

Eagle Point Golf Course Stormwater Assessment UNCW-CMS Report 09-05

To
New Hanover County Planning Department
North Carolina Coastal Federation
Eagle Point Golf Course
North Carolina State University

By

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Executive Summary

In order to obtain preliminary water quality information to guide future pollution mitigation measures, the University of North Carolina Wilmington's Aquatic Ecology Laboratory, a part of the Center for Marine Science, conducted a water sampling program on Eagle Point Golf Course, located in New Hanover County. The course is close to the Atlantic Intracoastal Waterway and the course runoff enters Little Creek, an unclassified tidal creek that joins Middle Sound, which is classified as SA ORW waters. Sampling was performed on six occasions from January-June 2009, at seven locations. Two sites receive surface runoff from off-site, one site receives water from off-site through a force main, one site is a pond on the course, two sites contain water that leaves the course and enters Little Creek, and one site is in Little Creek proper. At all sites, turbidity and suspended solids were usually low and non-problematic. Neither nitrate nor orthophosphate was found in elevated concentrations, demonstrating that Eagle Point Golf Course has good on-site nutrient management practices. Algal blooms were rare on-course, and chlorophyll *a* concentrations in Little Creek were very low, again verifying good nutrient management.

However, high fecal coliform bacteria counts occurred at both of the input sites that receive stormwater runoff from off-site. Concurrent with these elevated counts, the two sites that measured course discharges into upper Little Creek also showed high fecal bacteria counts, and Little Creek had fecal coliform counts exceeding the NC recreational water contact standard on two occasions, and counts exceeding the US shellfish water standards on three of the six occasions sampled. We note here that the site measuring force main inputs had generally low fecal coliform counts (as well as other pollutants) and this input does not appear to be a water quality problem. However, fecal bacteria entering the course from off-site via stormwater runoff is a significant problem to Eagle Point Golf Course and Little Creek. Thus, we conclude that stormwater best management practices (BMPs) and Low Impact Development (LID) measures need to concentrate on reduction of present and future fecal bacteria inputs into the course, and releases from the course to Little Creek. Since phytoplankton in the upper creek appear to be phosphorus-limited, and there is a correlation between fecal coliforms and phosphorus, control of phosphorus runoff should be a secondary consideration for BMPs.

Introduction

In 2003, Eagle Point Golf Course (Figure 1) entered ~218 acres of the 231.5 acre site into a conservation easement agreement with the North Carolina Coastal Federation, to ensure that the property would be retained in perpetuity in a predominantly natural, scenic and open space condition. In addition to preserving conservation values, Eagle Point provides important functions as a riparian buffer for the adjacent Little Creek and Middle Sound estuary, as the course is situated between intense urban development and an extremely fragile and valuable estuary. Although conservation measures taken by Eagle Point Golf Course have greatly minimized its stormwater runoff contribution to adjacent Little Creek, the course receives and absorbs significant off-site stormwater runoff from offsite sources such as the heavily-developed Porters Neck development and Golf Course, as well as from additional newly-constructed roadways and rapidly-increasing development found upstream from Eagle Point Golf Course. UNCW's 2001 water quality sampling of Little Creek (Mallin et al. 2002a) yielded mostly positive results, indicated in the following excerpts: "...Little Creek is a high-salinity system with few water quality problems." and "Thus, based on limited data, Little Creek was in generally good condition, although there is potential for occasional fecal bacterial contamination." However, since the 2001 sampling, upstream development has increased dramatically, and both Eagle Point Golf Course owners and area residents have expressed greater concerns about the water quality impacts associated with the increase in polluted stormwater runoff, and the inability of the existing on-site stormwater management systems to protect Little Creek and Middle Sound estuary.

This project will allow a team to design a water quality master plan for stormwater management at the Eagle Point Golf Course and surrounding lands using Low Impact Development (LID) measures and/or stormwater best management practices (BMPs). The team will evaluate the hydrologic, topographic and vegetative characteristics and stormwater runoff patterns and chemical composition of the waters. This information will be used to develop a water quality management plan for the 231.5-acre project site and adjacent properties (as needed).

The monitoring and research component of the LID demonstration project has been designed to demonstrate the water quality improvements obtained by installing these infiltration and treatment practices. According to Dr. Michael Burchell of North Carolina State University, there has been very little research in coastal North Carolina to demonstrate the water quality benefits for coastal shellfishing waters that can be obtained by installing LID practices. This preliminary water quality research (in this report) has been conducted by the Dr. Michael Mallin's Aquatic Ecology Laboratory, of the University of North Carolina Wilmington's Center for Marine Science.

Monitoring will be divided into three parts. First, the quality and quantity of stormwater entering and leaving the project site will be determined prior to any installation of LID practices (this report). Second, assuming successful receipt of further funding, the quality and quantity of stormwater leaving the portions of the project site where LID practices are installed as a result of this project will be determined. And finally, the

quality and quantity of stormwater inputs and outputs coming directly to and from individual installed LID practices will be determined.

Methods

The water quality research for this mini-grant was performed between January and July of 2009. Water quality sampling performed by UNCW included water temperature, conductivity/salinity, pH, dissolved oxygen, and turbidity, all by use of YSI field instrumentation. Water samples were collected on site by hand for fecal coliform bacteria, total suspended solids (TSS), chlorophyll *a*, nitrate, total nitrogen, orthophosphate, and total phosphorus determination. Laboratory analyses were performed utilizing Standard Methods (APHA 1995) and EPA procedures (USEPA 1997; Welschmeyer 1994). Samples were collected at seven stations from areas where stormwater enters the course, critical areas on the course impacted by stormwater (i.e., the creek on course), and the receiving creek off-site (Table 1; Figure 1).

Three inflow areas to the course were sampled. These were EP-PNRIN, a water body on the 4th hole that receives stormwater drainage inflow from an Assisted Living Center located across Porters Neck Road; EP-GATEIN, an area near the main gate of the golf course where stormwater from outside the course (Bald Eagle Lane and possibly some of Porters Neck Road) collects; and EP-FMIN, a stream site on the 6th hole where a force main delivers off-site water into the course. Two outflow areas were sampled on the course. These were EP-BROUT, the headwaters of Little Creek on the course sampled from a small footbridge under the entrance road to the course; and EP-OUT18, a low area adjacent to the 18th hole where drainage enters into the marsh bordering upper Little Creek. One pond on the course was sampled, the pond on the par 3 course was sampled from a bridge crossing the pond. Finally, one station was sampled in Little Creek proper from a dock in the backyard of a friendly property owner on 8101 Bald Eagle Lane (EP-LC). Samples were collected on the following dates: January 28, March 3, March 17, April 24, May 28, and June 17. We note that the June sample differed from the others because work had already commenced on a constructed wetland upstream of EP-BROUT and a lightning strike had affected a pump on the course as well. The EP-GATEIN site was dry on the dates of the January and April samplings.

Data were entered into Excel spreadsheets with summary statistics for each measured parameter (Tables 2-8). For several parameters, correlation and regression analyses were performed to explore potential relationships between parameters using a significance level of $\alpha = 0.05$.

Results

Water Temperature: Water temperatures ranged from 4.5°C in early March to 36.9°C in late May. In general, water temperatures were highest at the inflow site from Porters Neck Road (EP-PNRIN) and lowest in Little Creek (EP-LC).

Salinity: Four of the sites were freshwater throughout the study. One of the outflowing sites, EP-OUT18, was oligohaline with a mean salinity of 1.1 psu (practical salinity units), ranging from 0.6-1.4 psu. The Little Creek site was euhaline with a mean salinity of 31.4 psu ranging from 25.4-34.8 psu.

Dissolved oxygen: The State of North Carolina has a fresh and brackish water standard of 5.0 mg/L (ppm) for dissolved oxygen (DO). This standard was not violated during the January-March sampling (Table 2). In April there was mild hypoxia (low DO) at EP-PNRIN (3.3 mg/L), EP-BROUT (4.5 mg/L) and EP-OUT18 (4.2 mg/L). In May there was more severe hypoxia at EP-GATEIN (2.6 mg/L) and EP-OUT18 (1.6 mg/L). In June all sites had DO below the standard except for EP-PNRIN (6.6 mg/L). We note that warmer water holds less DO, and some decrease with increasing water temperatures is expected. On average, the lowest DO was observed at EP-OUT18, a somewhat stagnant area (4.8 mg/L), and the highest where the force main enters the stream on-course at EP-FMIN (10.6 mg/L).

Turbidity: the State of North Carolina has a freshwater turbidity standard of 50 NTU (nephelometric turbidity units) and a brackish water standard of 25 NTU. Between January and May, turbidity was at or below 16 NTU at all sites except for an outlier of 65 NTU at the force main site EP-FMIN (Table 3). In June there was a large peak of 602 NTU at the EP-GATEIN, reflecting effects from construction of the wetland upstream of the site. In general median turbidities reflect low turbidity.

Total suspended solids (TSS): There are no ambient water quality standards for TSS in North Carolina. Our laboratory considers concentrations above 25 mg/L to be elevated for water bodies on the Coastal Plain. On most sampling occasions, TSS concentrations were low, in single digits (Table 4). The few occasions where it was elevated occurred when turbidity was elevated as well. The highest level occurred in June downstream of the wetland construction. Overall, the highest median on-course TSS concentrations were found at the force main input site (EP-FMIN), although with one exception concentrations here were not high. For all data combined there was a very strong correlation between TSS and turbidity ($r = 0.99$, $p < 0.001$).

Nitrate: Nitrate is a commonly-elevated inorganic nutrient found in golf course runoff (Mallin and Wheeler 2000; Line et al. 2002). This was, however, not the case on Eagle Point Golf Course where nitrate concentrations were low (Table 5). Across all sites, nitrate-N concentrations ranged from 3.5 to 529.7 $\mu\text{g/L}$, with a mean of 63.2 and median of 37.2 $\mu\text{g/L}$. The highest concentration was observed in January at EP-PNRIN, which likely represented inputs from across Porters Neck Road rather than nitrate generated by Eagle Point. The second highest observed nitrate level was at the course outfall area EP-BROUT on March 17. On this date, the nitrate level at Little Creek was also elevated relative to other sampling dates for that site (Table 5). Nitrate concentrations in mid-course and outflowing areas were quite low compared to similar sites on several golf courses in New Hanover and Brunswick Counties (Mallin and Wheeler 2000). Thus, fertilization practices on Eagle Point apparently keep excess nitrate concentrations to a minimum. Compared with a selection of upland draining, mesohaline tidal creeks in

New Hanover County, nitrate concentrations in Little Creek were much less than levels in the upper creeks and similar to areas in mid-creek, nearer the Intracoastal Waterway (Mallin et al. 2004).

Total nitrogen: Total nitrogen (TN) reflects both inorganic nitrogen (nitrate and ammonium) and organic nitrogen. Project-wide, TN ranged from a minimum of 228.6 µg/L to 3,877.2 µg/L, with a mean and median of 926.3 and 766.3 µg/L, respectively. Spatially, the two sites with the highest mean TN values were the surface inflow sites EP-PNRIN and EP-GATEIN, with 1328.7 and 1377.1 µg/L, respectively, while the force main site EP-FM had an average of only 434.8 µg/L. Average TN values for the outflowing sites EP-BROUT and EP-OUT18 were 1056.7 and 937.5 µg/L, respectively, while Little Creek averaged 450.4 µg/L. None of the average TN concentrations among these sites are high in comparison to area creeks and waterways (Mallin et al. 2000; 2002; 2004).

Orthophosphate: Orthophosphate is the major inorganic form of phosphorus found in aquatic systems, and is a component of fertilizers. Compared with other land uses phosphorus export from golf courses can be high (Line et al. 2002). Across all Eagle Point sites, orthophosphate-P concentrations ranged from 3.8 to 276.9 µg/L, with a mean of 86.0 and median of 56.6 µg/L (Table 6). The highest orthophosphate concentrations on average were found at the stormwater inflow site EP-GATEIN, where mean and median orthophosphate concentrations were just below 200 µg/L (Table 6). Except for this sampling site, orthophosphate concentrations on this course were at or somewhat above concentrations found in a selection of New Hanover and Brunswick County golf courses (Mallin and Wheeler 2000). With the exception of elevated concentrations in March and June, orthophosphate concentrations in Little Creek were similar to concentrations found in several New Hanover County tidal creeks, both with and without golf courses (Mallin et al. 2004). In other area systems orthophosphate concentrations have been positively correlated with particulate matter (Mallin et al. 2002b). However, for the Eagle Point data there was no significant correlation between orthophosphate and either turbidity or TSS ($p > 0.05$).

Total phosphorus: Total phosphorus (TP) is comprised of inorganic and organic phosphorus. Across all sites, TP concentrations ranged from 11.0 to 482.5 µg/L, with a mean of 162.9 and median of 128.2 µg/L. Maximum concentrations were observed at the EP-GATEIN site, with a mean of 363.9 and median of 360.5 µg/L, while minimum values were in Little Creek (mean 55.7 µg/L) and the force main site (63.4 µg/L). Eagle Point TP concentrations were not as high as those found in a Piedmont North Carolina golf course (Line et al. 2002).

Nitrogen/phosphorus ratios: Algae generally contain nitrogen and phosphorus in molar ratios of approximately 16 (the Redfield ratio). When a water body has N/P ratios well exceeding 16, the growth of phytoplankton is generally considered to be limited by phosphorus inputs, and if N/P ratios are well below 16, phytoplankton growth is considered to be limited by nitrogen availability. Considering the entire data set, the mean and median TN/TP ratios were 17.8 and 14.0, respectively, essentially around the

Redfield ratio. Interestingly, the mean and median TN/TP ratios at input site EP-PNRIN were 24.9 and 24.0, while at the other surface inflow site EP-GATEIN they were 8.3 and 8.1, respectively, indicating that the stormwater-driven sources for these two sites were from quite different nutrient sources. We might conjecture that at the Porter's Neck Road site, the inputs were more dominated by fertilizer runoff with a higher N/P ratio, while near the gate site off Eagle Point Road, inputs may contain more phosphorus due to pet waste inputs (although we have not tested these hypotheses). Suburban lawns and driveways in residential areas are known to produce elevated phosphorus loads in runoff (Bannerman et al. 1993). In Little Creek, mean and median TN/TP ratios were 28.2 and 23.1, respectively, indicating that at least during this sampling period, phosphate inputs to the creek would be most likely to stimulate algal production. Phosphorus limitation of the upper regions of area tidal creeks has been experimentally verified, especially in spring, whereas limitation by N is common in higher salinity areas in the tidal creeks in New Hanover County (Mallin and Wheeler 2000; Mallin et al. 2004). Regardless, both nitrate and orthophosphate in the water samples from the course were generally low; offering little stimulation for potential algal bloom formation in Little Creek.

Chlorophyll a: Chlorophyll a is a common algal pigment that is used extensively as measure of phytoplankton biomass in water bodies. The State of North Carolina has a water quality standard of 40 µg/L (ppb) for both fresh and brackish water, above which is considered indicative of algal bloom-impacted waters. Most of the sites remained well below the water quality standard for each sampling event (Table 7). However, EP-OUT18 exceeded the standard considerably in both January and April. As this station receives runoff and associated nutrients from the golf course, and it is a site that is not well-flushed, the blooms are not surprising. It is notable that one of the input sites, EP-PNRIN, had minor blooms in April and June. This could represent phytoplankton entering the course from the pond across the road or minor blooms forming in response to nutrients from across the road. Eagle Point does maintain practices (black dye and copper sulfate) designed to limit algal bloom growth in ponds on-site.

We also note that Little Creek (EP-LC) maintained low chlorophyll a concentrations on all occasions sampled. Compared with other area tidal creeks (Mallin et al. 2004), the concentrations in Little Creek are much lower than those in the upper and middle areas of the creeks, and similar to sites adjoining the Intracoastal Waterway. Other tidal creeks that drain golf courses (Hewletts and Howe Creeks) show periodic algal blooms with chlorophyll concentrations well exceeding the North Carolina water quality standard (Mallin et al. 2004). As mentioned above, little nitrate appears to enter this creek, but there are periodic occasions when orthophosphate is somewhat elevated in the creek. Regardless, our sampling did not detect algal blooms during this study. In a four-month study from April-July 2001 our laboratory also found low chlorophyll a concentrations in all three areas of Little Creek that were sampled (Mallin et al. 2002).

Fecal coliform bacteria: Fecal coliform bacteria are enteric bacteria that may or may not be pathogenic, but are commonly used as indicators of the presence of potential pathogenic bacteria and viruses. North Carolina has a freshwater standard of 200 CFU

(colony-forming units)/100 mL of water for human contact (recreational waters) and there is a Federal shellfishing waters standard of 14 CFU/100 mL. The data show that Eagle Point Golf Course on occasion receives excessive fecal coliform bacteria from surface runoff and can at times export these bacteria into Little Creek (Table 8). The highest concentrations overall were found at EP-GATEIN and EP-PNRIN (which receive stormwater runoff from outside of the course), although the force main was not a problem in term of fecal bacteria inputs. In residential areas lawns and driveways have been shown to produce high concentrations of fecal bacteria in stormwater runoff (Bannerman et al. 1993). The par 3 pond (EP-POND3) had elevated fecal coliform counts only once, but the outflow stations EP-BROUT and EP-OUT18 both had high fecal bacteria counts on two occasions each. On those occasions, high counts also occurred at either EP-GATEIN or EP-PNRIN, or both input sites at the same time. Geometric mean fecal coliform concentrations in the outflow areas of Eagle Point were higher than those found in three out of four other area golf courses (Mallin and Wheeler 2000).

Twice (March and June) there were counts in Little Creek (EP-LC) that exceeded the human contact standard of 200 CFU/100 mL, and in April the counts exceeded the shellfishing standard (although counts on the course were not particularly high in April - Table 8). For similar salinity ranges, the geometric mean fecal coliform counts in Little Creek were greater than those of other area tidal creeks (Mallin et al. 2000) although we note that elevated salinities persist farther upstream in Little Creek compared with those other creeks (and closer to inland sources). The data indicate that the fecal coliform counts in our study do not bode well for continued open-status for shellfishing in this creek. In a four-month study from April-July 2001 our laboratory found considerably lower fecal coliform bacteria counts in all three areas of Little Creek that were sampled (Mallin et al. 2002b). Thus, based on limited data, fecal bacteria counts in this creek may be increasing along with increasing urbanization in this area.

In other area ecosystems, fecal coliform bacteria have shown strong positive relationships with particulate matter, either turbidity or TSS (Mallin et al. 2000, Mallin et al. 2002b). For all data combined on Eagle Point there was a significant positive relationship between fecal coliform bacteria and turbidity ($p = 0.03$). Statistical analysis produced the following regression equation:

$$\text{Fecal coliform concentrations} = 4.23(\text{turbidity}) + 546.8$$

However, the r^2 value was only 0.12, meaning that turbidity explains only about 12% of the variability in fecal coliform concentrations. Additionally, there was no significant relationship between fecal coliforms and TSS ($p > 0.05$). Thus, the majority of these bacteria are apparently not associated with particulate matter and are moving through the course waterways as free-living organisms.

Interestingly, orthophosphate was significantly, although not strongly, correlated with fecal coliform bacteria ($r^2 = 0.36$, $p = 0.023$). Phosphorus is a principal nutrient required by bacteria and has been found to be positively correlated to fecal bacteria in estuarine

locations in New Hanover County (Mallin et al. 2000). In experiments, additions of phosphorous have significantly stimulated sediment fecal bacteria growth in some instances (Toothman 2006).

Summary

Clearly, the biggest water quality issue with Eagle Point Golf Course is the high fecal bacteria counts that apparently originate from outside of the course, and enter Eagle Point as stormwater runoff. These bacteria pass through Eagle Point and rather readily from there enter Little Creek. On half of the sampling occasions, fecal coliform bacteria in Little Creek exceeded standards for safe shellfishing.

Compared with other area golf courses, nutrient concentrations on this golf course were surprisingly low. Management has noted that they utilize a GPS-based automated fertilizer spreader that is designed to deliver what nutrients are needed at the appropriate locations. Soil samples are sent to USDA, and these practices in combination are designed to minimize overuse of fertilizers. The low chlorophyll a concentrations in Little Creek reflect generally low inorganic nutrient (especially nitrate) inputs to the creek. We also note that measures of suspended material, turbidity and TSS, showed that these issues were not a problem at Eagle Point, even following rain events. As noted earlier, there was little influence of particulate matter on fecal coliform bacteria concentrations in this system.

Inputs from the force main contained generally low fecal coliform bacteria counts, and low nitrate and orthophosphate concentrations. Other than on one occasion, turbidity and TSS were also low where this input enters the creek on-course. Thus, the data indicate that inputs from the force main are not problematic to Eagle Point Golf Course or Little Creek; rather, surface inputs (from stormwater runoff) are the problem.

Thus, we conclude that fecal bacteria entering the course from off-site in stormwater runoff and exiting the course are a significant problem to Eagle Point Golf Course and Little Creek. We recommend that stormwater best management practices (BMPs) and Low Impact Development (LID) measures need to concentrate on reduction of present and future fecal bacteria inputs into the course, and releases from the course to Little Creek. As suspended matter measures are generally low, reduction or removal of free-living fecal bacteria should be targeted. Since phytoplankton in the upper creek appear to be largely phosphorus-limited, and there is a significant (although weak) correlation between fecal coliforms and phosphorus, control of phosphorus runoff should be a secondary consideration for BMPs.

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Table 1. Location of water sampling sites on and near Eagle Point Golf Course

Site	Location / Coordinates
EP-PNRIN GPS	Near Porters Neck Road at 4 th hole, input from across road N 34 17.443 W 77 45.853
EP-GATEIN GPS	Entrance bridge over low area, stormwater collection point N 34 17.108 W 77 45.300
EP-PAR3 GPS	Par 3 course pond bridge N 34 17.184 W 77 45.287
EP-FMIN GPS	Where force main enters 6 th hole stream N 34 17.300 W 77 45.538
EP-BROUT GPS	Footbridge where creek leaves to enter upper Little Creek N 34 17.108 W 77 45.404
EP-OUT18 GPS	low area 18 th hole near marsh, outflow to Little Creek marsh N 34 16.968 W 77 45.606
EP-LC	In Little Creek off dock of Winterbauer home 8101 Bald Eagle Lane

Table 2. Dissolved oxygen concentrations (mg/L) on Eagle Point golf course, January-June 2009.

date	EP-PNRIN	EP-GATEIN	EP-BROUT	EP-POND3	EP-OUT18	EPFMIN	EP-LC
1/28/09	11.0	NA	13.4	12.4	9.2	14.0	9.3
3/3/09	12.4	9.0	11.9	10.9	6.7	12.8	10.7
3/17/09	9.9	7.7	9.9	10.7	5.5	11.3	10.4
4/24/09	3.3	NA	4.5	6.3	4.2	9.5	6.2
5/28/09	6.9	2.6	5.3	8.7	1.6	11.8	6.0
*6/17/09	6.6	4.2	2.9	4.9	1.5	4.1	2.5
median	8.4	6.0	7.6	9.7	4.9	11.6	7.8
mean	8.4	5.9	8.0	9.0	4.8	10.6	7.5
std dev	3.4	3.0	4.3	2.9	3.0	3.5	3.2
max	12.4	9.0	13.4	12.4	9.2	14.0	10.7
min	3.3	2.6	2.9	4.9	1.5	4.1	2.5

* Digging begun on GATEIN site and lightning struck pump house so no flow at FMIN.
 BOLD - denotes when DO fell below NC standard of 5 mg/L
 NA - insufficient water to get data or sample

Table 3. Turbidity concentrations (NTU) on Eagle Point golf course, January-June 2009.

Date	EP-PNRIN	EP-GATEIN	EP-BROUT	EP-POND3	EP-OUT18	EPFMIN	EP-LC
1/28/09	3	NA	1	3	4	1	1
3/3/09	2	9	5	4	1	13	1
3/17/09	6	4	9	5	14	65	4
4/24/09	16	NA	1	2	3	2	4
5/28/09	1	1	6	1	1	1	5
*6/17/09	10	602	11	1	5	8	16
median	5	7	6	3	4	5	4
mean	6	154	6	3	5	15	5
std dev	6	299	4	2	5	25	6
max	16	602	11	5	14	65	16
min	1	1	1	1	1	1	1

* Digging begun on GATEIN site and lightning struck pump house so no flow at FMIN.
 BOLD - denotes when turbidity exceeded NC freshwater standard of 50 NTU
 NA - insufficient water to get data or sample

Table 4. Total suspended solids (TSS) concentrations (mg/L) on Eagle Point Golf Course, January-June 2009.

Date	EP-PNRIN	EP-GATEIN	EP-BROUT	EP-POND3	EP-OUT18	EPFMIN	EP-LC
1/28/09	7	NA	1	4	3	0	6
3/3/09	2	5	4	6	2	20	10
3/17/09	2	1	5	2	2	64	12
4/24/09	36	NA	1	2	12	2	21
5/28/09	2	6	4	2	2	2	15
*6/17/09	5	1140	5	4	2	12	29
median	4	6	4	3	2	7	14
mean	9	288	3	3	4	17	16
std dev	13	568	2	2	4	24	8
max	36	1140	5	6	12	64	29
min	2	1	1	2	2	0	6

* Digging begun on GATEIN site and lightning struck pump house so no flow at FMIN.
 NA - insufficient water to get data or sample

Table 5. Nitrate-N concentrations ($\mu\text{g/L}$) on Eagle Point Golf Course, January-June 2009.

Date	EP-PNRIN	EP-GATEIN	EP-BROUT	EP-POND3	EP-OUT18	EPFMIN	EP-LC
1/28/09	529.7	NA	34.2	19.3	4.0	4.9	18.2
3/3/09	66.1	104.0	148.1	48.8	6.8	45.2	7.7
3/17/09	65.5	54.1	337.9	52.1	74.2	73.8	90.1
4/24/09	11.0	NA	3.7	13.9	6.8	55.8	6.0
5/28/09	35.8	10.1	19.8	3.5	13.6	9.9	7.4
*6/17/09	38.6	79.4	61.3	20.0	97.5	132.8	18.3
median	52.1	66.8	47.8	34.4	10.2	50.5	13.0
mean	124.5	61.9	100.8	42.9	33.8	53.7	24.6
std dev	199.6	40.1	126.8	42.1	41.1	47.0	32.6
max	529.7	104.0	337.9	119.3	97.5	132.8	90.1
min	11.0	10.1	3.7	3.5	4.0	4.9	6.0

* Digging begun on GATEIN site and lightning struck pump house so no flow at FMIN.
NA - insufficient water to get data or sample

Table 6. Orthophosphate-P concentrations ($\mu\text{g/L}$) on Eagle Point Golf Course, January-June 2009.

Date	EP-PNRIN	EP-GATEIN	EP-BROUT	EP-POND3	EP-OUT18	EPFMIN	EP-LC
1/28/09	82.4	NA	10.5	155.9	48.9	3.8	11.8
3/3/09	21.6	185.9	123.1	151.3	33.2	7.7	15.0
3/17/09	19.5	207.3	171.1	162.2	87.5	16.1	77.2
4/24/09	21.7	NA	56.5	159.0	43.7	8.3	7.7
5/28/09	18.9	182.0	56.6	103.1	153.5	9.8	5.8
*6/17/09	22.6	164.9	240.9	276.9	205.3	46.6	63.1
median	21.7	184.0	89.9	157.5	68.2	9.1	13.4
mean	31.1	185.0	109.8	168.1	95.4	15.4	30.1
std dev	25.2	17.4	85.6	57.6	69.6	15.8	31.5
max	82.4	207.3	240.9	276.9	205.3	46.6	77.2
min	18.9	164.9	10.5	103.1	33.2	3.8	5.8

* Digging begun on GATEIN site and lightning struck pump house so no flow at FMIN.
NA - insufficient water to get data or sample

Table 7. Chlorophyll a concentrations (µg/L) on Eagle Point Golf Course, January-June 2009.

Date	EP-PNRIN	EP-GATEIN	EP-BROUT	EP-POND3	EP-OUT18	EPFMIN	EP-LC
1/28/09	3.1	NA	1.4	12.3	73.0	2.3	1.0
3/3/09	3.1	18.5	3.1	12.7	13.1	5.1	1.1
3/17/09	7.0	11.9	4.4	15.5	6.5	9.0	2.3
4/24/09	29.0	NA	7.4	3.7	138.0	10.0	2.0
5/28/09	6.0	11.0	7.0	5.0	19.0	3.0	1.0
*6/17/09	33.1	15.5	20.1	13.3	18.4	14.8	3.5
median	6.5	13.7	5.7	12.5	18.7	7.1	1.6
mean	13.6	14.2	7.2	10.4	44.7	7.4	1.8
std dev	13.7	3.5	6.7	4.8	51.6	4.8	1.0
max	33.1	18.5	20.1	15.5	138.0	14.8	3.5
min	3.1	11.0	1.4	3.7	6.5	2.3	1.0

* Digging begun on GATEIN site and lightning struck pump house so no flow at FMIN.
 BOLD - denotes when chlorophyll a exceeded NC standard of 40 µg/L
 NA - insufficient water to get data or sample

Table 8. Fecal coliform bacteria concentrations (CFU/100 mL) on Eagle Point Golf Course, January-June 2009.

Date	EP-PNRIN	EP-GATEIN	EP-BROUT	EP-POND3	EP-OUT18	EPFMIN	EP-LC
1/28/09	15	NA	29	6	5	0	10
3/3/09	15	760	50	14	39	39	3
3/17/09	580	1,875	1,375	24	175	95	850
4/24/09	29	NA	118	43	11	10	76
5/28/09	330	3,530	85	61	3,390	43	7
*6/17/09	>5,000	3,150	585	1,285	1,105	380	275
Geomean	66	1,995	151	44	106	20	39
mean	194	2,329	374	239	788	95	204
std dev	254	1,263	533	513	1,343	144	333
max	580	3,530	1,375	1,285	3,390	380	850
min	15	760	29	6	5	0	3

* Digging begun on GATEIN site and lightning struck pump house so no flow at FMIN.
 BOLD - denotes when fecal coliforms exceeded NC standard of 200 CFU/100 mL
 NA - insufficient water to get data or sample



Plate 1. Course input site EP-PNRIN; Porters Neck Road beyond white fence in background.

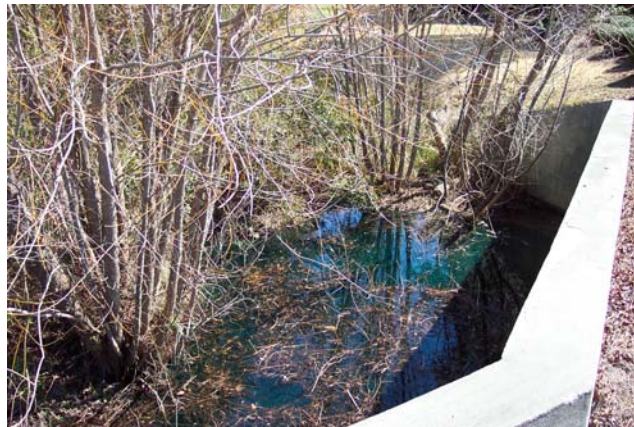


Plate 2. Course stormwater input site EP-GATEIN near main gate.



Plate 3. Course input site EP-FM, force main input.



Plate 4. Sampling site on pond on par 3 course EP-POND3, from bridge.



Plate 5. Course outflow site from small bridge, EP-BROUT.



Plate 6. Course outflow site between holes 1 and 18 in low area, EP-OUT18.



Plate 7. Little Creek sampling site from Winterbauer property EP-LC, with Eagle Point golf Course in background across creek.



Figure 1. Map of Eagle Point Golf Course showing water quality sampling sites. Porter's Neck Road is near the top of the map and Bald Eagle Lane is to the right, bordering Little Creek.