CITY of CHARLOTTE
Pilot BMP Monitoring Program

CATS - Bus Maintenance Operations Facility
Baysaver® Stormwater Treatment Structure

Final Monitoring Report

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Purpose

The purpose of this report is to document monitoring and data analysis activities undertaken by the City of Charlotte, Mecklenburg County, and North Carolina State University to determine the effectiveness and stormwater treatment capabilities of the Baysaver® stormwater treatment structure installed at the City of Charlotte-CATS-Bus Maintenance Operations Facility (BMOF).

Introduction

Hydrodynamic separators are a class of structural stormwater BMP that rely on the mechanisms of settling and separation to remove heavy particles (such as sediment) and floating particles (oil, grease, and gross solids) from a given watershed. Stormwater is routed into the flow-through system where the energy of the water carries it through the system in a particular flow path (typically a swirl action or through some filtration mechanism) where pollutants can be removed and stored in the system (EPA, 1999). Currently, there are a number of different models of hydrodynamic separators sold by private companies designed for use in stormwater treatment.

Hydrodynamic separators are designed primarily to remove sediment, oil, and grease from a given watershed. In addition, these systems have been shown to remove some nutrients and metals by various studies, primarily by slowing influent stormwater and allowing suspended particles to settle out. When flood control is a primary concern, hydrodynamic separators will not act to remediate the impact of imperious areas.

This report will focus on the effectiveness of the Baysaver®, a hydrodynamic separator produced by Baysaver Technologies Inc. that was installed at the CATS BMOF site. This unit works through gravitational separation by allowing some initial debris to settle before diverting low flows to a secondary chamber for further treatment. During large storm flows, some stormwater continues to be diverted to the secondary treatment chamber throughout the

course of the storm. Additional product information is available on the Baysaver Technologies website: http://www.baysaver.com/.

Site Description

The Baysaver® model 3k was installed at the Charlotte Area Transit System (CATS) Bus Maintenance and Operations Facility (BMOF). The drainage area for the system was approximately 2.28 acres and primarily consisted of concrete bus parking areas, driving lanes, and metal roofs (Figure 1). Both the inlet and outlet for the system consisted of 18-inch reinforced concrete pipes.

Figure 1: Photo of watershed area draining to BMP

Monitoring Plan and Data Analysis

Inflow and outflow monitoring took place in the 18-inch reinforced concrete pipes located immediately upstream and downstream of the BMP, respectively. During some storm events, the inlet pipe had the potential for a slight tail water condition. Monitoring consisted of measuring stormwater flows utilizing area-velocity flow meters and collecting flow-weighted composite samples using automated sampling equipment. Monitoring equipment was attached within the pipe system using expansion brackets as shown in Figure 2.

**Figure 2: Typical installation of area-velocity probe (left) and
sampler intake (right) with expansion bracket**

Monitoring efforts were initiated in July 2005 and continued until March 2007, with 28 individual storm events being collected / measured approximately once per month. Additional manual grab samples, from which levels of fecal coliform, *E. coli*, and oil & grease were measured, were collected for 7 of the 25 storm events (all 3 parameters were not analyzed for all 7 grab samples).

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 at the site was somewhat inconsistent with what would be expected. This BMP is not intended to be a detention system; thus, the flow that enters should be equal to the flow that exits during a given rain event. The area velocity meters used for monitoring the CATS BMOF Baysaver$^{®}$ produced different flow values at the inlet and outlet during many storm events (Figure 3), with either the inlet or outlet being higher for a given storm event. This

is likely due to the wide variability of factors that can affect area velocity flow measurement in smaller pipe systems for any given storm event. In addition, during some storm events, backwater conditions were present in the system, which may also have contributed to the variability of flow measurements. Although inflow and outflow flow measurements did not match as expected, it is felt that the flow weighted samples collected were reasonable estimations of event mean pollutant concentrations produced. In addition, concentration data were analyzed as part of this study, which is the primary measurement factor being used to evaluate efficiency relationships between influent and effluent pollutants.
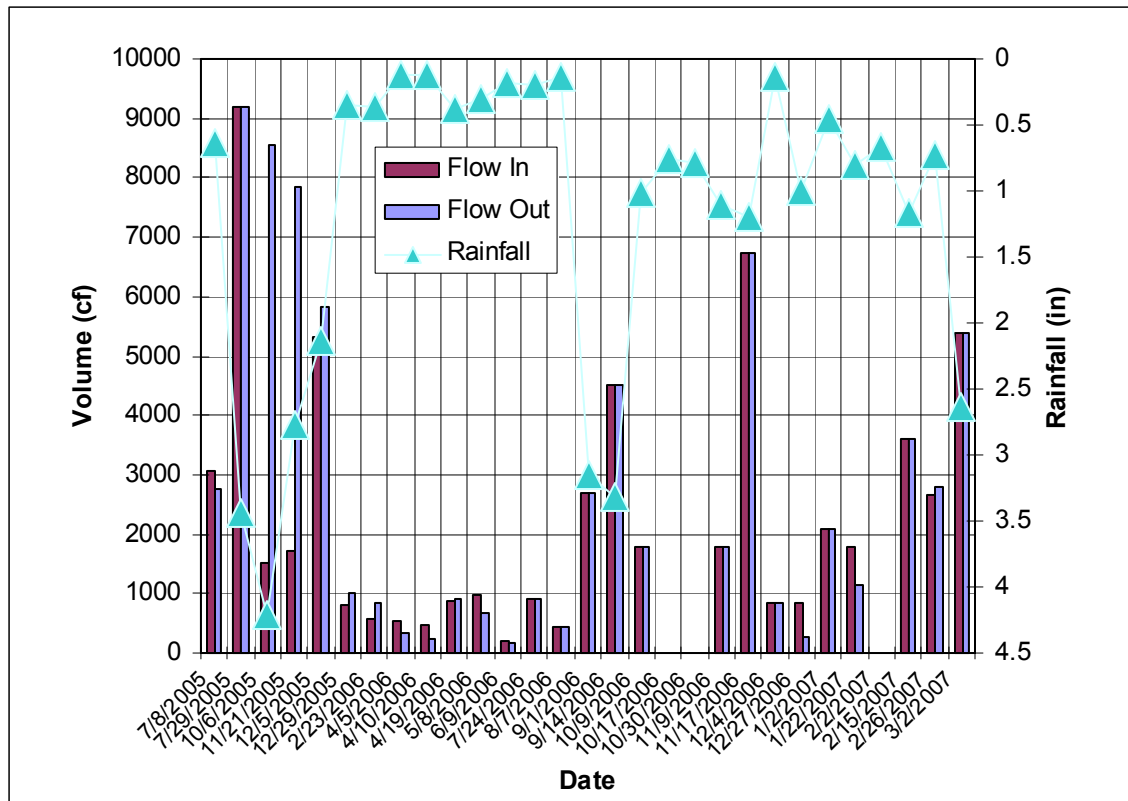

Figure 3: Influent and effluent volumes for various storm events

Water Quality Results

Figure 4 and Table 1 illustrate the performance of the CATS BMOF Baysaver® 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 BMP as stormwater runoff, was retained by the BMP. A negative ER represents a surplus of pollutant leaving the BMP, suggesting either internal production of pollutants, or more likely a loss of stored pollutants from previous storm events.

Negative ERs were calculated for all pollutants other than NH_4, NOx, TN, TP, and copper; however, none of these positive ERs were statistically significant ($p<0.05$). The performance of this BMP varied from a water quality standpoint. Changes in the ER were noted from storm to storm for many pollutants. According to statistical tests performed on the data set collected from the site, the CATS BMOF Baysaver® system significantly ($p<0.05$) increased COD and TKN (Figure 4 and Table 1).
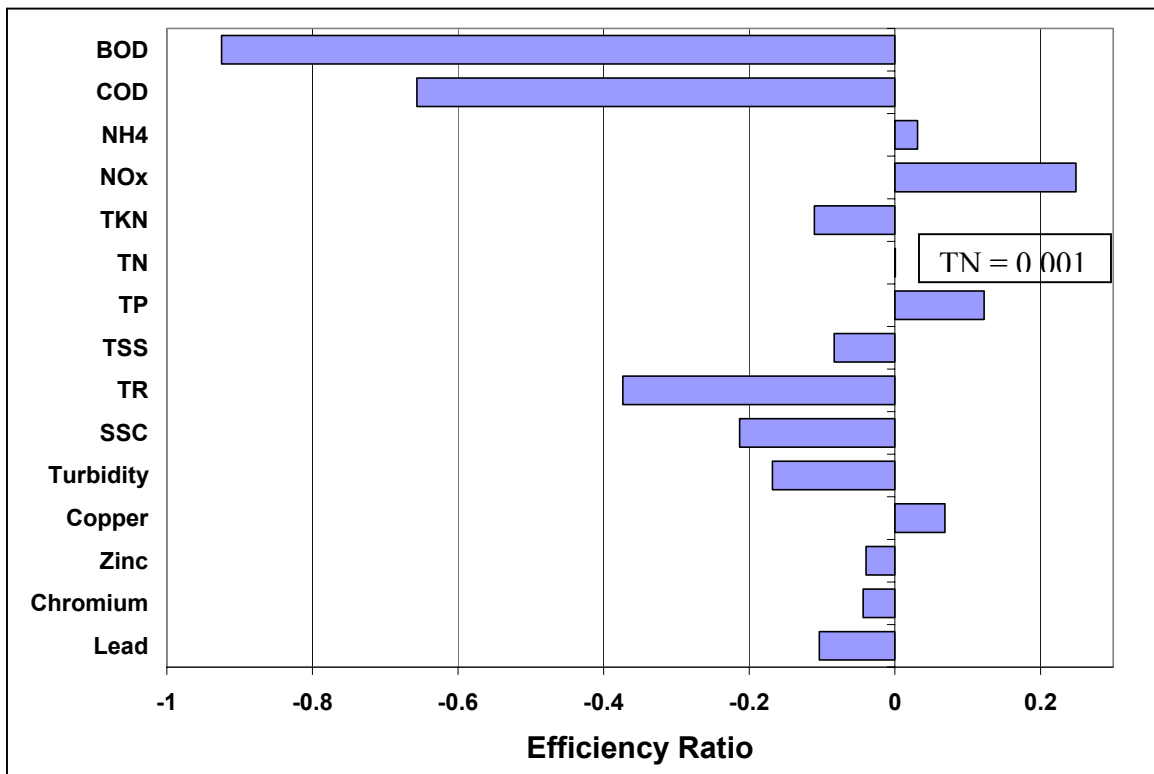

Figure 4: Efficiency ratios of selected pollutants based on pre- and post-BMP mean concentrations (EMCs) at the Baysaver®.

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	9	31.0	59.6	-0.925	0.0742	No
COD	ppm	12	106.2	175.9	-0.656	0.0425	Yes
NH4	ppm	28	0.2	0.2	0.031	0.1619	No
NOx	ppm	28	0.4	0.3	0.249	0.1031	No
TKN	ppm	28	1.0	1.1	-0.111	0.0242	Yes
TN	ppm	28	1.4	1.4	0.001	0.5278	No
TP	ppm	28	0.2	0.1	0.123	0.7434	No
TSS	ppm	28	45.0	48.7	-0.083	0.9607	No
TR	ppm	12	119.3	163.9	-0.374	0.0669	No
SSC	ppm	19	37.5	45.5	-0.213	0.9238	No
Turbidity	NTU	28	27.9	32.6	-0.168	0.1705	No
Copper	ppb	27	15.0	14.0	0.069	0.1964	No
Zinc	ppb	27	90.6	94.2	-0.040	0.637	No
Chromium	ppb	27	5.4	5.6	-0.043	0.7813	No
Lead	ppb	27	6.7	7.4	-0.104	0.6587	No

Sediment

The ER for TSS removal in the Baysaver® was -8% (significant at α=0.05). The storm to storm variability in TSS removal indicates that although there may be some treatment for TSS is occurring in the BMP, likely through sedimentation and filtration, there may also be some resuspension and passage of sediment during many storm events. Influent and effluent TSS concentrations substantially varied throughout the study, and statistically significant relationships were not found (Appendix A – Figure A1). The BMP was cleaned in early 2005 as part of the site construction close out and then again in March 2006, September 2006, and March 2007. Because only individual storm events were monitored, on a monthly basis, and not all storm events were captured, performing a mass balance was not feasible; therefore, it is possible for the BMP to show a negative pollutant removal (conservation of mass can not be applied).

In addition to the TSS samples taken at the site, 19 storm events were sampled for SSC as well. All SSC samples were taken after the system was serviced. SSC is considered by some to be a more accurate analysis of sediment concentration in a given sample (Glysson et al., 2000) as it more effectively takes large sediment particles into account. TSS analysis methods have some inherent

error that can result in poor data quality (Kayhanian et al., 2005). The ER for SSC removal in the Baysaver® was -21% (significant at α=0.05). SSC concentrations for each storm can be seen in Appendix A – Figure A2.

It should be noted that there was a substantially lower number of samples analyzed for SSC than TSS (Table 1) and that collecting samples from the bottom of the pipe (conventional method) could result in non-representative samples during some storm events (Andoh et al., 2002 and Kayhanian et al., 2005). This is due to the orientation of sediment particles being conveyed during a storm event in a given pipe. Heavier particles tend to flow along the bottom of the pipe, while lighter particles flow along the water surface. It is desirable to collect a sample which is pulled from the entire flow stream, which may not have occurred during some larger storm events. However, this was not a feasible goal for the purpose of this study, as the Pilot BMP monitoring program has employed conventional monitoring protocols to analyze various types of BMPs.

A review of literature shows the Baysaver® was tested as part of the New Jersey Corporation for Advanced Technology (NJCAT) Program. In the study, the manufacturer's claims regarding laboratory SSC removal (51%) were verified per the New Jersey Department of Environmental Protection (NJDEP) treatment efficiency calculation methodology. This indicates that under the correct circumstances, this hydrodynamic separator can be an effective sediment treatment device. Observation of the laboratory testing method; however, showed that the test was performed using high concentrations of sediments (205 mg/L average) with an average d_{50} of 85 microns.

The conditions under which the system was tested in the laboratory (as discussed in the NJCAT report) likely differ from those experienced during the Charlotte pilot BMP monitoring program. Although no particle size analysis was performed on the influent or effluent sediment from the BMP, a brief study of the soils in Mecklenburg County shows that the dominant soils types in the area are loam, sandy loam, and sandy clay loam. The estimated d_{50} for these soils ranges between 98 and 35 (Munoz-Carpena and Parsons, 2005), which suggests the potential presence of smaller soil particles than those described in the NJCAT

report (a sandy loam which only included approximately 5% clay, D_{50} = 85 microns). The difference in soil particle distribution can not be verified due to the lack of a particle size analysis, but there may be differences based on the soils present in the surrounding areas. In addition, other sources of suspended sediment may occur in urban stormwater runoff based on watershed characteristics. Sediment makeup can impact hydrodynamic separator function (Andoh et al. 2002 and Barbaro, 2005). Small sediment particles can be more difficult to remove from the flow stream and can be considered non-settleable suspended solids. The presence of settleable solids is important in the function of BMPs that rely on hydraulics instead of filtering to remove solids.

It also should be noted that the low influent SSC concentration (37.5 mg/L) was different than the influent SSC concentration used in the lab study (205 mg/L average). This could also have a substantial impact on the system performance. As part of the laboratory testing on the Baysaver[®], the system was tested with various influent SSC concentrations and under various flow conditions. None of the tests resulted in an effluent SSC concentration lower than 31.3 mg/L, and only 2 of the 19 tests resulted in effluent SSC concentrations lower than 37.5 mg/L (the SSC EMC for the CATS-BMOF site). It is likely that this low influent sediment EMC impacted the performance of the system.

In addition to the documentation pertaining to the function of the Baysaver[®] with regard to pollutant removal efficiency, there have been hydrodynamic devices studied and input into the International Stormwater BMP Database (ISBD). Table 2 shows the median pollutant effluent concentration for Hydrodynamic devices in the International Stormwater BMP database (Geosyntec, 2006). The median effluent TSS concentration determined for the CATS-BMOF Baysaver[®] (48.7 mg/L) is relatively close to that reported by Geosyntec, 2006 (36 mg/L) in a report summarizing studies in the International Stormwater BMP Database. As discussed above, low inflow concentrations likely contributed to the low ER reported for the Baysaver[®] in this study. This indicates that the influent TSS concentration (45 mg/L) may have been at or below the irreducible concentration for hydrodynamic devices. It should be noted that the

report by Geosyntec (2006) indicated a significant difference in the influent and effluent EMC for hydrodynamic devices in the International Stormwater BMP Database; however, the composition of the influent sediment and the influent concentrations are not reported.

Table 2: Comparison of Median Effluent Concentration for Various Hydrodynamic Devices

Parameter	Baysaver at CATS - BMOF		International Stormwater BMP database (Geosyntec, 2006)		
	Median of Effluent EMCs (mg/L)	Significant Difference between influent and effluent EMC ?	Median of Effluent EMCs (mg/L)	Significant Difference between influent and effluent EMC ?	Number of BMPs Studied
TSS	48.7	No	36	Yes	14
TN	1.4	No	2.16	No	2
TKN	1.1	Yes	1.31	No	4
NOx	0.3	No	0.25	No	4
TP	0.1	No	0.16	Yes	12
Zinc	94.2	No	100	Yes	11
Copper	14.0	No	15	No	9
Lead	7.4	No	6.7	Yes	8

Nutrients and Organic Material

Baysaver® removal rates for TN and TP are not readily documented by other studies; however, the median effluent concentrations can be compared to the International Stormwater BMP Database (Table 2). By comparison, this study showed effluent concentrations that were lower than other hydrodynamic separator studies. A major pollutant removal mechanism typical of hydrodynamic devices is sedimentation. Since many pollutants are associated with sediment, this pollutant removal mechanism can have a substantial impact (Vaze and Chiew, 2004) on some nutrients. In this case, however, a low TSS removal efficiency may be tied to the low removal efficiency of other pollutants.

Oxygen Demand:

Biochemical 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. The Baysaver[®] BOD removal efficiency was -92% and the COD removal efficiency was -66%. This is likely tied to the low TSS removal efficiency determined for the device.

There was a lack of literature pertaining to the function of hydrodynamic devices in the removal of COD and BOD, so comparisons to national studies were not made.

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. Hydrodynamic devices are not considered nitrogen reducing BMPs and are not expected to employ the same mechanisms of pollutant removal as other BMPs (oxidation-reduction reactions, plant uptake, etc.). Thus, nutrient removal in hydrodynamic devices would presumably be low. TKN, NOx, NH_4, and TN removal in the CATS BMOF Baysaver[®] was -11%, 25%, 3%, and 0.001% respectively. The analysis showed the relationship for TKN to be statistically significant. The relatively high removal of NOx indicates some anaerobic conditions within the system, likely in the sediment stored within the device. The removal of NOx, and slight removal of NH_4 (also the increases in BOD and COD) would seem to indicate that organic nitrogen is being exported from the system.

The effluent concentrations of these nitrogen species can be compared, to some degree, with other hydrodynamic devices in the International Stormwater BMP Database. Geosyntec (2006) reported the median effluent concentrations for TKN, NOx, and TN as 1.31 mg/L, 0.25 mg/L, and 2.16 mg/L, respectively. The monitoring study performed on the Baysaver[®] at the CATS BMOF showed median effluent concentrations of 1.1 mg/L, 0.3 mg/L, and 1.4 mg/L, respectively.

In comparison with the ISBD, the median effluent concentration of TN was low. Median effluent TKN and NOx concentrations were comparable to those reported in the ISBD. Inflow and outflow TN concentrations for each storm can be seen in Appendix A – Figure A3. Influent EMCs for TKN and TN were low, likely leading to low removal efficiencies.

Phosphorous:

TP removal in the CATS BMOF Baysaver® was 12%, a statistically insignificant relationship. 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. The removal of NOx would suggest some anoxic conditions occur in this device, the same conditions needed for phosphorous export; however, is it interesting that there is some TP removal despite the low TSS removal.

      The median effluent concentration of TP was comparable for the CATS BMOF data and for hydrodynamic devices in the ISBD. The median effluent concentration of TP determined for the Baysaver® (0.10 mg/L) is essentially the same as that reported by Geosyntec (2006) (0.16 mg/L). Since the median influent concentration of TP calculated for the device was 0.09 mg/L, it is probable that this hydrodynamic separator receives stormwater with a TP concentration so close to an irreducible concentration, that a low removal efficiency results. Inflow and outflow TP concentrations for each storm can be seen in Appendix A – Figure A4, there are obvious storm-to-storm removal efficiency fluctuations.

Metals

As for most of the other pollutants discussed in this document, 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.

The Baysaver® exhibited a metal removal efficiency that would be expected based on the low TSS removal. Zinc, copper and lead removal in the system was -4%, 7% and -10%, respectively. The lead concentrations were consistently at or below the minimum detectable level (5 mg/L), thus, efficiency ratios and median effluent concentrations cannot be evaluated. Compared to other studies performed on hydrodynamic devices, the median effluent concentration of zinc (94.2 mg/L) was comparable to that reported in the ISBD (100 mg/L). The median effluent concentration of copper (14 mg/L) was also comparable to that reported in the ISBD (15 mg/L) (Table 2). Again, the low removal efficiency is likely related to the low TSS removal that was shown. Due to metals binding to sediment, the relationship between TSS removal and metals removal is likely.

CONCLUSIONS

Based on the monitoring data collected and analyzed for this study at the CATS BMOF, the Baysaver® did not significantly reduce the majority of the measured stormwater pollutants at the site. Although the BMP was routinely maintained at semi-annual to annual intervals, removal efficiencies were found to be negative in regards to TSS, likely due to resuspension of previously stored sediment. Additionally, removal efficiencies for TN, and TP were low. It is also likely that the low influent concentration of pollutants entering this hydrodynamic BMP was a factor which impacted these findings. In addition, sampling at the invert of the stormwater pipes may also have been a factor for some storm events monitored.

Effluent concentrations of TSS, TP, and TN were comparable to or lower than those reported for hydrodynamic devices in the International Stormwater BMP database, indicating that although the efficiency ratios determined for various pollutants were less than the 85% removal efficiency desired by the City of Charlotte, the low influent concentrations likely played a role in the BMP performance.

Compared to the report prepared for the Baysaver® as part of the NJCAT program, the sediment removal efficiency at the CATS BMOF site was low. It should be noted, however, that the sediment entering the CATS BMOF Baysaver® was presumably different than that used in the laboratory described in the NJCAT report. Low influent sediment concentrations and the presumed fine sediment particles in the influent likely played a role in the low TSS efficiency described in this report, as low concentrations of fine particles are hard to remove from stormwater.

There is some debate among the water quality profession concerning the most appropriate methodology to quantify suspended sediment concentrations in surface water quality samples. While TSS is the most commonly evaluated parameter, suspended sediment concentration (SSC) is considered by some to be a more appropriate way to quantify this pollutant; however, it should be noted that the City of Charlotte's NPDES stormwater permit requires stormwater BMPs to be adequately designed to reduce TSS by 85% in stormwater runoff. Therefore, a TSS removal efficiency of 85% is the predominate indicator of BMP performance evaluation within the City's BMP monitoring program. For comparison purposes, both TSS and SSC samples were collected and analyzed for a number of storm events monitored at this BMP site. The TSS removal efficiency was -8%, while the SSC removal efficiency was -21% at the CATS BMOF site.

Other pollutants of concern such as TN, TP, and various metals were removed by the BMP with a low efficiency (Figure 4 and Table 1); however, the median effluent concentrations of TN and TP were lower than those reported by Geosyntec, 2006 in an analysis of hydrodynamic devices in the International

Stormwater BMP Database. Influent concentrations were potentially close enough to the irreducible concentration such that efficiency ratios indicate lower performance.

A number of the analyses did not produce statistically significant results regarding the difference in influent and effluent pollutant concentration (Table 2). The storm by storm removal efficiencies seen in Appendix A (figures A1-A4) show the fluctuation in removal efficiency that occurred throughout the study. Similar fluctuations were also reported by Andoh et al. (2002), who observed variable TSS removal performance yet relatively consistent effluent TSS concentrations. A similar consistent effluent TSS concentration was not observed in this study, possibly due to the low influent TSS concentration.

While the removal efficiencies reported for the Baysaver[®] BMP in this study were less than the 85% TSS removal efficiency criteria in the City's NPDES stormwater permit, the results apply to the BMP's performance within one specific land use type (that being impervious areas associated with commercial/municipal parking areas and roof tops). In addition, it should be noted that the influent EMCs reported at the CATS BMOF facility were comparable to influent EMCs reported for other conventional BMPs with similar land use types studied under the City's program.

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Baysaver Website: http://www.baysaver.com/

APPENDIX A

Additional Graphs and Tables

Table A1: Results of statistical between inlet and outlet BMP concentrations of selected pollutants at the CATS BMOF Baysaver[®]

Parameter	Assumed Distribution	Reject Based on KS Test	Paired *t*-Test	Wilcoxian Signed - Rank Test	Significant ?
			p - value		
BOD	Log	Yes	0.0716	0.0742	No
COD	Log	Yes	0.1359	0.0425	Yes
NH4	Log	Yes	0.2709	0.1619	No
NOx	Log	Yes	0.0557	0.1031	No
TKN	Log	no	0.0938	0.0242	Yes
TN	Log	Yes	0.7625	0.5278	No
TP	Log	Yes	0.7111	0.7434	No
TSS	Log	no	0.6997	0.9607	No
TR	Log	Yes	0.0678	0.0669	No
SSC	Log	no	0.8116	0.9238	No
Turbidity	Log	Yes	0.0466	0.1705	No
Copper	Log	no	0.1185	0.1964	No
Zinc	Log	no	0.9226	0.637	No
Chromium	Log	Yes	0.5949	0.7813	No
Lead	Log	Yes	0.5907	0.6587	No

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.

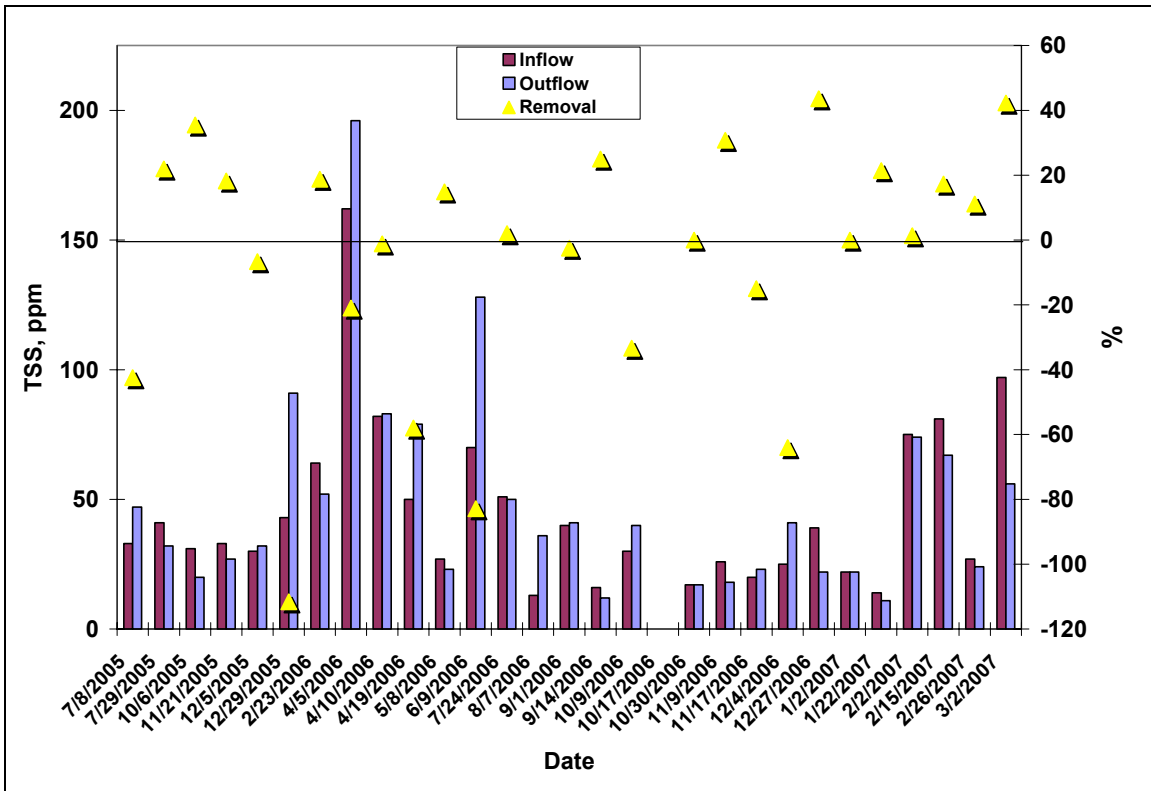2. Statistical tests were performed on log-transformed data except for copper, in which case raw data were used.

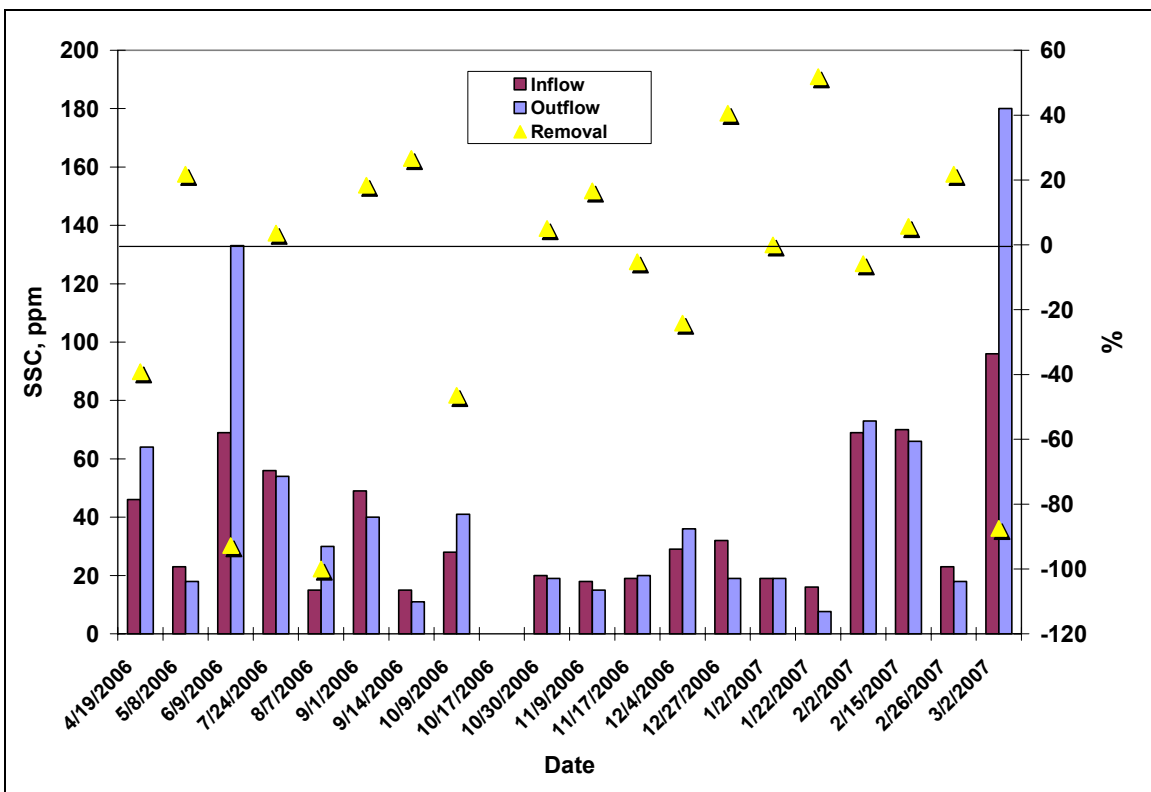**Figure A1: Change in TSS concentration due to BMP treatment by storm event.**

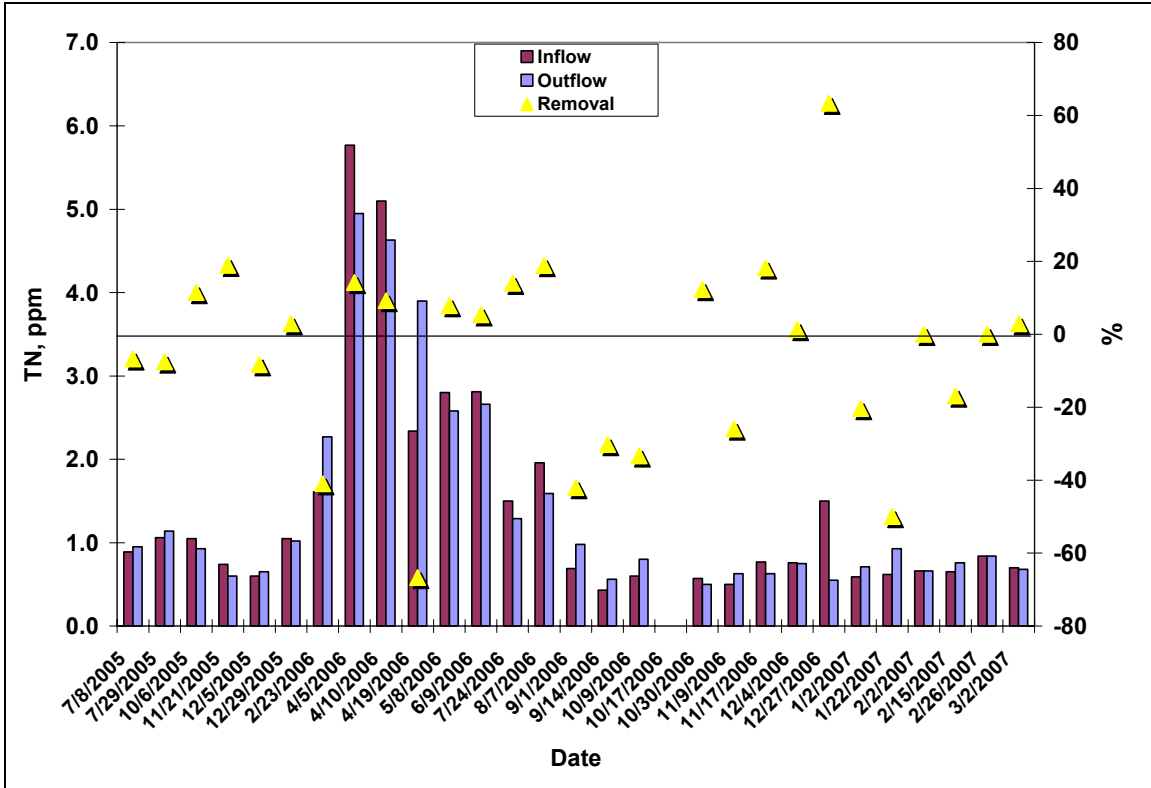**Figure A2: Change in SSC concentration due to BMP treatment by storm event.**

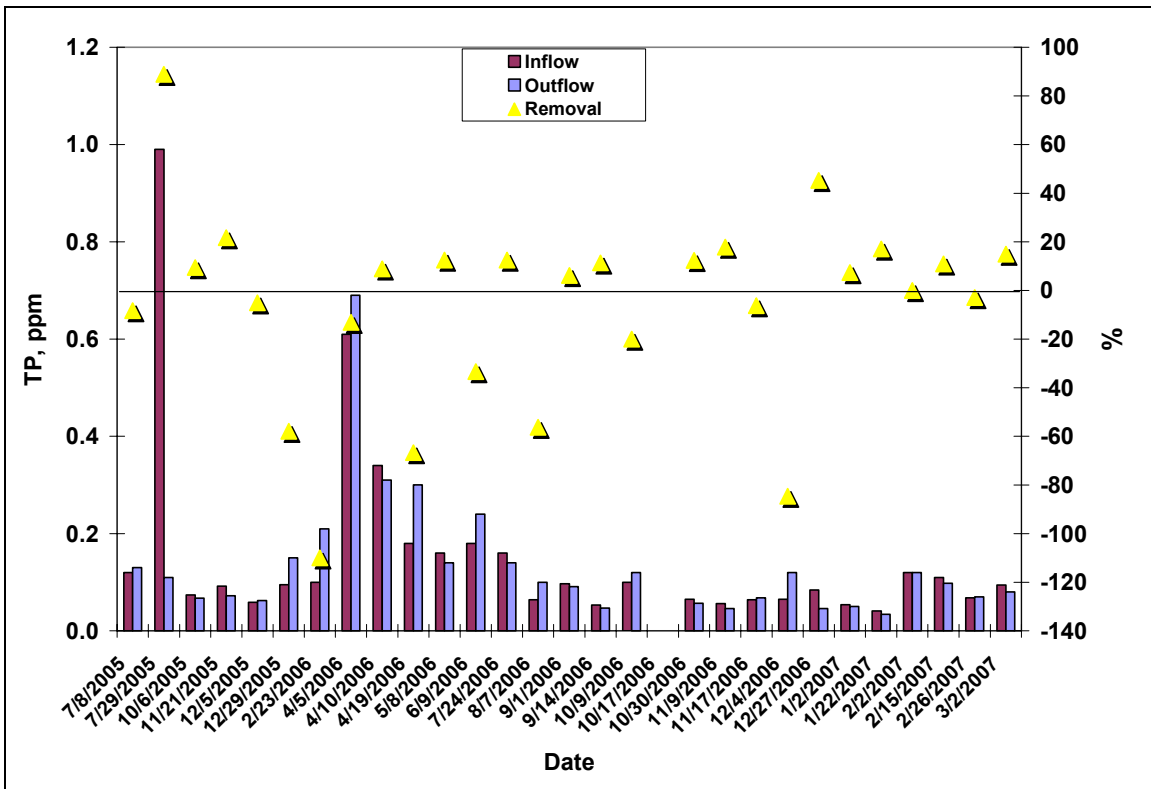**Figure A3: Change in TN concentration due to BMP treatment by storm event.**

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

APPENDIX B

Monitoring Protocol

Stormwater BMP performance Monitoring Protocol for:

CATS Bus Maintenance and Operations Facility
Baysaver® BMP

Description of Site:
The CATS-BMOF Baysaver® BMP is a manufactured proprietary BMP serving a portion of the Bus Maintenance and Operations Facility for the City of Charlotte.

Watershed Characteristics (estimated)
Watershed served by Baysaver Unit is approximately 2.28 acres and is 100% impervious concrete and metal roof surfaces. Primary use of the watershed is for bus parking.

Sampling equipment
Monitoring will take place in the 18" RCP pipes at the sampling manholes located immediately upstream and downstream of the BMP. During storm events this pipe may experience a tail water condition. As a result it is necessary to utilize a low profile Area-Velocity meter at this location. The Area-Velocity meter should be positioned just upstream of the flared section of RCP and not further upstream to avoid any potential turbulence caused by upstream structures.

Inlet Sampler
Primary device: 18" diameter RCP
Secondary Device: ISCO model 750 area-velocity meter
Sampler   ISCO 3712 Avalanche
Bottle Configuration four 1 gal polypropylene bottles

Outlet Sampler
Primary Device: 18" diameter RCP
Secondary Device: ISCO Model 750 area- velocity meter
Sampler   ISCO 3712 Avalanche
Bottle Configuration four 1 gal polypropylene bottle
Rain gage   ISCO model 674 installed onsite

Sampler settings

> <u>Inlet Sampler</u>
> Sample Volume   200 mL
> Pacing   102 Cu Ft.
> Set point enable   None

> <u>Outlet Sampler</u>
> Sample Volume   200mL
> Pacing   102 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**.**