CITY of CHARLOTTE
Pilot BMP Monitoring Program

University Executive Park Dry Detention Basin
Final Monitoring Report

January 2007

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Submitted To:
City of Charlotte-Storm Water Services

Purpose

The purpose of this report is to document monitoring and data analysis activities undertaken by the City of Charlotte, NC and NC State University to determine the effectiveness and stormwater treatment capabilities of the University Executive Park Dry Detention Basin.

Introduction

Dry detention basins are designed primarily to reduce peak flows from urbanized watersheds. In addition, these systems remove some pollutants, primarily by slowing influent stormwater and allowing suspended particles to settle out. Dry detention basins are designed to capture stormwater and slowly release it. Unlike wet detention basins (wet ponds), these systems are designed to completely drain and remain dry in-between rain events. When flood control is a primary concern, dry detention basins are often used to remediate the impact of newly constructed imperious area. In North Carolina, properly designed extended dry detention basins are given credit for the removal of total suspended solids (TSS), total nitrogen (TN), and total phosphorous (TP). NCDENR gives extended dry detention basins credit for 50% TSS removal, 10% TN removal, and 10% TP removal (NCDENR, 2006).

Site Description

The University Executive Park Dry Detention is an extended dry detention basin in Charlotte, NC, treating a commercial office park and its associated parking and landscaped areas. The watershed draining to the detention area is approximately 5.9 acres and has an imperviousness of approximately 70%. The detention basin is fully vegetated with grass, which appears to be well maintained and frequently mowed. Some erosion and sediment deposition has occurred within the detention bottom. Although the inlet to the detention basin is adjacent to the outlet, the topography of the detention bottom causes low flows to follow a circuitous flow path such that influent flows do not circumvent the system. A 24-

inch RCP with a flared end section routes stormwater to the dry detention basin. The invert of the inlet pipe is approximately 6 inches higher than the average elevation of the detention bottom. The outlet utilizes a 14-inch circular orifice to draw down the detained stormwater. The orifice is fixed to a fabricated concrete headwall attached to a 15-inch RCP. A cast-in-place emergency concrete spillway is installed over the detention berm. It is unlikely that the emergency spillway was utilized during any monitoring events (Figure 1).

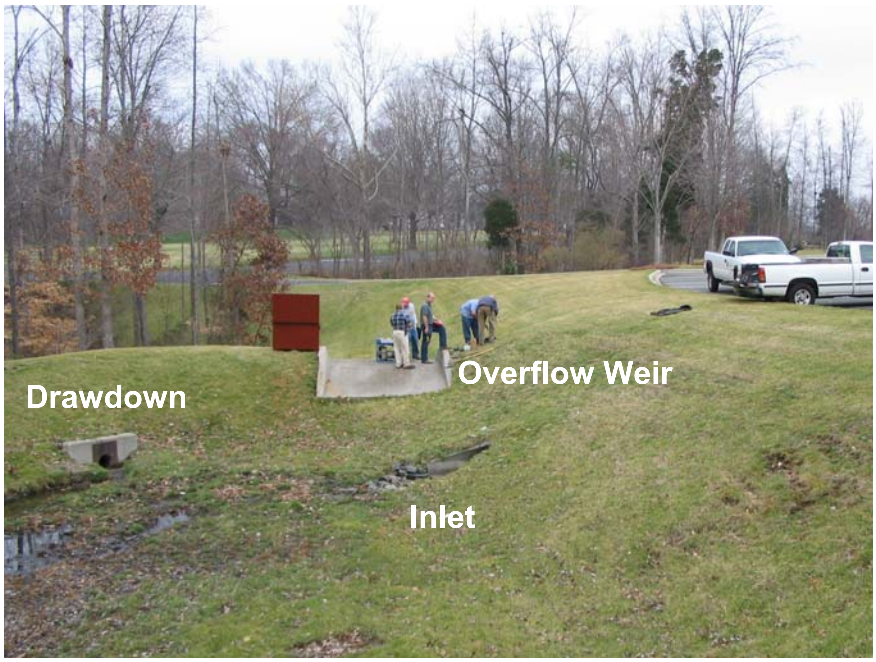

Figure 1: Inlet and Outlet Configuration at University Dry Detention Basin.

Monitoring Plan and Data Analysis

Inlet monitoring took place in the 24-inch reinforced concrete pipe at the south end of the detention basin. During most storm events, this pipe experienced a slight tail water condition. As a result, it was necessary to utilize an Area-Velocity meter at this location. The area velocity probe was installed using an expansion bracket with the probe situated in the bottom of the culvert pointing upstream. The strainer was installed in the invert of the culvert, downstream of the area velocity probe. Drawdown within the detention basin was controlled by a 14” circular orifice. A model 750 bubbler was used in conjunction with a stage-discharge relationship for determination of flow through the outlet. The stage-discharge relationship for the orifice/bubbler combination was determined using an Excel spreadsheet model utilizing common orifice discharge equations. The bubbler was attached to a solid concrete block and situated upstream 12" and to the side 12" of the center of the orifice plate (Figure 2). Bubbler elevation was set so that it was level with the invert of the orifice plate.

Figure 2: Outlet Monitoring at University Dry Detention Basin.

Monitoring efforts were initiated in February 2005 and continued until July 2006, with 17 storm events being collected / measured. Additional manual grab samples, from which levels of fecal coliform, *E. coli*, and oil & grease were measured, were collected for 8 of the 17 storm events.

Average inflow and outflow event mean concentration (EMC) values for each pollutant were used to calculate a BMP efficiency ratio (ER):

$$ER = (EMC_{inflow} - EMC_{outflow}) / EMC_{inflow}$$

where EMC_{inflow} and $EMC_{outflow}$ represent the mean BMP inflow and outflow EMCs across all storm events. Removal rates were also calculated on a storm-by-storm basis. Some authors have suggested that reporting BMP effectiveness in terms of percent removal may not give a completely accurate picture of BMP performance in some situations (Urbonas, 2000; Winer, 2000; Strecker et al., 2001; US EPA, 2002). For example, if the influent concentration of a pollutant is extremely low, removal efficiencies will tend to be low due to the existence of an "irreducible concentration", lower than which no BMP can achieve (Schueler, 1996). For these relatively "clean" storms, low removal efficiencies may lead to the erroneous conclusion that the BMP is performing poorly, when in fact pollutant targets may be achieved. Caution should be used when interpreting BMP efficiency results that rely on a measure of percent or proportion of a pollutant removed.

Water quality data were compiled so paired events could be analyzed for significant changes in water quality from the inlet to the outlet. A student's t test is frequently used to test for statistical significance; however, this test relies on the assumption that the data set being analyzed is normally distributed. For data sets which contain less than 25 samples, it is difficult to determine how the data are distributed. Nevertheless, the data were checked for normality using the Kolmogorov-Smirnov (K-S) test. If the raw data were not normally distributed, a log transform of the data set was performed and it was once again tested for normality. In the case that the K-S test showed normal distribution for both the raw and log-transformed data, the log transform data were chosen for analysis.

Fortunately, there are tests that can show statistical significance regardless of distribution. A Wilcoxian Signed Rank (WSR) test is one example of a non-parametric statistical procedure (can show significance regardless of the distribution of a data set). This procedure was performed in addition to the Student's t test for all parameters. In the case that neither the raw data nor the log-transformed data could be verified as having a normal distribution, the outcome of the WSR was considered the only measure of statistical significance. If a particular data set had conflicting statistical results (Student's t test and WSR had two different results) the WSR was assumed correct. See Appendix A.

Data Analysis Results

Flow Results

The flow data collected from this site were found to be inaccurate, and while suitable for collecting flow-paced samples, could not be used for mass pollutant removal analysis. These flow data consistently showed that the amount of water leaving University Dry Detention basin was substantially more than the amount entering the basin (Figure 3). It is highly unlikely that the detention basin is receiving water from a local watershed (watershed draining to the basin via overland flow), which would be the only reasonable explanation, other than measurement error, for this increase.

The simple method is used by NCDENR (2006) to determine the expected runoff volume that would be produced during a given storm event. During the storm on 2/25/2005, approximately 0.51 inches of rainfall were produced. Using the simple method, the runoff volume from this storm should be approximately 7427 cf. The data collected from the inlet sampling station indicated that the storm produced only 3493 cf, less than half the estimated amount. Conversely, the outlet data show an effluent volume of 8067 cf, similar to the simple method estimate.

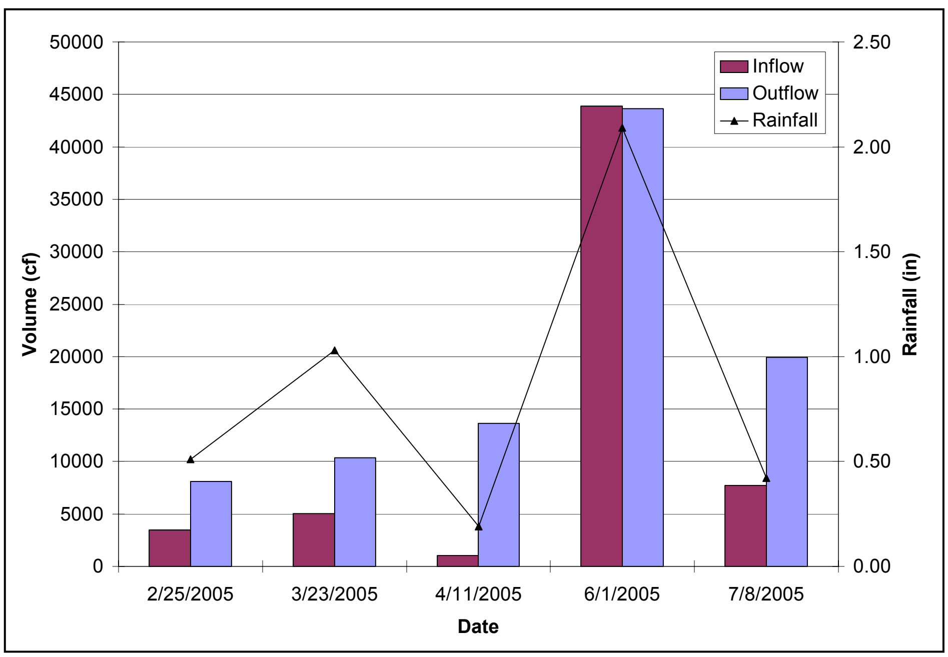

Figure 3: Influent and Effluent Stormwater Volume for First 5 Storms Captured.

This dry detention basin does not appear to receive significant amounts of runoff from a local watershed; thus, it was evident that the inflow data from the basin was in error. It is probable that tail water conditions at the inlet (and the general inaccuracy of area velocity meters used in intermittent flow conditions) caused these erroneous readings. Fortunately, since this BMP is not designed to reduce stormwater volume, the influent volume is assumed to be the same as the effluent volume. Thus, estimates of concentration reductions (efficiency ratios) are assumed to be reasonable estimates of basin function. Mass reduction calculations are not necessary if the inflow volume was reasonably equal to the outflow volume.

Water Quality Results

Figure 5 and Table 1 illustrate the performance of University Dry Detention basin with regard to pollutant removal. The pollutant removal efficiency is described by the efficiency ratio (ER) which is discussed above. A positive ER indicates that the pollutant, which entered the basin as stormwater runoff, was retained by the basin. A negative ER represents a surplus of pollutant leaving the BMP, suggesting either internal production of nutrients, or loss of stored pollutant from previous storm events.

Negative ERs were calculated for COD, fecal coliform, total phosphorous (TP), although none of these pollutant increases were statistically significant ($p<0.05$). This indicates that the basin was potentially a source for these pollutants. The performance of this basin from a water quality stand point varied. Small reductions in sediment and metals were calculated; however, nutrient reductions were inconsistent.

According to statistical tests, University Dry Detention basin significantly ($p<0.05$) reduced the following pollutants in stormwater runoff: NH_4, NOx, and zinc (Figure 5 and Table 1). NH_4 and NOx are not associated with particulate matter, suggesting that there was some microbiological activity in the basin. Zinc tends to be associated with particulate matter, suggesting that there was some settling/sedimentation in University Dry Detention basin.

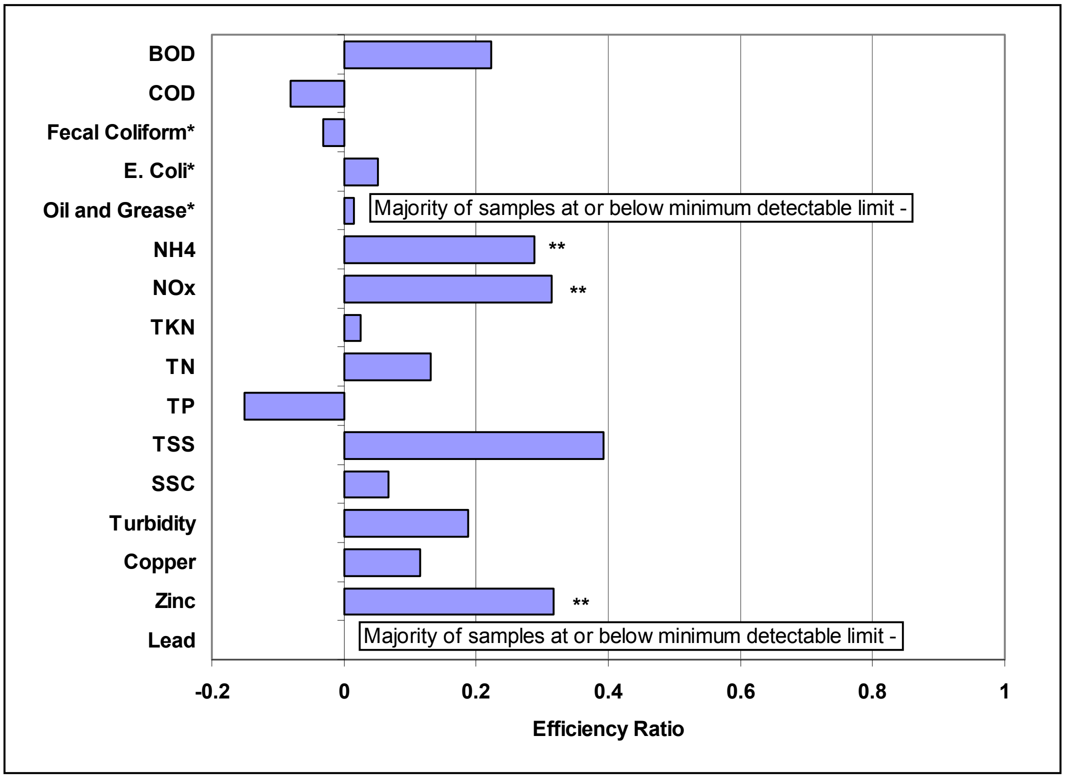

Figure 5: Efficiency ratios of selected pollutants based on pre- and post-BMP mean concentrations (EMCs) at University Dry Detention basin.

*** Grab samples taken to evaluate this pollutant**

**** Indicates a statistically significant relationship**

Efficiency ratio (ER) = $(EMC_{inflow} - EMC_{outflow}) / EMC_{inflow}$

Table 1: Summary of Water Quality Results

Parameter	Units	# of Samples	Influent EMC	Effluent EMC	ER	p-value	Significant ($p < 0.05$)
BOD	ppm	16	4.9	3.8	22%	0.070	
COD	ppm	17	24.1	26.0	-8%	0.151	
Fecal Coliform	col. / 100 ml	9	9532.2	9833.3	-3%	0.148	
E-Coli	MPN / 100 ml	9	1647.8	1563.3	5%	1.000	
NH_4	ppm	17	0.3	0.2	29%	**0.030**	**Yes**
NOx	ppm	17	0.6	0.4	31%	**0.020**	**Yes**
TKN	ppm	17	1.0	1.0	2%	0.927	
TN	ppm	17	1.6	1.4	13%	0.644	
TP	ppm	17	0.2	0.2	-15%	0.080	
TSS	ppm	17	15.8	9.6	39%	0.064	
SSC	ppm	6	12.9	12.0	7%	0.563	
Turbidity	NTU	17	9.0	7.3	19%	0.712	
Copper	ppb	17	4.8	4.2	11%	0.537	
Zinc	ppb	17	76.6	52.4	32%	**0.001**	**Yes**

Sediment

The ER for TSS removal in University Dry Detention basin was 0.39 (significant at α=0.05). This indicates that treatment for TSS is occurring in the basin, likely through sedimentation and filtration. This is potentially related to the ERs noted for other sediment-borne metals that were analyzed (Vaze and Chiew, 2004). State regulations give extended dry detention ponds 50% TSS removal credit, which was not achieved at University. Small particles are not easily removed from a given flow stream; therefore, a TSS removal efficiency of 39% is reasonable.

Table 2 shows the pollutant removal percentages reported by various studies performed on dry detention basins. Winer, 2000, is a compilation of 9 studies performed on stormwater dry ponds that are located in the National Pollutant Removal Performance Database. University Dry Detention functions poorly compared to TSS removal rates reported by other studies. The median effluent TSS concentration determined for University Dry Detention basin is lower than that reported by Winer, 2000 (Table 3). This indicates that University may function adequately given the TSS concentrations it receives. Lower inflow concentrations likely contribute to the relatively low ER reported for University Dry Detention. Inflow and outflow TSS concentrations for each storm can be seen in Appendix A – Figure A1.

Table 2: Comparison of Removal Efficiencies for Various Dry Detention Basins

Parameter	University	Morehead	Winer - CWP, 2000	Schueler - Article 77
NH_4	29	19	--	9
NO_x	31	-6	3.5	-2
Total N (TN)	13	14	25	26
Total P (TP)	-15	-9	19	14
TSS	39	67	47	71
Copper	11	20	26	26
Zinc	32	36	26	26

Table 3: Comparison of Median Effluent Concentration for Various Dry Detention Basins

Parameter	University	Morehead	Winer - CWP, 2000
Total N (TN)	1.33	1.26	0.86
Total P (TP)	0.13	0.13	0.18
TSS	7	5	28
Copper	3.9	5.6	9
Zinc	49	60	98

Nutrients and Organic Material

The removal rates for TN and TP were lower than those found by others (Table 2). The major pollutant removal mechanism typical of dry detention basins is sedimentation (NCDENR, 2006). Since many pollutants are associated with sediment, this pollutant removal mechanism can have a substantial impact (Vaze and Chiew, 2004) on some nutrients. University Dry Detention also exhibited some other removal mechanisms as was evidenced by removal of NH_4 and NOx.

Oxygen Demand:

Biological oxygen demand (BOD_5) and COD are typical measurements of the amount of organic matter in stormwater runoff. Any process that contributes to the decomposition of organic matter will cause a reduction of BOD_5 and COD.

Physically, this can occur by adsorption onto particles and subsequent filtration and sedimentation. University dry detention basin removed BOD with an efficiency of 22% and increased COD (-8%).

There was a lack of literature pertaining to the function of dry detention basins in the removal of COD and BOD, so comparisons to national studies were not made. Compared to Morehead Dry Detention, University did not perform well with respect to BOD and COD removal. Based on the increase in COD throughout the system, there is likely some source of organic, non biologically degraded chemicals added to the flow stream as the stormwater passes through the system.

Nitrogen:

Soluble pollutants can be removed by chemical adsorption to suspended particles followed by sedimentation of those particles, and by plant uptake and microbial transformations. In stormwater treatment practices (such as wet ponds and wetlands) which rely on biogeochemical reactions, a major removal mechanism of the various forms of nitrogen present in a natural system is bacterial transformation. However, dry detention basins remove pollutants primarily through sedimentation (NCDENR, 2006) and normally do not employ the same mechanisms of pollutant removal as other BMPs. Thus, nutrient removal in dry detention basins would presumably be low. TKN, NOx, NH_4, and TN removal in University was 2%, 31%, 29%, and 13% respectively.

Literature as to the TKN removal capabilities of dry detention basins is not readily available; however, the dry detention basin functioned well in removing NH_4 and NOx compared to other studies (Table 2), both pollutant concentrations being significantly reduced ($p<0.05$). These pollutants are not associated with particulate matter, the dominant pollutant removal mechanism in dry detention basins, and, thus, relatively high removal rates are unexpected. Appendix A – Figures A2 and A3 show that the removal of these two pollutants was variable; however, leading to some uncertainty in the results. Nonetheless, there appeared to be pollutant removal mechanisms other than just sedimentation occurring in this basin. Portions of the basin may retain water long enough to create anoxic conditions, thus providing the proper conditions for NOx conversion to nitrogen gas.

TN removal was found to be lower than observed in other studies; however, the TN removal was very similar to that determined for Morehead Dry Detention. NCDENR (2006) gives a 10% TN removal credit to extended dry detention basins. University slightly exceeds this removal rate at 13%, thus removing TN at close to the state-assigned rate. The effluent concentration of TN was higher than those reported by Winer, 2000 as shown in Table 3, and the TN EMC is not significant (at the $\propto = 0.05$ confidence limit), leading to the conclusion that this system has inconsistent TN removal capabilities. Inflow and outflow TN concentrations for each storm can be seen in Appendix A – Figure A4. A lack of statistical significance is apparent in Figure A2 as the TN removal efficiency varies substantially from storm to storm.

Phosphorous:

TP removal in University Dry Detention Basin was -15%. Adsorption onto iron-oxide and aluminum-oxide surfaces and complexation with organic acids accounts for a large portion of phosphorus removal from the water column. In some natural systems, these particles can fall out of solution and be stored on the bottom of the treatment system. Under some conditions, phosphorous can be released from the sediment, adding to the effluent mass of TP. Additionally, the removal of NOx would suggest some anoxic conditions occur in this basin, the same conditions needed for phosphorous export. It is also possible that fertilization of this grassed area is resulting in an accumulation of exportable phosphorous. This was also theorized as the cause of the poor TP removal in Morehead Dry Detention.

NCDENR (2006) gives 10% TP removal credit to dry detention ponds. University dry detention does not meet this standard and also does not remove TP at a rate consistent with other studies (Table 2). It should be noted that the median effluent concentration of TP determined for University (0.13 mg/L) is lower than that determined by Winer, 2000 (0.18 mg/L). The TP effluent concentration was identical to that determined for Morehead Dry Detention. Since the median influent concentration of TP calculated for University is 0.12 mg/L, it is probable that this dry detention basin receives stormwater with a TP concentration so close to the irreducible concentration, that a low removal efficiency results. Inflow and outflow TP concentrations for each storm can be seen in Appendix A – Figure A5. Figure A5 illustrates the dramatic fluctuation in removal efficiency through the course of the study. The results regarding TP removal in University Dry Detention were extremely similar to those produced in analyzing data from Morehead Dry Detention.

Pathogens and Oil and Grease

Fecal Coliform removal in University was -3%, while E.coli removal was 5%. Overall, this represents poor efficiency in removing pathogens. Since pathogens can be removed through sedimentation, it was slightly unexpected that fecal coliform removal would be -3% considering the TSS removal in University (39%). It is possible that this grassed area is attracting fauna which, in turn, are adding to the effluent pathogens. There are little data on pathogen removal in dry detention basins; however, the study by Winer (2000) gives an indication through the general category "bacteria," which includes fecal streptococci, enterococci, fecal coliform, E. coli, and total coliform. Winer (2000) reports the bacteria removal efficiency of dry detention basins as 78%. Overall, University Dry Detention basin can not be considered a treatment device for fecal coliform and E. coli.

Oil and Grease removal in University Dry Detention basin could not be analyzed as the majority of the samples were at or below the detectable limit for both the inflow and the outflow. This made evaluating any changes in pollutant concentration impossible.

Metals

As for most of the other pollutants, trace metals can be removed from the water column through physical filtering and settling/sedimentation. Additionally, trace metals readily form complexes with organic matter, which can then become attached to suspended particles. As with phosphorus, the storage of metals on sediments creates conditions under which the pollutant is susceptible to future loss/transformation if conditions are favorable, particularly if their storage zone becomes saturated.

University Dry Detention basin performed relatively well in regard to metal removal. A statistically significant reduction was found for zinc. This is likely related to the TSS removal efficiency that was determined for the system (ER = 0.39). Copper and zinc removal in the system was 11% and 32%, respectively. Lead removal could not be determined, as all of the influent and effluent samples were less than or at the minimum detectable level. Compared to other studies performed on dry detention basins, the removal of copper and zinc in University is similar, with copper removal being slightly lower and zinc removal being slightly higher than what was determined for the other basins. University functioned similarly to Morehead with respect to metal removal. Additionally, effluent concentrations of copper and zinc were lower than those compiled in Winer, 2000, (Table 3) further indicating that this basin functions reasonably well in removing TSS and metals.

CONCLUSIONS

- University Dry Detention basin performed near what is expected by NCDENR only for TN removal. For extended dry detention basins, NCDENR gives 50% TSS, 10% TN, and 10% TP removal credit. University had a pollutant removal efficiency of 39% for TSS, 13% for TN, but only -15% for TP. However, the low effluent concentrations of TP and TSS are not necessarily indicative of poor pollutant removal. Despite University showing promise in removing some species of nitrogen, the data seem inconclusive as to this BMP’s nutrient removal capabilities.

Based on these results, dry detention basins should be considered for peak flow reduction and for TSS removal; however, the low nutrient removal assigned by the state seems justified.

- Sedimentation is considered to be a major pollutant removal mechanism in University Dry Detention based on the relatively efficient removal of sediment and sediment bound pollutants. Due to the removal of NH_4 and NOx, however, it is not the only removal mechanism, and biological processes are likely occurring to some extent as well.
- Metal removal efficiency in the University Dry Detention basin was consistent with results from other studies performed on dry detention basins. Effluent copper and zinc concentrations were lower than those observed in other studies.
- There was generally poor performance by University Dry Detention with respect to pathogenic bacteria. Perhaps this was due to fauna being attracted to green space in an otherwise urban environment. Based upon this study, dry detention basins should not be implemented if pathogenic bacteria are a target pollutant.

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APPENDIX A

Additional Graphs and Tables

Table A1: Results of statistical between inlet and outlet BMP concentrations of selected pollutants at University Dry Detention

Parameter	Assumed Distribution	Reject Based on KS Test	Paired *t*-Test	Wilcoxian Signed - Rank Test	Significant ?
			***p* - value**		
BOD5	Lognormal	Yes	0.105	0.070	
COD	Lognormal	No	0.205	0.151	
Fecal Coliform	Lognormal	No	0.303	0.148	
E. Coli	Lognormal	Yes	0.513	1.000	
NH4	Lognormal	No	**0.022**	**0.030**	**Yes**
NO3 + NO2 (NOx)	Lognormal	Yes	**0.026**	**0.020**	**Yes**
Nitrogen, TKN	Lognormal	No	0.891	0.927	
Nitrogen, Total	Lognormal	Yes	0.345	0.644	
Total Phosphorus	Lognormal	Yes	0.263	0.080	
TSS	Lognormal	No	0.103	0.064	
SSC	Lognormal	No	0.733	0.563	
Turbidity	Lognormal	No	0.691	0.712	
Copper	Lognormal	No	0.402	0.537	
Zinc	Lognormal	No	**0.002**	**0.001**	**Yes**

1. Rejection ($\alpha=0.05$) of Kolmogorov-Smirnov goodness-of-fit test statistic implies that the assumed distribution is not a good fit of these data.

2. Statistical tests were performed on log-transformed data except for copper, in which case raw data were used.

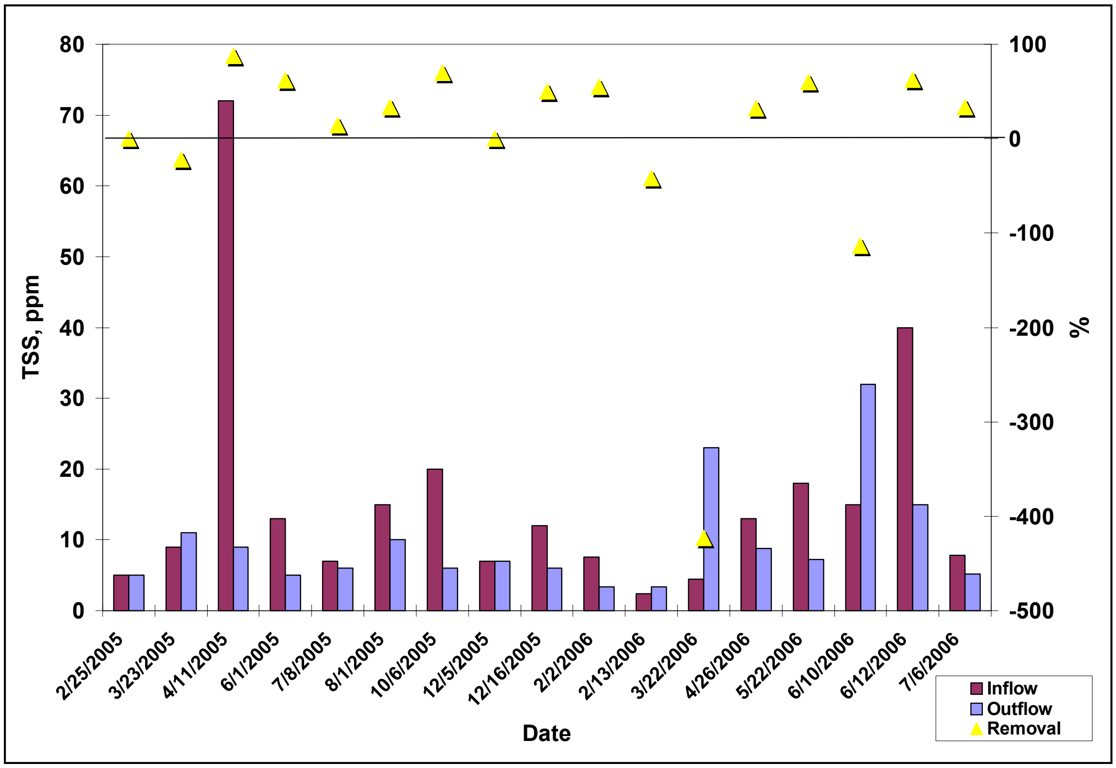

Figure A1: Change in TSS concentration due to BMP treatment by storm event.

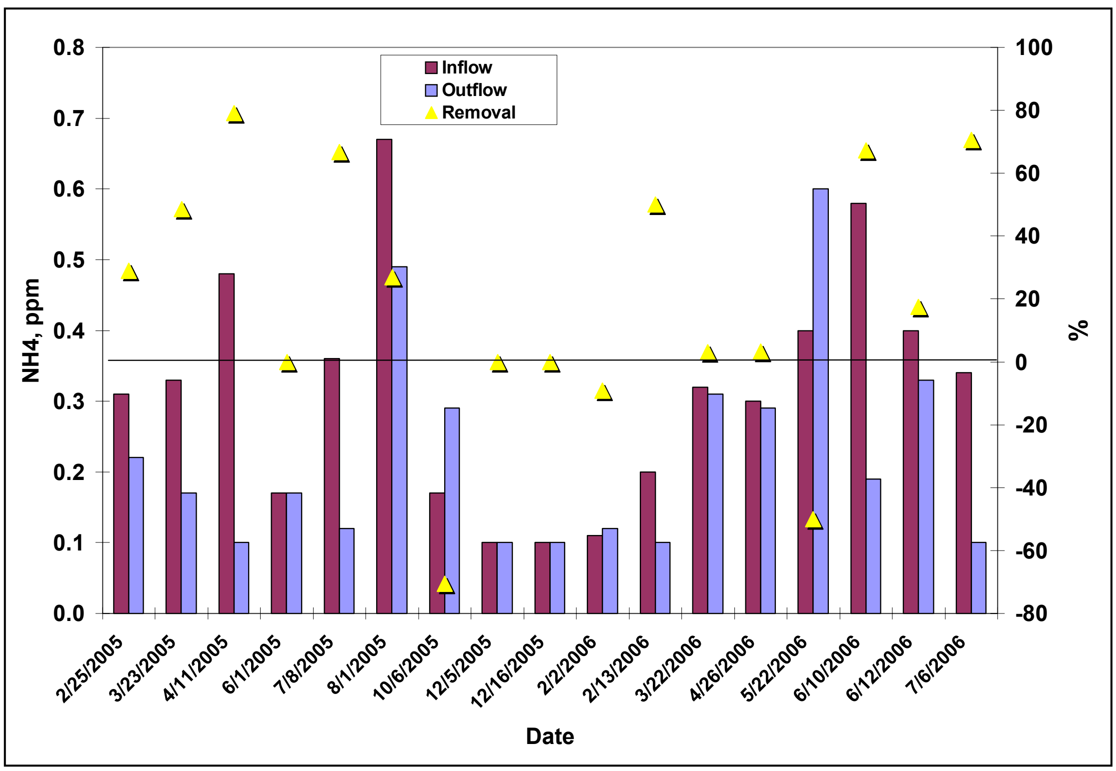

Figure A2: Change in NH_4 concentration due to BMP treatment by storm event.

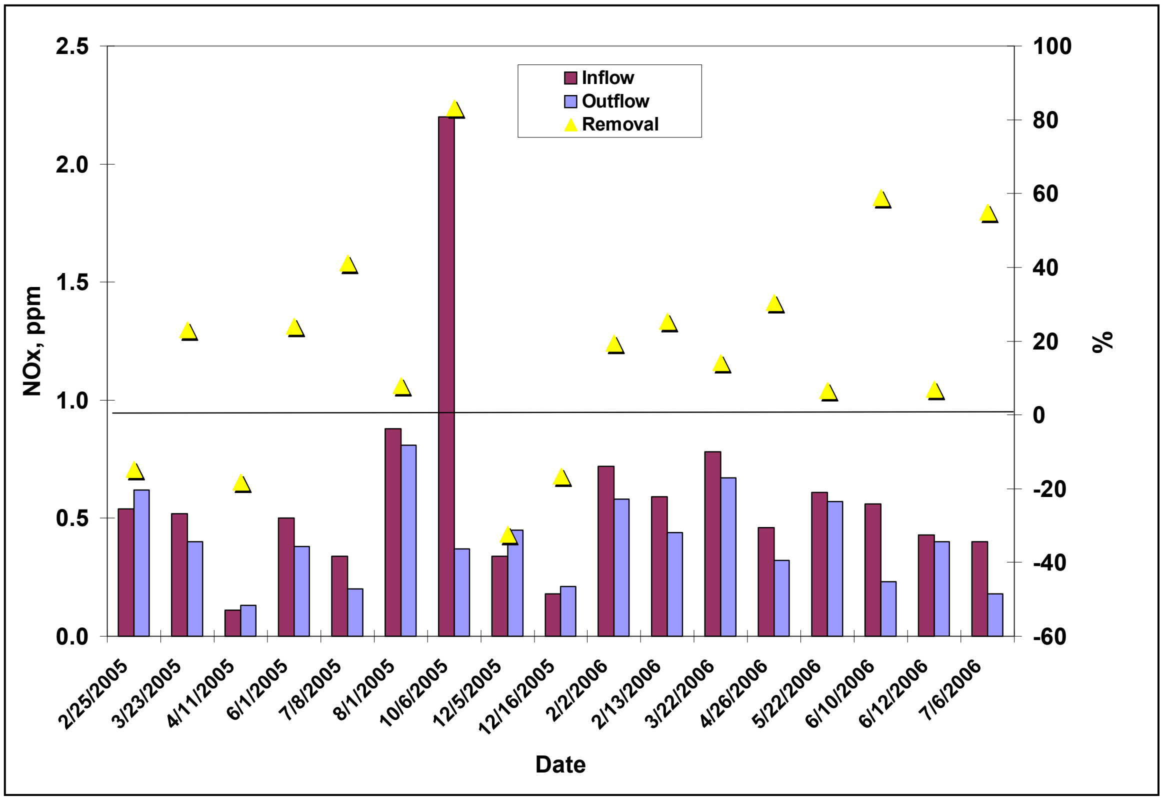

Figure A3: Change in NOx concentration due to BMP treatment by storm event.

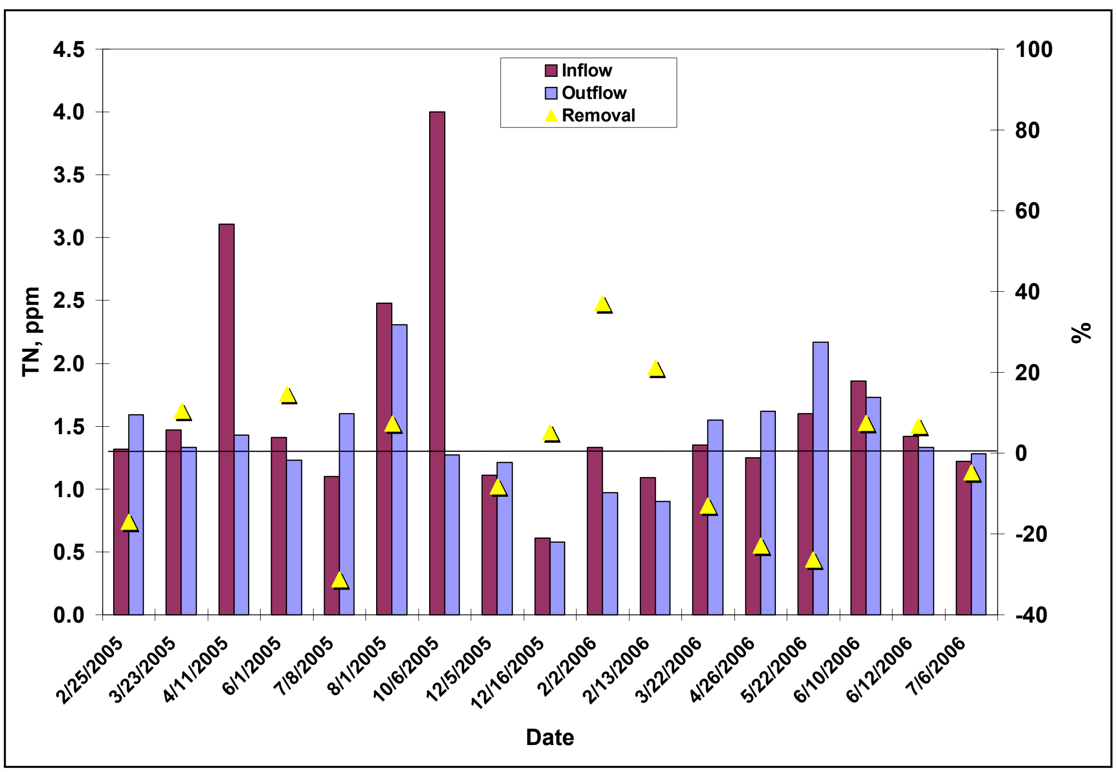

Figure A4: Change in TN concentration due to BMP treatment by storm event.

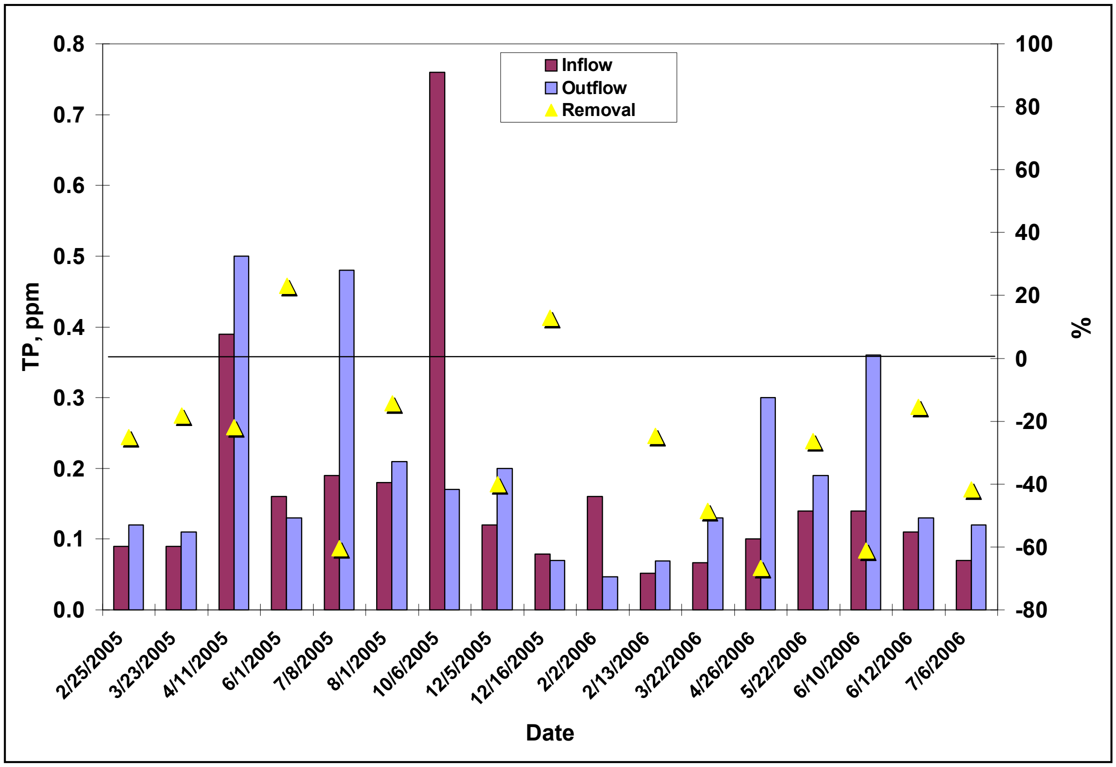

Figure A5: Change in TP concentration due to BMP treatment by storm event.

APPENDIX B

Monitoring Protocol

Stormwater BMP performance Monitoring Protocol for:

University Executive Park Dry Detention

Description of Site:

The University Executive Park Dry Detention is an extended dry detention basin treating a commercial office park and associated parking areas as well as some green space. The detention basin is fully vegetated with grass (which appears to be well maintained and frequently mowed). Some erosion as well as sediment deposition has occurred within the detention bottom. The age of the basin is unknown at this time. Although the inlet to the detention basin is near the outlet, topography of the detention bottom causes low flows to follow a circuitous flow path such that contact time within the basin is not short circuited. A 24" RCP with a flared section acts as the dry detention inlet. The invert of the inlet pipe is approximately 6" higher than the average elevation of the detention bottom. The outlet utilizes a 14" circular orifice to allow for drawdown of stormwater detained within. The orifice is on the side of a fabricated concrete headwall attached to a 15" RCP. A cast in place emergency spillway is installed over the detention berm. It is unlikely that the emergency spillway will be utilized for any monitoring events.

Watershed Characteristics (estimated)

The watershed feeding the detention basin has been delineated as approximately 5.9 acres with commercial office space as the primary land use. The Curve number for the watershed is estimated at 85 with 70% impervious.

Sampling equipment

Inlet monitoring should take place in the 24" RCP pipe at the south end of the detention basin. During storm events this pipe will experience a slight tail water condition. As a result it is necessary to utilize an Area-Velocity meter at this location. It is advised that the area velocity meter and the sample intake strainer be installed "from downstream". The area velocity meter probe should be installed with the use of an expansion bracket with the probe situated in the bottom of the culvert pointing upstream. The strainer should be installed in the invert of the culvert approximately 24" downstream of the area velocity probe which should be installed as far upstream of the flared culvert section as is possible to still allow maintenance. Outlet detention is controlled by a 14" circular orifice. A model 750 bubbler will be used in conjunction with a stage-discharge relationship for determination of flow thru the outlet. The state-discharge relationship for the orifice/bubbler combination has been determined and has been included with this monitoring protocol. The bubbler should be installed upstream of the orifice and a minimum of 12” from the orifice plate. It is advised that the bubbler be attached to a solid concrete block and situated upstream 12” and to the side 12” of the center of the orifice plate. Bubbler elevation should be set so that it is level with the invert of the orifice plate.

Inlet Sampler

Primary device:	24” diameter RCP
Secondary Device:	ISCO model 750 area-velocity meter
Bottle Configuration	18.9 L polypropylene bottle

Outlet Sampler

Primary Device:	1 14” diameter circular orifice
Secondary Device:	Model 720 Bubbler
Bottle Configuration	18.9 L polypropylene bottle
Rain gage	ISCO model installed onsite

Sampler settings

Inlet Sampler

Sample Volume	200 mL
Pacing	185 cu ft
Set point enable	None

Outlet Sampler

Sample Volume	200 mL
Pacing	185 cu ft
Set point enable	none

As monitoring efforts continue it is very likely that the user will need to adjust the sampler settings based on monitoring results. The user should keep detailed records of all changes to the sampler settings. One easy way to accomplish this is to printout the settings once data has been transferred to a PC.

Sample Collection and Analysis

Samples should be collected and analyzed in accordance with the *Stormwater Best Management Practice (BMP) Monitoring Protocol* for the City of Charlotte and Mecklenburg County Stormwater Services.

General Monitoring Protocol

Introduction

The protocols discussed here are for use by City of Charlotte and Mecklenburg County Water Quality personnel in setting up and operating the stormwater BMP monitoring program. The monitoring program is detailed in the parent document "Stormwater Best Management Practice (BMP) Monitoring Plan for the City of Charlotte"

Equipment Set-up

For this study, 1-2 events per month will be monitored at each site. As a result, equipment may be left on site between sampling events or transported to laboratory or storage areas between events for security purposes. Monitoring personnel should regularly check weather forecasts to determine when to plan for a monitoring event. When a precipitation event is expected, sampling equipment should be installed at the monitoring stations according to the individual site monitoring protocols provided. It is imperative that the sampling equipment be installed and started prior to the beginning of the storm event. Failure to measure and capture the initial stages of the storm hydrograph may cause the "first flush" to be missed.

The use of ISCO refrigerated single bottle samplers may be used later in the study if future budgets allow. All samplers used for this study will be configured with 24 1000ml pro-pak containers. New pro-pak containers should be used for each sampling event. Two different types of flow measurement modules will be used depending on the type of primary structure available for monitoring

Programming

Each sampler station will be programmed to collect up to 96 individual aliquots during a storm event. Each aliquot will be 200 mL. in volume. Where flow measurement is possible, each sampling aliquot will be triggered by a known volume of water passing the primary device. The volume of flow to trigger sample collection will vary by site depending on watershed size and characteristic.

Sample and data collection

Due to sample hold time requirements of some chemical analysis, it is important that monitoring personnel collect samples and transport them to the laboratory in a timely manner. For the analysis recommended in the study plan, samples should be delivered to the lab no more than 48 hours after sample collection by the automatic sampler if no refrigeration or cooling of samples is done. Additionally, samples should not be collected/retrieved from the sampler until the runoff hydrograph has ceased or flow has resumed to base flow levels. It may take a couple of sampling events for the monitoring personnel to get a good "feel" for how each BMP responds to storm events. Until that time the progress of the sampling may need to be checked frequently. Inflow sampling may be completed just after cessation of the precipitation event while outflow samples may take 24-48 hours after rain has stopped to complete. As a result it may be convenient to collect the inflow samples then collect the outflow samples several hours or a couple of days later.

As described above, samples are collected in 24 1,000mL containers. In order for samples to be flow weighted these individual samples will need to be composited in a large clean container; however, future use of single bottle samplers will likely reduce the need for this step. The mixing container should be large enough to contain 24,000mL plus some extra room to avoid spills. Once the composited sample has been well mixed, samples for analysis should be placed in the appropriate container as supplied by the analysis laboratory.

Chain of custody forms should be filled in accordance with Mecklenburg County Laboratory requirements.

Collection of rainfall and flow data is not as time dependent as sample collection. However it is advised that data be transferred to the appropriate PC or storage media as soon as possible.

Data Transfer

Sample analysis results as well as flow and rainfall data should be transferred to NCSU personnel on a quarterly basis or when requested. Transfer may be completed electronically via email or by file transfer.