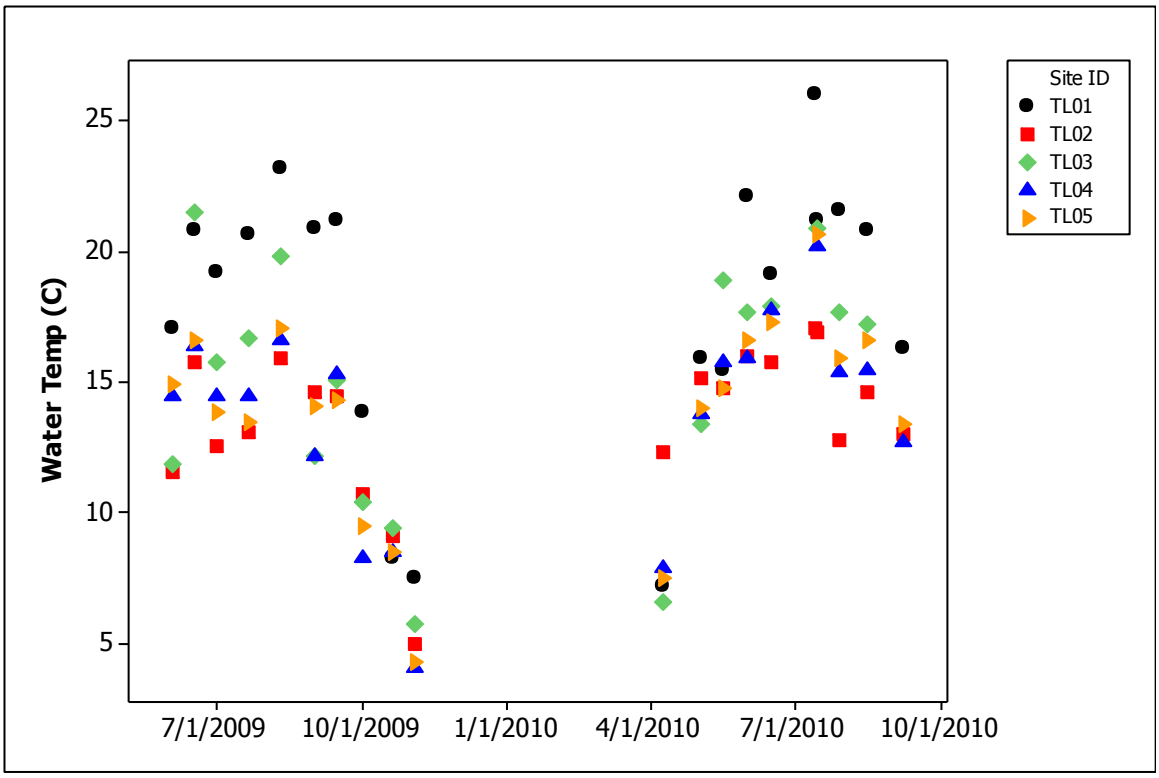

Figure 41: Water temperature measurements at the primary sampling sites by date.

Literature Cited:

Bureau of Fisheries and Habitat Management (2005) "Wisconsin Lakes" Wisconsin Department of Natural Resources Publication pp. 45.

Shaw Byron et al. (2002) "Understanding Lake Data" Cooperative Extension Publishing, Madison WI