Eno River Watershed Surface Water Quality Monitoring Project In and Around Hillsborough, North Carolina
April 2010 – March 2011

Prepared for the Orange County Erosion Control Division
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Conclusions of the Study

The results of this study suggest that the existing water quality in the Eno River in the vicinity of Hillsborough, NC is similar to that of other Piedmont North Carolina rivers that receive surface and subsurface runoff from a mixture of land uses including forest, agriculture, suburban and urban development. As would be expected, elevations of nutrient concentrations (nitrogen and phosphorus) were evident at the sampling site below the waste water treatment plant as compared with samples taken above the plant. Stroud Creek had elevated concentrations of nitrogen compared to other tributaries, a finding which remains unexplained and warrants further investigation relative to ongoing questions of sources of nitrogen "loading" in the Eno River.

Summary of the Study

- **A one year investigation of the existing water quality conditions in the Eno River and its tributaries in the vicinity of Hillsborough, NC was done with biweekly sampling from April 2010 through March 2011. Sites sampled included the Eno West Fork, the Eno East Fork, Seven Mile Creek, a site above the town water supply intake dam, a site above the waste water treatment plant, Cates Creek, a site downstream of the waste water treatment plant and Stroud's Creek.**

- **Data collected included Site, Date, Time, Conductivity, pH, Dissolved Oxygen, Total Suspended Solids, Turbidity, Total Kjeldahl Nitrogen, Ammonia Nitrogen, Nitrate+Nitrite Nitrogen, Total Phosphorus, Fecal Coliform Bacteria, Enterococcus Bacteria, Chlorophyll a and Pheopigments. Rainfall and Stream Discharge data were obtained.**

- **Rainfall for the year (April1, 2010 – March 31, 2011) totaled 34.3 inches indicating a somewhat dryer than normal year.**

- **On the dates sampled the Eno River discharge rate ranged from a low of 2.7 ft^3/sec in August to a high of 110 ft^3/sec in March.**

- **In the main axis of the Eno River and its tributaries the following water quality parameters were considered to be normal and expected: Water temperature, conductivity, pH, dissolved oxygen, total suspended solids, turbidity, total Kjeldahl nitrogen, ammonia, chlorophyll a and pheopigments.**

- **Nitrate+nitrite nitrogen and total phosphorus were frequently elevated above background at the site below the waste water treatment plant, probably as a result of the permitted discharge of secondary treated waste water. Nitrate + nitrite were also elevated in Stroud's Creek for unknown reasons. Background concentrations at other sites were moderate, as expected for a mixed suburban, agricultural and forested drainage basin.**

- **Total phosphorus was occasionally elevated above background at the site below the waste water treatment plant probably as a result of permitted discharge of secondary treated waste water. Background concentrations at other sites were frequently below detection limits.**

- **Fecal coliform bacteria counts averaged above NC State standards for swimming at the sites above and below the waste water treatment plant but were below standards at other sites. Enterococcus bacteria counts averaged above NC State standards for swimming at all sites except the one located near the city water intake.**

Background

Pursuant to Orange County Request for Proposal for Surface Water Quality Monitoring (RFP #5153), Desper Geoscience Consulting and Education, LLC, responded and was selected to perform the surface water quality monitoring detailed in the RFP. The contract was awarded and the water quality monitoring began on April 9, 2010.

Methods

Monitoring Sites

During the course of the study eight (8) monitoring sites were selected by the Orange County Erosion Control Division, and were field verified by Erosion Control staff with Desper Geoscience Consulting and Education, LLC, staff. GPS locations were taken and recorded for each site (Table 1). The following sites were identified for sampling:

- West Fork of Eno River immediately upstream of confluence of West and East Forks
- East Fork of Eno River immediately upstream of confluence of West and East Forks
- Seven Mile Creek immediately upstream of confluence with Eno River
- Eno River above the water supply intake dam
- Eno River immediately upstream of Town of Hillsborough Waste Water Treatment Plant (WWTP)
- Cates Creek immediately upstream of confluence with Eno River
- Eno River at downstream limits of Town of Hillsborough
- Stroud's Creek immediately upstream of confluence with Eno River

Table 1. Locations of the Eno River Sample Sites

	Latitude	Longitude
West Fork Eno	36 8' 6.15" N	79 9' 35.06" W
East Fork Eno	36 8' 8.96" N	79 9' 32.86" W
Seven Mile Creek	36 4' 8.03" N	79 8' 0.12" W
Eno Above Intake Dam	36° 4' 16.9" N	79 7' 50.0" W
Eno Upstream of WWTP	36 4' 22.42" N	79 5' 25.10" W
Cates Creek	36 4' 9.26" N	79 5' 6.19" W
Eno Downstream of WWTP	36 4' 32.12" N	79 4' 18.13" W
Stroud's Creek	36 5' 8.86" N	79 3' 44.02" W

On July 2, 2010, the Seven Mile Creek site was dropped and a site located above the town water supply intake dam was added.

Parameters and Monitoring

As directed by the Orange County Erosion Control Division, the following parameters were monitored at each site: Parameters are listed with their NCDENR surface water quality standard (upper limit per 15A NCAC 2B).

1. Fecal coliform bacteria (200/100ml water)
2. Chlorophyll a (40 ug/l)
3. Total suspended solids (20 mg/l for high quality waters)
4. Turbidity (25 NTU)
5. Ammonia (none listed but used in nitrogen loading calculations)
6. Total Kjeldahl nitrogen (none listed but used in nitrogen loading calculations)
7. Nitrate + nitrite-nitrogen (nitrate 10mg/l drinking water – also used in nitrogen loading)
8. Total Phosphorous (none listed but used in phosphorus loading)
9. Enterococcus bacteria (35/100 ml water) (added October 2010)

The monitoring plan was developed jointly by staff from the Orange County Erosion Control Division and Desper Geoscience Consulting and Education, LLC. The plan was to sample the seven identified stream locations every other week which began on April 9, 2010, and concluded on March 25, 2011. All field procedures and Standard Operating Procedures (SOPs) used in this project are in full compliance with the standard procedures used by the North Carolina Department of Environment and Natural Resources Division of Water Quality-Environmental Sciences Section, Ecosystems Unit, Ambient Monitoring System as described in their Quality Assurance Plan. The chosen contract lab for processing samples is Tritest Laboratory, Inc, in Raleigh, NC, and is fully accredited, certified, and approved by the State of North Carolina and the EPA.

On each of the 26 sampling days, we collected water samples for the laboratory analyses listed above. Samples were collected in Tritest- supplied sterile bottles and transported in timely compliance with the Ambient Monitoring System Quality Assurance Plan. Chain of custody was documented. Field parameters (pH, Dissolved Oxygen (DO), Conductivity, temperature) were measured and recorded at each site using approved and calibrated field instruments. Sampling activities and environmental conditions were recorded at each site, per sampling event, in a field log book dedicated to this project.

All of the data collected in this study are tabulated in the Appendix (Appendix Tables 1 – 6). These data include date and time of sampling, water temperature, conductivity, pH, dissolved oxygen, total suspended solids, turbidity, total Kjeldahl nitrogen, ammonia, nitrate+nitrite, total phosphorus, chlorophyll a, Pheopigments, fecal coliform bacteria and Enterococcus bacteria.

Rainfall

Rainfall data were obtained from the Town of Hillsborough.

River Flow and Ambient Water Quality

River flow data were obtained from the USGS website site that reports real-time and historic data from a USGS gage located in the Eno River in Hillsborough, NC ((http://waterdata.usgs.gov/nc/nwis/dv/?site_no=02085000&PARAmeter_cd=00060,00065). Also available from the USGS website are water quality data collected 6 to 8 times per year which included dissolved oxygen, pH, ammonia, nitrate + nitrite and total phosphorus. These data were averaged over an 11 year period (2000 – 2010; 82 samples) and are reported for comparison in the results section of this report.

Data Analysis

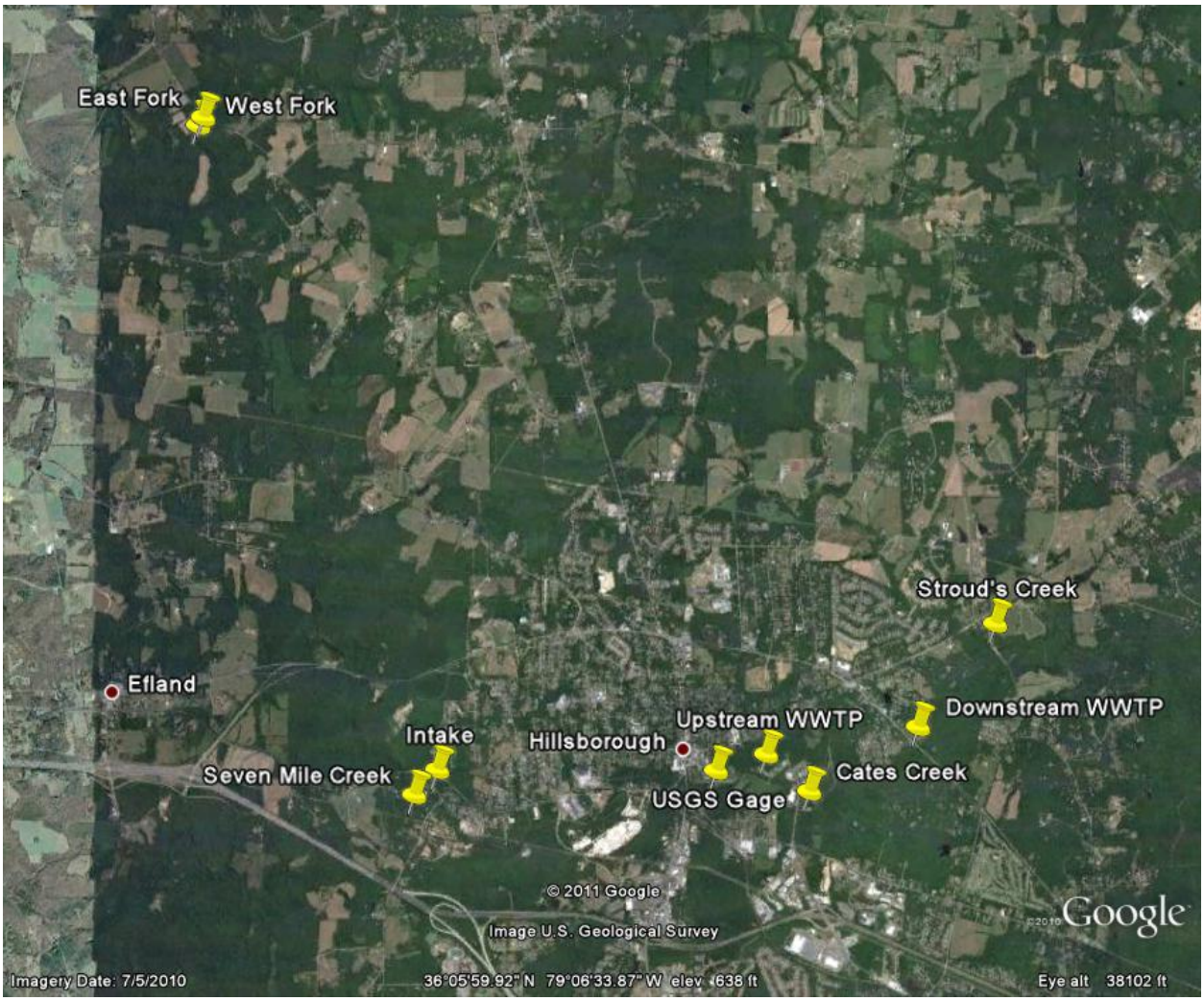
Three dimensional charts of the environmental data included all data collected at the sites. The charts graph conditions through time as a function of distance downstream, with the tributary creek data included in relation to their position entering the main stem of the Eno.

In the statistical analyses reported here a relationship between two parameters that have a statistical "p" value of < 0.05 was used as a cut off (meaning there is a probability of less than 5% that chance along can explain the statistical relationship).

Multiple correlation analysis was done among all parameters which included the data for all sites and all dates. A correlation of +1.0 means a perfect relationship between two parameters (as "X" increases "Y" increases, 0.0 means no correlation at all between "X" and "Y', -1.0 means a perfect negative correlation (as "X" increases "Y" decreases). Correlations do not mean a cause and effect relationship. Correlations are discussed only in cases where the "p" value was <0.05

Statistical comparison of environmental data were done for the six locations including the Intake Site, thus limiting the analysis to the samples collected from July 2010 through March 2011. The Seven mile site data were excluded from the statistical analysis since they were only collected from April – June, 2010. All data reported as "<" or ">" were used in the analysis by removing the symbols from the number. Two statistical tests comparing multiple means were preformed on the sets of data for each parameter measured except water temperature and pheopigments. Water temperature varied little among the different sites on any one date and almost all pheopigments were below detection (< 2.0 ug/l). The two statistical test used were the Tukey Test (most conservative) and a Newman-Keuls Test (somewhat less conservative). The Sites were considered different when p<0.05.

Figure 1. Google Earth photograph showing the locations of the eight sites sampled in the Eno River and its tributaries near Hillsborough, NC.

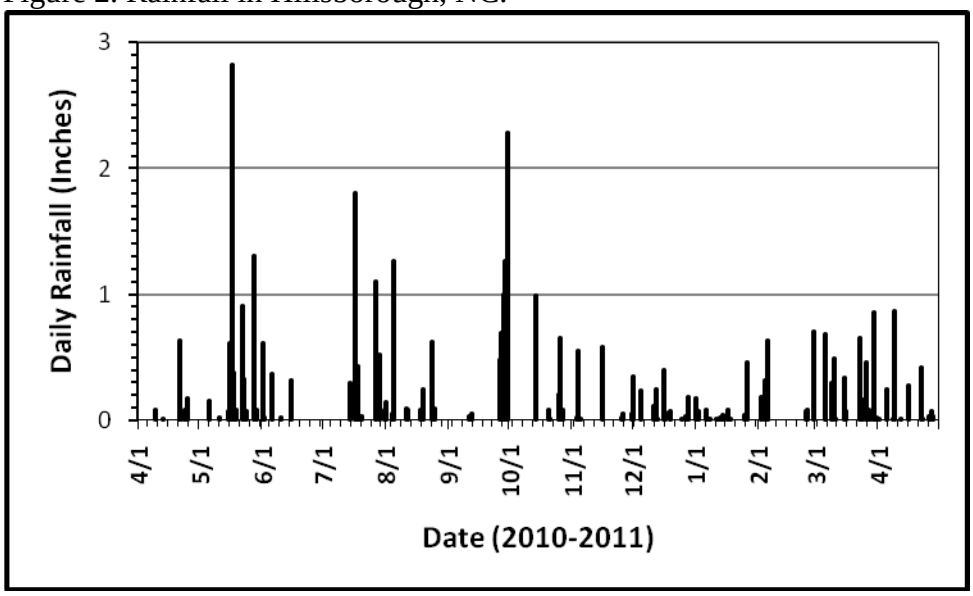


Results and Discussion

Rainfall

The precipitation (rainfall) for the year (April1, 2010 – March 31, 2011) totaled 34.3 inches, less than the annual average of 43 inches. Most of the daily rainfall totals were less than 1 inch (Figure 2). Eight days had rainfall totaling more than 1 inch.

Figure 2. Rainfall in Hillsborough, NC.



River Flow

Average daily discharge rates in the Eno River at Hillsborough (Figure 3) ranged from a low of approximately 2 ft^3/sec in mid-September to a high of approximately 900 ft^3/sec in early October. The overall pattern was typical for piedmont rivers with a late summer minimum and a late spring maximum. However, within the overall pattern, rates were highly variable depending upon runoff caused by rainfall (Figure 2). Discharge rates measured on the dates samples were collected ranged from a low of 2.7 ft^3/sec in August to a high of 110 ft^3/sec in March (Table 2).

Figure 3. Average daily discharge rate at the USGS Eno River gage in Hillsborough, NC

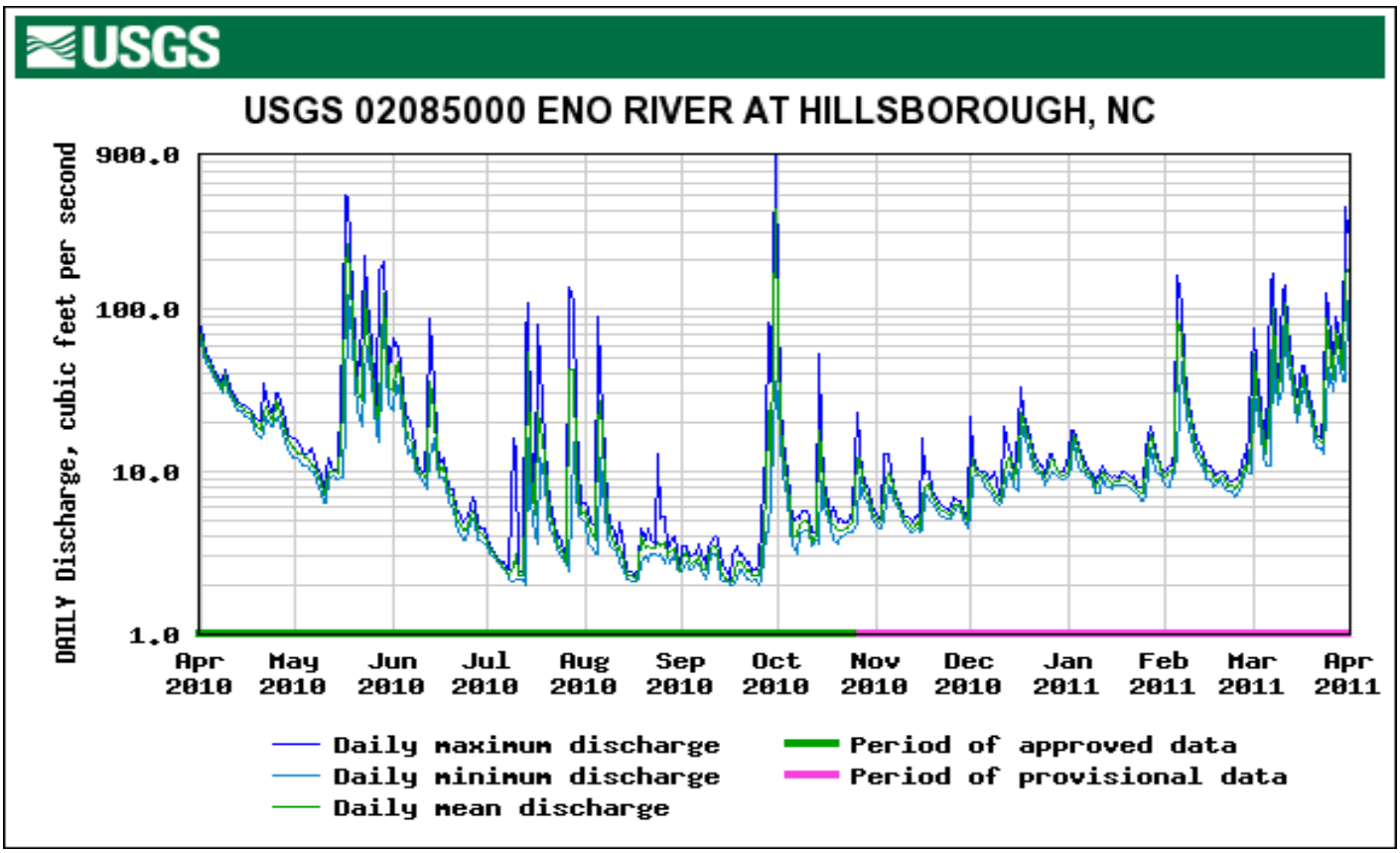


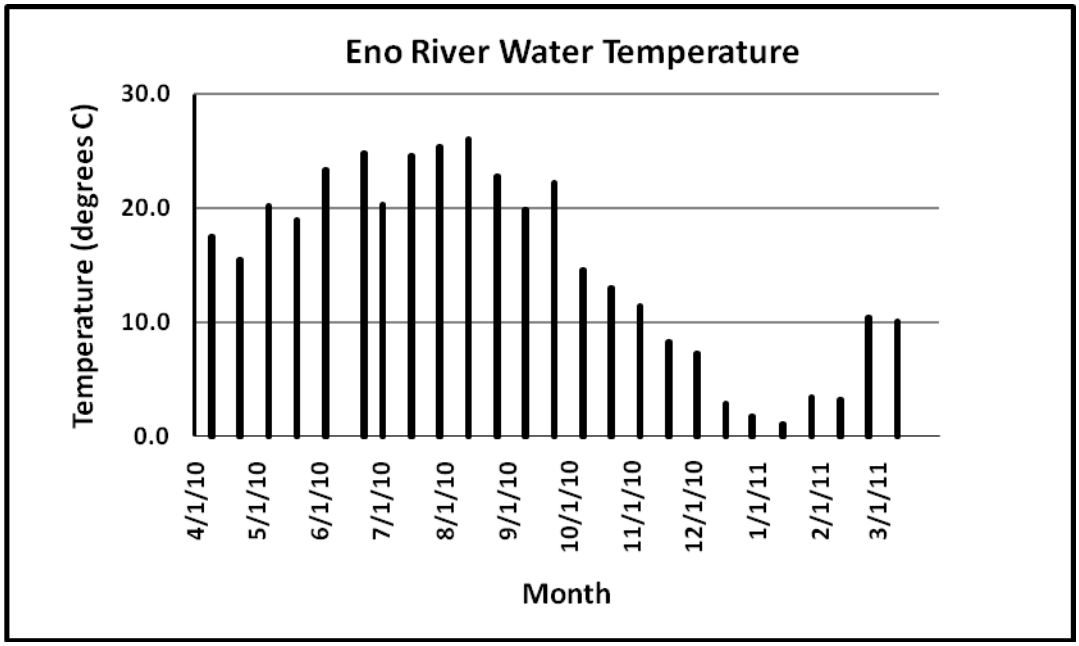
Table 2. Average daily discharge rate of the Eno River at the USGS gage in Hillsborough, NC on the dates water samples were collected.

Date	Discharge (ft^3/sec)	Date	Discharge (ft^3/sec)
4/9/2010	40.0	10/8/2010	4.7
4/23/2010	21.0	10/22/2010	4.4
5/7/2010	11.0	11/5/2010	9.8
5/21/2010	30.0	11/19/2010	7.0
6/4/2010	26.0	12/3/2010	10.0
6/23/2010	4.3	12/17/2010	23.0
7/2/2010	3.4	12/30/2010	9.4
7/16/2010	5.4	1/14/2011	8.7
7/30/2010	7.0	1/28/2011	15.0
8/13/2010	2.7	2/11/2011	14.0
8/27/2010	3.0	2/25/2011	9.2
9/10/2010	3.4	3/11/2011	110.0
9/24/2010	23.0	3/25/2011	65.0

Water Temperature

Water temperatures (Figure 4) in the Eno River varied seasonally with highs in the upper 20° C in August to lows of near freezing (0°C). Water temperatures are normal and of no concern to questions of water quality in the Eno River at Hillsborough, NC.

Figure 4. Average Eno River water temperature on the sampling dates for the Eno River West, Eno River East, upstream and downstream WWTP sites. Data excludes the tributaries.



Conductivity

Conductivity is a measure of the ability of an aqueous sample to carry an electrical current and is dependent upon the number and types of ions in solution. Mean conductivity of Eno River waters sampled were low, ranging from a low of 58 S in the Eno River West tributary to a high of 139 S at the most downstream site sampled, Dn-WWT (Table 3). There were significant increases moving down stream in both the main axis of the river and its tributaries (Tables 4 - 5), a trend that is clearly illustrated in Figure 5. There was no strong seasonal pattern to conductivity. Conductivities are normal and of no concern to questions of water quality in the Eno River at Hillsborough, NC.

Table 3. Mean Conductivity (S) ranking sites from least to greatest.

Rank	Location	Mean Value (Siemens)
1	Eno West	58.3
2	Eno East	66.8
3	Intake	69.6
4	Up-WWTP	85.9
5	Stroud's	110.3
6	Cates	120.7
7	Dn-WWTP	138.7

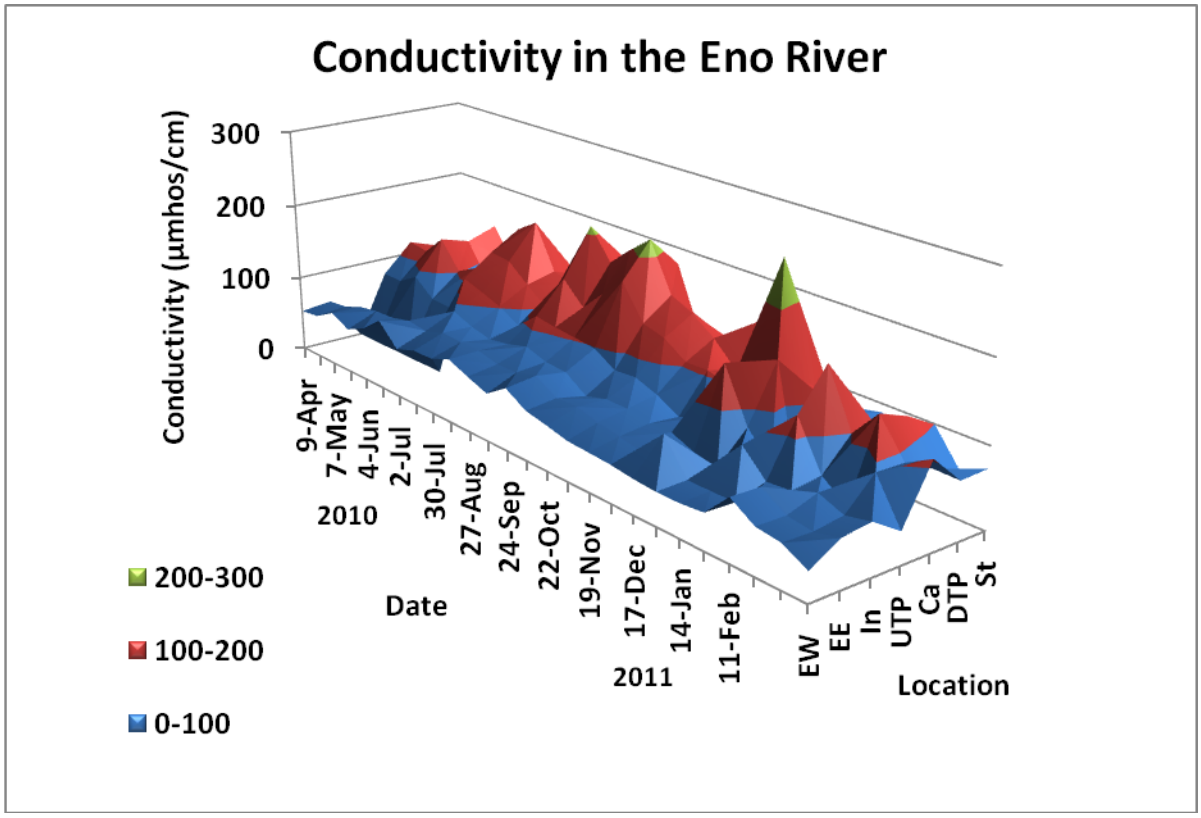
Table 4. Tukey's test for significant differences ($p<0.05$) among Sites for Conductivity.

Location	Eno West	Eno East	Intake	Up - TP	Cates	Dn. - TP	Stroud's
Eno West							
Eno East	no						
Intake	no	no					
Up - TP	no	no	no				
Cates	YES	YES	YES	YES			
Dn. - TP	YES	YES	YES	YES	no		
Stroud's	YES	YES	YES	no	no	no	

Table 5. Newman-Keuls test for significant differences ($p<0.05$) among Sites Conductivity.

Location	Eno West	Eno East	Intake	Up - TP	Cates	Dn. - TP	Stroud's
Eno West							
Eno East	no						
Intake	no	no					
Up - TP	YES	no	no				
Cates	YES	YES	YES	YES			
Dn. - TP	YES	YES	YES	YES	no		
Stroud's	YES	YES	YES	YES	no	YES	

Figure 5. Chart of conductivity in the Eno River as a function of sampling date and location. EW = Eno west, EE = Eno east, In = near the intake to the water supply above dam, UTP = upstream of the waste water treatment plant, Ca = Cates Creek, DTP = downstream of the waste water treatment plant, St = Stroud's Creek.



pH

The average pH of Eno River waters was slightly on the basic side of neutral (7.00) except that Cates Creek was somewhat acidic with a pH of 6.48 (Table 6). There were few significant differences among the sites except for Cates Creek that was significantly different from all other sites (Tables 7 – 8). pH values are normal and of no concern to questions of water quality in the Eno River at Hillsborough, NC. USGS data averaged from a site upstream of the WWTP from 2000 – 2010 equaled 6.71 pH units, somewhat more acidic than the Up-WWTP average of 7.10 reported here.

Table 6. Mean pH ranking Sites from least to greatest.

Rank	Location	Mean Value
1	Cates	6.48
2	Up-WWTP	7.10
3	Intake	7.24
4	Stroud's	7.24
5	Eno East	7.27
6	Eno West	7.32
7	Dn-WWTP	7.33

Table 7. Tukey's test for significant differences ($p<0.05$) among Sites for pH.

Location	Eno West	Eno East	Intake	Up - TP	Cates	Dn. - TP	Stroud's
Eno West							
Eno East	no						
Intake	no	no					
Up - TP	YES	no	no				
Cates	YES	YES	YES	YES			
Dn. - TP	no	no	no	YES	YES		
Stroud's	no	no	no	no	YES	no	

Table 8. Newman-Keuls test for significant differences ($p<0.05$) among Sites for pH.

Location	Eno West	Eno East	Intake	Up - TP	Cates	Dn. - TP	Stroud's
Eno West							
Eno East	no						
Intake	no	no					
Up - TP	YES	YES	YES				
Cates	YES	YES	YES	YES			
Dn. - TP	no	no	no	YES	YES		
Stroud's	no	no	no	no	YES	no	

Dissolved Oxygen

Average dissolved oxygen values (Table 9) were relatively high at all sites with no indication of hypoxic (low oxygen) conditions at any site. Although the range in mean values among sites was great, there were no significant differences among sites. The Seven Mile Creek data averaged a relatively low 5.47mg/l (Appendix Table 3). Seven mile Creek was excluded from the statistical analysis because it was only sampled from April – June. Dissolved oxygen concentrations are normal and of no concern to questions of water quality in the Eno River at Hillsborough, NC. USGS data averaged from a site upstream of the WWTP from 2000 – 2010 equaled 8.37 mg/l, comparable to the concentrations reported here.

Table 9. Mean Dissolved Oxygen (mg/l) ranking Sites from least to greatest.

Rank	Location	Mean Value (mg/l)
1	Intake	7.70
2	Eno East	7.96
3	Dn-WWTP	7.98
4	Up-WWTP	8.03
5	Stroud's	9.11
6	Eno West	9.25
7	Cates	9.38

Turbidity

The mean values of turbidity in the Eno River (Table 10) in the vicinity of Hillsborough are low relative to the EPA standard for drinking water sources of 50 Nephalometric Turbidity Units (NTU) and the North Carolina DENR standard of 25 NTU. There were no significant differences among means but the data were highly variable and, as would be expected, strongly correlated with river discharge rate. The correlation coefficient of turbidity as a function of discharge rate (0.72) was highly significant ($p<0.01$). The lowest turbidity measured was 1.2 in Cates Creek and the highest was 39.8 in Stroud's Creek (Appendix Tables). Turbidity values are normal and of no concern to questions of water quality in the Eno River at Hillsborough, NC.

Table 10. Mean Turbidity (NTU) ranking Sites from least to greatest. CC = correlation coefficient of turbidity as a function of discharge rate on the sampling dates.

Rank	Location	Mean Value (NTU)	CC
1	Eno East	4.4	0.59
2	Cates	4.5	0.81
3	Eno West	4.7	0.68
4	Up-WWTP	6.3	0.86
5	Stroud's	6.3	0.89
6	Intake	6.4	0.83
7	Dn-WWTP	7.2	0.70

Total Suspended Solids

As with turbidity, the mean values for Total Suspended Solids (TSS) were low (Table 11) and there were no significant differences in the values among the sites. Not only were values low but over 50% were below the detection limit (Appendix Tables). The correlation coefficient of TSS as a function of discharge rate (0.71) was highly significant ($p<0.01$). Total suspended solids concentrations are normal and of no concern to questions of water quality in the Eno River at Hillsborough, NC.

Table 11. Mean Total Suspended Solids (TSS mg/l) ranking Sites from least to greatest.

Rank	Location	Mean Concentration (m/L)
1	Cates	2.8
2	Eno East	3.2
3	Eno West	3.3
4	Stroud's	3.6
5	Up-WWTP	3.6
6	Dn-WWTP	4.4
7	Intake	4.7

Total Kjeldahl Nitrogen

Total Kjeldahl Nitrogen (TKN) includes all organic nitrogen plus ammonia (dissolved and particulate). Mean TKN concentrations ranged from a low of 0.39 mg/l at Cates Creek to a high of 0.77mg/l at Eno East sites (Table 12). Cates Creek and Stroud's Creek had significantly lower concentrations than the Eno East and Eno West sites (Tables 13 - 14) with the other sites falling in between in a pattern of decreasing concentrations from upstream to downstream in the main axis of the river (Figure 5). These TKN values can be considered to be moderate concentrations are probably not of concern to questions of water quality in the Eno River at Hillsborough, NC.

Table 12. Mean Total Kjeldahl Nitrogen (TKN mg/l) ranking Sites from least to greatest.

Rank	Location	Mean Concentration (mg/l)
1	Cates	0.39
2	Stroud's	0.44
3	Up-WWTP	0.55
4	Intake	0.60
5	Dn-WWTP	0.60
6	Eno West	0.71
7	Eno East	0.77

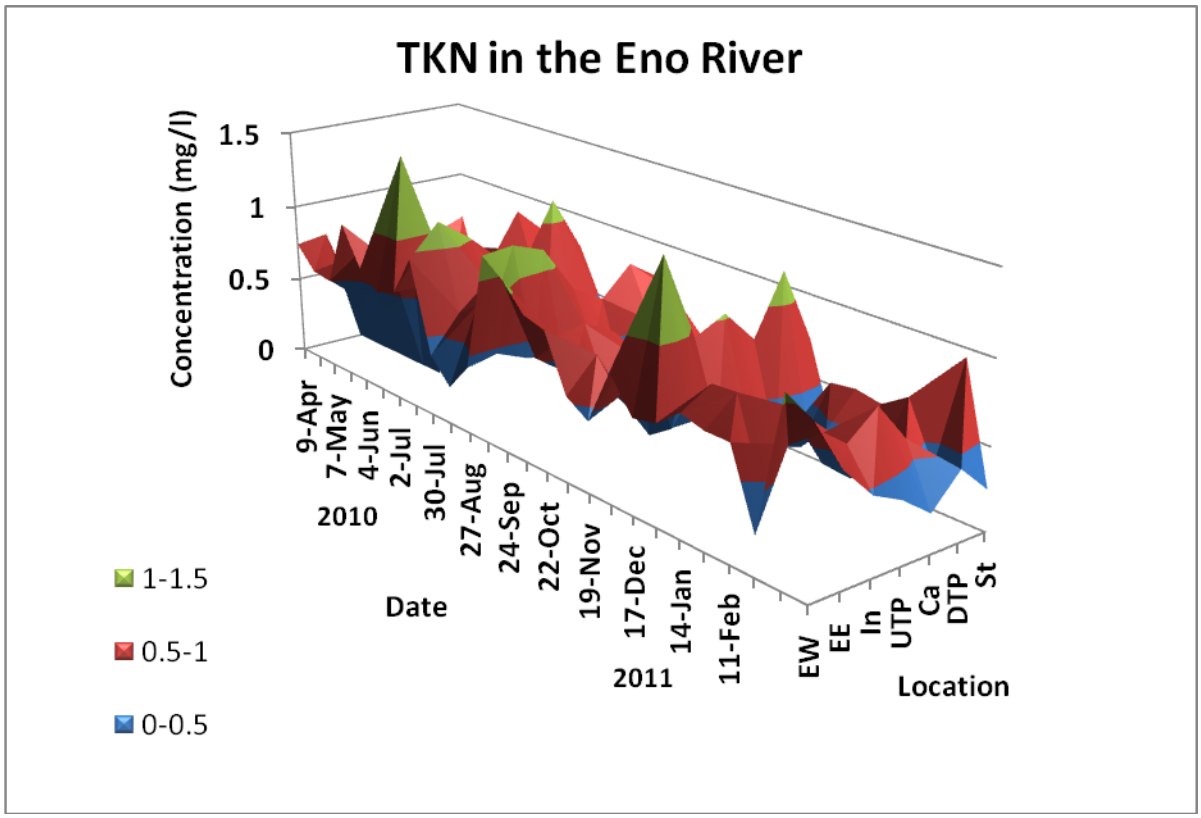
Table 13. Tukey's test for significant differences ($p<0.05$) among Sites for Total Kjeldahl Nitrogen (TKN) concentration data.

Location	Eno West	Eno East	Intake	Up - TP	Cates	Dn. - TP	Stroud's
Eno West							
Eno East	no						
Intake	no	no					
Up - TP	no	no	no				
Cates	YES	YES	no	no			
Dn. - TP	no	no	no	no	no		
Stroud's	YES	YES	no	no	no	no	

Table 14. Newman-Keuls test for significant differences ($p<0.05$) among Sites for Total Kjeldahl Nitrogen (TKN) concentration data.

Location	Eno West	Eno East	Intake	Up - TP	Cates	Dn. - TP	Stroud's
Eno West							
Eno East	no						
Intake	no	no					
Up - TP	no	YES	no				
Cates	YES	YES	YES	no			
Dn. - TP	no	no	no	no	YES		
Stroud's	YES	YES	no	no	no	no	

Figure 5. Chart of total Kjeldahl nitrogen (TKN) in the Eno River as a function of sampling date and location. EW = Eno west, EE = Eno east, In = near the intake to the water supply above dam, UTP = upstream of the waste water treatment plant, Ca = Cates Creek, DTP = downstream of the waste water treatment plant, St = Stroud's Creek.



Ammonia

Ammonia concentrations were low with most being below the detection limit (0.02 mg/l). Ammonia concentrations are normal and of no concern to questions of water quality in the Eno River at Hillsborough, NC. USGS data averaged from a site upstream of the WWTP from 2000 – 2010 equaled 0.056 mg/l, comparable to the concentrations reported here.

Nitrate + Nitrite

Mean nitrate + nitrite concentrations were relatively low at the middle and upper sites but increased significantly at the Dn-WWTP and Stroud's Creek sites (Tables 15 - 17). There were a number of spikes in concentrations scattered throughout the year at these two sites that did not appear to be related (Figure 6). The increase at the Dn-WWTP may be explained as nitrate from the waste water treatment plant effluent. The cause of the large increase in the Stroud's Creek site is unknown. The concentrations of nitrate + nitrate at the Dn-WWTP and Stroud's creek were significantly negatively correlated with river flows on the dates sampled (p= -0.43 at both Dn-WWTP and Stroud's Creek). The negative correlation with flow may indicate the effects of dilution during higher runoff periods. These relatively high values are of concern because they may represent significant loading of nitrogen which can add to eutrophication potential further downstream in the Eno River. USGS data averaged from a site upstream of the WWTP from 2000 – 2010 equaled 0.252 mg/l, higher than the concentrations reported here for the Up-WWTP site.

Table 15. Mean Nitrate + Nitrate Nitrogen (NO_x mg/l) ranking Sites from least to greatest.

Rank	Location	Mean Concentration (mg/l)
1	Intake	0.12
2	Cates	0.13
3	Up-WWTP	0.17
4	Eno West	0.19
5	Eno East	0.25
6	Dn-WWTP	1.19
7	Stroud's	1.20

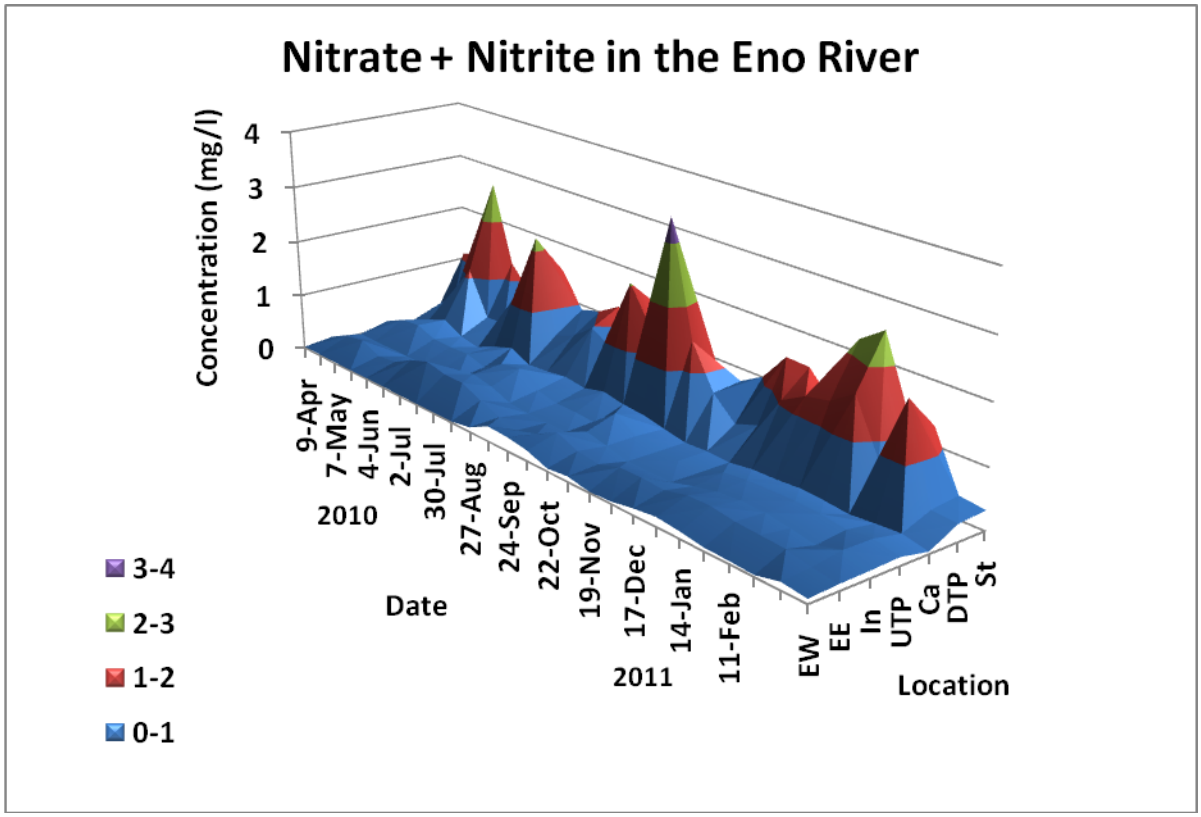
Table 16. Tukey's test for significant differences ($p<0.05$) among Sites for Nitrate + Nitrite Nitrogen (mg/l) concentration data.

Location	Eno West	Eno East	Intake	Up - TP	Cates	Dn. - TP	Stroud's
Eno West							
Eno East	no						
Intake	no	no					
Up - TP	no	no	no				
Cates	no	no	no	no			
Dn. - TP	YES	YES	YES	YES	YES		
Stroud's	YES	YES	YES	YES	YES	no	

Table 16. Newman-Keuls test for significant differences ($p<0.05$) among Sites for Nitrate + Nitrite Nitrogen (mg/l) concentration data.

Location	Eno West	Eno East	Intake	Up - TP	Cates	Dn. - TP	Stroud's
Eno West							
Eno East	no						
Intake	no	no					
Up - TP	no	no	no				
Cates	no	no	no	no			
Dn. - TP	YES	YES	YES	YES	YES		
Stroud's	YES	YES	YES	YES	YES	no	

Figure 6. Chart of nitrate+nitrite nitrogen in the Eno River as a function of sampling date and location. EW = Eno west, EE = Eno east, In = above the water supply intake dam, UTP = upstream of the waste water treatment plant, Ca = Cates Creek, DTP = downstream of the waste water treatment plant, St = Stroud's Creek.



Total Phosphorus

Mean total phosphorus concentrations were low at the middle and upper sites and in all the tributaries with most values recorded as below the detection limit (<0.05). Concentrations increased significantly at the Dn-WWTP site (Tables 18 - 20) due to frequent spikes in concentration scattered throughout the year (Figure 7). The greatest concentration was measured in July at 0.30 mg/l. The significant increase at the Dn-WWTP may be explained as phosphate from the waste water treatment plant effluent. There was no significant correlation of concentration with river flows on the dates sampled. The occasionally moderate spikes in total phosphorus may be of concern if they are found to represent significant loading into the Eno River which could add to eutrophication potential further downstream in the Eno River. USGS data averaged from a site upstream of the WWTP from 2000 – 2010 equaled 0.055 mg/l, equal to the concentrations reported here for the Up-WWTP site.

Table 18. Mean Total Phosphorus (mg/l) ranking Sites from least to greatest.

Rank	Location	Mean Value
1	Intake	0.05
2	Cates	0.05
3	Eno West	0.05
4	Eno East	0.05
5	Up-WWTP	0.06
6	Stroud's	0.06
7	Dn-WWTP	0.14

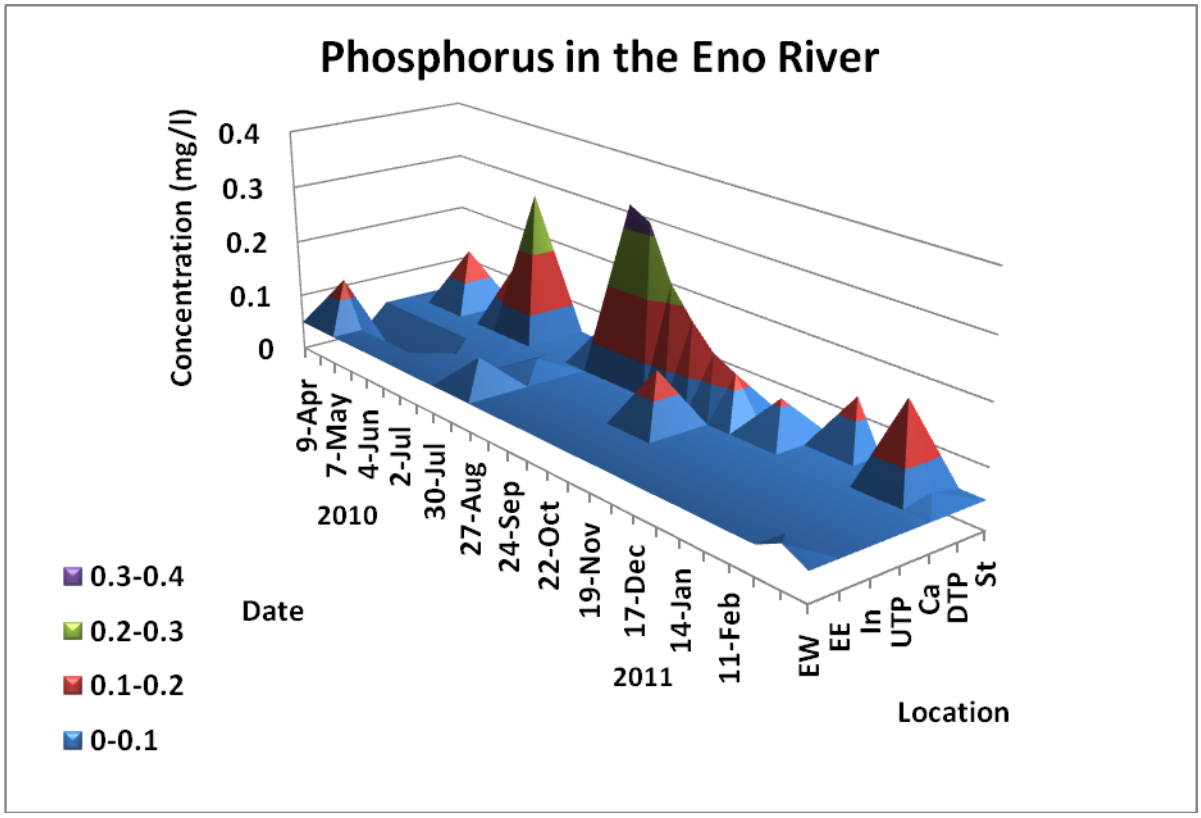
Table 19. Tukey's test for significant differences (p<0.05) among Sites for Total Phosphorus data.

Location	Eno West	Eno East	Intake	Up - TP	Cates	Dn. - TP	Stroud's
Eno West							
Eno East	no						
Intake	no	no					
Up - TP	no	no	no				
Cates	no	no	no	no			
Dn. - TP	YES	YES	YES	YES	YES		
Stroud's	no	no	no	no	no	YES	

Table 20. Newman-Keuls test for significant differences (p<0.05) among Sites for Total Phosphorus data.

Location	Eno West	Eno East	Intake	Up - TP	Cates	Dn. - TP	Stroud's
Eno West							
Eno East	no						
Intake	no	no					
Up - TP	no	no	no				
Cates	no	no	no	no			
Dn. - TP	YES	YES	YES	YES	YES		
Stroud's	no	no	no	no	no	YES	

Figure 7. Chart of total phosphorus in the Eno River as a function of sampling date and location. EW = Eno west, EE = Eno east, In = above the water supply intake dam, UTP = upstream of the waste water treatment plant, Ca = Cates Creek, DTP = downstream of the waste water treatment plant, St = Stroud's Creek.



Chlorophyll *a* and Pheopigments

The mean concentrations of chlorophyll a were extremely low relative to the EPA and DENR standard of 40 ug/l for surface waters (Table 21). In the Tukey test Table 22) there were no significant differences while in the less conservative Newman-Keuls test the Eno West and Intake Sites had significantly higher concentrations compared to the Up-WWTP site (Table 23). Chlorophyll a concentrations are normal and of no concern to questions of water quality in the Eno River at Hillsborough, NC.

Pheopigments concentrations (Appendix Tables) were low and mostly below detection (<2.0 ug/l) and are of no concern to questions of water quality in the Eno River at Hillsborough, NC.

Table 21. Mean concentrations of Chlorophyll a at the Eno river sampling sites ranked from least to greatest.

Rank	Location	Mean Concentration (µg/l)
1	Cates	2.7
2	Stroud's	2.8
3	Down WWTP	2.8
4	Up WWTP	2.8
5	Eno_East	4.3
6	Intake	5.2
7	Eno West	5.5

Table 22. Tukey's test for significant differences ($p<0.05$) among Sites for Chlorophyll *a* concentration.

Location	Eno West	Eno East	Intake	Up - TP	Cates	Dn. - TP	Stroud's
Eno West							
Eno East	no						
Intake	no	no					
Up - TP	no	no	no				
Cates	no	no	no	no			
Dn. - TP	no	no	no	no	no		
Stroud's	no	no	no	no	no	no	

Table 23. Newman-Keuls test for significant differences ($p<0.05$) among Sites for Chlorophyll *a* concentration.

Location	Eno West	Eno East	Intake	Up - TP	Cates	Dn. - TP	Stroud's
Eno West							
Eno East	no						
Intake	no	no					
Up - TP	YES	no	YES				
Cates	no	no	no	no			
Dn. - TP	no	no	no	no	no		
Stroud's	no	no	no	no	no	no	

Fecal Coliform Bacteria

Fecal Coliform Bacteria

Mean fecal coliform bacteria concentrations were mostly below the 200/100ml DENR standard for surface water human contact (Table 24). However the Down WWTP and Up WWTP exceeded the standard. The Up WTTP and Down WWTP sites were significantly greater than the Intake site (Tables 25 - 26). Most of the concentrations are similar to those encountered in other rivers and streams in suburban/agricultural landscapes but the two elevated sites may be of concern for swimming. There were no strong temporal patterns in values (Figure 8).

Table 24. Geomean FC counts (colonies/100ml) ranking Sites from least to greatest.

Rank	Location	Geomean # Colonies/100ml
1	Intake	60
2	Stroud's	128
3	Cates	129
4	Eno_East	151
5	Eno_West	158
6	Down WWTP	220
7	Up_WWTP	263

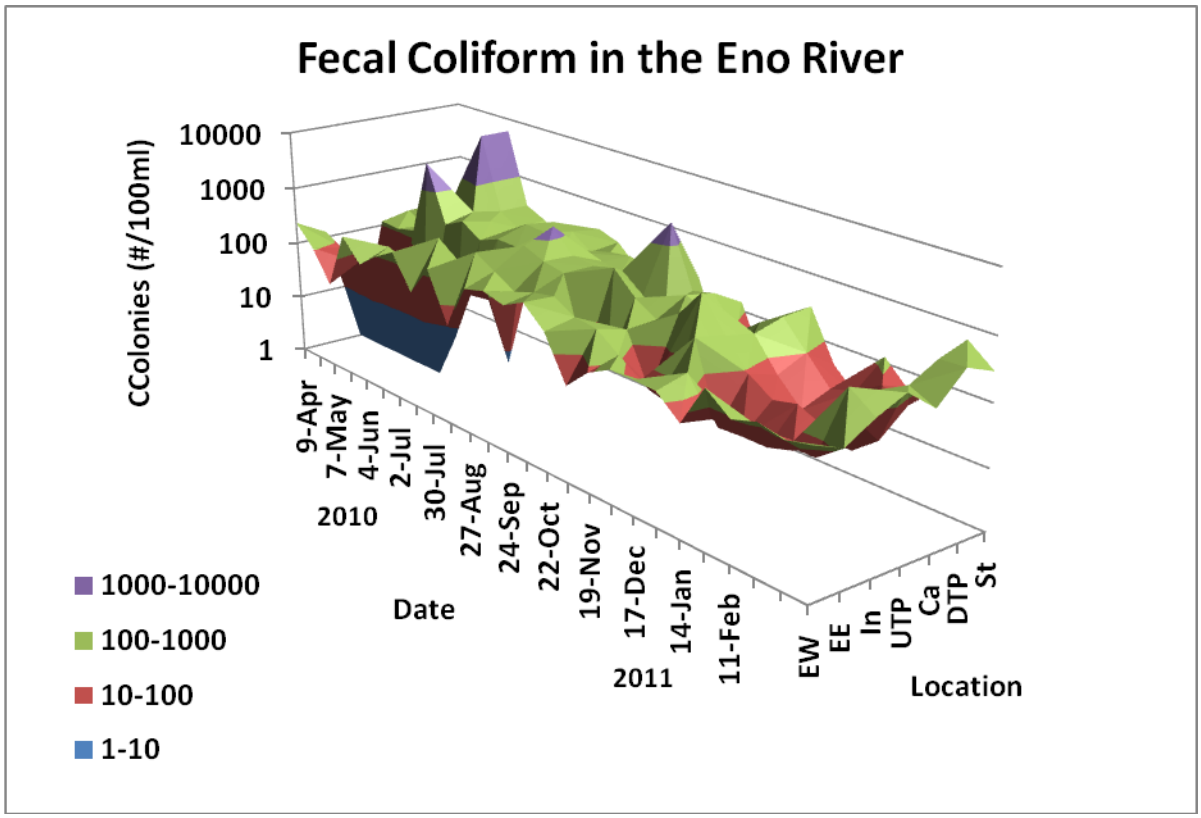
Table 25. Tukey's test for significant differences ($p<0.05$) among Sites using log FC transformed data.

Location	Eno West	Eno East	Intake	Up - TP	Cates	Dn. - TP	Stroud's
Eno West							
Eno East	no						
Intake	no	no					
Up - TP	no	no	YES				
Cates	no	no	no	no			
Dn. - TP	no	no	YES	no	no		
Stroud's	no	no	no	no	no	no	

Table 26. Newman-Keuls test for significant differences ($p<0.05$) among Sites using log FC transformed data.

Location	Eno West	Eno East	Intake	Up - TP	Cates	Dn. - TP	Stroud's
Eno West							
Eno East	no						
Intake	YES	YES					
Up - TP	no	no	YES				
Cates	no	no	no	no			
Dn. - TP	no	no	YES	no	no		
Stroud's	no	no	no	no	no	no	

Figure 8. Chart of fecal coliform bacteria in the Eno River as a function of sampling date and location. EW = Eno west, EE = Eno east, In = above the water supply intake dam, UTP = upstream of the waste water treatment plant, Ca = Cates Creek, DTP = downstream of the waste water treatment plant, St = Stroud's Creek.



Enterococcus Bacteria

Enterococcus counts are used by health officials for opening/closing swimming beaches. Geomean *Enterococcus* counts range from 18 to 156 counts/100 ml (Table 27). The only significant difference in counts was between the Intake and the Up WWTP sites using the less conservative Newman-Keuls test (Tables 28 – 29). The Intake and Down WWTP site were below the NC DENR standard of 35/100ml for swimming however the other 5 sites were above the standard suggesting concern for human contact activities such as swimming. There was no seasonal or upstream/downstream pattern in the *Enterococcus* data (Figure 9).

Table 27. Geomean Enterococcus counts (colonies/100ml) using log transformed data ranking Sites from least to greatest.

Rank	Location	Geomean # Colonies/100ml
1	Intake	18
2	Down WWTP	34
3	Eno_East	43
4	Stroud's	48
5	Cates	53
6	Eno_West	89
7	Up_WWTP	156

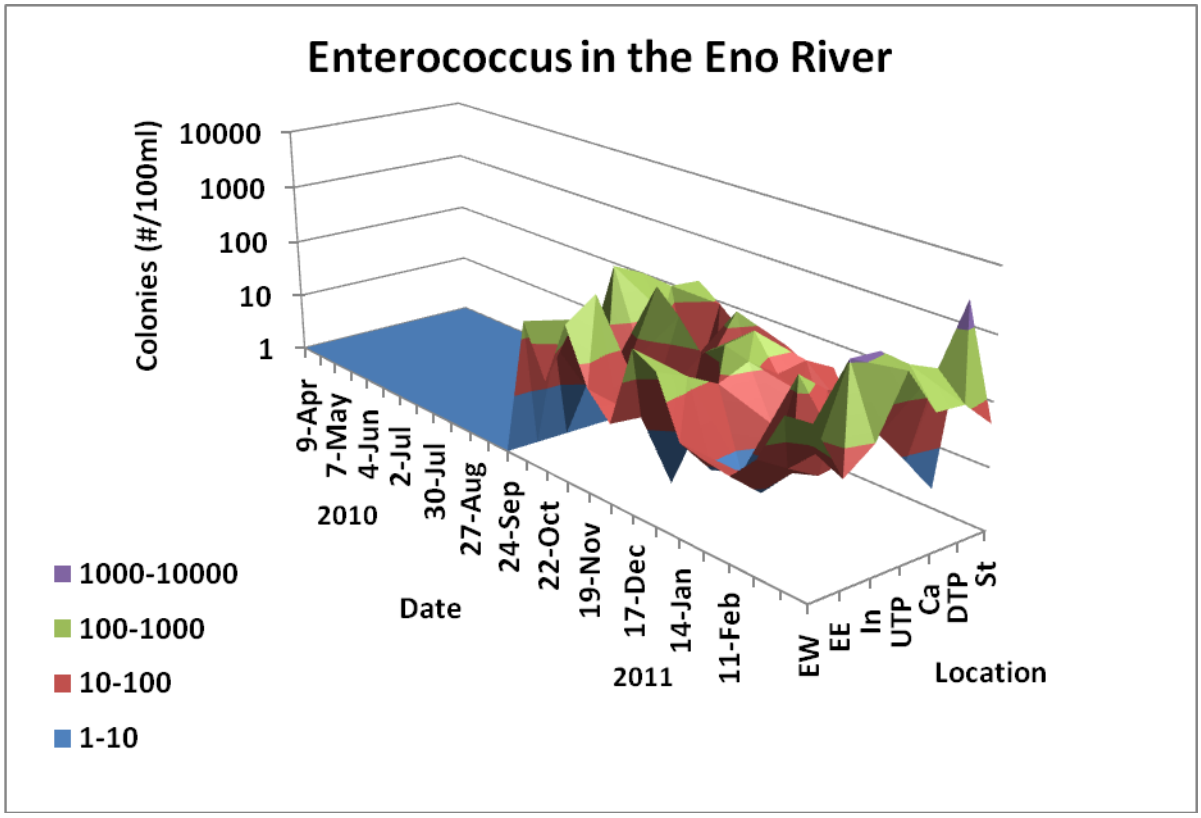
Table 28. Tukey's test for significant differences (p<0.05) among Sites using log Enterococcus transformed data.

Location	Eno West	Eno East	Intake	Up - TP	Cates	Dn. - TP	Stroud's
Eno West							
Eno East	no						
Intake	no	no					
Up - TP	no	no	YES				
Cates	no	no	no	no			
Dn. - TP	no	no	no	no	no		
Stroud's	no	no	no	no	no	no	

Table 29. Newman-Keuls test for significant differences (p<0.05) among Sites using log Enterococcus transformed data.

Location	Eno West	Eno East	Intake	Up - TP	Cates	Dn. - TP	Stroud's
Eno West							
Eno East	no						
Intake	no	no					
Up - TP	no	no	YES				
Cates	no	no	no	no			
Dn. - TP	no	no	no	no	no		
Stroud's	no	no	no	no	no	no	

Figure 9. Chart of Enterococcus bacteria in the Eno River as a function of sampling date and location. EW = Eno west, EE = Eno east, In = above the water supply intake dam, UTP = upstream of the waste water treatment plant, Ca = Cates Creek, DTP = downstream of the waste water treatment plant, St = Stroud's Creek.

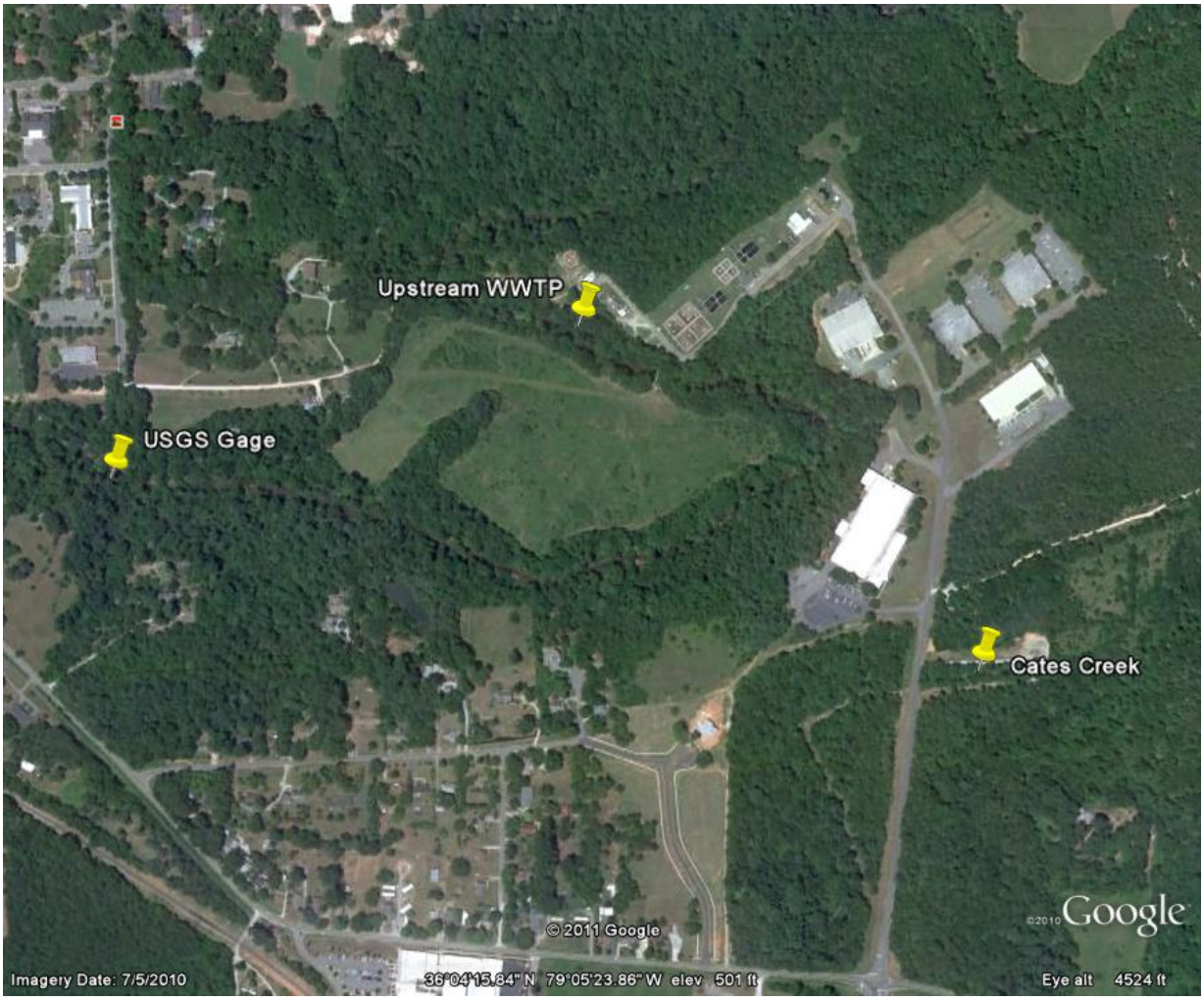


Appendix

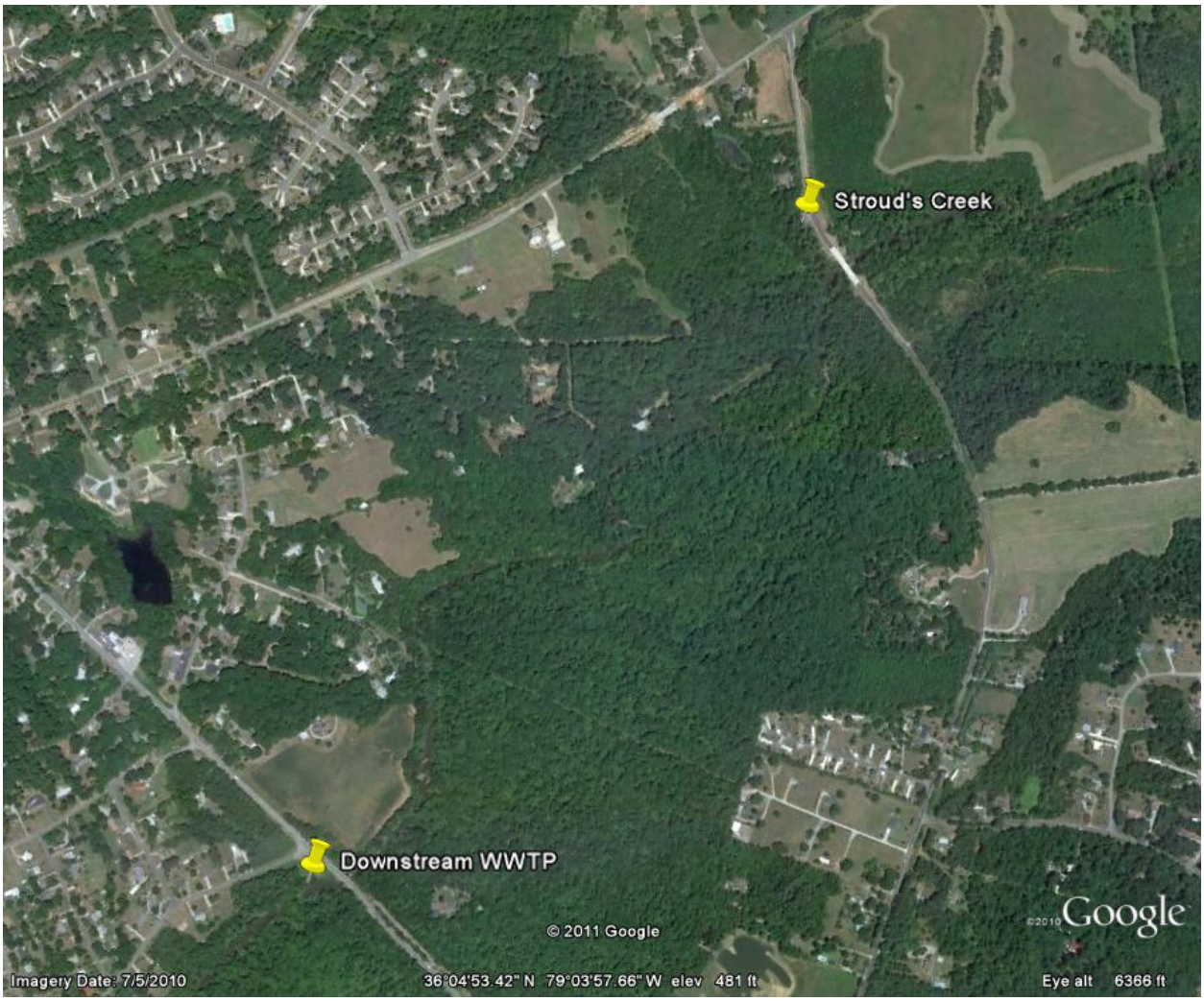
Appendix Figure 1. Detailed view of the locations of Eno River West and East Fork sampling sites.

Appendix Figure 2. Detailed view of the locations of Eno River Seven Mile Creek and above the Intake sampling sites.

Appendix Figure 3. Detailed view of the locations of the USGS Gage, Eno River Upstream WWTP and Cates Creek sampling sites.



Appendix Figure 4. Detailed view of the locations of the Eno River Downstream WWTP and Stroud's Creek sampling sites



Appendix Table 1. Eno River West station data. Tem = temperature (^{o}C), Con = conductivity (siemens), DO = dissolved oxygen (mg/l), TSS = total dissolved solids (mg/l), Turb = turbidity (NTU), TKN = total Kjeldahl nitrogen (mg/l), NH_3 = ammonia nitrogen (mg/l), NO_x = nitrate + nitrite nitrogen (mg/l), TP = total phosphorus (mg/l), FC = fecal coliform bacteria/100ml, EntC = Enterococcus/100ml, Chla = chlorophyll a (ug/l), Pheo = Pheopigments (ug/l).

Date	Time	Tem	Con	pH	DO	TSS	Turb	TKN	NH_3	NOx	TP	FC	EntC	Chl*a*	Pheo
04/09/10	12:15PM	16.7	53	7.16	8.39	<2.5	4.9	0.74	<0.02	0.08	<0.05	235		<2.0	5.7
04/23/10	12:12PM	15.5	56	7.12	8.82	<2.6	3.6	0.60	<0.02	0.20	<0.05	108		<2.0	3.7
05/07/10	12:30PM	19.0	70	7.24	7.56	<2.5	4.6	0.58	<0.02	0.40	<0.05	31		4.7	<2.0
05/21/10	11:55AM	19.2	58	7.11	7.64	5.1	6.0	1.01	<0.02	0.08	<0.05	300		16.7	<2.0
06/04/10	11:24AM	23.5	70		5.96	<2.5	4.2	0.76	<0.02	0.11	<0.05	125		2.7	<2.0
06/23/10	10:33AM	23.2	91	7.27	6.93	<2.5	2.6	0.65	<0.02	0.54	<0.05	230		4.7	<2.0
07/02/10	10:55AM	18.8	63	7.43	7.95	2.7	2.8	0.70	<0.02	0.15	<0.05	365		2.0	<2.0
07/16/10	9:54AM	23.7	72	7.38	6.65	<2.5	3.1	0.96	<0.02	0.23	<0.05	100		3.3	<2.0
07/30/10	11:04AM	24.2	73	7.44	6.62	<2.5	2.2	0.39	<0.02	0.21	<0.05	330		<2.0	<2.0
08/13/10	11:36AM	24.6	83	7.44	6.41	<2.6	1.8	<0.25	<0.02	0.44	<0.05	50		3.3	<2.0
08/27/10	11:38AM	20.0	71	7.32	7.11	<2.6	2.3	0.42	0.08	0.20	<0.05	280		4.0	<2.0
09/10/10	12:10PM	16.5	62	7.22	8.17	3.3	3.4	1.17	0.26	0.14	<0.05	350		12	<2.0
09/24/10	11:21AM	18.2	80	7.11	7.03	3.5	5.5	1.07	0.24	0.10	<0.05	280		18	<2.0
10/08/10	11:53AM	14.2	63	7.05	8.15	3.6	5.8	0.91	0.18	0.12	<0.05	425	206	20	<2.0
10/22/10	11:23AM	12.8	58	7.47	8.11	<2.7	4.8	0.87	0.05	0.18	<0.05	200	30	3.3	<2.0
11/05/10	12:14AM	11.7	51	7.57	8.31	2.6	2.7	0.53	0.09	0.06	<0.05	38	344	4.7	<2.0
11/19/10	11:37AM	8.0	49	7.46	9.43	<2.6	3.7	0.44	<0.02	0.18	<0.05	87	47	<2.0	<2.0
12/03/10	12:15PM	7.3	47	7.19	10.20	<2.5	3.6	0.79	0.04	0.06	<0.05	138	19	3.3	<2.0
12/17/10	1:25PM	3.6	44		12.93	<2.5	4.7	0.58	0.11	0.12	<0.05	138	396	4.0	<2.0
12/30/10	12:51PM	2.1	42	7.26	13.48	<2.6	5.8	0.61	0.16	0.14	<0.05	132	250	<2.0	<2.0
01/14/11	1:01PM	1.0	42	7.30	14.84	<2.5	7.0	0.73	0.12	0.24	<0.05	62	30	2.7	<2.0
01/28/11	12:45PM	3.2	45	7.25	11.03	<2.5	8.0	0.69	0.06	0.33	<0.05	300	24	2.0	<2.0
02/11/11	12:50PM	2.8	76	7.19	11.83	2.6	6.4	0.69	0.05	0.22	<0.05	150	21	5.3	<2.0
02/25/11	12:52PM	11.1	57	7.10	8.62	2.8	3.2	<0.25	0.03	0.27	<0.05	200	55	<2.0	2.1
03/11/11	12:04PM	10.0	53	7.28	9.38	12.4	10.2	1.08	0.13	0.18	0.07	162	347	7.3	<2.0
03/25/11	12:40PM	13.8	37	7.24	8.72	5.2	6.3	1.00	0.08	0.16	<0.05	200	386	7.0	<2.0

Appendix Table 2. Eno River East station data. Tem = temperature (^oC), Con = conductivity (siemens), DO = dissolved oxygen (mg/l), TSS = total dissolved solids (mg/l), Turb = turbidity (NTU), TKN = total Kjeldahl nitrogen (mg/l), NH_3 = ammonia nitrogen (mg/l), NO_x = nitrate + nitrite nitrogen (mg/l), TP = total phosphorus (mg/l), FC = fecal coliform bacteria/100ml, EntC = Enterococcus/100ml, Chla = chlorophyll a (ug/l), Pheo = Pheopigments (ug/l).

Date	Time	Tem	Con	pH	DO	TSS	Turb	TKN	NH_3	NOx	TP	FC	EntC	Chl*a*	Pheo
04/09/10	11:05AM	16.7	57	7.33	8.22	4.4	5.4	0.77	0.06	0.08	<0.05	124		8.7	3.9
04/23/10	11:10AM	15.5	60	7.00	7.98	3.3	4.8	0.43	<0.02	0.23	0.13	84		3.3	<2.0
05/07/10	11:06AM	19.7	69	6.99	6.39	4.8	5.9	0.72	0.14	0.29	<0.05	58		<2.0	<2.0
05/21/10	10:44AM	19.9	74	7.15	6.94	6.8	7.8	0.62	<0.02	0.14	<0.05	125		15.4	<2.0
06/04/10	10:20AM	23.3	75	7.07	5.43	4.3	6.7	0.77	<0.02	0.18	<0.05	200		6.3	<2.0
06/23/10	9:30AM	24.3	81	7.12	5.91	3.5	5.2	1.71	<0.02	0.36	<0.05	156		4.7	<2.0
07/02/10	9:50AM	19.4	78	7.25	6.79	2.5	4.1	0.69	<0.02	0.48	<0.05	150		3.3	<2.0
07/16/10	9:05AM	24.1	86	7.25	5.5	3.5	6.0	1.16	<0.02	0.40	<0.05	660		2.7	<2.0
07/30/10	10:07AM	25.1	84	7.27	5.15	3.1	6.2	0.62	<0.02	0.40	<0.05	370		<2.0	<2.0
08/13/10	10:16AM	26.4	84	7.36	5.15	2.7	3.7	0.72	<0.02	0.24	0.10	655		2.0	<2.0
08/27/10	10:20AM	24.6	77	7.16	5.31	<2.5	2.6	0.46	<0.02	0.10	<0.05	420		2.0	<2.0
09/10/10	11:09AM	22.5	78	7.28	5.89	4.6	4.1	1.19	0.07	0.04	<0.05	260		14.0	<2.0
09/24/10	10:19AM	24.4	85	7.07	4.47	3.5	4.7	0.54	0.06	0.14	<0.05	340		4.0	<2.0
10/08/10	10:49AM	15.4	68	7.04	5.71	2.9	5.5	0.73	0.02	0.33	<0.05	400	63	<2.0	<2.0
10/22/10	10:27AM	13.5	69	7.31	5.09	<2.8	2.6	0.62	<0.02	0.18	<0.05	250	222	<2.0	<2.0
11/05/10	11:12AM	12.0	61	7.79	7.14	<2.9	3.4	0.73	0.13	0.13	<0.05	225	770	5.3	<2.0
11/19/10	10:35AM	9.7	57	7.34	7.81	<2.6	2.4	0.53	0.11	0.25	<0.05	120	10	2.0	<2.0
12/03/10	11:01Am	7.9	52	6.91	9.15	<2.5	3.3	0.94	0.12	0.26	<0.05	69	17	4.0	<2.0
12/17/10	12.25PM	3.7	85		12.67	2.7	6.1	1.46	0.04	0.23	<0.05	75	84	6.7	<2.0
12/30/10	11:34AM	2.2	43	7.28	12.45	<2.5	3.7	0.68	0.08	0.33	<0.05	179	152	5.3	3.2
01/14/11	12:07PM	1.7	43	7.25	13.49	<2.5	3.8	0.84	0.06	0.34	<0.05	50	8	4.0	<2.0
01/28/11	11:45AM	3.5	44	7.23	10.58	3.2	5.4	0.85	0.03	0.28	<0.05	50	12	<2.0	<2.0
02/11/11	11:40AM	3.0	75	7.07	10.97	3.0	4.1	0.38	<0.02	0.26	<0.05	75	8	4.7	<2.0
02/25/11	11:51AM	10.4	56	7.03	8.19	2.6	3.3	0.68	0.03	0.24	<0.05	62	28	<2.0	<2.0
03/11/11	11:04AM	10.7	52	7.40	9.24	7.0	7.4	0.83	<0.02	0.16	<0.05	62	68	10	<2.0
03/25/11	11:44AM	14.4	59	7.32	8.46	6.5	6.4	0.67	<0.02	0.11	<0.05	125	44	6.7	<2.0

Appendix Table 3. Seven Mile Creek station data. Tem = temperature (^{o}C), Con = conductivity (siemens), DO = dissolved oxygen (mg/l), TSS = total dissolved solids (mg/l), Turb = turbidity (NTU), TKN = total Kjeldahl nitrogen (mg/l), NH_3 = ammonia nitrogen (mg/l), NO_x = nitrate + nitrite nitrogen (mg/l), TP = total phosphorus (mg/l), FC = fecal coliform bacteria/100ml, EntC = Enterococcus/100ml, Chla = chlorophyll a (ug/l), Pheo = Pheopigments (ug/l).

Date	Time	Tem	Con	pH	DO	TSS	Turb	TKN	NH_3	NOx	TP	FC	EntC	Chl*a*	Pheo
04/09/10	12:15PM	18.7	80	6.98	4.58	4.3	5.9	0.88	<0.02	0.07	<0.05	510		<2.0	3.5
04/23/10	12:12PM	17.5	67	7.21	7.96	3.7	5.3	0.40	<0.02	0.26	<0.05	61		3.3	4.6
05/07/10	12:30PM	25.5	96	7.25	6.05	5.2	6.3	0.83	<0.02	0.28	<0.05	47		8.7	<2.0
05/21/10	11:55AM	21.6	68	7.12	6.49	13.0	9.1	0.70	<0.02	0.13	<0.05	75		12.5	<2.0
06/04/10	11:24AM	24.8	100	6.84	3.51	6.1	13.5	0.46	0.02	0.03	<0.05	144		5.3	<2.0
06/23/10	10:33AM	28.0	120	7.01	4.21	4.3	4.3	0.96	<0.02	<0.02	<0.05	31		6.7	<2.0

Appendix Table 4. Eno River at the Intake station data. Tem = temperature (^oC), Con = conductivity (siemens), DO = dissolved oxygen (mg/l), TSS = total dissolved solids (mg/l), Turb = turbidity (NTU), TKN = total Kjeldahl nitrogen (mg/l), NH_3 = ammonia nitrogen (mg/l), NO_x = nitrate + nitrite nitrogen (mg/l), TP = total phosphorus (mg/l), FC = fecal coliform bacteria/100ml, EntC = Enterococcus/100ml, Chla = chlorophyll a (ug/l), Pheo = Pheopigments (ug/l).

Date	Time	Tem	Con	pH	DO	TSS	Turb	TKN	NH_3	NOx	TP	FC	EntC	Chl*a*	Pheo
07/02/10	10:55AM	25.8	94	7.24	4.91	7.4	6.7	0.65	<0.02	<0.02	<0.05	6		12	<2.0
07/16/10	9:54AM	27.5	84	7.27	5.20	3.8	8.2	1.02	<0.02	0.26	<0.05	50		6.7	<2.0
07/30/10	11:04AM	27.9	78	7.28	5.70	5.5	11.8	0.78	<0.02	0.19	<0.05	56		16	<2.0
08/13/10	11:36AM	29.2	82	7.67	6.54	4.3	3.9	0.40	<0.02	0.05	<0.05	6		11.3	<2.0
08/27/10	11:38AM	26.7	90	6.18	3.41	3.6	3.0	0.38	<0.02	<0.02	<0.05	860		5.3	<2.0
09/10/10	12:10PM		81	7.10	4.02	11.1	2.8	1.12	0.03	<0.02	<0.05	620		14.7	<2.0
09/24/10	11:21AM	25.3	79	7.30	6.19	<2.5	2.3	0.40	<0.02	<0.02	<0.05	530		4.7	<2.0
10/08/10	11:53AM	18.3	60	7.12	4.46	3.5	6.0	0.76	0.05	0.19	<0.05	25	<10	<2.0	<2.0
10/22/10	11:23AM	16.1	68	7.36	5.72	3.7	3.4	0.41	<0.02	0.11	<0.05	25	17	<2.0	<2.0
11/05/10	12:14AM	14.2	67	7.53	6.17	<2.6	3.0	0.36	0.03	<0.02	<0.05	162	40	<2.0	2.1
11/19/10	11:37AM	10.7	61	7.44	7.79	<2.5	2.3	<0.25	<0.02	<0.02	<0.05	24	<10	<2.0	<2.0
12/03/10	12:15PM	9.6	63		8.39	3.5	3.6	0.34	<0.02	<0.02	<0.05	19	1	4.7	<2.0
12/17/10	1:25PM	2.4	51		12.41	2.8	4.4	0.94	<0.02	0.13	<0.05	325	<10	3.3	<2.0
12/30/10	12:51PM	2.6	46	7.35	13.48	<2.6	3.8	0.47	<0.02	0.22	<0.05	18	84	<2.0	<2.0
01/14/11	1:01PM	3.0	85	7.43	13.71	<2.6	4.4	0.46	<0.02	0.26	<0.05	<20	5	<2.0	<2.0
01/28/11	12:45PM	4.4	55	7.29	10.96	2.6	5.4	0.71	<0.02	0.25	<0.05	<20	4	<2.0	7.2
02/11/11	12:50PM	7.0	58	7.16	9.98	6.7	10.8	0.77	<0.02	0.19	<0.05	25	11	5.3	<2.0
02/25/11	12:52PM	11.2	69	7.04	8.10	4.7	5.7	0.68	0.03	0.12	<0.05	38	15	<2.0	<2.0
03/11/11	12:04PM	10.1	57	7.13	9.16	11.2	24.0	0.69	<0.02	0.24	<0.05	462	1120	2.7	<2.0
03/25/11	12:40PM	15.0	64	7.24	7.67	7.6	12.8	0.47	0.03	0.12	<0.05	238	98	2.7	<2.0

Appendix Table 5. Eno River Up WWTP (waste water treatment plant) station data. Tem = temperature (^{o}C), Con = conductivity (siemens), DO = dissolved oxygen (mg/l), TSS = total dissolved solids (mg/l), Turb = turbidity (NTU), TKN = total Kjeldahl nitrogen (mg/l), NH_3 = ammonia nitrogen (mg/l), NO_x = nitrate + nitrite nitrogen (mg/l), TP = total phosphorus (mg/l), FC = fecal coliform bacteria/100ml, EntC = Enterococcus/100ml, Chla = chlorophyll a (ug/l), Pheo = Pheopigments (ug/l).

Date	Time	Tem	Con	pH	DO	TSS	Turb	TKN	NH_3	NOx	TP	FC	EntC	Chl*a*	Pheo
04/09/10	9:40AM	18.6	78	7.19	6.80	<2.5	3.3	0.66	<0.02	0.12	<0.05	118		4.0	<2.0
04/23/10	9:40AM	15.3	78	7.06	8.02	<2.5	4.4	<0.25	<0.02	0.28	<0.05	112		<2.0	3.3
05/07/10	9:28AM	20.8	93	7.05	5.61	<2.5	4.6	0.3	<0.02	0.32	<0.05	136		8.7	<2.0
05/21/10	9:06AM	18.3	72	6.96	7.21	14.0	10.3	0.64	<0.02	0.19	<0.05	3000		9.3	<2.0
06/04/10	8:44AM	23.4	70	6.88	6.21	7.7	12.6	0.65	<0.02	0.18	<0.05	300		<2.0	4.2
06/23/10	8:07AM	26.2	120	7.08	4.88	<2.5	3.4	0.71	<0.02	0.20	<0.05	445		6.0	<2.0
07/02/10	8:28AM	21.4	111	7.10	5.74	<2.5	2.9	0.36	<0.02	0.10	<0.05	270		2.7	<2.0
07/16/10	7:42AM	25.1	102	6.82	4.75	<2.5	6.4	0.84	<0.02	0.31	0.05	370		5.3	<2.0
07/30/10	8:15AM	26.1	86	6.81	4.58	2.8	10.2	0.68	0.04	0.37	<0.05	360		<2.0	<2.0
08/13/10	8:30AM	26.8	109	7.12	4.61	<2.5	3.0	0.39	<0.02	0.13	0.07	320		4.0	<2.0
08/27/10	8:25AM	23.2	105	7.06	5.25	<2.5	2.6	0.34	<0.02	0.05	<0.05	1400		4.0	<2.0
09/10/10	8:55AM	19.7	102	7.32	5.99	<2.5	1.9	0.83	<0.02	0.05	<0.05	590		2.0	<2.0
09/24/10	8:36AM	23.2	99	7.01	4.61	<2.5	3.1	0.52	<0.02	<0.02	<0.05	530		<2.0	<2.0
10/08/10	8:55AM	14.1	82	6.87	7.32	<2.6	5.4	0.66	<0.02	0.35	<0.05	660	683	<2.0	<2.0
10/22/10	8:59AM	12.7	84	7.12	6.70	<2.7	2.1	0.56	<0.02	0.12	<0.05	288	61	<2.0	<2.0
11/05/10	8:48AM	11.0	74	6.99	6.80	<2.6	2.7	0.40	0.08	<0.02	0.14	175	579	<2.0	<2.0
11/19/10	8:41AM	7.3	58	7.00	8.34	<2.6	2.2	<0.25	<0.02	0.04	<0.05	300	262	<2.0	<2.0
12/03/10	9:15AM	6.9	70	6.84	9.22	<2.5	3.7	0.59	<0.02	<0.02	<0.05	880	91	7.3	<2.0
12/17/10	10:50AM	1.9	147		12.90	3.5	4.9	1.03	<0.02	0.19	<0.05	250	173	2.0	<2.0
12/30/10	9:45AM	1.4	82	7.32	13.28	<2.6	3.6	0.47	<0.02	0.24	<0.05	90	135	<2.0	<2.0
01/14/11	9:40AM	0.7	49	7.34	13.38	<2.6	4.7	0.37	<0.02	0.25	<0.05	50	20	3.3	<2.0
01/28/11	10:12AM	3.3	121	7.10	10.11	3.2	6.3	0.56	<0.02	0.26	<0.05	62	172	<2.0	<2.0
02/11/11	10:00AM	3.2	63	7.13	11.45	5.0	11.2	0.39	<0.02	0.24	<0.05	38	49	4.0	<2.0
02/25/11	9:41AM	10.1	41	7.11	8.43	<2.6	4.0	0.56	<0.02	0.18	<0.05	88	18	<2.0	3.3
03/11/11	9:33AM	9.9	93	7.23	9.19	15.8	29.2	0.84	<0.02	0.23	<0.05	300	1050	2.0	<2.0
03/25/11	9:37AM	14.0	40	7.20	7.88	8.9	15.6	0.38	<0.02	0.14	<0.05	388	770	4.0	<2.0

Appendix Table 6. Cates Creek station data. Tem = temperature (^{o}C), Con = conductivity (siemens), DO = dissolved oxygen (mg/l), TSS = total dissolved solids (mg/l), Turb = turbidity (NTU), TKN = total Kjeldahl nitrogen (mg/l), NH_3 = ammonia nitrogen (mg/l), NO_x = nitrate + nitrite nitrogen (mg/l), TP = total phosphorus (mg/l), FC = fecal coliform bacteria/100ml, EntC = Enterococcus/100ml, Chla = chlorophyll a (ug/l), Pheo = Pheopigments (ug/l).

Date	Time	Tem	Con	pH	DO	TSS	Turb	TKN	NH_3	NOx	TP	FC	EntC	Chl*a*	Pheo
04/09/10	8:45AM	15.5	116	7.25	8.88	<2.5	5.0	0.49	<0.02	0.02	<0.05	150		2.70	<2.0
04/23/10	9:00AM	13.3	112	6.64	9.74	<2.6	3.2	<0.25	<0.02	0.16	<0.05	100		<2.0	<2.0
05/07/10	9:00AM	18.0	138	6.65	7.96	<2.6	4.0	<0.25	<0.02	0.29	<0.05	136		<2.0	<2.0
05/21/10	8:39AM	16.4	102	6.27	8.64	4.40	7.4	0.32	<0.02	0.11	<0.05	200		2.00	<2.0
06/04/10	8:10AM	21.1	116	6.60	7.83	3.30	9.4	0.39	<0.02	0.04	<0.05	400		<2.0	2.60
06/23/10	7:43AM	23.0	147	6.69	7.57	2.50	3.7	0.69	<0.02	0.20	<0.05	350		4.00	<2.0
07/02/10	7:55AM	18.3	144	6.48	8.17	<2.6	2.1	<0.25	0.02	0.32	<0.05	200		<2.0	<2.0
07/16/10	7:10AM	24.1	122	6.65	6.88	<2.5	5.8	0.80	<0.02	0.15	<0.05	530		2.70	<2.0
07/30/10	7:35AM	24.2	101	6.82	6.96	3.10	13.0	0.40	<0.02	0.18	<0.05	500		<2.0	<2.0
08/13/10	7:30AM	24.5	149	7.02	6.73	<2.5	2.8	0.31	<0.02	0.23	<0.05	340		<2.0	<2.0
08/27/10	7:45AM	20.9	121	6.81	7.08	<2.5	1.9	<0.25	<0.02	0.18	<0.05	380		<2.0	<2.0
09/10/10	8:20AM	17.5	149	6.95	7.64	<2.6	2.0	0.72	<0.02	0.27	<0.05	365		<2.0	<2.0
09/24/10	8:10AM	21.6	175	6.73	5.54	<2.5	1.4	<0.25	<0.02	0.20	<0.05	340		<2.0	<2.0
10/08/10	8:30AM	13.3	131	6.57	8.47	<2.6	1.6	0.27	<0.02	0.17	<0.05	175	399	<2.0	<2.0
10/22/10	8:35AM	12.0	123	6.60	8.48	<2.6	<1.0	0.41	<0.02	0.09	<0.05	62	113	<2.0	<2.0
11/05/10	8:25AM	10.6	104	6.67	9.06	<2.6	3.3	0.39	0.04	<0.02	<0.05	325	19	3.30	<2.0
11/19/20	8:15AM	7.2	105	6.57	9.69	<2.6	1.4	<0.25	<0.02	0.04	<0.05	19	31	<2.0	<2.0
12/03/10	8:50AM	6.2	98	6.12	10.25	<2.5	2.1	<0.25	<0.02	<0.02	<0.05	56	<1	3.3	<2.0
12/17/10	10:20AM	3.1	134		12.53	<2.5	5.5	0.83	<0.02	0.08	<0.05	200	216	4.7	<2.0
12/30/10	9:20AM	1.5	152	7.06	13.44	<2.5	1.2	<0.25	<0.02	0.09	<0.05	62	62	3.3	<2.0
01/14/11	9:10AM	0.1	1	7.10	14.93	<2.5	3.0	0.30	<0.02	0.12	<0.05	25	44	2	<2.0
01/28/11	9:40Am	2.8	170	7.06	11.31	<2.6	3.2	0.46	<0.02	0.10	<0.05	12	70	3.3	<2.0
02/11/11	9:31AM	1.8	101	6.94	12.74	<2.5	4.0	<0.25	<0.02	0.06	<0.05	12	11	3.3	<2.0
02/25/11	8:55AM	9.9	135	6.63	8.49	<2.6	1.6	0.41	<0.02	0.10	<0.05	25	30	<2.0	<2.0
03/11/11	9:04AM	8.6	92	7.01	10.04	8.4	24.2	0.60	<0.02	0.13	0.05	250	488	3.3	<2.0
03/25/11	9:09AM	11.0	109	7.19	9.10	3.8	8.8	<0.25	<0.02	0.04	<0.05	162	137	5.3	<2.0

Appendix Table 7. Eno River Downstream WWTP (waste water treatment plant) station data. Tem = temperature (^{o}C), Con = conductivity (siemens), DO = dissolved oxygen (mg/l), TSS = total dissolved solids (mg/l), Turb = turbidity (NTU), TKN = total Kjeldahl nitrogen (mg/l), NH_3 = ammonia nitrogen (mg/l), NO_x = nitrate + nitrite nitrogen (mg/l), TP = total phosphorus (mg/l), FC = fecal coliform bacteria/100ml, EntC = Enterococcus/100ml, Chla = chlorophyll a (ug/l), Pheo = Pheopigments (ug/l).

Date	Time	Tem	Con	pH	DO	TSS	Turb	TKN	NH_3	NOx	TP	FC	EntC	Chl*a*	Pheo
04/09/10	10:35AM	18.3	102	7.27	6.82	4.3	5.1	0.62	<0.02	0.19	<0.05	92		4.0	<2.0
04/23/10	10:35AM	15.6	95	7.18	7.53	3.4	4.4	0.32	<0.02	0.53	0.06	228		3.3	<2.0
05/07/10	10:26AM	21.5	127	7.15	5.34	5.7	6.6	0.58	<0.02	1.13	0.15	96		<2.0	6.2
05/21/10	10:08AM	18.8	84	7.13	6.95	9.9	13.6	0.64	<0.02	0.35	<0.05	>6000		6.7	<2.0
06/04/10	9.45AM	23.5	104	6.98	5.10	10.9	17.6	0.68	<0.02	0.36	<0.05	320		2.3	3.0
06/23/10	9:00AM	25.9	170	7.18	4.60	4.0	5.9	0.98	<0.02	1.14	0.17	210		<2.0	<2.0
07/02/10	9:18AM	22.0	188	7.31	5.89	6.3	5.4	0.56	<0.02	2.22	0.3	94		3.3	<2.0
07/16/10	8:31AM	25.8	131	7.18	4.51	5.1	10.2	1.14	<0.02	0.56	<0.05	450		2.7	<2.0
07/30/10	9:10AM	26.4	122	7.19	4.81	8.2	19.5	0.46	<0.02	0.7	<0.05	400		<2.0	<2.0
08/13/10	9:36AM	26.6	209	7.33	4.24	4.6	5.0	0.47	0.02	0.98	0.05	230		2.7	<2.0
08/27/10	9:31AM	23.5	171	7.40	5.54	<2.5	4.6	<0.25	<0.02	0.75	0.13	300		2.0	<2.0
09/10/10	10:05AM	21.0	197	7.55	5.42	2.7	2.7	0.9	<0.02	2.05	0.34	340		3.3	<2.0
09/24/10	9:32AM	23.3	219	7.33	4.62	6.9	6.8	0.58	<0.02	1.4	0.32	280		2.0	<2.0
10/08/10	9:57AM	14.7	158	6.88	6.75	<2.8	4.8	0.82	<0.02	3.43	0.23	2200	183	<2.0	<2.0
10/22/10	9:50AM	13.3	145	7.29	5.98	<2.6	3.1	0.52	<0.02	1.46	0.18	212	3	<2.0	<2.0
11/05/10	9:43AM	11.3	124	7.51	6.68	<2.8	3.7	0.62	0.09	0.72	0.14	262	4	<2.0	<2.0
11/19/10	9:43AM	8.4	95	7.31	8.14	<2.6	3.0	<0.25	<0.02	0.35	0.12	80	173	<2.0	<2.0
12/03/10	10:24AM	7.2	93	7.40	9.73	<2.5	2.7	0.51	<0.02	0.49	0.06	162	7	7.3	<2.0
12/17/10	11:40AM	2.7	253		13.26	3.5	5.8	1.19	<0.02	1.07	0.11	275	63	2.7	<2.0
12/30/10	10:50AM	1.6	114	7.44	13.55	<2.6	2.9	0.38	<0.02	1.29	<0.05	102	74	2.0	<2.0
01/14/11	11:00AM	1.0	100	7.41	13.93	<2.5	3.7	0.63	<0.02	1.37	<0.05	38	6	2.0	<2.0
01/28/11	11:10AM	3.9	99	7.38	10.42	<2.8	5.0	0.65	<0.02	1.64	<0.05	50	52	2.0	<2.0
02/11/11	11:00AM	4.1	91	7.25	11.05	5.8	10.6	0.62	<0.02	0.74	<0.05	88	58	5.3	<2.0
02/25/11	10:45AM	10.2	121	7.18	8.10	<2.6	3.2	0.72	0.03	1.89	0.19	62	8	<2.0	<2.0
03/11/11	10:32AM	10.0	72	7.27	9.11	13.1	24.8	0.38	<0.02	0.32	0.06	440	308	4.7	<2.0
03/25/11	11:09AM	13.9	72	7.25	7.87	8.0	16.3	0.43	<0.02	0.29	<0.05	460	126	2.7	<2.0

Appendix Table 8. Stroud's Creek station data. Tem = temperature (^{o}C), Con = conductivity (siemens), DO = dissolved oxygen (mg/l), TSS = total dissolved solids (mg/l), Turb = turbidity (NTU), TKN = total Kjeldahl nitrogen (mg/l), NH_3 = ammonia nitrogen (mg/l), NO_x = nitrate + nitrite nitrogen (mg/l), TP = total phosphorus (mg/l), FC = fecal coliform bacteria/100ml, EntC = Enterococcus/100ml, Chla = chlorophyll a (ug/l), Pheo = Pheopigments (ug/l).

Date	Time	Tem	Con	pH	DO	TSS	Turb	TKN	NH_3	NOx	TP	FC	EntC	Ch*a*	Phe
04/09/10	10:10AM	16.0	99	7.39	8.55	2.8	4.1	0.69	<0.02	1.09	<0.05	122		<2.0	<2.0
04/23/10	10:10AM	14.2	94	7.09	8.83	3.6	7.2	<0.25	<0.02	1.19	<0.05	152		4.6	<2.0
05/07/10	9:59AM	18.8	140	7.06	7.19	2.8	4.8	0.3	<0.02	2.66	<0.05	64		<2.0	4.2
05/21/10	9:40AM	17.0	99	7.01	7.96	5.1	8.7	0.45	<0.02	1.27	<0.05	>6000		5.0	<2.0
06/04/10	9:18AM	21.5	93	7.05	6.50	7.4	15.6	0.51	<0.02	0.85	0.05	320		<2.0	4.6
06/23/10	8:36AM	23.6	136	7.25	6.61	<2.5	4.4	0.80	<0.02	1.50	<0.05	220		<2.0	5.9
07/02/10	8:55AM	19.0	131	7.28	7.37	3.3	3.4	0.43	<0.02	1.50	<0.05	100		3.0	<2.0
07/16/10	8:10AM	23.9	111	7.10	5.85	3.6	11.9	0.78	<0.02	0.91	<0.05	210		2.3	<2.0
07/30/10	8:43AM	24.2	123	7.06	6.23	<2.5	8.9	0.48	<0.02	1.02	<0.05	340		<2.0	<2.0
08/13/10	9:08AM	24.6	150	7.30	6.11	<2.5	3.0	0.29	<0.02	1.24	<0.05	260		<2.0	<2.0
08/27/10	8:58AM	21.1	152	7.20	6.14	<2.5	2.1	<0.25	<0.02	0.67	<0.05	119		<2.0	<2.0
09/10/10	9:30AM	18.1	163	7.24	7.86	3.3	2.1	0.77	<0.02	1.54	0.12	116		2.0	<2.0
09/24/10	9:07AM	21.7	180	7.14	5.38	3.6	2.8	0.71	<0.02	0.81	0.16	69		4.3	<2.0
10/08/10	9:35AM	13.9	104		8.58	<2.8	2.4	<0.25	<0.02	1.76	<0.05	200	169	<2.0	<2.0
10/22/10	9:25AM	12.3	110	7.24	8.45	<2.6	1.4	0.37	<0.02	0.78	0.05	<20	91	2.0	<2.0
11/05/10	9:20AM	10.8	103	7.31	8.69	<2.6	2.4	0.31	0.05	0.78	<0.05	138	43	<2.0	4.5
11/19/10	9:12AM	7.9	148	7.11	9.69	<2.6	1.5	0.25	<0.02	1.01	<0.05	17	20	<2.0	<2.0
12/03/10	9:49AM	6.8	97	7.21	10.37	<2.5	2.0	0.42	<0.02	1.49	<0.05	28		4.3	<2.0
12/17/10	11:15AM	4.3	82		12.64	<2.5	4.2	0.73	<0.02	1.47	<0.05	300	31	<2.0	<2.0
12/30/10	10:20AM	2.1	81	7.47	13.88	<2.5	1.4	<0.25	<0.02	1.02	<0.05	48	41	<2.0	2.8
01/14/11	10:22AM	1.1	79	7.50	14.77	<2.8	1.8	<0.25	<0.02	2.22	0.13	20	7	<2.0	2.7
01/28/11	10:44AM	4.1	90	7.19	10.48	<2.6	3.7	0.49	<0.02	2.50	<0.05	125	91	2.3	<2.0
02/11/11	10:32AM	2.9	74	7.24	12.05	<2.5	5.6	0.29	<0.02	1.32	<0.05	50	58	2.7	<2.0
02/25/11	10:15AM	10.5	99	7.34	9.01	<2.6	2.7	0.36	<0.02	1.30	<0.05	75	2	<2.0	<2.0
03/11/11	10:10AM	8.8	57	7.17	9.83	16.2	39.8	0.95	<0.02	0.38	<0.05	630	>2420	5.5	<2.0
03/25/11	10:06AM	11.9	73	7.17	8.75	9.1	23	0.25	<0.02	0.33	<0.05	294	46	8.4	<2.0