Susquehanna River Monitoring

Monitoring water quality and fecal coliform bacteria in the Upper Susquehanna River, summer 2008

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ABSTRACT

During the summer of 2008, the Upper Susquehanna River was sampled weekly and tested for biotic and abiotic factors of water quality in continuation of an ongoing study. The Biological Field Station has conducted this survey since 1992 to ensure that water quality standards were maintained below the Village of Cooperstown's sewage point of discharge in the Susquehanna River. The purpose of this research was to ensure that the concentrations of nutrients and fecal coliform are assimilated into the river at a healthy rate as well as to identify and locate any unauthorized sources of pollution. Every week eleven sites were sampled and monitored for temperature, dissolved oxygen, specific conductivity, pH, total phosphorus, total nitrogen, ammonia, and nitrate and nitrite. Fecal coliform bacteria was evaluated once.

INTRODUCTION

Running a total of 444 miles, the Susquehanna River serves as the main freshwater tributary to the Chesapeake Bay. The Susquehanna drains a watershed that spans approximately 27,500 square miles (Zurmuhlen 2006). Situated at the head of the river, the Village of Cooperstown relies on the Susquehanna for the discharge of its wastewater. Serving approximately 3,000 permanent residents as well as a seasonal influx of tourists, the Cooperstown Wastewater Treatment Plant processes up to 800,000 gallons of sewage daily during the summer (Bauer 2005). The effluent is discharged into the Susquehanna River below site SR 12, approximately 4119 meters from source. Animal waste and agricultural run-off are also contribute to the nutrient levels in the river (Coyle 2007).

The river's capacity to assimilate nutrients is limited. If this capacity is exceeded, the health and stability of the Susquehanna's ecosystem can be endangered. Organic pollution and excessive algal production resulting from nutrient loading can cause the dissolved oxygen levels of a body of water to decline due to bacterial respiration (Hill 2002). Low concentrations of dissolved oxygen threaten the population of game fish in the Susquehanna as well as the overall diversity of aquatic life.

The population dynamics of fecal coliform bacterial colonies facilitate the determination of the effects of the effluent discharge into the Susquehanna. Fecal

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coliform bacteria alone are relatively harmless, but their presence in a stream indicates the presence of fecal matter and other potential pathogens (APHA 1992).

METHODS

The Upper Susquehanna River was sampled and tested weekly from July 11th to August 14th, 2008 at eleven sites between its outlet on Otsego Lake and the confluence of the Susquehanna River and Oak Creek (Figure 1). Sites 1, 3, and 6 were accessed by boat while the others were accessed by car.

A Eureka Manta® portable water quality multiprobe or Hydrolab® Scout II was used at each site to measure temperature, Specific Conductivity, Dissolved Oxygen and pH. The Eureka was calibrated before each sampling to ensure accuracy. A Eureka Amphibian® field display was connected to the Manta and used to record and store water quality data.

Water samples for chemical analysis were collected in acid-washed Nalgene bottles at the sites. The samples were stored in a cooler with ice to prevent microbial growth and taken back to the field station to be processed. The samples were tested for nitrate+nitrite, ammonia, total nitrogen and total phophorus using a Lachat QwikChem FIA + Water Analyzer®. Total phosphorus was determined by persulfate digestion followed by the ascorbic acid method (Liao and Martin 2001), total nitrogen by the cadmium reduction following peroxodisulfate digestion (Ebina et. al (1983), ammonia by the phenolate method (Liao 2001), and nitrate+nitrite by the cadmium reduction method (Pritzlaff 2003).

Fecal coliform bacterial colonies were analyzed by using the filter technique (APHA 1992). Predetermined volumes (10 mL, 50 mL or 100 mL) of each sample were passed through a pre-sterilized filter and placed in a pre-sterilized Fisher® dish containing coliform growth medium. Each volume was run in triplicate. Between sites, the equipment was dipped in 70% ethanol and rinsed vigorously in hot tap water. Between each site the tips of the forceps were dipped in ethanol and then passed through the flame of a Bunsen burner. After filtration, the samples were cultured in an incubator bath for approximately 24 hours at 44.5 degrees Celsius. The blue circular fecal coliform colonies on each plate were then counted and recorded.

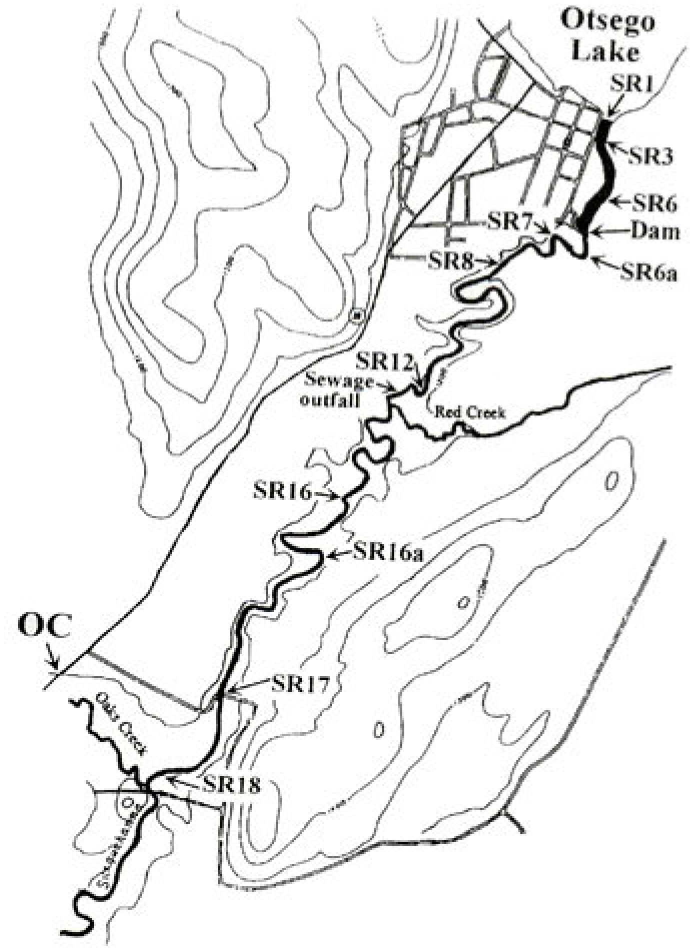

Figure 1. Upper Susquehanna River displaying sampling sites. Site descriptions in Table 1.

Table 1. Locations and descriptions of sampling sites along the Upper Susquehanna River.

<u>Susquehanna River 1</u>:
0 m from source. Source of the Susquehanna River at the Otsego Lake outlet; accessed by boat.

<u>Susquehanna River 3</u>:
144 m from source. Under the Main Street Bridge; accessed by boat.

<u>Susquehanna River 6</u>:
575 m from source. Adjacent from white drainage pipe just north of the dam at Bassett Hospital; accessed by boat.

Table 1 (cont.). Locations and descriptions of sampling sites along the Upper Susquehanna River.

Susquehanna River 6a:
1012 m from source. Below the dam at Bassett Hospital, accessed from the north corner of the lower parking lot of Bassett Hospital.

Susquehanna River 7:
1533 m from source. Below the dam at Bassett Hospital, accessed from the southern corner of the lower parking lot of Bassett Hospital.

Susquehanna River 8:
1724 m from source. Under the Susquehanna Ave. bridge west of the Clark Sports Center, accessed by slope beside the bridge.

Susquehanna River 12:
4119m from source. Just above the sewage discharge of the Cooperstown Wastewater Treatment Plant, nearby Cooperstown High School.

Susquehanna River 16:
5460 m from source. Small bridge perpendicular to the road on Clark Property accessed by crossing a gated bovine grazing area (cow field).

Susquehanna River 16a:
5939 m from source. Distinct bend in river alongside road on Clark property, in field directly across from large house with hayrolls in front. Accessed by long path found on the right side of the field.

Susquehanna River 17:
8143 m from source. Abandoned bridge on dead-end street on Phoenix Mill Rd.

Susquehanna River 18:
9867 m from source. Railroad trestle about 200 m north of the railroad crossing on Rt. 11 going out of Hyde Park, accessed by walking on the railroad tracks. Trains occasionally come through, so caution is necessary.

RESULTS AND DISCUSSION

The results for the 2008 Susquehanna River monitoring indicate a positive change in the overall quality of the water. The river's dissolved oxygen content was elevated in comparison to recent years, and the concentrations of nutrients such as total phosphorus and total nitrogen decreased substantially; these findings indicate that the Susquehanna has not been subjected to significant pollution this year. Other factors such as temperature, pH and specific conductivity remained within normal ranges and followed the Susquehanna's historical patterns.

Temperature

Temperatures along the Susquehanna River followed historical patterns and did not deviate greatly from the previous year. The average temperature for the summer of 2008 was 21.72ºC, an increase of 0.39 degrees from last year's average temperature of 21.33ºC (Coyle 2007). The highest recorded temperature this year was 24.51ºC at site SR17 on 18 July. The lowest recorded temperature this year was 19.91ºC at site SR17 on 11 July. Figure 2 is a graphical representation of temperature profiles from 1998-2008.

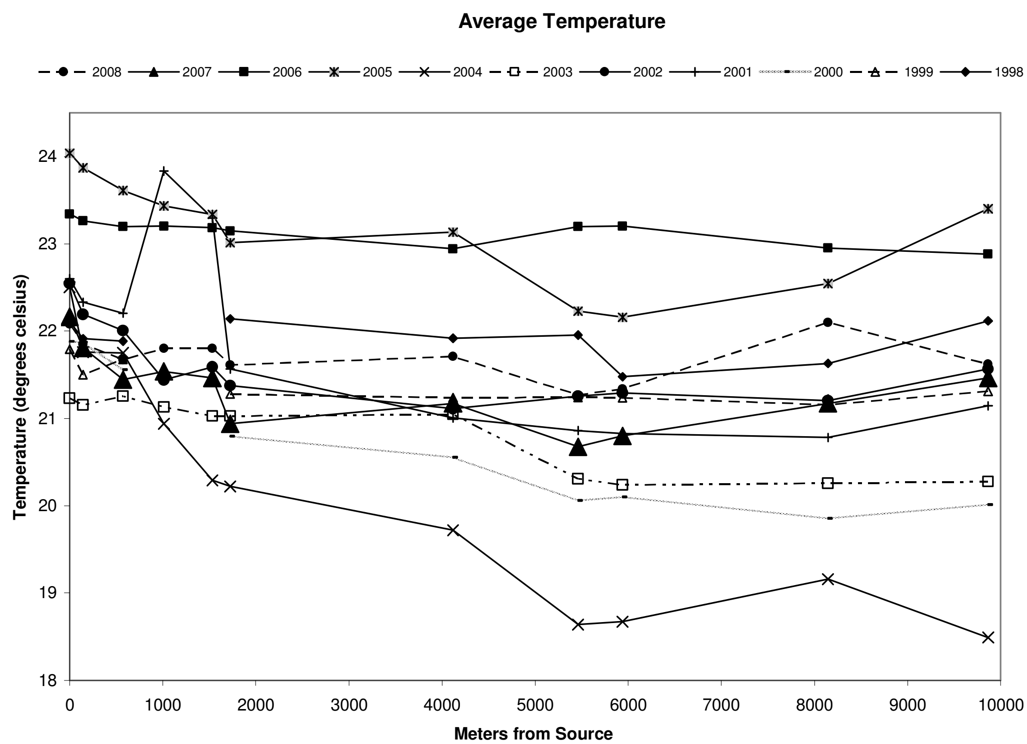

Figure 2. A profile of mean temperature along the Susquehanna, summers 1998 (Dewey 1999), 1999 (Dietz 2000), 2000 (Hill 2001), 2001 (Hill 2002), 2002 (Schlierman 2003), 2003 (Polus 2004), 2004 (Hill 2005), 2005 (Bauer 2006), 2006 (Zurmuhlen 2007), 2007 (Coyle 2008), and 2008.

pH

pH is a measure of a solution's acidity or alkalinity. The average pH for this summer was 8.03, an increase from last year's average of 7.98 (Coyle 2007). The highest recorded pH was 8.29 at site SR3 on July 18, and the lowest recorded pH was 7.78 at site SR3 on August 19. Figure 3 is a graph of mean pH profiles from 1998-2008.

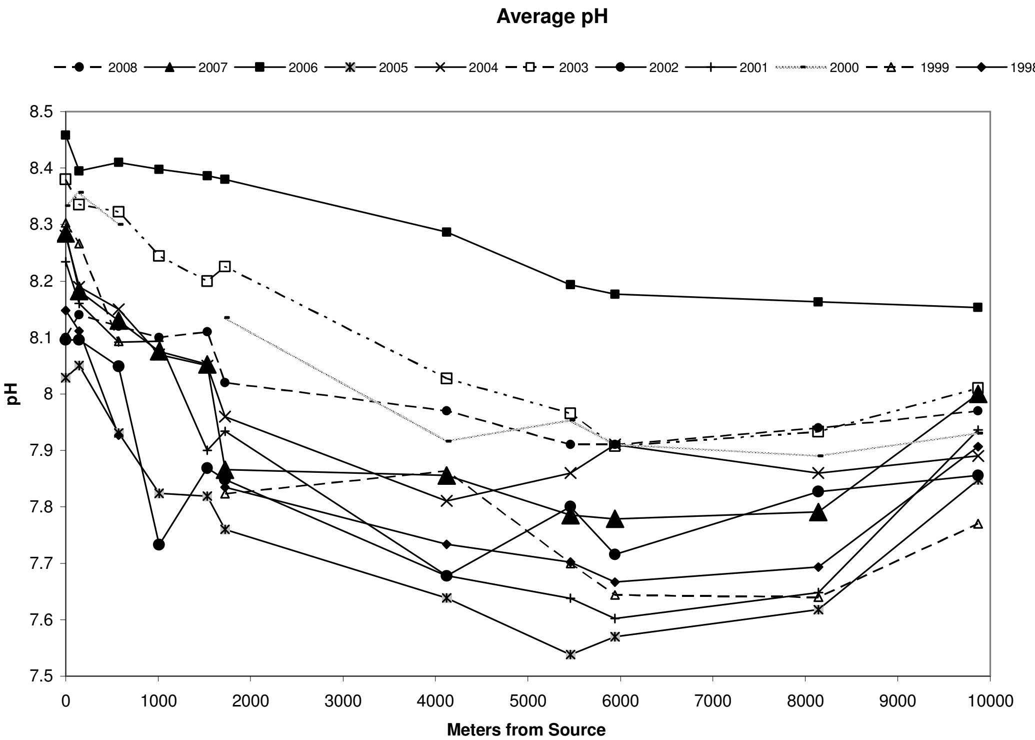

Figure 3. A profile of mean pH along the Susquehanna, summers1998 (Dewey 1999), 1999 (Dietz 2000), 2000 (Hill 2001), 2001 (Hill 2002), 2002 (Schlierman 2003), 2003 (Polus 2004), 2004 (Hill 2005), 2005 (Bauer 2006), 2006 (Zurmuhlen 2007), 2007 (Coyle 2008), and 2008.

Conductivity

Average conductivity levels observed on the Susquehanna over previous years are illustrated in Figure 4. The average conductivity level for this summer was 283 umho/cm, a decrease of 38 umho/cm from last year's average conductivity level of 321 umho/cm (Coyle 2007). The highest conductivity level was 356 umho/cm at site SR16a (5939 m from source) on 18 July and the lowest conductivity level was 255 umho/cm at site SR1 (0 m from source) on 14 August. In summer 2007, the Susquehanna conductivity levels lay in a range above what had been observed in previous years. However, the conductivity levels for this year dropped back down into the ranges which had been typically observed prior to 2007. In recent years, increasing chloride levels in Otsego Lake have been attributed to increased road salting in the area (Coyle 2007); 2008's depressed conductivity levels may indicate that runoff from road salting this year was decreased. Figure 4 is a graph of mean conductivity profiles from 1998-2008.

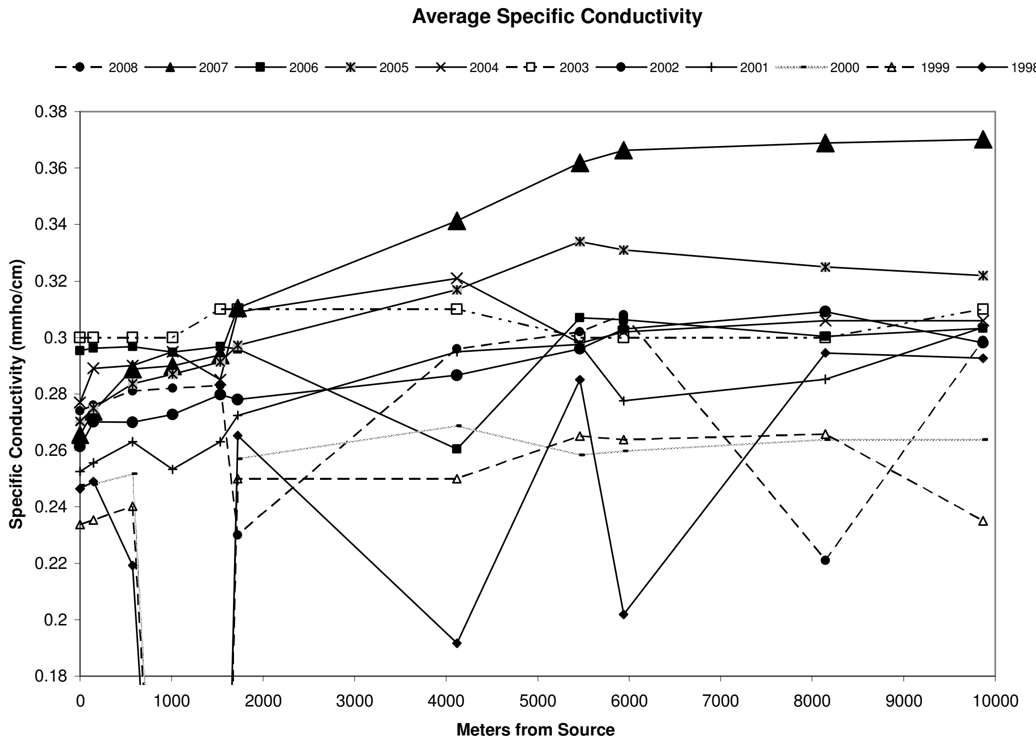

Figure 4. A mean specific conductivity profile of the Susquehanna, summers1998 (Dewey 1999), 1999 (Dietz 2000), 2000 (Hill 2001), 2001 (Hill 2002), 2002 (Schlierman 2003), 2003 (Polus 2004), 2004 (Hill 2005), 2005 (Bauer 2006), 2006 (Zurmuhlen 2007), 2007 (Coyle 2008), and 2008.

Dissolved Oxygen

Dissolved oxygen can be used to assess the general water quality of a site. Low concentrations of dissolved oxygen can serve as indicators of an increase in water temperature, nutrient loading, and excessive bacterial respiration due to algal population booms (Hill 2002). Low levels of dissolved oxygen can disturb a site's ecosystem and make it inhospitable to certain game fish and other species of aquatic life. The Cooperstown Wastewater Treatment Plant is required by its NYSDEC discharge permit to maintain a minimum dissolved oxygen level of 5.00 mg/L downstream of its discharge point (Polus 2004). Wastewater is discharged directly into the river just below site SR12 (11,254 feet below source).

The dissolved oxygen levels for this year were elevated from those of last year. The average concentration this year was 8.47 mg/L, an increase of .67 mg/L from last year's average of 7.8 mg/L. The highest recorded concentration was 12.45 mg/L at site SR7 on 18 July, and the lowest recorded concentration was 6.26 mg/L at site SR16a on 18 July. This year's increase in dissolved oxygen indicates that the wastewater treatment plant is successfully meeting the minimum standards for dissolved oxygen content in its discharge. These findings also show no indication that any unidentified sources of oxygen-depleting pollution have been introduced upstream of the treatment plant sampling site (SR12). Figure 5 is a graph of mean dissolved oxygen profiles from 1998-2008.

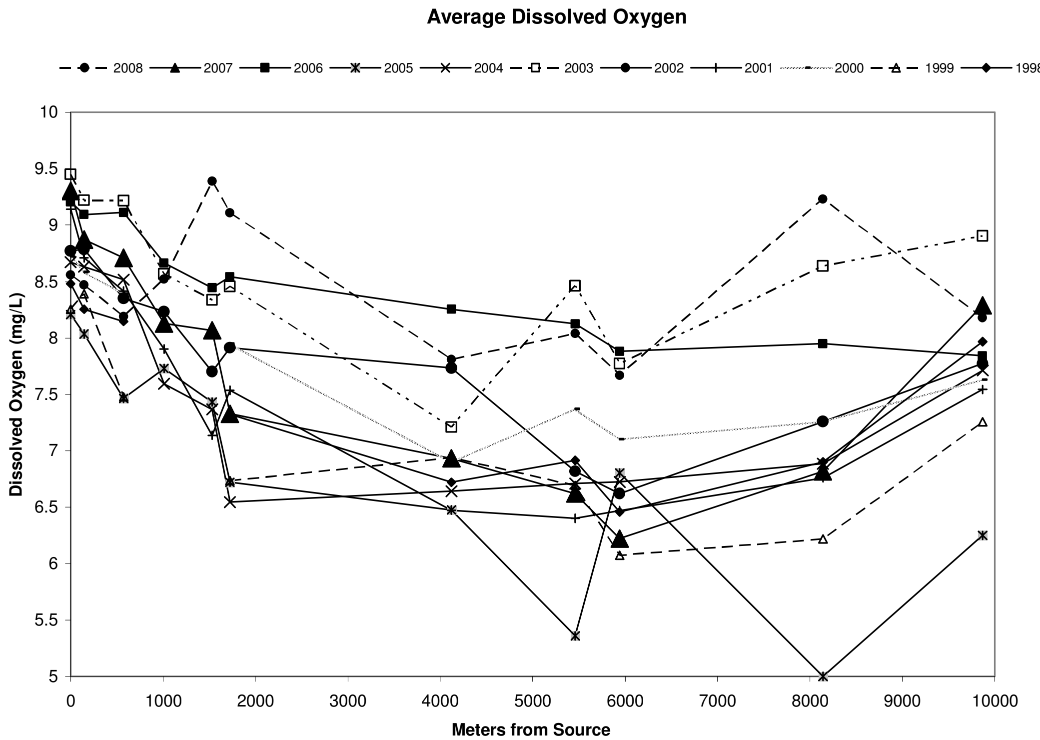

Figure 5. A mean dissolved oxygen profile of the Susquehanna, summers1998 (Dewey 1999), 1999 (Dietz 2000), 2000 (Hill 2001), 2001 (Hill 2002), 2002 (Schlierman 2003), 2003 (Polus 2004), 2004 (Hill 2005), 2005 (Bauer 2006), 2006 (Zurmuhlen 2007), 2007 (Coyle 2008), and 2008.

Total Phosphorus

A high concentration of phosphorus is a result of nutrient loading, which can cause algal population booms that result in depressed dissolved oxygen levels due to increased levels of decomposer bacterial respiration (Hill 2002). When this year's total phosphorus statistics were calculated, any BD (Below Detection) readings were entered as 0 μg/L. The average concentration for this year was 49.8 μg/L, which is a decrease of 31.0 μg/L from last year's average of 79.9 μg/L. The highest observed concentration was 96.8 μg/L at site SR16 on July 11, and the lowest observed concentration was 0 μg/L at site SR3 on 24 July. This year's phosphorus concentrations were significantly lower than last year's; this correlates with the Susquehanna's increase in dissolved oxygen this year. Figure 6 illustrates the total phosphorus concentrations for this and previous years.

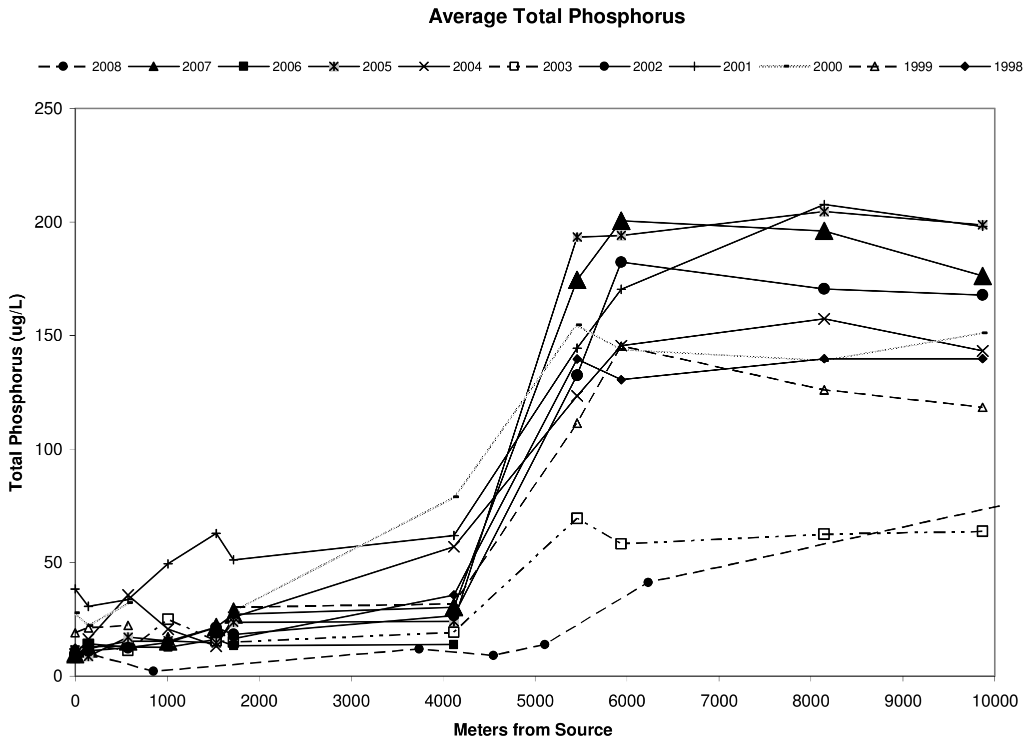

Figure 6. Total Phosphorus profile of the Susquehanna, summers1998 (Dewey 1999), 1999 (Dietz 2000), 2000 (Hill 2001), 2001 (Hill 2002), 2002 (Schlierman 2003), 2003 (Polus 2004), 2004 (Hill 2005), 2005 (Bauer 2006), 2006 (Zurmuhlen 2007), 2007 (Coyle 2008), and 2008.

Nitrate+Nitrite

Nitrates and nitrites are inorganic forms of nitrogen which when introduced in excess to a body of water may contribute to algal booms that depress the dissolved oxygen content of the water. These nutrients are typically introduced by wastewater, agricultural runoff, or precipitation (Lampert and Sommer 1997). When this year's nitrate+nitrite average was calculated, any BD (Below Detection) readings were inputted as 0 mg/L. This year's average concentration of nitrate+nitrite was .22 mg/L, a decrease of .185 mg/L from last year's average of .405 mg/L (Coyle 2007). The highest recorded concentration of nitrate+nitrite was .649 mg/L at site SR17 on 11 July. The lowest recorded concentration of nitrate+nitrite was 0 mg/L at sites SR1, SR3, SR7, SR8, SR12, SR16, SR16a, SR17, and SR18 on 24 July. Figure 7 is a graph of mean nitrate+nitrite levels for 1998-2008.

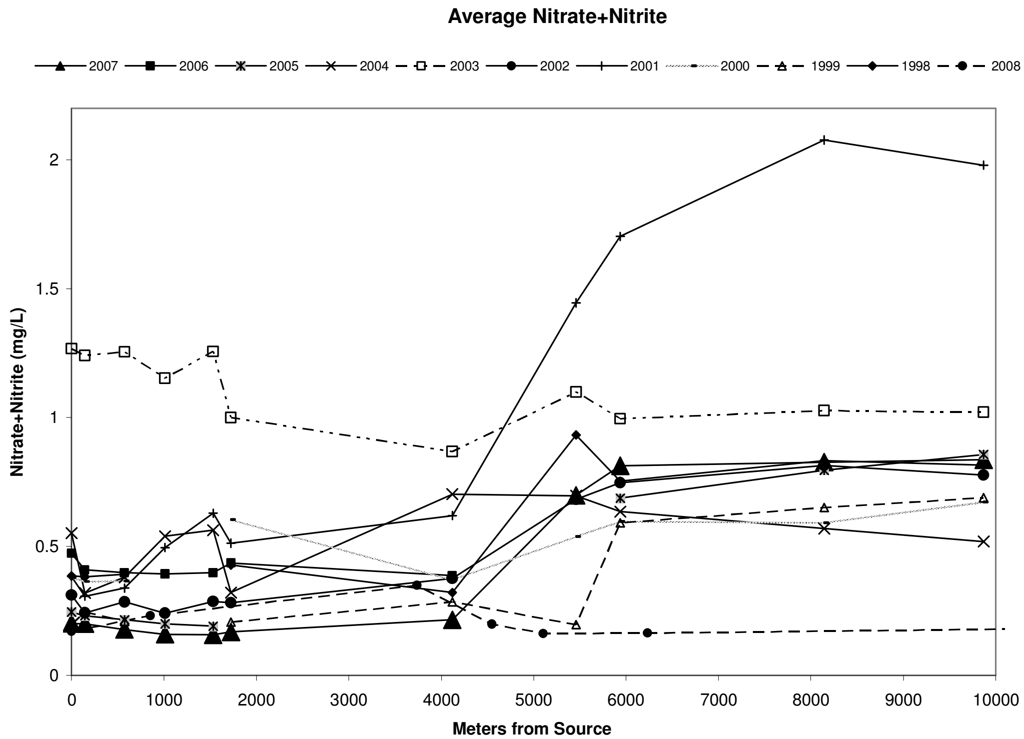

Figure 7. Mean Nitrate+Nitrite profile of the Susquehanna, summers1998 (Dewey 1999), 1999 (Dietz 2000), 2000 (Hill 2001), 2001 (Hill 2002), 2002 (Schlierman 2003), 2003 (Polus 2004), 2004 (Hill 2005), 2005 (Bauer 2006), 2006 (Zurmuhlen 2007), 2007 (Coyle 2008), and 2008.

Ammonia

Ammonia is a form of inorganic nitrogen which in excess can cause many of the problems that high nitrate+nitrite concentrations can cause. It often originates from agricultural and wastewater runoff (Coyle 2007). When the ammonia average was calculated, any BD (Below Detection) readings were inputted as 0 mg/L. The average ammonia concentration for this summer was .04 mg/L, a decrease of .0488 mg/L from last year's average of .0888 mg/L. 2008 is the second year in which the field station has monitored ammonia levels in the Susquehanna, so there is no historical trend to indicate whether these ammonia levels are normal or not. Figure 8 is a graph of mean ammonia levels for 2007-2008.

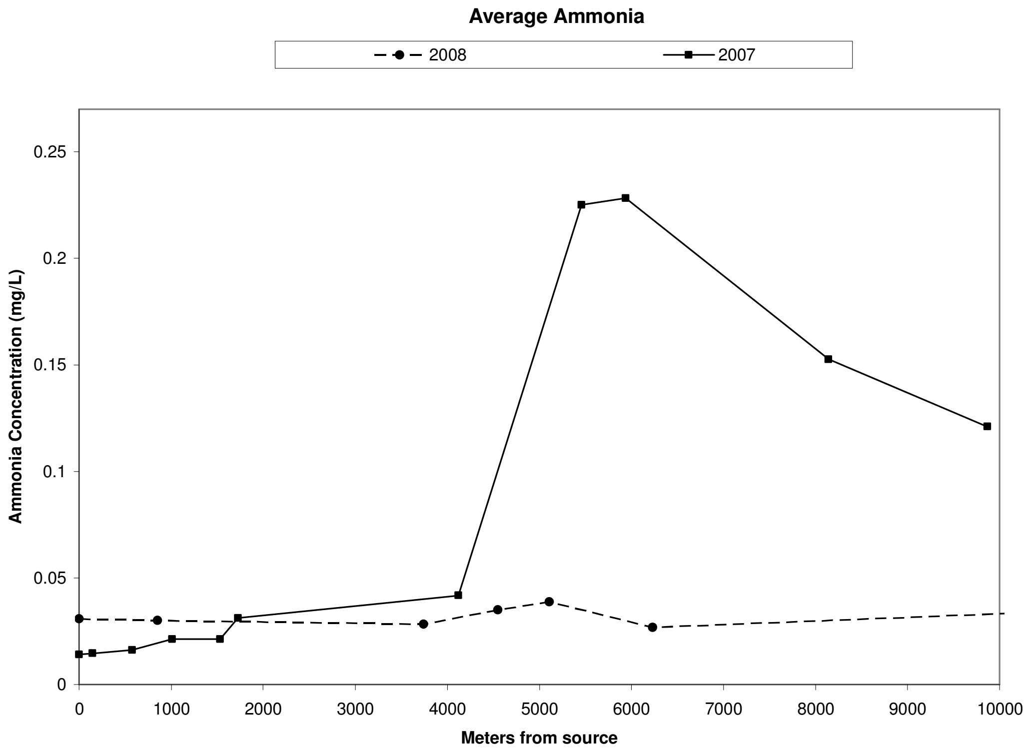

Figure 8. Mean ammonia profile of the Susquehanna, summer 2007 (Coyle 2008) and 2008.

Total Nitrogen

Total Nitrogen is a measure which includes the ammonia and nitrate+nitrite concentrations as well as organic compounds containing nitrogen. This year's total nitrogen levels are sharply depressed in comparison to last year's. When the total nitrogen average was calculated, any BD (Below Detection) readings were inputted as 0 mg/L. The average concentration of total nitrogen this summer was .309 mg/L, a decrease of .434 mg/L from last years' average of .743 mg/L (Coyle 2007). The highest observed concentration was .981 mg/L at site SR17 on 11 July. The lowest observed concentration was 0 mg/L at sites SR1, SR3, SR7, SR12, SR16, SR17, and SR18 on 24 July. Figure 9 is a graph of mean Total Nitrogen levels for 2005-2008.

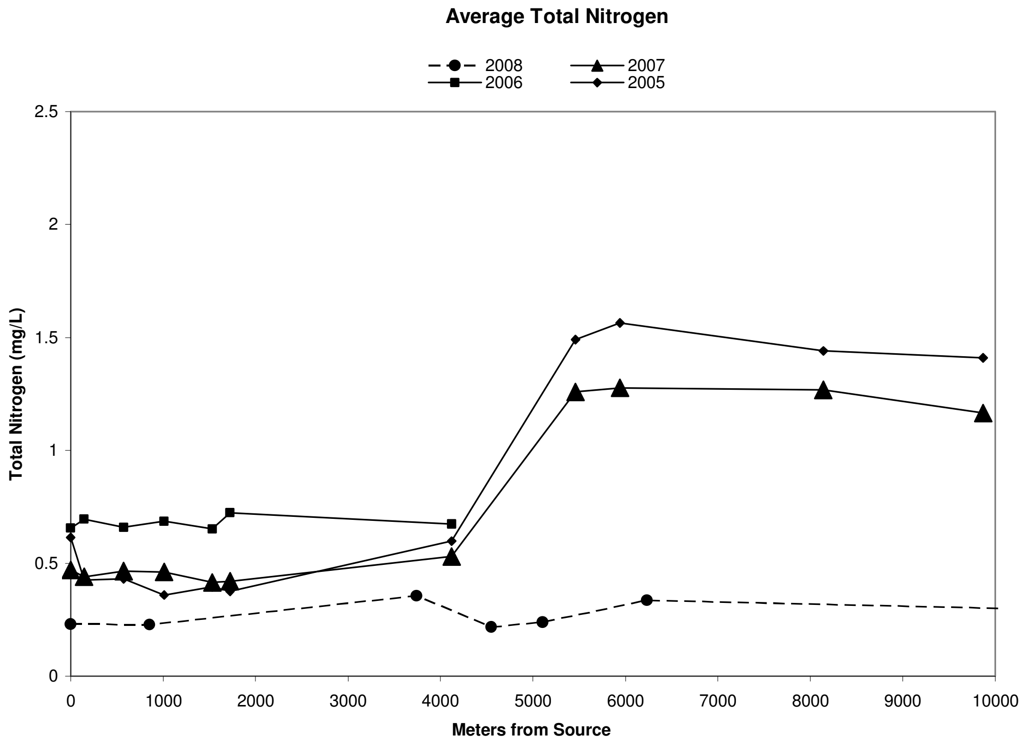

Figure 9. Total Nitrogen profile of the Susquehanna, summers 2005 (Bauer 2006), 2006 (Zurmuhlen 2007), 2007 (Coyle 2008), and 2008.

Fecal Coliforms

Although relatively harmless themselves, fecal coliform bacteria populations can be used to indicate the presence of fecal matter in a body of water and the harmful bacteria which usually accompany it. The average concentration of fecal coliform bacteria this summer was 43 colonies/mL, a decrease of 172 colonies/mL from last year's average of 215 colonies/mL (Coyle 2007). The 2008 fecal coliform readings were only taken from one set of samples (collected on 19 August), so the average may not accurately represent the Susquehanna fecal coliform levels for the whole summer. Figure 10 is a graph of mean fecal coliform levels for 1998-2008.

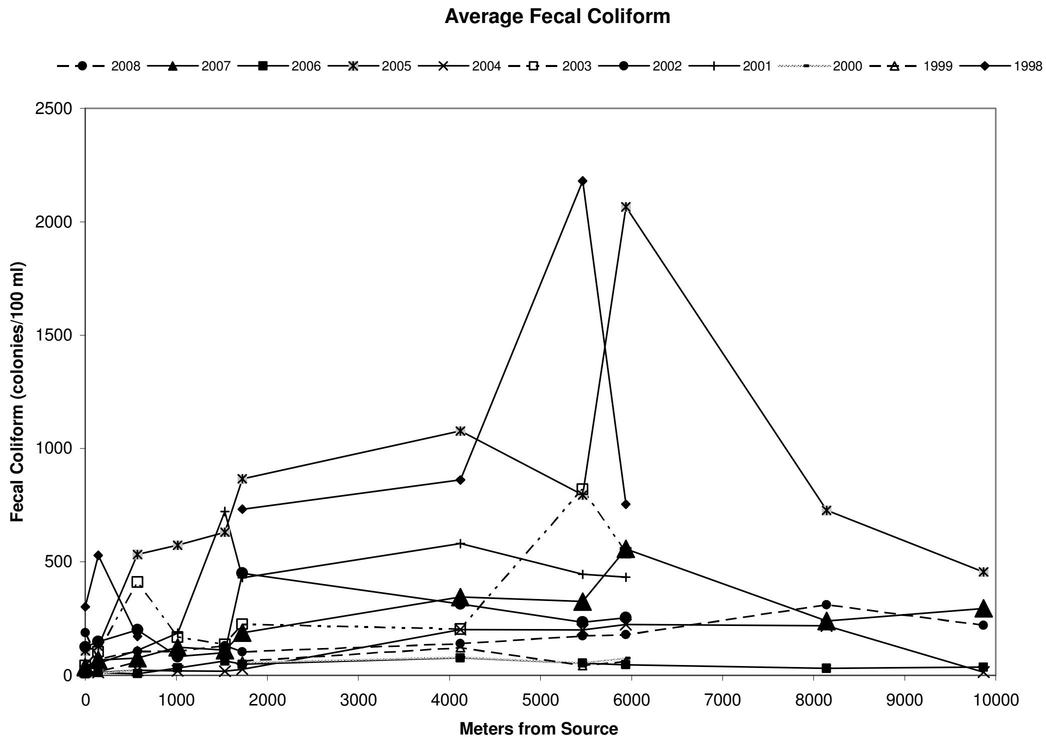

Figure 10. Mean fecal coliform profile of the Susquehanna, summers1998 (Dewey 1999), 1999 (Dietz 2000), 2000 (Hill 2001), 2001 (Hill 2002), 2002 (Schlierman 2003), 2003 (Polus 2004), 2004 (Hill 2005), 2005 (Bauer 2006), 2006 (Zurmuhlen 2007), 2007 (Coyle 2008), and 2008.

SUMMARY AND CONCLUSIONS

The Susquehanna River seems to have almost completely recovered from the effects of the severe flooding that it experienced in 2006. Temperature and pH along the river showed little variation from previous years. The specific conductivity average for this year was 13.4% lower than last year's average, but it still lies within the Susquehanna's recent historical conductivity ranges.

The dissolved oxygen concentration has increased by 8.6% from last year's. Correspondingly, the levels of nutrients such as Total Phosphorus, Total Nitrogen, ammonia and Nitrate+Nitrite have decreased. The increase in dissolved oxygen content is positive because a higher level of dissolved oxygen makes the Susquehanna for more species of game fish and other forms of aquatic life, and the decrease in nutrients indicates that the river is not in danger of nutrient loading, which might result in algal booms that depress the dissolved oxygen content. This decrease in nutrients may be related to an increase in river flow in 2008; a flow increase would dilute the nutrient and fecal coliform content of the river and lower the concentrations (Albright, personal communication).

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