CITY of CHARLOTTE
Pilot BMP Monitoring Program

Morehead Place Dry Detention Basin
Final Monitoring Report

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Prepared By:
Jon Hathaway, EI; *William F. Hunt* PE, PhD; *and Amy Johnson, PhD*
Department of Biological and Agricultural Engineering
NC STATE UNIVERSITY

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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 Morehead Place 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

Located in Charlotte, NC, the Morehead Place Dry Detention basin receives runoff from a commercial office park, associated parking areas, and some landscaped areas. The watershed draining to the basin was approximately 3.8 acres with nearly 70% of the watershed being impervious surfaces. The watershed was typical of commercial office parks with well managed landscaping and facilities.

The detention basin was fully vegetated with grass which appeared to be well maintained and frequently mowed. Some erosion, as well as sediment deposition, has occurred within the detention bottom. The detention basin is approximately 10 years old. The outlet utilized a 4-inch rectangular hole to allow drawdown of stormwater. The orifice was on the side of a fabricated masonry riser approximately 4 feet high and the top of the riser served as the emergency overflow. A sampler box was placed on the riser to collect outflow samples. (Figure 1).

Figure 1: Outlet Structure at Morehead Dry Detention Basin.

The detention facility was designed and constructed to satisfy the City of Charlotte's stormwater detention ordinance requiring that post development peak discharge of the 2 year - 24 hour and 10 year - 24 hour design storm be held to pre-development levels. Generally speaking, dry detention basins are not designed to provide significant water quality improvement other than the associated reduction in stream bank erosion which is a possible result of their detention function. This study was designed to test the function of this dry detention basin as a water quality Best Management Practice (BMP).

Monitoring Plan and Data Analysis

In order to facilitate accurate monitoring of outflow from the detention basin, a 12 gauge stainless steel circular orifice plate was installed at the outlet opening (Figure 2). The installed orifice had a diameter of 3.5 inches. An ISCO

730 bubbler module was fitted to an ISCO Avalanche composite sampler to enable flow paced collection of outlet samplers. The inlet culvert showed signs of occasional submergence during high flow events. As a result, an ISCO low profile area velocity meter was installed in the invert of the inlet culvert for measurement of inflow rate.

Figure 2: Orifice Plate installed at Morehead Dry Detention Basin.

Monitoring efforts were initiated in December 2004 and continued until February 2006, with 14 storm events being, at least partially, collected and measured at the time these data were analyzed. However, due to sample collection failures, inflow and outflow composite samples were collected for only 11 of these storms. Manual grab samples, from which levels of fecal coliform, E. coli, and oil & grease were measured, were collected for 12 of the 14 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 set is 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, it could not be used for mass pollutant removal analysis. These flow data consistently showed that the amount of water leaving Morehead Dry Detention basin was substantially less than the amount entering the basin (Figure 3). It is highly unlikely that the detention basin is reducing the volume of stormwater leaving the watershed by the percentages indicated by these data. Detention basins, by design, do not substantially reduce the volume of runoff entering the storm drainage network.

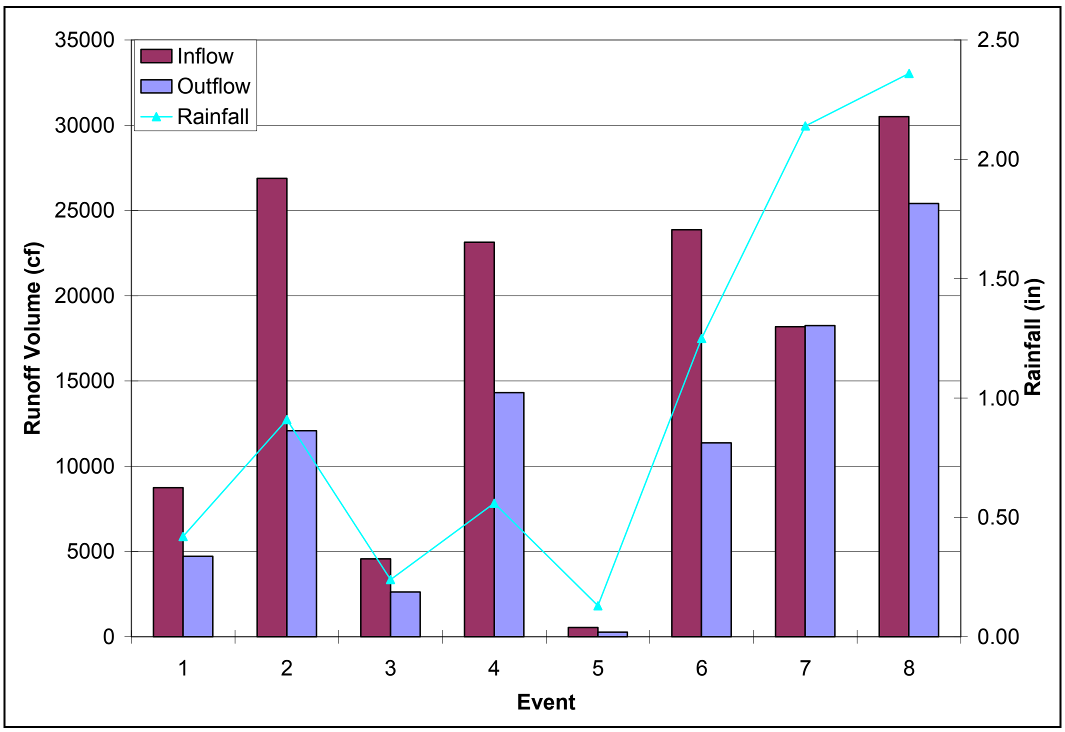

Figure 3: Influent and Effluent Stormwater Volume for First 8 Storms Captured.

It is believed that the area velocity meter consistently over-predicted the amount of entering runoff. 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 1/14/2005 (Event #2) approximately 0.91 inches of rainfall were produced. Using the simple method, the runoff volume from this storm should be approximately 8500 cf. The data collected from the inlet sampling station indicated that the storm produced 26,900 cf, more than 3 times the anticipated amount.

Further questions arise when studying a sample hydrograph illustrating these data (Figure 4). This figure indicates that the peak inflow is 6.1 cfs, while the peak outflow is approximately 0.5 cfs. This represents a dramatic reduction in peak flow; however, the measured peak inflow seems to be exaggerated.

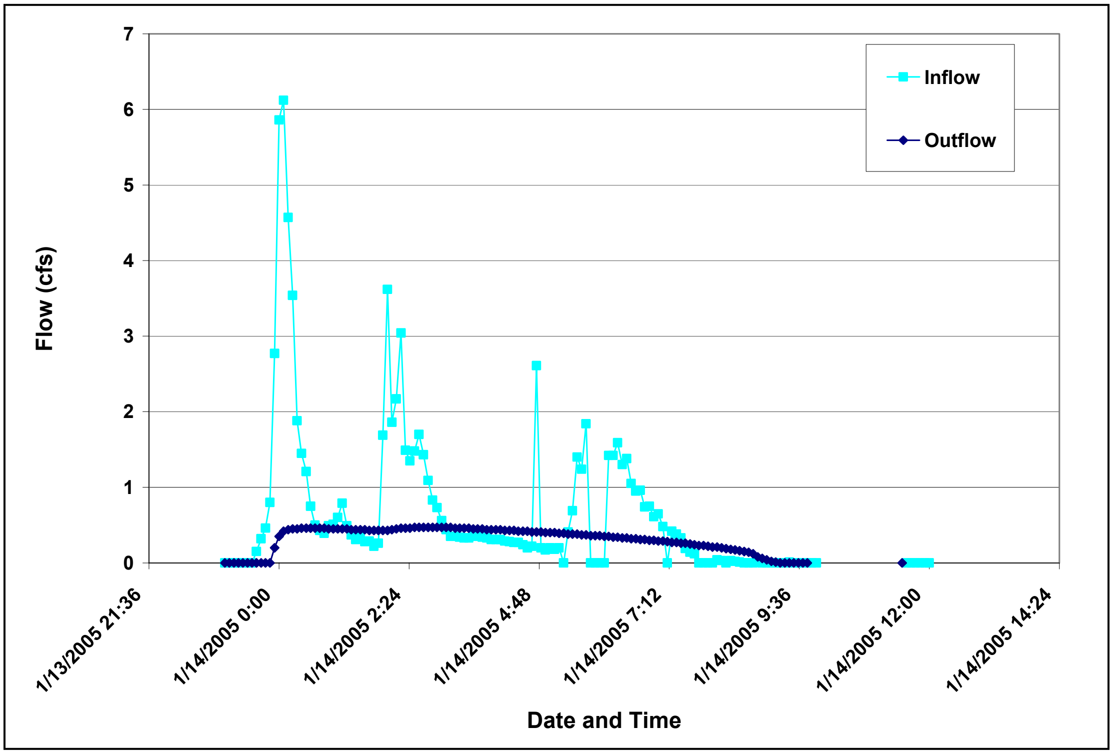

Figure 4: Sample Hydrograph – 0.91 inch Storm

A simple hydrologic analysis method can be used to calculate the expected peak runoff rate from this watershed during the storm that occurred on 1/14/2005. The rational method is commonly used to estimate peak runoff from a given watershed.

The rational equation is as follows:

$$Q = CIA$$

Where: Q = peak flow (cfs)
C = runoff coefficient for watershed (dimensionless)
I = rainfall intensity (in/hr)
A = watershed area (acres)

For this example, it was assumed that during this small storm, the pervious sections of the parking lot will not produce substantial amounts of runoff. Thus, the watershed area is assumed to be just the impervious areas in the watershed, approximately 2.7 acres. The accepted runoff coefficient for impervious pavement is 0.98. Lastly, based on data obtained from Douglas International Airport, the peak rainfall intensity during this storm was approximately 0.5 inches per hour.

Using these values, the expected peak flow for the storm is 1.3 cfs. This is only 20% of the peak flow measured at the inlet of the dry detention system (6.1 cfs). The peak flow measured at the inlet of the dry detention system seems to be excessive given the size of the storm event and the expected peak flow that would be produced during such a storm. This further leads to the assumption that these inflow data are unreliable.

This dry detention basin is not designed as volume reducing BMP; thus, it is evident that the flow data from the basin are somewhat in error. Additionally, 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 is reasonably equal to the outflow.

Water Quality Results

Figure 5 and Table 1 illustrate the performance of Morehead 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.

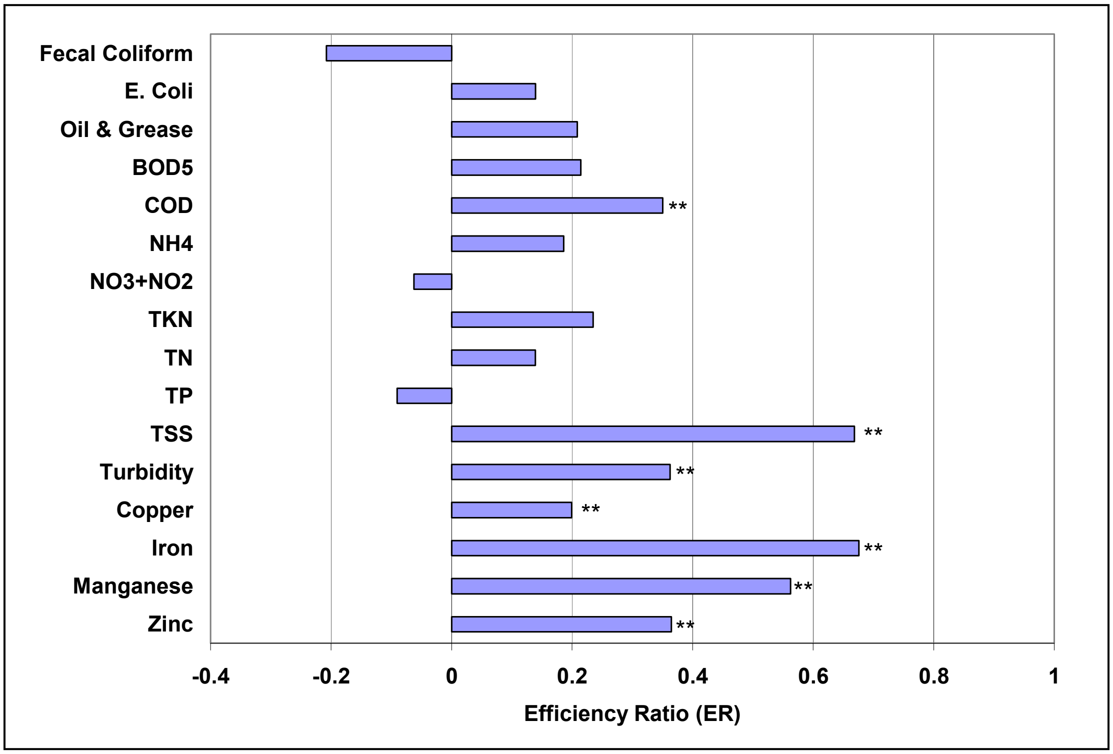

Figure 5: Efficiency ratios of selected pollutants based on pre- and post-BMP mean concentrations (EMCs) at Morehead Dry Detention basin.

**** Indicates a statistically significant relationship**

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

Negative ERs were calculated for fecal coliform, NOx, and 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. Reductions in sediment and metals were calculated; however, nutrient reductions were inconsistent.

According to statistical tests, Morehead Place Dry Detention basin significantly ($p<0.05$) reduced the following pollutants in stormwater runoff: COD, TSS, turbidity, copper, iron, manganese, and zinc (Figure 5 and Table 1). All of these pollutants tend to be associated with particulate matter, suggesting that settling/sedimentation is a major mechanism of pollutant removal in Morehead Place Dry Detention basin.

Table 1: Summary of Water Quality Results

Parameter	Units	# of Samples	Influent EMC	Effluent EMC	ER	p-value	Significant ($p < 0.05$)
Fecal	col. / 100 ml	12	3737.5	4514.2	-21%	0.4131	no
E-Coli	MPN / 100 ml	12	1232.5	1060.8	14%	1	no
Oil & Grease	ppm	12	6.2	4.9	21%	0.0547	no
BOD	ppm	12	4.6	3.8	18%	0.1055	no
COD	ppm	12	29.1	19.5	33%	0.0117	**yes**
NH_4	ppm	12	0.2	0.2	14%	0.0645	no
NOx	ppm	12	0.5	0.5	-11%	0.6377	no
TKN	ppm	12	1.0	0.8	20%	0.2402	no
TN	ppm	12	1.4	1.3	10%	0.3652	no
TP	ppm	12	0.1	0.2	-13%	0.7646	no
TSS	ppm	12	15.0	5.3	65%	0.002	**yes**
Turbidity	NTU	12	8.3	5.4	34%	0.0137	**yes**
Copper	ppb	12	7.0	5.8	17%	0.0332	**yes**
Iron	ppb	6	518.3	168.0	68%	0.0313	**yes**
Manganese	ppb	6	32.0	14.0	56%	0.0313	**yes**
Zinc	ppb	12	95.6	63.2	34%	0.001	**yes**

Sediment

The ER for TSS removal in Morehead Place Dry Detention basin was 0.67 (significant at $p<0.05$). This indicates that a substantial amount of 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 less than achieved in Morehead. Small particles are not easily removed from a given flow stream; therefore, a TSS removal efficiency of 67% is very good. Morehead Dry Detention basin performed comparably well (from a TSS removal perspective) compared to wetlands and wet ponds monitored for the City of Charlotte by NCSU-BAE.

Turbidity removal was substantially lower than TSS (ER = 0.36). Burton and Pitt (2002) recognized that turbidity is associated with smaller particles than

TSS. Smaller particles are harder to remove from a flow stream, as the energy required to carry such a particle is low. It is reasonable that the BMP would facilitate removal of large particles with more efficiency than it would remove TSS.

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. Morehead Place Dry Detention functions well compared to TSS removal rates reported by other studies. One dry detention basin located in Greenville, N.C., (Schueler, 2000) showed TSS results close to those reported for Morehead. The median effluent TSS concentration determined for Morehead Place Dry Detention basin is less than that reported by Winer, 2000 (Table 3). This strengthens the conclusion that Morehead efficiently removes TSS from the stormwater it receives. 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	Morehead	Winer - CWP, 2000	Schueler - Article 77
NH_4	19	--	9
NO_x	-6	3.5	-2
Total N (TN)	14	25	26
Total P (TP)	-9	19	14
TSS	67	47	71
Copper	20	26	26
Zinc	36	26	26

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

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

Nutrients and Organic Material

The removal rates for most major nutrient pollutants were lower than those found by other researchers (Table 2). The major pollutant removal mechanism in many Dry Detention basins is settling (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. Conversely, pollutants which are primarily removed via microbial action (such as NOx) are not easily removed in systems that rely on sedimentation.

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. Morehead Place Dry Detention basin removed BOD with an efficiency of 21% and significantly ($p<0.05$) reduced COD with an efficiency of 35%. There was a lack of literature pertaining to the function of dry detention basins in the removal of COD and BOD, so comparisons to other studies could not be made. Compared to other studies performed by NCSU-BAE for the City of Charlotte, Morehead functioned worse than Edward's Branch Wetland and Pierson Pond in terms of BOD and COD removal, but better than Shade Valley Pond.

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 do not employ the same mechanisms of pollutant removal as other BMPs. Thus, nutrient removal is noticeably lower in dry detention basins. TKN, NOx, NH_4, and TN removal in Morehead was 23%, -6%, 19%, and 14% 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 compared to other studies (Table 2). NOx and TN removal was found to be lower than observed in other studies; however, Table 2 shows that most dry detention basins do not function as nitrogen removing BMPs. NCDENR (2006) gives a 10% TN removal credit to extended dry detention basins. Morehead slightly exceeds this removal rate at 14%, and thus removes TN reasonably similarly to the state-assigned rate. The effluent concentration of TN is higher than those reported by Winer, 2000 as shown in Table 3, and the TN EMC is not significant, leading to the conclusion that this system has inconsistent removal capabilities. Inflow and outflow TN concentrations for each storm can be seen in Appendix A – Figure A2. 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 Morehead Place Dry Detention Basin was -9%. 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. However, in a dry detention system, in which water is not ponded for extended periods of time, it is unlikely that this is occurring (drains in 15 hours after a storm of greater than 2 inches). This makes a TP removal rate of -9% an oddity. It is possible that fertilization of this grassed area is resulting in an accumulation of exportable phosphorous.

It is important to note that the median effluent concentration of TP determined for Morehead (0.13 mg/L) is lower than that determined by Winer, 2000 (0.18 mg/L). Since the median influent concentration of TP calculated for Morehead is 0.12 mg/L, it is possible that this dry detention basin receives stormwater with a TP concentration so close to the irreducible concentration, that a low removal efficiency results. It is NCSU's opinion that this is likely the explanation for "poor" TP performance.

NCDENR (2006) gives 10% TP removal credit to dry detention ponds. Morehead dry detention does not meet this standard and also does not remove TP at a rate consistent with other studies (Table 2). Inflow and outflow TP concentrations for each storm can be seen in Appendix A – Figure A3. Figure A3 illustrates the dramatic fluctuation in removal efficiency through the course of the study.

Pathogens

Fecal Coliform was added by Morehead Dry detention (20%), while E.coli removal was 14%. Overall, this represents poor efficiency in removing pathogens. Since pathogens can be removed through sedimentation, it was slightly surprising that fecal coliform would be added by 20%, considering the significant TSS removal in Morehead. It is possible that this grassed area is attracting fauna which, in turn, are adding to the effluent pathogens. There are little data pertaining to 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, Morehead Place Dry Detention basin can not be considered a treatment device for fecal coliform and E. coli.

Oil and Grease removal in Morehead Dry Detention had an ER of 21%. Unfortunately, there is a lack of data from other dry detention sites for this pollutant. Studies performed by NCSU-BAE for the City of Charlotte showed similar removal of Oil and Grease in Pierson Pond and Bruns Avenue Wetland. Poor Oil and Grease removal (ER = -1.7) was measured at Edward's Branch

Wetland. Compared to other stormwater BMPs studied for oil and grease removal in the City of Charlotte, Morehead Place Dry Detention performs well.

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.

Morehead Place Dry Detention basin performed well in regard to metal removal. Statistically significant reductions were found for copper, iron, manganese, and zinc. This is likely related to the TSS removal efficiency that was determined for the system (ER = 0.67). Copper, iron, manganese, and zinc removal in the system was 20%, 68%, 56%, and 36% respectively. Compared to other studies performed on dry detention basins, the removal of copper and zinc in Morehead is similar, with copper removal being slightly lower and zinc removal being slightly higher than what was determined for the other basins. Additionally, effluent concentrations of copper and zinc were lower than those compiled in Winer, 2000, (Table 3) further indicating that this basin functions well in removing TSS and metals. Sedimentation within this dry detention basin is assumed to be a major mechanism for pollutant removal.

CONCLUSIONS

- Morehead Place Dry Detention basin performed near what is expected by NCDENR for TSS and TN removal. For extended dry detention basins, NCDENR gives 50% TSS, 10% TN, and 10% TP removal credit. Morehead had a pollutant removal efficiency of 67% for TSS, 14% for TN, but only -9% for TP. The low TP removal can be attributed to relatively clean inflow. Based on these results, dry detention basins should be considered for peak flow reduction and for TSS removal; however, they are not recommended for nutrient removal.

- Sedimentation is considered the dominant pollutant removal mechanism in Morehead Place Dry Detention based on the efficient removal of sediment and sediment bound pollutants.
- Metal removal efficiency in the Morehead Place 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. Iron and manganese removal was over 50%, further indicating the high metal removal efficiency of the system.
- There was no consistent performance by Morehead Place 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 no credit should be assigned to dry detention basins for pathogenic bacteria removal.

REFERENCES

Burton, Jr., G.A., and R.E. Pitt. 2002. Stormwater Effects Handbook: a Toolbox for Watershed Managers, Scientists, and Engineers. CRC Press., New York.

Schueler, T. 1996. Irreducible pollutant concentrations discharged from stormwater practices. Technical Note 75. Watershed Protection Techniques. 2:369-372.

Schueler, T., and H.K. Holland. 2000. *The Practice of Watershed Protection*. Center for Watershed Protection, Ellicott City, Maryland.

Strecker, E.W., M.M. Quigley, B.R. Urbonas, J.E. Jones, and J.K. Clary. 2001. Determining urban stormwater BMP effectiveness. J. Water Resources Planning and Management. 127:144-149.

U.S. Environmental Protection Agency and Amer. Soc. Civil Engineers. 2002. Urban Stormwater BMP Performance Monitoring: A Guidance Manual for Meeting the National Stormwater Database Requirements. U.S. EPA. EPA-821-B-02-001. Washington, DC.

Urbonas, B.R. 2000. Assessment of stormwater best management practice effectiveness (chapter 7). *In:* (eds). Heaney, J.P., R. Pitt, R. Field. Innovative Urban Wet-Weather Flow Management Systems. EPA/600/R-99/029. Washington, DC.

Vaze, J. and F.H.S. Chiew. 2004. Nutrient loads associated with different sediment sizes in urban stormwater and surface pollution. J. Environmental Engineering. 130:391-396.

Winer, R. March 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. U.S. EPA Office of Science and Technology

APPENDIX A

Additional Graphs and Tables

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

Parameter	**Assumed Distribution**	**Reject Based on KS Test[1]**	**Paired *t*-Test[2]**	**Wilcoxian Signed - Rank Test**	**Significant ?**
			***p* - value**		
Fecal Coliform	Lognormal	No	0.4306	0.4131	
E. Coli	Lognormal	No	0.9861	1	
Oil & Grease	Lognormal	No	0.0829	0.0547	
BOD5	Lognormal	No	0.1178	0.1055	
COD	Lognormal	No	**0.0043**	**0.0117**	**yes**
NH4	Lognormal	No	0.0732	0.0645	
NO3 + NO2 (NOx)	Lognormal	No	0.9748	0.6377	
Nitrogen, TKN	Lognormal	No	0.1322	0.2402	
Nitrogen, Total	Lognormal	No	0.4021	0.3652	
Total Phosphorus	Lognormal	No	0.4658	0.7646	
Suspended Residue (TSS)	Lognormal	No	**0.0002**	**0.002**	**yes**
Turbidity	Lognormal	No	**0.0121**	**0.0137**	**yes**
Copper	Normal	No	**0.0397**	**0.0332**	**yes**
Iron	Lognormal	No	**0.0004**	**0.0313**	**yes**
Manganese	Lognormal	No	**0.0003**	**0.0313**	**yes**
Zinc	Lognormal	No	**0.0001**	**0.001**	**yes**

1. Rejection (α=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.

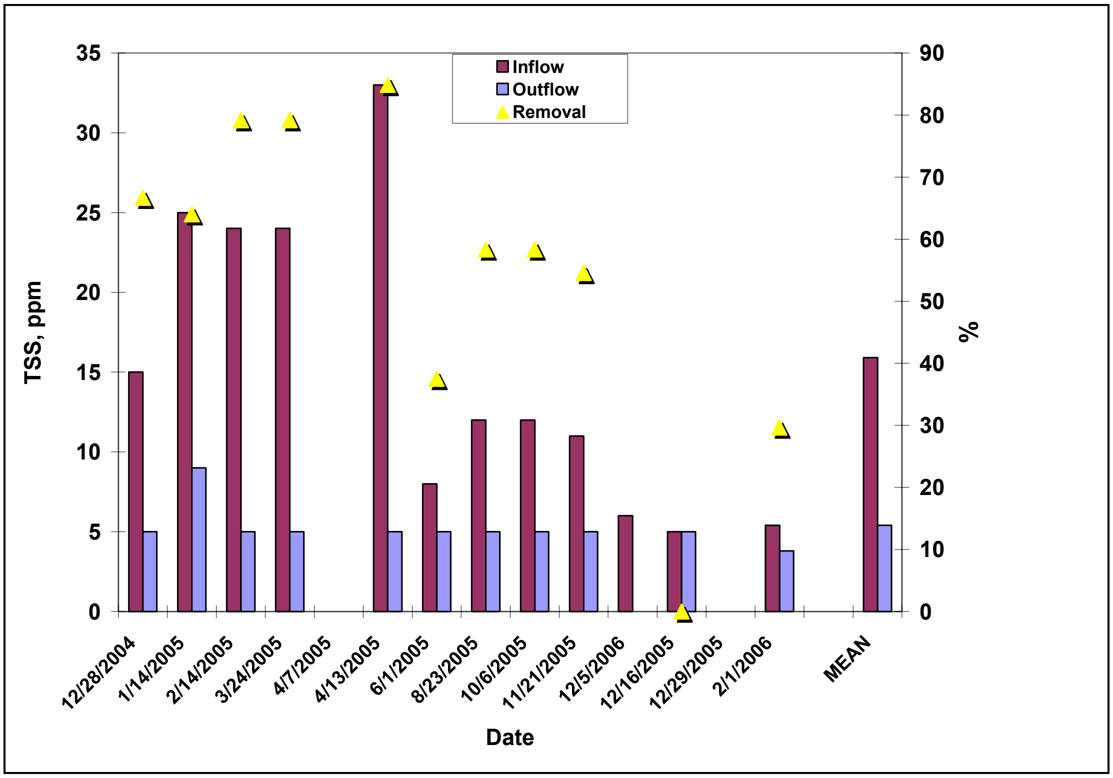

Figure A1: Change in TSS concentration due to BMP treatment by storm event.

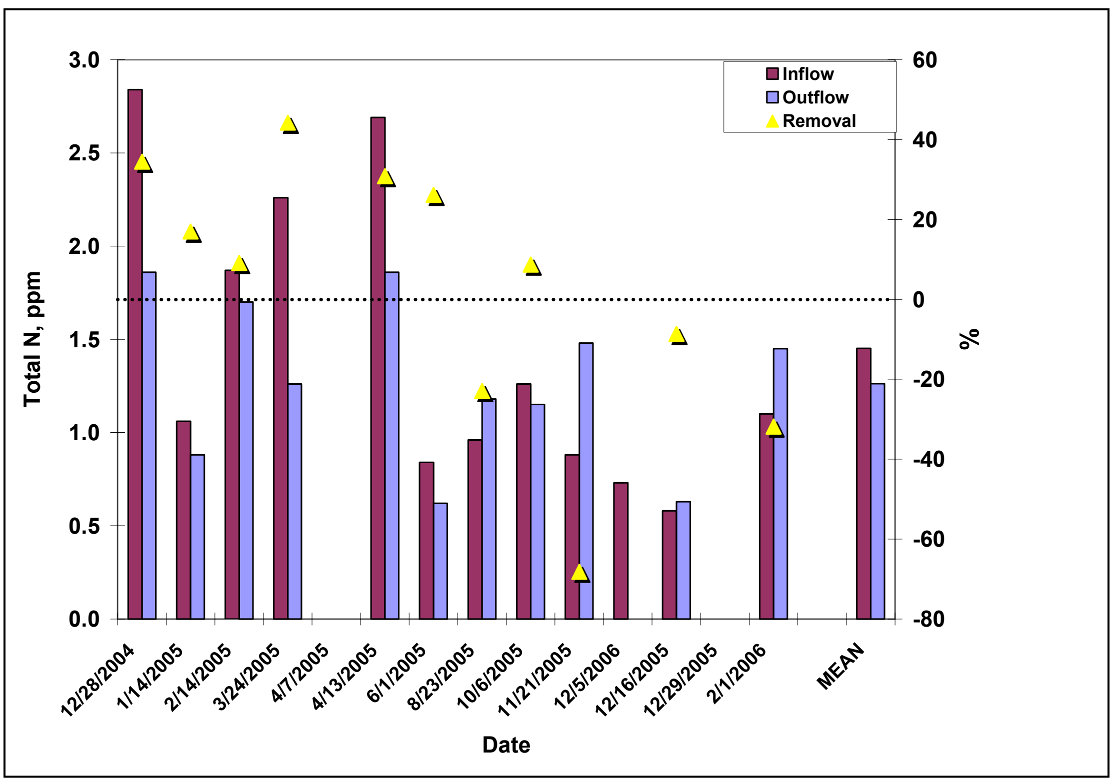

Figure A2: Change in TN concentration due to BMP treatment by storm event.

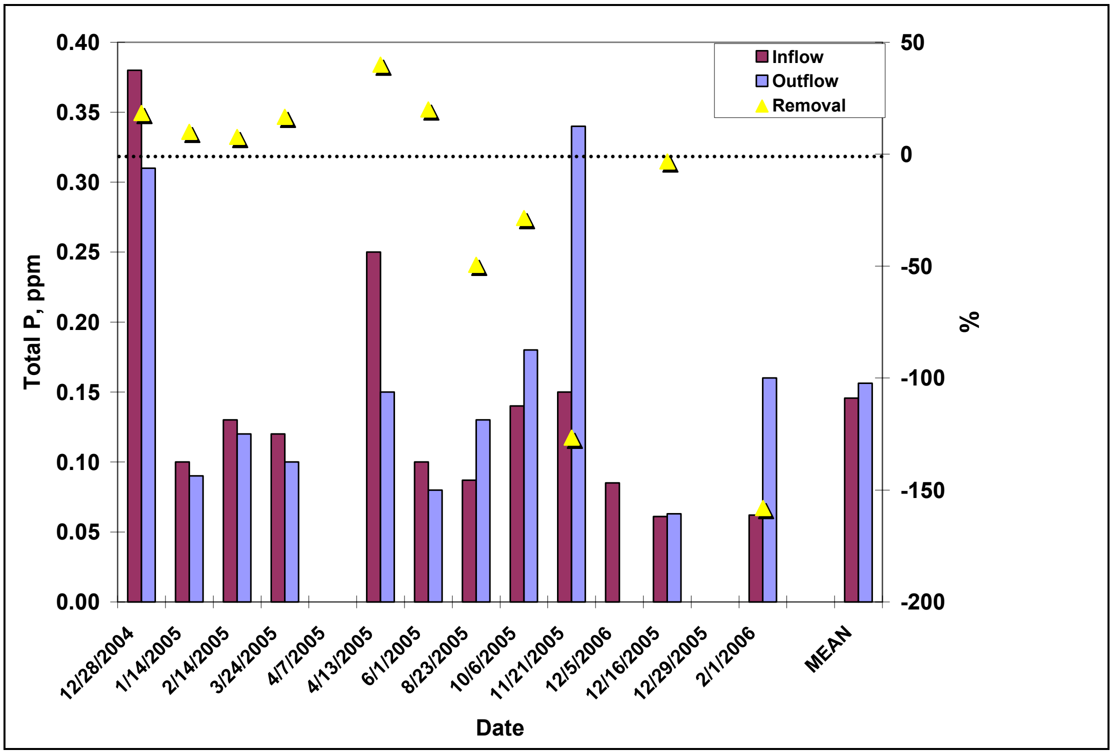

Figure A3: Change in TP concentration due to BMP treatment by storm event.

APPENDIX B

Monitoring Protocol

Stormwater BMP performance Monitoring Protocol for:

Morehead Place Dry Detention

Description of Site:

The Morehead Place Dry Detention is a dry detention 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. The outlet utilizes a 3.5" circular orifice to allow for drawdown of stormwater detained within. The orifice is on the side of a fabricated masonry riser approximately 4' high. The top of the riser serves as the emergency overflow.

Watershed Characteristics (estimated)

The watershed was roughly discretized at 3.8 acres and has a CN of approximately 85 with 70% imperviousness within the watershed.

Sampling equipment

Inlet monitoring should take place in the 24" RCP pipe at the west end of the detention basin. During storm events this pipe will experience a tail water condition. As a result it is necessary to utilize an Area-Velocity meter at this location. The Area-Velocity meter should be positioned upstream of the flared section of RCP. It may be possible to access the culvert from the upstream drop structure.

Outlet detention is controlled by a 3.5" circular orifice. This orifice has been installed to replace the 4" roughly cut outlet "hole" so that accurate measurements of outflow can be made. The orifice plate has been made so that it can be removed after the study period. An ISCO bubbler should be used to measure flow from the outlet structure. The bubbler should be located at least 6" from the orifice plate and not placed in from of the orifice plate. The bubbler should be located at the same elevation as the invert of the orifice. A stage-flow relationship chart has been supplied for use with the sampler to aid in flow measurement. The specifics of the stage-flow data should be verified with as built conditions

<u>Inlet Sampler</u>
Primary device: 24" diameter RCP
Secondary Device: ISCO model 750 area-velocity meter
Bottle Configuration 18.9 L polypropylene bottle

<u>Outlet Sampler</u>
Primary Device: 1 3.5" diameter circular orifices
Secondary Device: Model 720 Bubbler
Bottle Configuration 18.9 L polypropylene bottle
Rain gage ISCO model installed onsite

Sampler settings

<u>Inlet Sampler</u>
Sample Volume 200 mL
Pacing 120 Cu Ft.
Set point enable None

<u>Outlet Sampler</u>
Sample Volume 200mL
Pacing 120 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 have 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.