"Monitoring the Effectiveness of Best Management Practice in Removing Pollutants from Urban Stormwater Runoff"

"Bioretention, DC Sandfilter, and BaySaver"

Site Locations: Benning Road Bridge, DC Village, and W Street Parking Facility

Duration: October 1, 2004 – December 31, 2006

Reported by

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TABLE OF CONTENTS

Acronyms

- Heavy Metals: As: Arsenic; Cd: Cadmium; Cr: Chromium; Cu: Copper;
- Hg: Mercury; Pb: Lead; Zn: Zinc
- NH_3-N: Nitrogen as ammonia
- NO^-_2-N: Nitrogen as nitrite
- NO^-_3-N: Nitrogen as nitrate
- PO^{3-}_4-P: Phosphorus as phosphate
- DO: Dissolved Oxygen
- BOD: Biological Oxygen Demand
- FC: Fecal Coliform
- TSS: Total Suspended Solids
- TDS: Total Dissolved Solids
- T: Temperature
- In: Influent concentration
- Out: Effluent concentration
- Avg.: Average
- St dev.: Standard deviation
- BMP: Best Management Practices

Synopsis

This report is based on field sampling that was conducted between February 14, 2005 and October 27, 2006 to measure the effectiveness of the biorentention site at the Benning Road Bridge over the Anacostia River, the DC Sand filter underneath a parking lot at DC Village, and a BaySaver underneath the parking lot at the W Street parking lot in removing pollutants from urban stormwater runoff. Influent and effluent samples were collected from 15, 12, and 18 at Benning Road, DC Village, and W Street respectively. Only major rainfall events, greater than 0.1 inches of rain, with an antecedent dry period of 72 hours, in compliance with EPA regulations for further analysis in the laboratory were monitored.

The report is divided into four sections; methodology, results, conclusions, and appendix. The methodology section presents the basic methods used for all three sites and highlights the instruments that were used in investigating the amount of pollutants present in the runoff. The results section includes tabular and graphical representations of the physical, chemical and biological characteristics of concern tested in each of the 15 sample events and analysis behind the overall numbers that result from compiling all of the data for a given parameter together. All values presented are averaged values of triplicate measurements and their corresponding standard deviations are shown in the tabular form. The appendix comprises all of the raw data results from the laboratory analysis performed during this project.

In general, after all of the analysis, it is the view of Dr. Glass that the results imply that the DC Sand filter is working properly and is properly maintained. The bioretention at Benning Road was not performing well during the study and it is believed to be undersized for the amount of runoff that results during an average storm in this area. The BaySaver did not perform well for the majority of this investigation; however, once the device was cleaned performance did improve substantially. All of the devices, no matter whether they were maintained or designed properly, did perform better than if there was no device present at all, for at least some parameters of interest.

Benning Road Bioretention Site

DC Village Sand Filter

W Street Parking Facility BaySaver

Methodology

Introduction

In order to capture the highest concentration of water pollutants the focus is normally on "first flush" discharge samples thus, samples are normally collected after a major storm event after at least 72 hours of extended dry period has elapsed from one

Table 1: Analytical Techniques for Each Contaminant	
Contaminant	***Analytical Technique***
Cd, Cr, Cu, Hg, Pb, As, Zn	*Atomic Absorption Spectrometer with Furnace Module*
NH_4^+-N	*Ion Chromatography - Cation*
NO^-_2-N, NO^-_3-N, PO^{3-}_4-P	*Ion Chromatography - Anion*
BOD	*5-day Biological Oxygen Demand Involving the Use of Dissolved Oxygen Meter*
DO	*Dissolved Oxygen Meter*
TSS	*Total Suspended Solids Dried at 103-105°C*
PAH	*High Pressure Liquid Chromatography*
TDS	*Total Dissolved Solids Dried at 600^{o}C*
Temperature	*Thermocouple*
pH	*pH-probe*

event to another. Rain events are monitored by checking the local weather station or weather related internet sites. Stormwater runoff samples from the all sites are collected into cleaned 4 liter jars for further analysis in the lab.

Collection Procedure

Sample collection took place shortly after a rain event began or from ISCO samplers that were programmed prior to the event in order to ensure accuracy in measured parameters. Samples were collected into storage bins that are placed at specific points of the bioretention system to collect both inlet and outlet discharge samples. The inlet and outlet samples discharged into the bins are then transferred into two precleaned airtight jars having a capacity of 4 liters. At the other two sites water was collected directly into the pre-cleaned glass jars. After collection, specific parameters such as pH, dissolved oxygen (DO) level and temperature are measured on site and reference is made to the laboratory manual in performing the required test. The collected discharge samples were then transported to the lab for other laboratory analysis.

Laboratory Analysis

As soon as the sample gets to the lab the pH, DO and temperature were measured again using the procedures in the laboratory manual to determine any deviation in on-site measurements. Approximately 200 ml of inlet and outlet samples are put into 250 ml beakers for the necessary measurements and all parameters in triplicate to eliminate any errors. Organic content of storm water run off samples were determined from chemical oxygen demand (COD) and biological oxygen demand (BOD) analysis. Method of analyzing the COD level can be found in the Hach Water analysis handbook. The BOD levels of the samples were also measured as soon as the samples reached the lab. In order to accomplish this, a total of 6 BOD bottles with air tight stoppers are filled with samples. Three of the BOD bottles contain the inlet discharge samples and the other 3 BOD bottles contained the outlet discharge samples. In filling the bottles care was taken to ensure that air was not trapped in the bottles. The bottles were then placed in boxes and stored in a dark area for 5 days. At the end of the 5 days, the DO levels of both inlet and outlet samples were measured and the BOD level was determined from calculation. To determine the solid content of the samples, total suspended solids (TSS) and total dissolved solids (TDS) measurements are taken within 24 hrs of sample collection by following the procedure in the Standard Methods for the Examination of Water and Wastewater (Standard Methods, 20th Ed.)..

Nutrients of concern analyzed in the laboratory include; total phosphorus, nitrite (NO_2^- - N), nitrate (NO_3^- - N), phosphate (PO_4^{-3} – P) and ammonia. The Hach Water analysis handbook gives a precise method of measuring the total phosphorus content. NO_2^- - N, NO_3^- - N, PO_4^{-3} – P and ammonia were analyzed with the Dionex IC DX- 120 instrument and the technique is based on ion chromatography (IC) and liquid chromatography (LC). Both inlet and outlet discharge samples were filtered prior to any IC analysis. Part-per billion (ppb) concentrations of heavy metals in the samples were analyzed using atomic absorption spectroscopy (AAS) and both inlet and outlet samples were filtered prior to AAS analysis. Ideally for accuracy in test results, it is recommended that all IC and AAS analysis should be performed on fresh samples or within 24hrs of sample collection however samples that cannot be analyzed within this time frame can be preserved on short term basis (1 to 2 days) or long period (6 months) for future analysis (Standard Methods, 20th Ed.). Short term preservation can be achieved by refrigerating the samples at 4^oC. Acid preservation is not recommended for nitrites since this may cause bacterial conversion of NO_2^- to NO_3^-. Samples for NO_3^- analysis can be preserved longer by addition of 2 mL concentrated H_2SO_4 and then refrigerated at 4^oC. Samples that have to be stored for a longer time before any phosphate analysis can be preserved by adding 40 mg $HgCl_2$/L to the samples before refrigerating at 4^oC. In the case of ammonia preservation for up to 28 days for future analysis is possible by either freezing at -20^oC with any acid addition or by adding acid until the pH is less than 2 before refrigerating at 4^oC. Prior to refrigeration at 4^oC, samples for heavy metal analysis can be preserved by acidifying with conc. nitric acid (HNO_3) until the pH is less than 2 (Standard Methods, 20^{th} Ed.).

Results

In the field of stormwater management there are many variables that cause fluctuations in the performance of stormwater devices. The three devices monitored in this study have drastically varying performance characteristics. In addition, the three sites monitored were drastically different sites with different designs for capturing flow, different overall areas which lead to largely varying peak flow rates, and all three sites were designed with different purposes in mind. When monitoring the devices from varying sites there are no set rules that reveal what makes a site a good performing site and another a bad performing site. Unlike in drinking water treatment and wastewater treatment, the guidelines for stormwater devices do not call for a give concentration to meet, but rather typically are designed to retain a certain amount of flow.

There are, however, a range of values that have been presented in Table 2 from the National Stormwater Best Management Practices Database that show a broad range of values that are found in stormwater. This overview of the range of values found in previous studies encompasses all of the concentrations of parameters going into the three sites of this study, with a few noteworthy exceptions. The heavy metals concentrations of Cadmium, Chromium, Arsenic, and Mercury were found to be higher in the runoff from the Benning Road bridge and the W Street Parking lot than the maximum values found in the National database. The DC Village parking lot had no values that exceeded the values found in the National database. This is most likely the result of the DC Village parking lot being a very small area with relatively little use in comparison to the Benning Road Bridge and the W Street industrial parking lot. The DC Village parking lot never contained more than 15 cars throughout the course of this study, while the Benning Road bridge is a major thoroughfare in the city with thousands of car traffic per day and the W Street Parking lot stores over 100 heavy vehicles and contains piles of asphalt, sand, and other road materials.

Table 2: From the ASCE Maximum and Minimum Values for Water Quality Parameters in the National Stormwater Best Management Practices Database

Water Quality Parameter	Maximum Value	Minimum Value-	Unit
CADMIUM, DISSOLVED	0.008	-0.0075	mg/l
CHROMIUM, DISSOLVED	0.012	-0.0005	mg/l
COD	2030	-12.14	mg/l
COPPER, DISSOLVED	0.05	-0.005	mg/l
IRON, DISSOLVED	0.518	0.004	mg/l
LEAD, DISSOLVED	0.2905	-0.005	mg/l
NITRATE NITROGEN, TOTAL	28	-5	mg/l
NITRITE PLUS NITRATE	9.09	-0.01	mg/l
NITROGEN, AMMONIA, TOTAL	9	-0.5	mg/l
OIL & GREASE	66.7	-1.5	mg/l
OXYGEN, DISSOLVED	13.93	0.02	mg/l
pH (STANDARD UNITS)	10.3	4.2	SU
PHOSPHORUS, DISSOLVED	8.42	0.0022	mg/l
PHOSPHORUS, TOTAL	80.2	-0.1	mg/l
RESIDUE, TOTAL FILTRABLE	11000	38	mg/l
RESIDUE, TOTAL NONFILTRABLE	7100	-12.5	mg/l
TEMPERATURE, WATER	33.22	9.6	°C
ZINC, DISSOLVED	2.618	-0.05	mg/l

(Negative if below detection limit, zero values excluded)

Perhaps a better comparison between the values found in the USEPA's priority and non-priority pollutants for fresh water, and the values found going into and out of the three sites is more appropriate. With these values, that take into the impact the pollutants have on aquatic life and the possibility of the use of the water as drinking water downstream, the heavy metal concentrations coming from the sites are of larger concern. Many of the parameters found on the priority pollutants list are found in excess going into and out of the three sites monitored, again with the exception of the DC Village site.

Table 3 Chronic Priority Pollutants for Fresh Water (USEPA)

Pollutant	Chronic Concentration (ppb)
Copper	9
Cadmium	0.25
Zinc	120
Chromium	11
Lead	2.5
Arsenic	150
Mercury	0.77

Table 4 Non-Priority Pollutants (USEPA)

Pollutant	Concentration (mg/L)
pH	6.5-9.0
Dissolved Oxygen	Dependent
Temperature	Dependent
TSS	80
TDS	250
PAH	0
Total Nitrogen	10
Total Phosphorus	0.1

Comparing the values found in Tables 3 and 4 with the values for the measured parameters in Table 5 that contains the summary of results for the Benning Road bioretention it is evident that several parameters are excessive. Copper, Cadmium, Lead, and Mercury had average concentrations into and out of the BMP in excess of the priority pollutant concentrations. All of the non-priority pollutants were in a reasonable range of values, however the efficiency of removal did not compare well to other bioretention studies.

The results of the DC Sand Filter at DC Village are shown in Table 6. When comparing the values in Table 6 with the priority and non-priority pollutants found in Table 4 and 5, only Cadmium exceeded the concentration found on the priority pollutants list in both the influent and the effluent. TSS exceeded the value found in the non-priority pollutant list however the value of the effluent was sufficiently below this concentration due to the performance of the filter.

Prior to the cleaning of the BaySaver at the W Street parking lot, every parameter was elevated when compared to stormwater runoff from the other two sites, as can be seen in Table 7. When compared to Table 3 and Table 4, Copper, Cadmium, Mercury, TSS, and TP were all elevated both going into and coming out of the BaySaver. After the BaySaver was cleaned all of the values decreased however these values decreased for the influent and the effluent. Thus after only sampling 3 events where no significant difference between the concentrations entering or leaving the device, no conclusions can be made to the devices performance after maintenance. The removal efficiency of the BaySaver for all parameters both pre- and post-cleaning was poor. No one pollutant was removed at above 90%. The system is designed to store pollutants not remove them.

Table 5 Summary of Bioretention Data

Contaminant	**Influent Avg. and Std. Dev.**	**Effluent Avg. and Std. Dev**	***Removal Efficiency***
pH	**8.09 ± 0.46**	**7.75 ± 0.46**	
D.O.	**5.87 ± 1.87**	**5.80 ± 0.88**	
Temp. (°C)	**19 ± 3.5**	**18.3 ± 4.1**	
TSS	**176 ± 396**	**24 ± 28**	***86%***
TDS	**146 ± 353**	**14 ± 24**	***91%***
Cu	**23 ± 29**	**11 ± 29**	***53%***
Cd	**9 ± 32**	**2 ± 9**	***78%***
Zn	**70 ± 32**	**52 ± 27**	***26%***
Cr	**10 ± 7**	**5 ± 4**	***50%***
Pb	**47 ± 179**	**16 ± 56**	***66%***
As	**29 ± 112**	**31 ± 119**	***-6%***
Hg	**54 ± 126**	**42 ± 86**	***22%***
TP	**0.5 ± 0.4**	**0.2 ± 0.2**	***60%***
PO_4^{-3}	**0.0 ± 0.1**	**0.0 ± 0.1**	***0%***
NO_2^-	**0.4 ± 0.6**	**0.3 ± 0.5**	***-25%***
NO_3^-	**0.2 ± 0.3**	**0.2 ± 0.2**	***0%***
NH_4^+	**22 ± 55**	**16 ± 40**	***27%***
COD	***112 ± 92***	***66 ± 43***	***41%***

Table 6 Summary of DC Sand Filter Data

Contaminant	**Influent Avg. and Std. Dev.**	**Effluent Avg. and Std. Dev**	***Removal Efficiency***
pH	**6.6 ± 0.9**	**6.6 ± 0.3**	
D.O.	**6.2 ± 1.2**	**6.7 ± 1.7**	
Temp. (°C)	**22.8 ± 4.6**	**22.8 ± 4.7**	
TSS	**96 ± 232**	**11 ± 3.2**	***88%***
TDS	**54 ± 125**	**10 ± 2**	***81%***
Cu	**6 ± 4**	**4 ± 3**	***33%***
Cd	**1 ± 1**	**3 ± 6**	***-200%***
Zn	**12 ± 2**	**12 ± 2**	***0%***
Cr	**0.3 ± 0.2**	**0.3 ± 0.2**	***0%***
Pb	**0.3 ± 0.2**	**0.4 ± 0.4**	***0%***
As	**2.3 ± 0.8**	**2.2 ± 1.0**	***0%***
Hg	**0.8 ± 0.8**	**0.8 ± 1.2**	***0%***
TP	**0.3 ± 0.4**	**0.2 ± 0.2**	***40%***
PO_4^{-3}	**0.2 ± 0.5**	**0.2 ± 0.6**	***0%***
NO_2^-	**0.2 ± 0.4**	**0.2 ± 0.4**	***0%***
NO_3^-	**0.3 ± 0.4**	**1.1 ± 1.4**	***-300%***
NH_4^+	**2.8 ± 3.1**	**1.3 ± 0.7**	***53%***
COD	***62 ± 43***	***38 ± 41***	***39%***

Table 7 Summary of BaySaver Pre-Cleaning Data

Contaminant	**Influent Avg. and Std. Dev.**	**Effluent Avg. and Std. Dev**	***Removal Efficiency***
pH	**6.8 ± 0.4**	**6.8 ± 0.5**	
D.O.	**7.8 ± 1.4**	**7.4 ± 1.4**	
Temp. (ºC)	**22.9 ± 5.1**	**22.6 ± 4.1**	
TSS	**290 ± 499**	**111 ± 64**	***62%***
TDS	**230 ± 426**	**75 ± 30**	***67%***
Cu	**12 ± 8**	**10 ± 6**	***17%***
Cd	**12 ± 31**	**4 ± 9**	***64%***
Zn	**20 ± 15**	**19 ± 10**	***4%***
Cr	**5.1 ± 7.1**	**2.7 ± 2.0**	***46%***
Pb	**48 ± 137**	**1.2 ± 1.3**	***97%***
As	**38 ± 112**	**10 ± 10**	***74%***
Hg	**98 ± 128**	**90 ± 163**	***9%***
TP	**0.6 ± 0.3**	**0.4 ± 0.2**	***24%***
PO_4^{-3}	**0.3 ± 0.3**	**13 ± 22**	***-37%***
NO_2^-	**1.5 ± 5.3**	**0.8 ± 2.2**	***48%***
NO_3^-	**0.8 ± 1.3**	**1.7 ± 3.0**	***-107%***
NH_4^+	**1.4 ± 1.2**	**1.0 ± 1.2**	***27%***
COD	***118 ± 43***	***102 ± 47***	***13%***

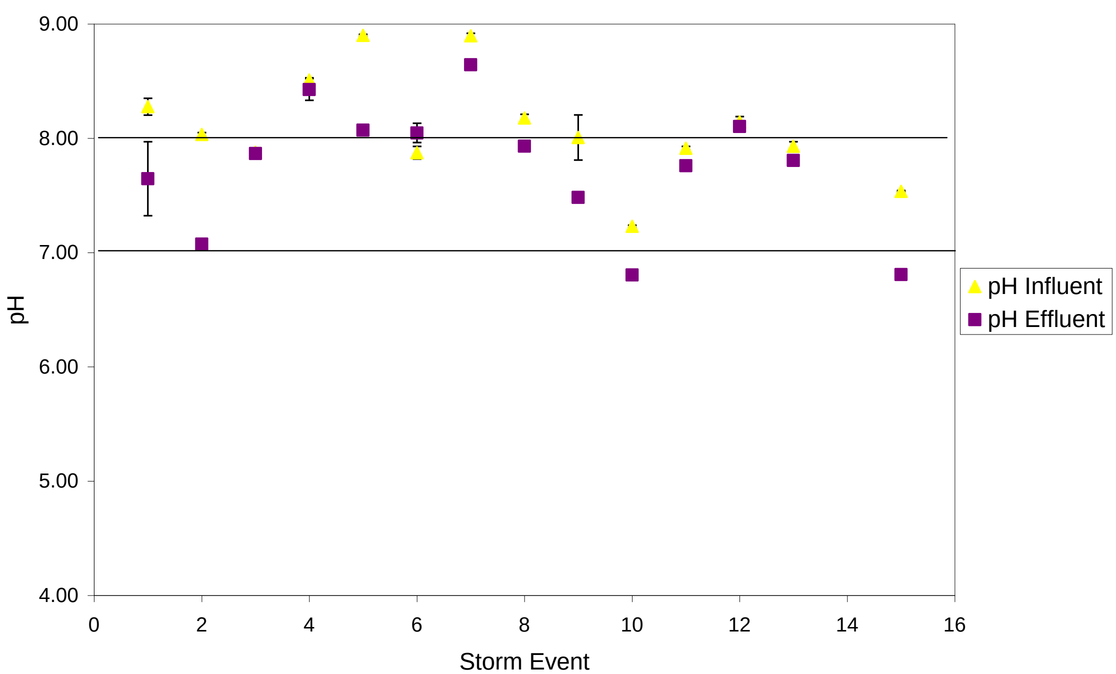
Table 8 Summary of BaySaver Post-Cleaning Data

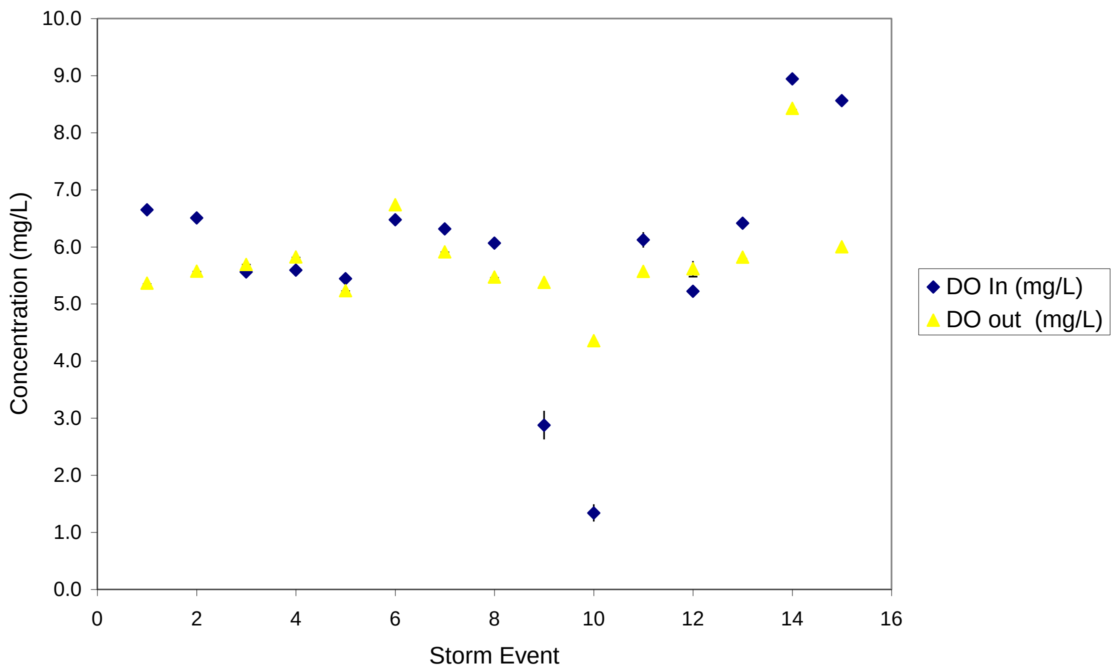
Contaminant	**Influent Avg. and Std. Dev.**	**Effluent Avg. and Std. Dev**	***Removal Efficiency***
pH	**6.8 ± 0.9**	**7.2 ± 0.5**	
D.O.	**9.2 ± 0.5**	**8.0 ± 1.2**	
Temp. (ºC)	**18 ± 4.8**	**19 ± 4.0**	
TSS	**3.3 ± 3.0**	**3.1 ± 2.7**	***7%***
TDS	**64 ± 15**	**73 ± 30**	***-15%***
Cu	**8 ± 5**	**11 ± 1**	***-41%***
Cd	**154 ± 37**	**170 ± 28**	***-10%***
Zn	**3 ± 6**	**17 ± 2**	***-4%***
Cr	**1.8 ± 1.1**	**2.5 ± 0.8**	***-37%***
Pb	**0.8 ± 0.5**	**0.8 ± 0.8**	***0%***
As	**3.5 ± 5.1**	**8.4 ± 2.9**	***-141%***
Hg	**0 ± 0**	**0 ± 0**	***0%***
TP	**0.4 ± 0.4**	**0.7 ± 0.4**	***-70%***
PO_4^{-3}	**0.2 ± 0.0**	**0.1 ± 0.1**	***50%***
NO_2^-	**0.2 ± 0.2**	**0.4 ± 0.4**	***-100%***
NO_3^-	**0.1 ± 0.2**	**0 ± 0**	***100%***
NH_4^+	**0.7 ± 0.8**	**0.5 ± 0.9**	***29%***
COD	***43 ± 19***	***41 ± 21***	***5%***

Results for the Bioretention Site

1. Storm event number, date of event, pH, DO, and temperature values.

Storm No	Date	pH Influent	St. Dev	pH Effluent	St. Dev.	DO In (mg/L)	St. Dev	DO out (mg/L)	St. Dev.	T In (C)	St. Dev	T Out (C)	St. Dev.
1	2/14/2005	8.3	0.1	7.6	0.3	6.7	0.1	5.4	0.0	15.5	2.2	13.5	2.8
2	2/24/2005	8.0	0.0	7.1	0.0	6.5	0.0	5.6	0.0	15.2	0.8	12.9	0.9
3	3/8/2005	7.9	0.0	7.9	0.0	5.6	0.0	5.7	0.0	13.5	0.3	11.8	0.2
4	3/20/2005	8.5	0.0	8.4	0.1	5.6	0.0	5.8	0.0	21.4	0.1	21.5	0.1
5	3/24/2005	8.9	0.0	8.1	0.0	5.4	0.0	5.2	0.0	12.6	0.2	11.2	0.2
6	4/4/2005	7.9	0.1	8.0	0.1	6.5	0.1	6.7	0.0	21.4	0.1	21.6	0.1
7	4/8/2005	8.9	0.0	8.6	0.0	6.3	0.0	5.9	0.0	20.1	0.4	21.1	0.1
8	4/22/2005	8.2	0.0	7.9	0.0	6.1	0.1	5.5	0.0	17.2	0.1	17.9	0.2
9	4/29/2005	8.0	0.2	7.5	0.0	2.9	0.3	5.4	0.1	20.3	0.2	20.0	0.2
10	5/16/2005	7.2	0.0	6.8	0.0	1.3	0.2	4.4	0.0	22.1	0.1	18.4	0.1
11	5/20/2005	7.9	0.0	7.8	0.0	6.1	0.1	5.6	0.0	19.7	0.1	19.3	0.0
12	5/24/2005	8.1	0.0	8.1	0.0	5.2	0.0	5.6	0.1	18.8	0.1	18.6	0.1
13	6/3/2005	7.9	0.0	7.8	0.0	6.4	0.0	5.8	0.0	19.5	0.1	19.6	0.1
14	6/7/2005					8.9	0.0	8.4	0.0	23.7	0.1	23.5	0.0
15	6/30/2005	7.5	0.0	6.8	0.0	8.6	0.0	6.0	0.1	23.5	0.1	23.5	0.1

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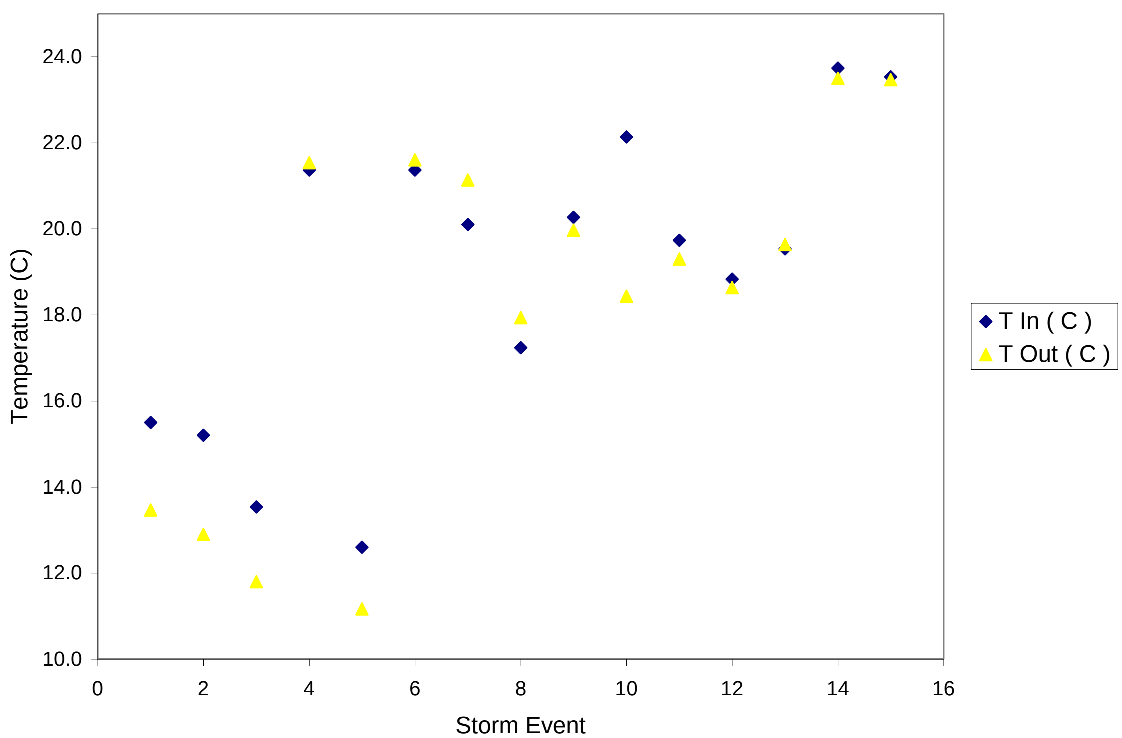
Storm Event
DO In (mg/L)
DO out (mg/L)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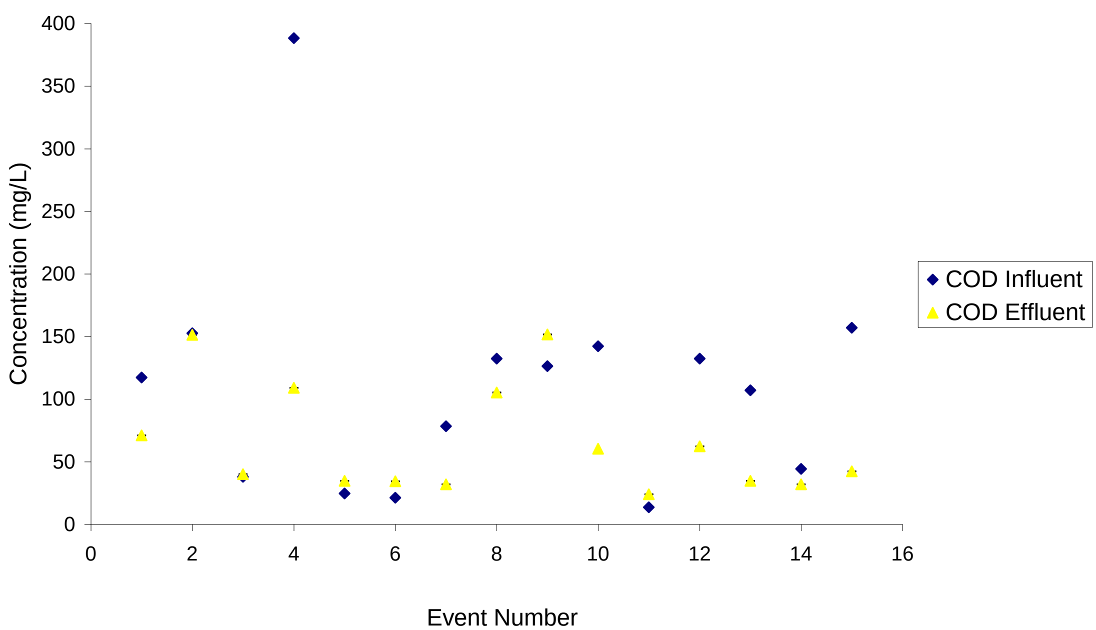
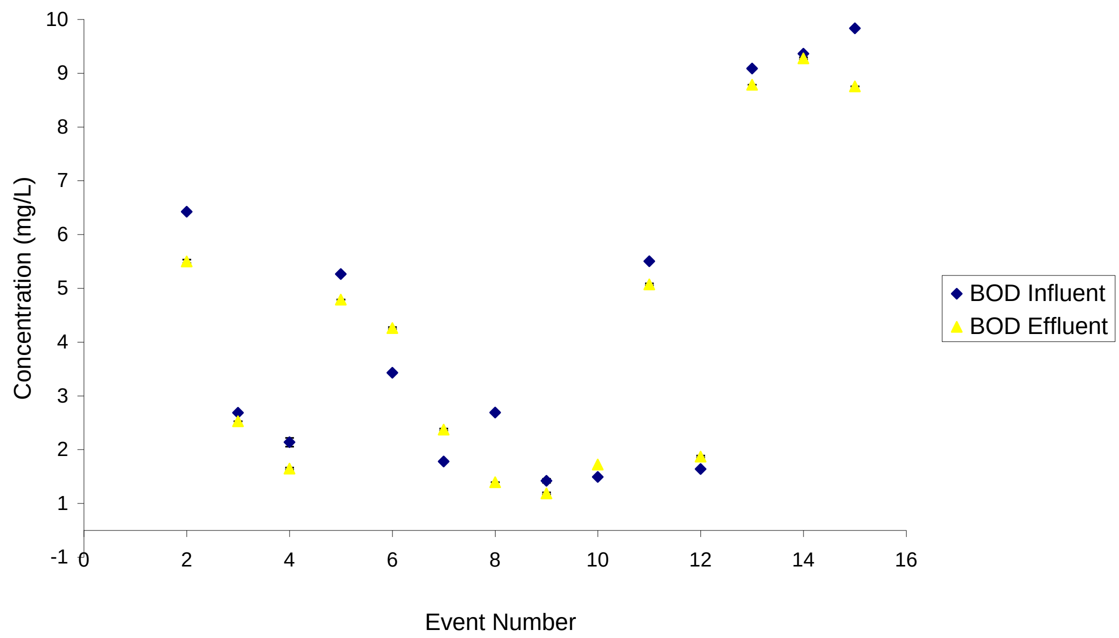
12
14
16
Storm Event
T In (C)
T Out (C)

2. Storm event number, date of event, chemical and biological oxygen demand values.

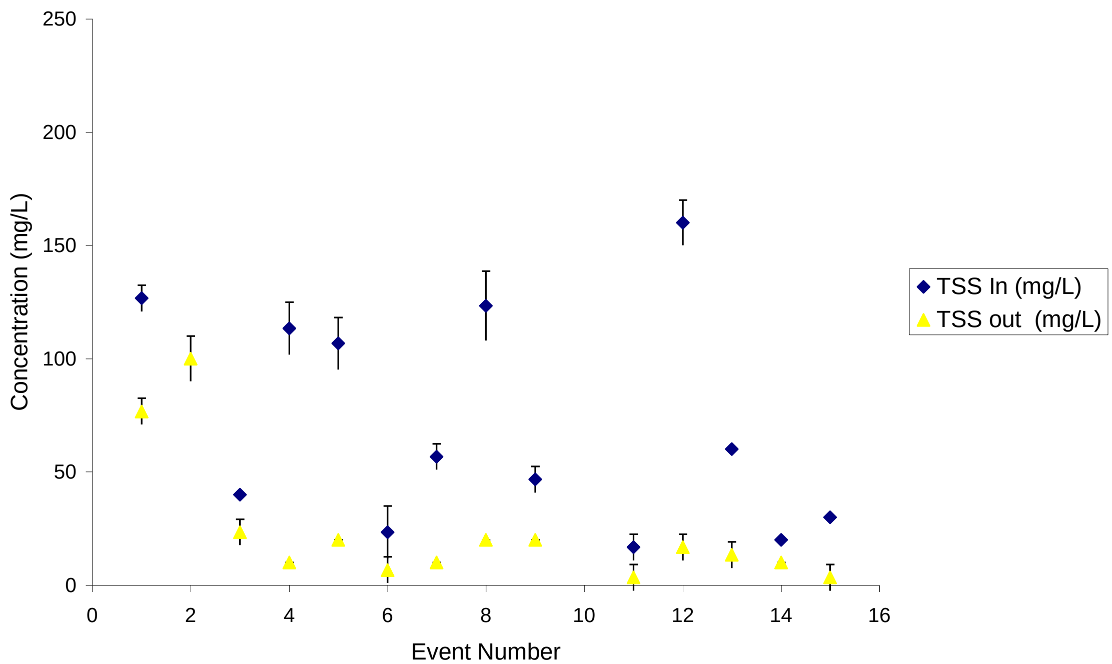
Storm No	Date	COD Influent (mg/L)	St. Dev	COD Effluent (mg/L)	St. Dev.	BOD Influent (mg/L)	St. Dev	BOD Effluent (mg/L)	St. Dev.
1	2/14/2005	117.3	0.6	71.0	2.0				
2	2/24/2005	152.7	2.5	151.3	4.2	5.9	0.1	5.0	0.0
3	3/8/2005	38.0	1.7	40.0	1.0	2.2	1.1	2.0	1.2
4	3/20/2005	388.3	2.9	109.0	14.7	1.6	0.0	1.1	0.1
5	3/24/2005	24.7	4.5	34.7	0.6	4.8	0.1	4.3	0.0
6	4/4/2005	21.3	15.9	34.3	1.2	2.9	0.3	3.8	0.1
7	4/8/2005	78.3	3.1	32.0	1.0	1.3	0.0	1.9	0.1
8	4/22/2005	132.3	2.5	105.3	1.5	2.2	0.8	0.9	0.2
9	4/29/2005	126.3	8.7	151.7	3.5	0.9	0.1	0.7	0.0
10	5/16/2005	142.3	0.6	60.3	1.5	1.0	0.1	1.2	0.2
11	5/20/2005	13.7	0.6	24.0	2.0	5.0	0.2	4.6	0.5
12	5/24/2005	132.3	1.5	62.3	0.6	1.1	0.1	1.4	0.2
13	6/3/2005	107.0	3.6	34.7	0.6	8.6	0.1	8.3	0.2
14	6/7/2005	44.3	3.1	32.0	1.0	8.9	0.0	8.8	0.1
15	6/30/2005	157.0	0.0	42.3	1.5	9.3	0.0	8.3	0.1

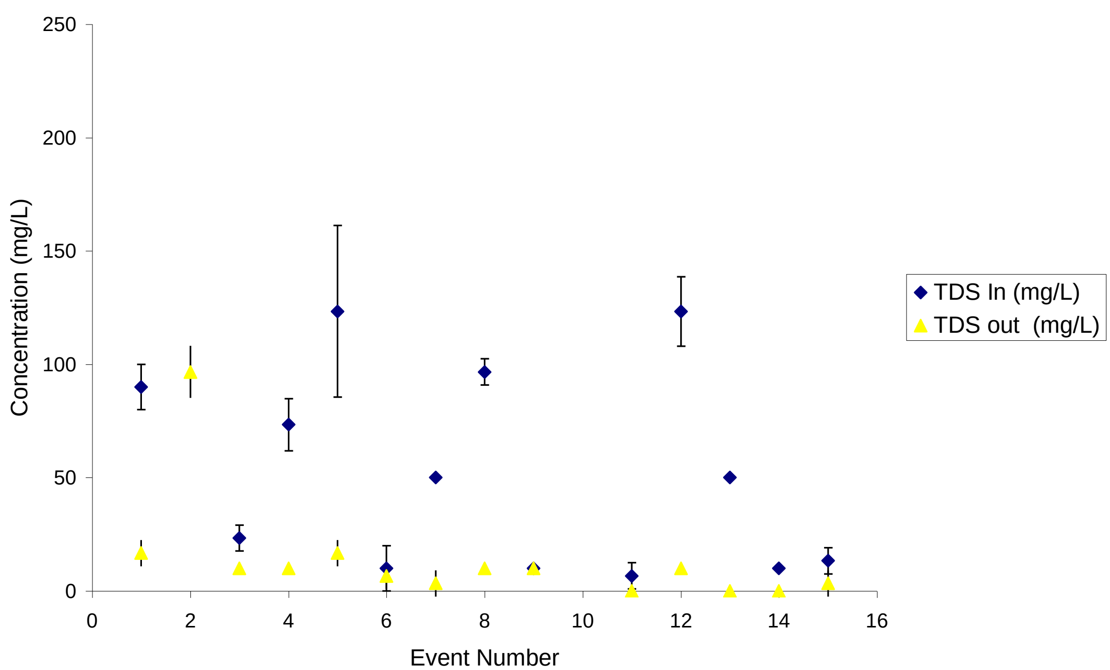




3. Storm event number, date of event, total suspended and total dissolved solid values.

Storm No	Date	TSS In (mg/L)	St. Dev	TSS out (mg/L)	St. Dev.	TDS In (mg/L)	St. Dev	TDS out (mg/L)	St. Dev.
1	2/14/2005	126.7	5.8	76.7	5.8	90.0	10.0	16.7	5.8
2	2/24/2005	1543.3	90.7	100.0	10.0	1363.3	73.7	96.7	11.5
3	3/8/2005	40.0	0.0	23.3	5.8	23.3	5.8	10.0	0.0
4	3/20/2005	113.3	11.5	10.0	0.0	73.3	11.5	10.0	0.0
5	3/24/2005	106.7	11.5	20.0	0.0	123.3	37.9	16.7	5.8
6	4/4/2005	23.3	11.5	6.7	5.8	10.0	10.0	6.7	5.8
7	4/8/2005	56.7	5.8	10.0	0.0	50.0	0.0	3.3	5.8
8	4/22/2005	123.3	15.3	20.0	0.0	96.7	5.8	10.0	0.0
9	4/29/2005	46.7	5.8	20.0	0.0	10.0	0.0	10.0	0.0
10	5/16/2005								
11	5/20/2005	16.7	5.8	3.3	5.8	6.7	5.8	0.0	0.0
12	5/24/2005	160.0	10.0	16.7	5.8	123.3	15.3	10.0	0.0
13	6/3/2005	60.0	0.0	13.3	5.8	50.0	0.0	0.0	0.0
14	6/7/2005	20.0	0.0	10.0	0.0	10.0	0.0	0.0	0.0
15	6/30/2005	30.0	0.0	3.3	5.8	13.3	5.8	3.3	5.8


250
200
150
100
50
0
0
2
4
6
8
10
12
14
16
Concentration (mg/L)
Event Number
TSS In (mg/L)
TSS out (mg/L)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200
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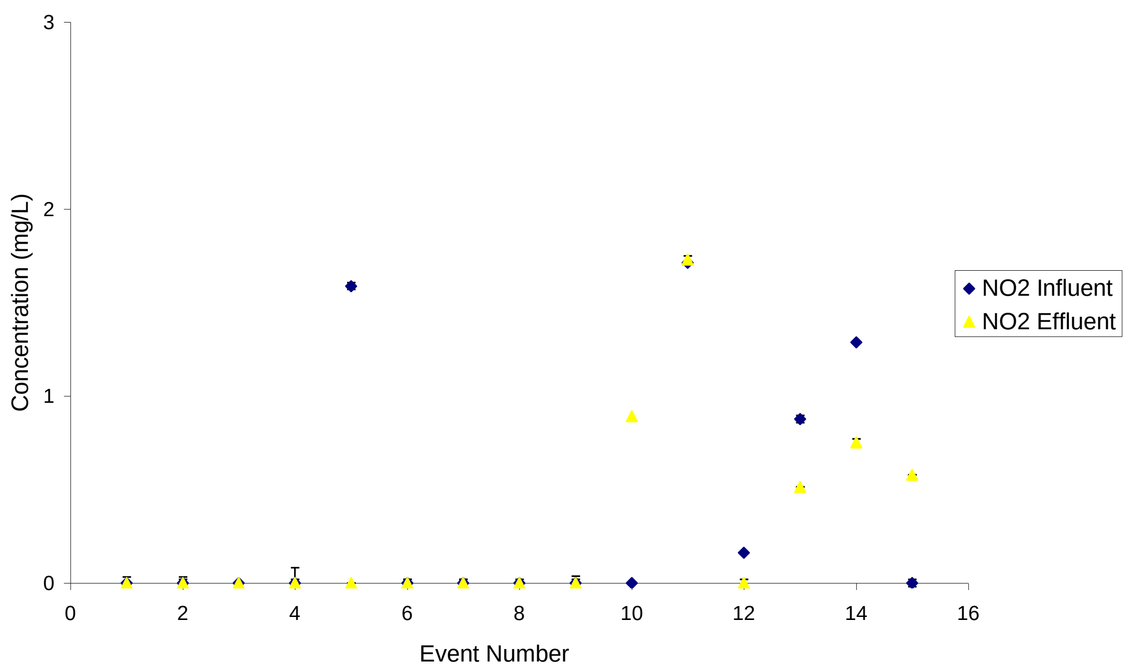
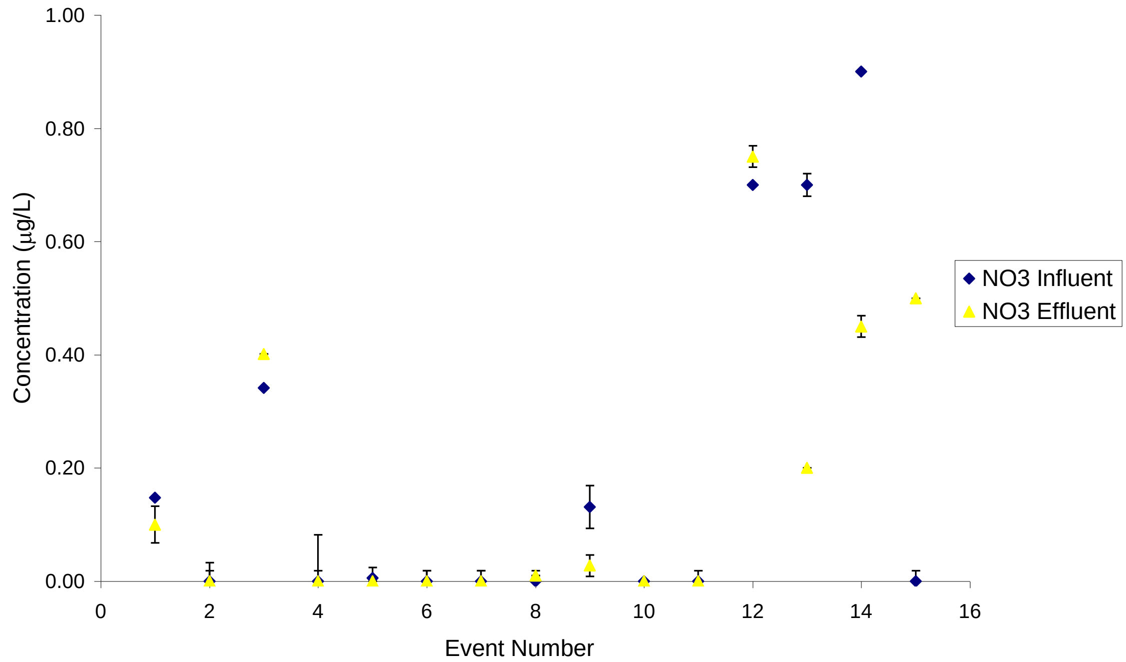
0
0
2
4
6
8
10
12
14
16
Concentration (mg/L)
Event Number
TDS In (mg/L)
TDS out (mg/L)

4. Storm event number, date of event, NO_2, NO_3, and PO_4 concentration values

Storm No	Date	NO2 Influent mg/L	St. Dev	NO2 Effluent mg/L	St. Dev.	NO3 Influent mg/L	St. Dev	NO3 Effluent mg/L	St. Dev.	PO4 Influent mg/L	St. Dev	PO4 Effluent mg/L	St. Dev.
1	2/14/2005	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.2	0.0
2	2/24/2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	3/8/2005	0.0	0.0	0.0	0.0	0.3	0.0	0.4	0.0	0.1	0.0	0.1	0.0
4	3/20/2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	3/24/2005	1.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	4/4/2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	4/8/2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	4/22/2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	4/29/2005	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
10	5/16/2005	0.0	0.0	0.9	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	5/20/2005	1.7	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
12	5/24/2005	0.2	0.3	0.0	0.0	0.7	0.0	0.8	0.1	0.3	0.0	0.0	0.0
13	6/3/2005	0.9	0.0	0.5	0.0	0.7	0.0	0.2	0.0	0.0	0.0	0.1	0.2
14	6/7/2005	1.3	0.0	0.8	0.0	0.9	0.0	0.5	0.1	0.3	0.0	0.3	0.0
15	6/30/2005	0.0	0.0	0.6	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0

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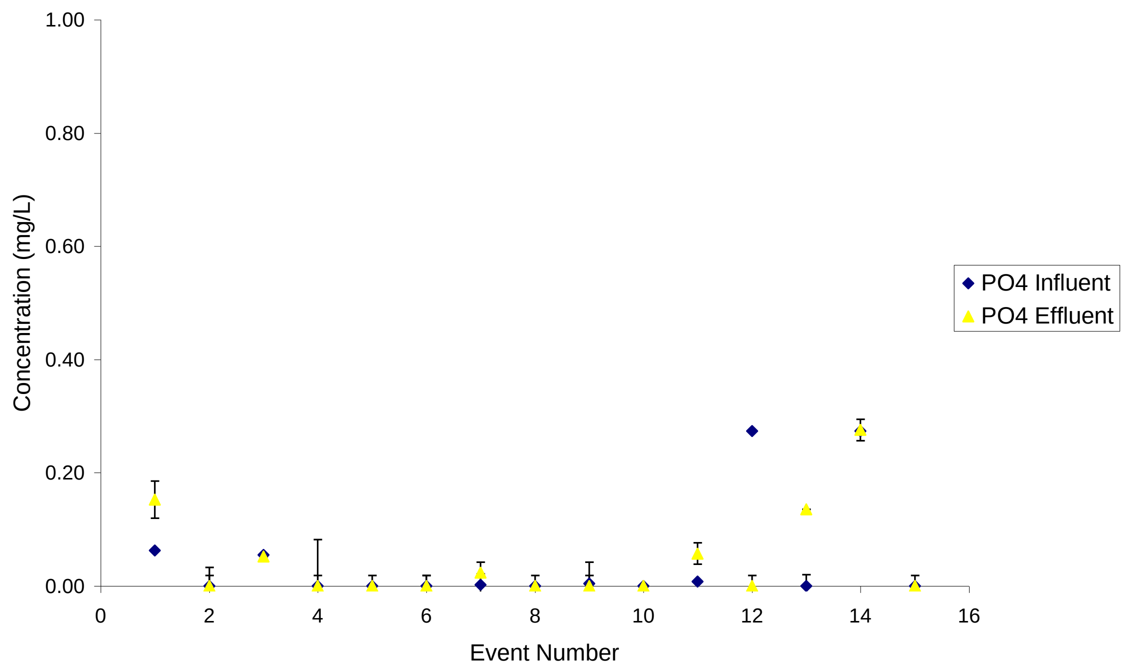
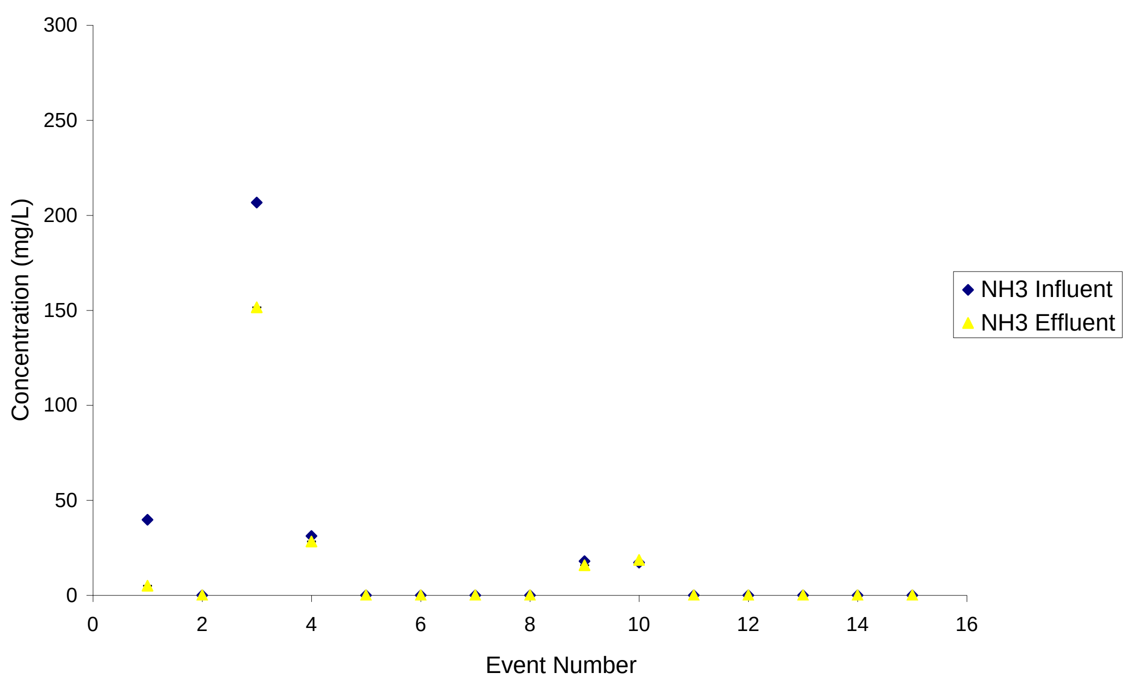
0.80
0.60
0.40
0.20
0.00
Concentration (µg/L)
0
2
4
6
8
10
12
14
16
Event Number
NO3 Influent
NO3 Effluent


1.00
0.80
0.60
0.40
0.20
0.00
Concentration (mg/L)
0
2
4
6
8
10
12
14
16
Event Number
PO4 Influent
PO4 Effluent

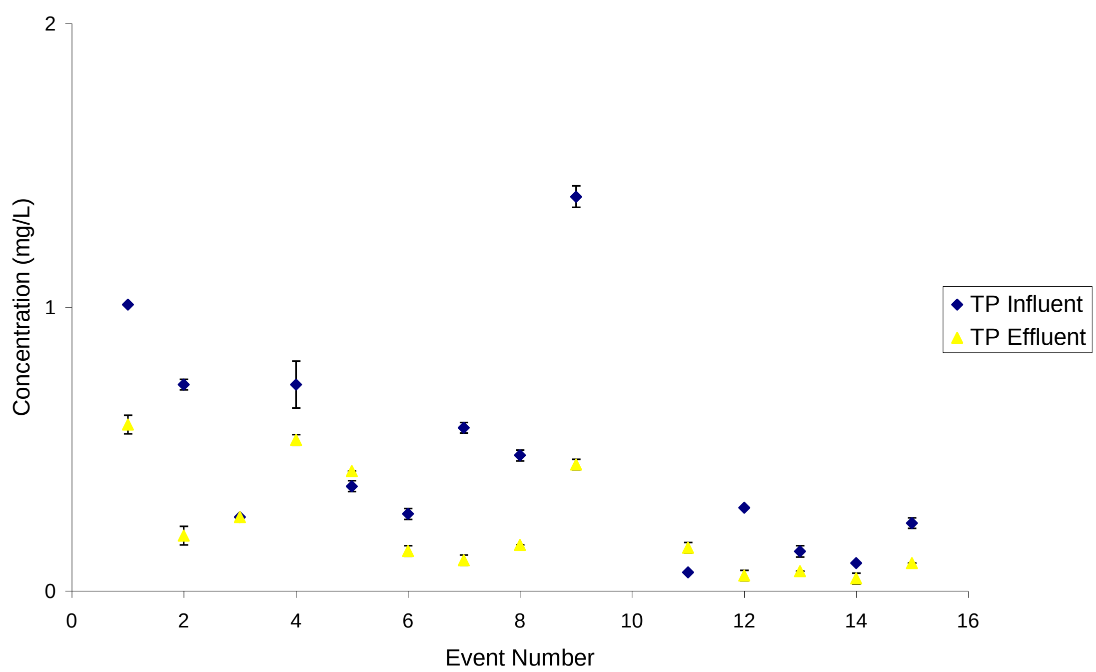
5. Storm event number, date of event, and ammonia concentration values.

Storm No	Date	NH3 Influent mg/L	St. Dev	NH3 Effluent mg/L	St. Dev.
1	2/14/2005	39.8	10.5	5.0	4.3
2	2/24/2005	No meas	No meas	No meas	No meas
3	3/8/2005	206.7	8.0	151.5	13.4
4	3/20/2005	31.2	0.3	28.3	0.5
5	3/24/2005	0.0	0.0	0.0	0.0
6	4/4/2005	0.0	0.0	0.0	0.0
7	4/8/2005	0.0	0.0	0.0	0.0
8	4/22/2005	0.0	0.0	0.0	0.0
9	4/29/2005	18.0	0.1	15.8	0.1
10	5/16/2005	17.3	0.1	18.6	0.6
11	5/20/2005	0.0	0.0	0.0	0.0
12	5/24/2005	0.0	0.0	0.0	0.0
13	6/3/2005	0.0	0.0	0.0	0.0
14	6/7/2005	0.0	0.0	0.0	0.0
15	6/30/2005	0.0	0.0	0.0	0.0



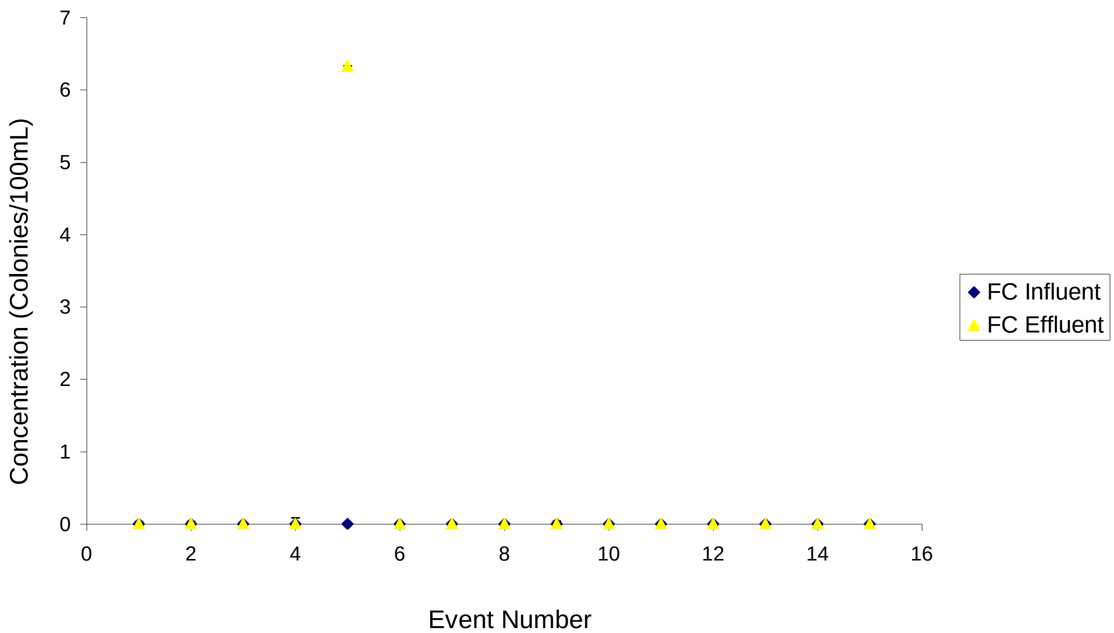
6. Storm event number, date of event, and TP concentration values.

Storm No	Date	TP Influent mg/L	St. Dev	TP Effluent mg/L	St. Dev.
1	2/14/2005	1.0	0.0	0.6	0.0
2	2/24/2005	0.7	0.0	0.2	0.0
3	3/8/2005	0.3	0.0	0.3	0.0
4	3/20/2005	0.7	0.1	0.5	0.0
5	3/24/2005	0.4	0.0	0.4	0.0
6	4/4/2005	0.3	0.0	0.1	0.0
7	4/8/2005	0.6	0.0	0.1	0.0
8	4/22/2005	0.5	0.0	0.2	0.0
9	4/29/2005	1.4	0.0	0.4	0.0
10	5/16/2005				
11	5/20/2005	0.1	0.0	0.2	0.0
12	5/24/2005	0.3	0.0	0.1	0.0
13	6/3/2005	0.1	0.0	0.1	0.0
14	6/7/2005	0.1	0.0	0.0	0.0
15	6/30/2005	0.2	0.0	0.1	0.0



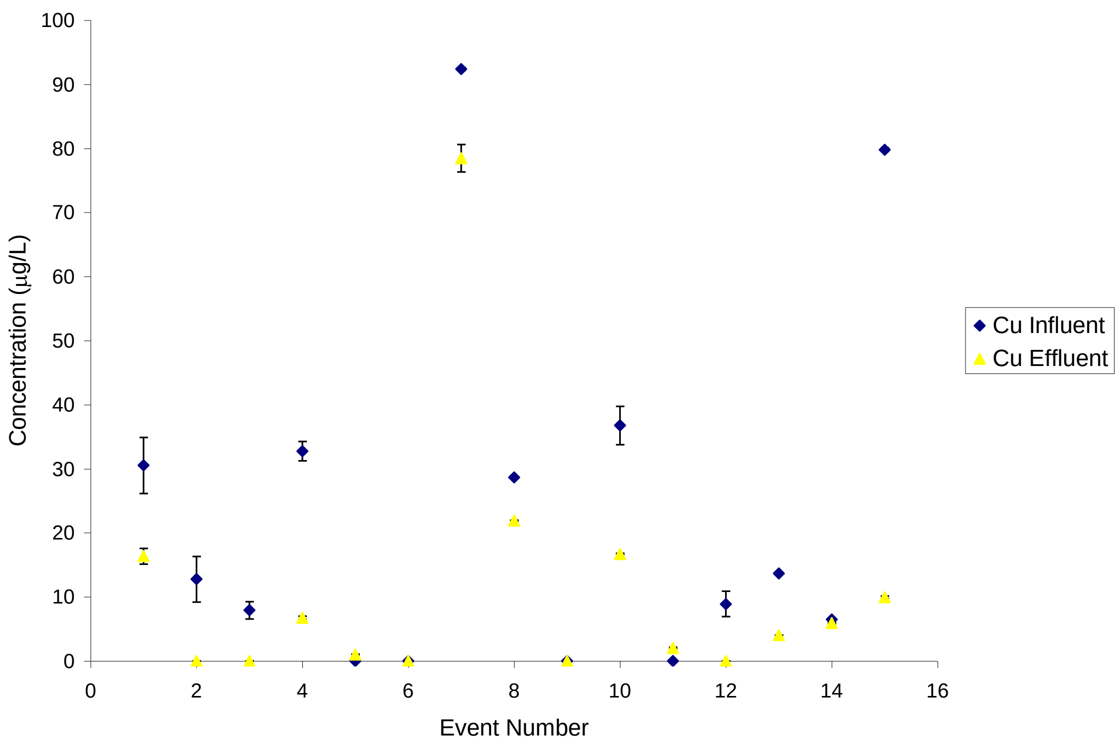
7. Storm event number, date of event, and Fecal coliforms concentration values.

Storm No	Date	FC Influent	St. Dev	FC Effluent	St. Dev.
1	2/14/2005	0.0	0.0	0.0	0.0
2	2/24/2005	0.0	0.0	0.0	0.0
3	3/8/2005	0.0	0.0	0.0	0.0
4	3/20/2005	0.0	0.0	0.0	0.0
5	3/24/2005	0.0	0.0	6.3	11.0
6	4/4/2005	0.0	0.0	0.0	0.0
7	4/8/2005	0.0	0.0	0.0	0.0
8	4/22/2005	0.0	0.0	0.0	0.0
9	4/29/2005	0.0	0.0	0.0	0.0
10	5/16/2005	0.0	0.0	0.0	0.0
11	5/20/2005	0.0	0.0	0.0	0.0
12	5/24/2005	0.0	0.0	0.0	0.0
13	6/3/2005	0.0	0.0	0.0	0.0
14	6/7/2005	0.0	0.0	0.0	0.0
15	6/30/2005	0.0	0.0	0.0	0.0



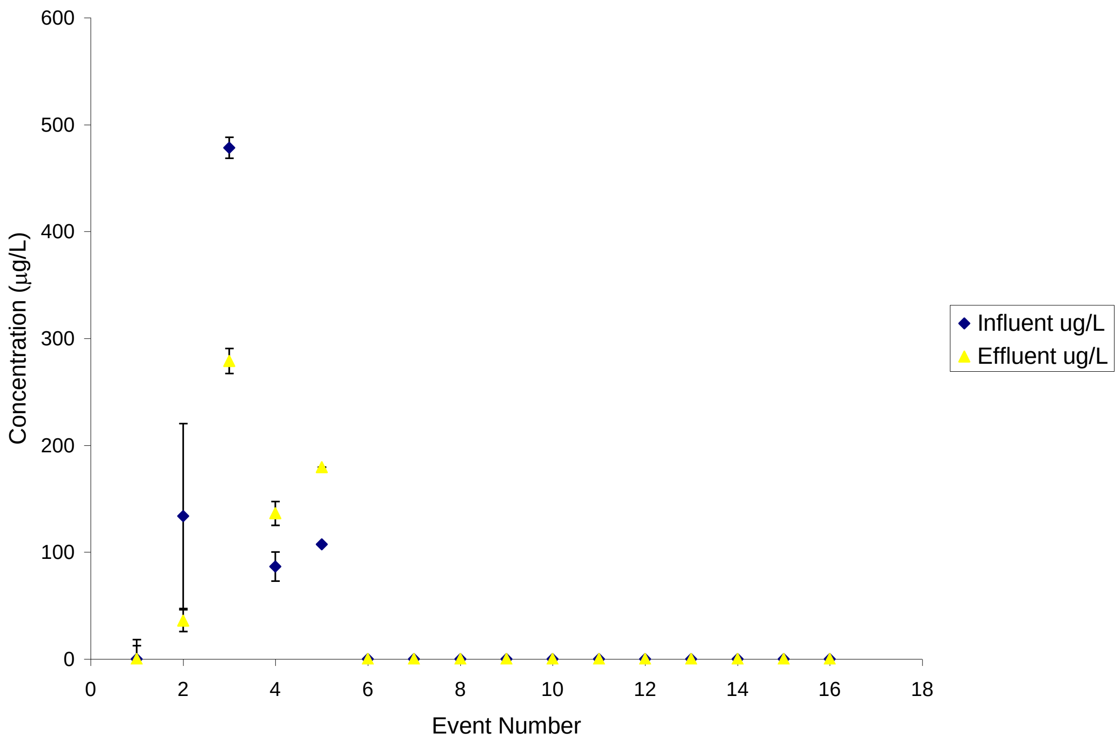
8. Storm event number, date of event, and copper concentration values.

Storm No	Date	Cu Influent (ug/L)	St. Dev	Cu Effluent (ug/L)	St. Dev.
1	2/14/2005	30.5	4.4	16.4	1.2
2	2/24/2005	12.8	3.6	0.0	0.0
3	3/8/2005	7.9	1.3	0.0	0.0
4	3/20/2005	32.8	1.5	6.8	0.2
5	3/24/2005	0.0	0.0	1.0	0.1
6	4/4/2005	0.0	0.0	0.0	0.0
7	4/8/2005	92.4	0.2	78.5	2.1
8	4/22/2005	28.7	0.1	21.9	0.1
9	4/29/2005	0.0	0.0	0.0	0.0
10	5/16/2005	36.8	3.0	16.7	0.1
11	5/20/2005	0.0	0.0	2.0	0.1
12	5/24/2005	8.9	2.0	0.0	0.0
13	6/3/2005	13.7	0.1	4.0	0.0
14	6/7/2005	6.5	0.1	5.9	0.1
15	6/30/2005	79.8	0.3	9.9	0.2



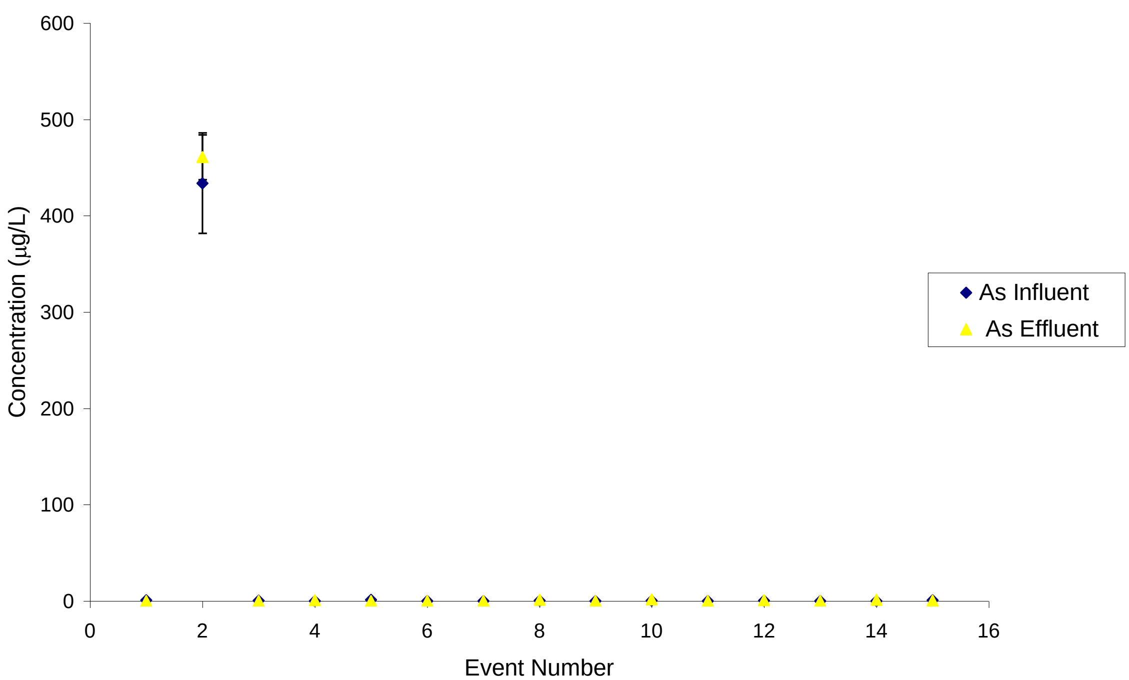
8. Storm event number, date of event, and mercury concentration values.

Storm No	Date	Hg Influent (ug/L)	St. Dev	Hg Effluent (ug/L)	St. Dev.
1	2/14/2005	133.7	18.1	35.8	12.5
2	2/24/2005	478.3	86.4	279.0	10.3
3	3/8/2005	86.5	9.8	136.3	11.7
4	3/20/2005	107.2	13.6	179.3	11.2
5	3/24/2005	0.0	0.0	0.0	0.0
6	4/4/2005	0.0	0.0	0.0	0.0
7	4/8/2005	0.0	0.0	0.0	0.0
8	4/22/2005	0.0	0.0	0.0	0.0
9	4/29/2005	0.0	0.0	0.0	0.0
10	5/16/2005	0.0	0.0	0.0	0.0
11	5/20/2005	0.0	0.0	0.0	0.0
12	5/24/2005	0.0	0.0	0.0	0.0
13	6/3/2005	0.0	0.0	0.0	0.0
14	6/7/2005	0.0	0.0	0.0	0.0
15	6/30/2005	0.0	0.0	0.0	0.0



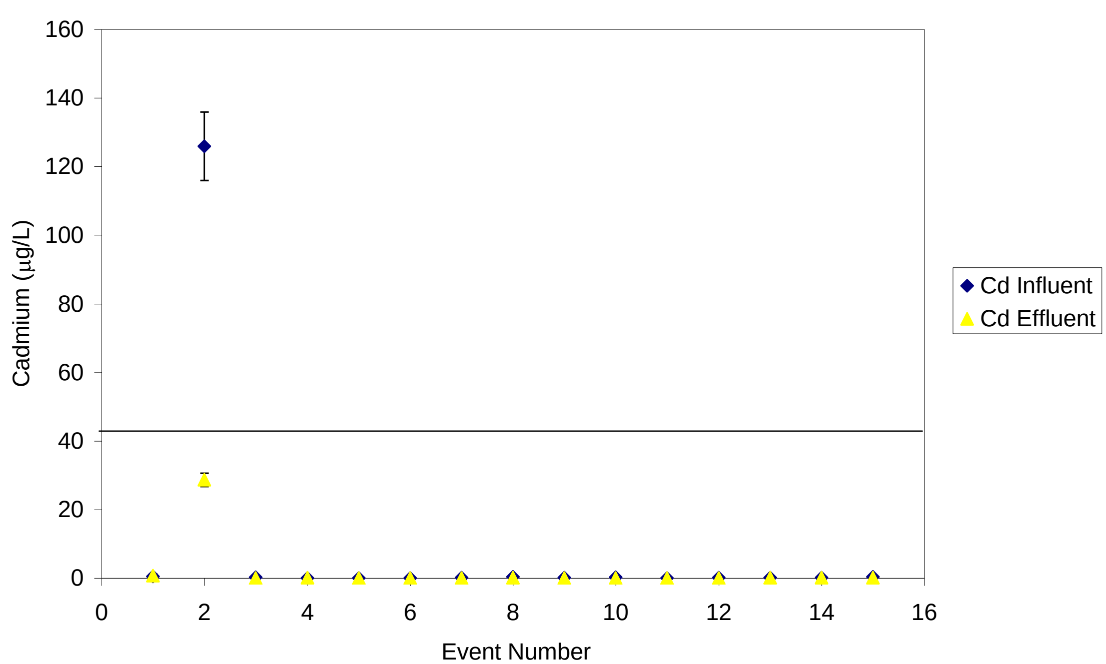
9. Storm event number, date of event, and arsenic concentration values.

Storm No	Date	As Influent	St. Dev	As Effluent	St. Dev.
1	2/14/2005	1.0	0.2	0.0	0.0
2	2/24/2005	433.8	52.1	460.8	23.4
3	3/8/2005	0.6	0.1	0.0	0.0
4	3/20/2005	0.0	0.0	0.8	0.1
5	3/24/2005	1.4	0.2	0.0	0.0
6	4/4/2005	0.0	0.0	0.0	0.0
7	4/8/2005	0.0	0.0	0.0	0.0
8	4/22/2005	0.5	0.0	1.1	0.1
9	4/29/2005	0.0	0.0	0.0	0.0
10	5/16/2005	0.6	0.1	1.7	0.0
11	5/20/2005	0.0	0.0	0.0	0.0
12	5/24/2005	0.3	0.1	1.0	0.1
13	6/3/2005	0.0	0.0	0.0	0.0
14	6/7/2005	0.0	0.0	1.1	0.1
15	6/30/2005	0.9	0.1	0.6	0.0



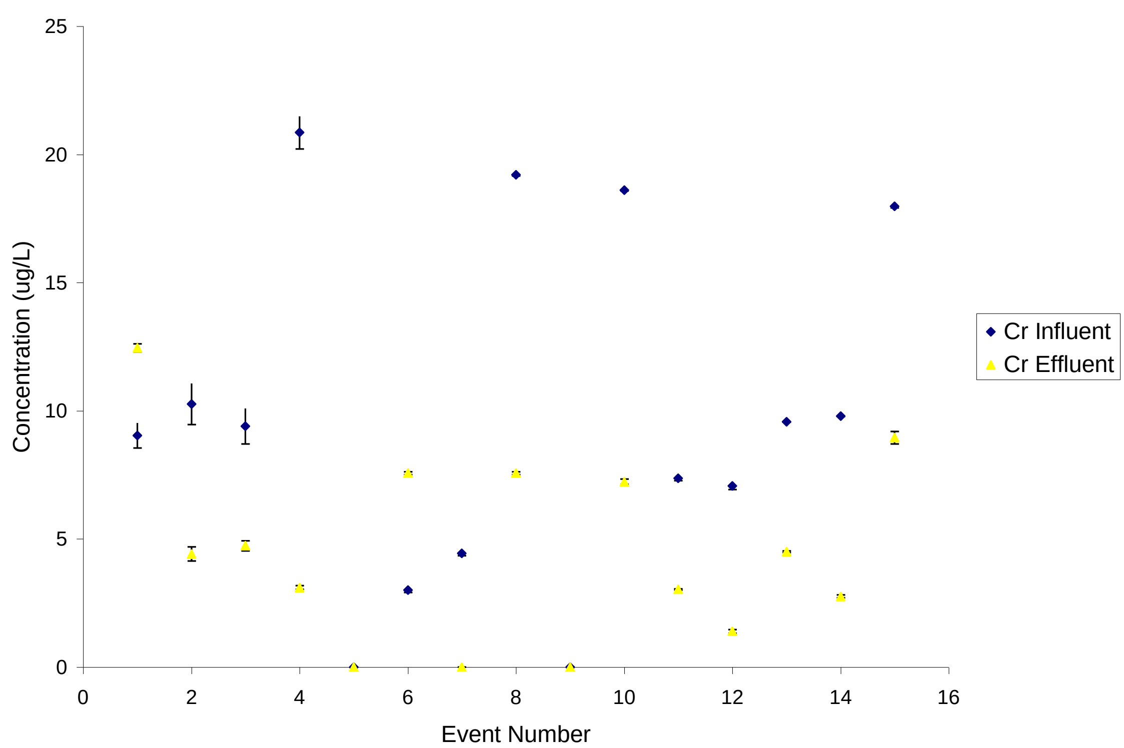
10. Storm event number, date of event, and cadmium concentration values.

Storm No	Date	Cd Influent (ug/L)	St. Dev	Cd Effluent (ug/L)	St. Dev.
1	2/14/2005	0.4	0.0	0.7	0.5
2	2/24/2005	125.9	10.0	28.6	1.9
3	3/8/2005	0.3	0.1	0.0	0.0
4	3/20/2005	0.0	0.0	0.1	0.0
5	3/24/2005	0.0	0.0	0.0	0.0
6	4/4/2005	0.0	0.0	0.0	0.0
7	4/8/2005	0.1	0.0	0.0	0.0
8	4/22/2005	0.4	0.0	0.1	0.0
9	4/29/2005	0.1	0.0	0.0	0.0
10	5/16/2005	0.2	0.0	0.0	0.0
11	5/20/2005	0.0	0.0	0.0	0.0
12	5/24/2005	0.2	0.0	0.0	0.0
13	6/3/2005	0.1	0.0	0.1	0.0
14	6/7/2005	0.1	0.0	0.1	0.0
15	6/30/2005	0.3	0.0	0.2	0.0



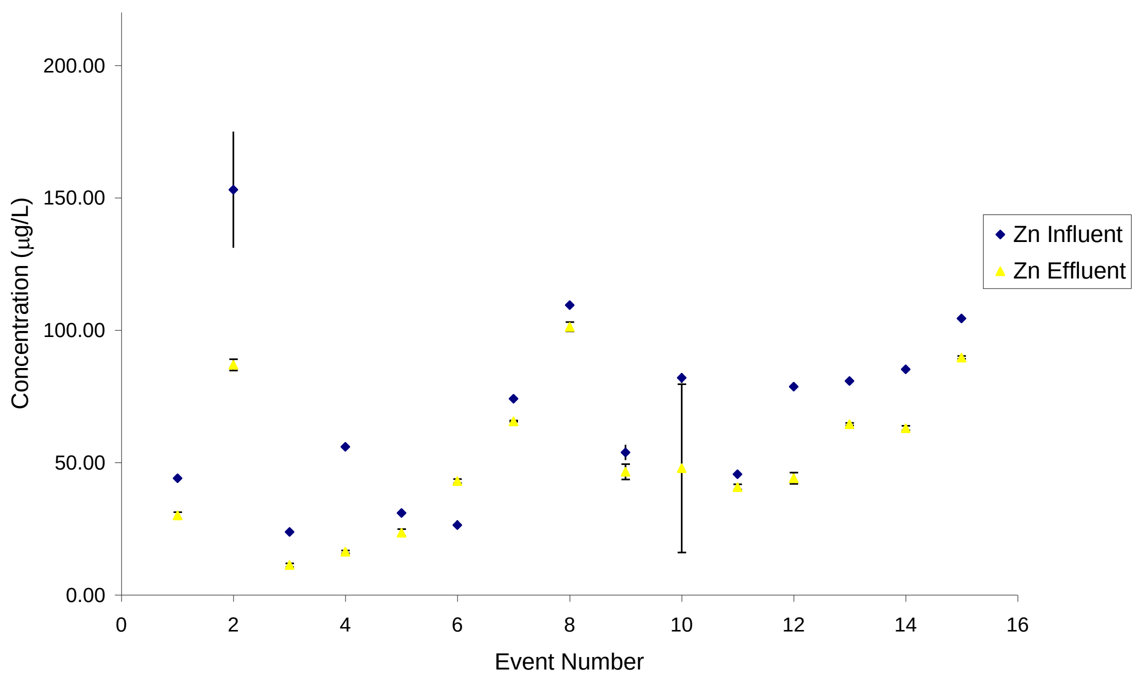
11. Storm event number, date of event, and chromium concentration values.

Storm No	Date	Cr Influent (ug/L)	St. Dev	Cr Effluent (ug/L)	St. Dev.
1	2/14/2005	9.0	0.5	12.5	0.2
2	2/24/2005	10.3	0.8	4.4	0.3
3	3/8/2005	9.4	0.7	4.7	0.2
4	3/20/2005	20.9	0.6	3.1	0.1
5	3/24/2005	0.0	0.0	0.0	0.0
6	4/4/2005	3.0	0.1	7.6	0.1
7	4/8/2005	4.4	0.1	0.0	0.0
8	4/22/2005	19.2	0.0	7.6	0.1
9	4/29/2005	0.0	0.0	0.0	0.0
10	5/16/2005	18.6	0.0	7.2	0.1
11	5/20/2005	7.4	0.1	3.0	0.0
12	5/24/2005	7.1	0.1	1.4	0.1
13	6/3/2005	9.6	0.0	4.5	0.0
14	6/7/2005	9.8	0.0	2.8	0.1
15	6/30/2005	18.0	0.1	9.0	0.2



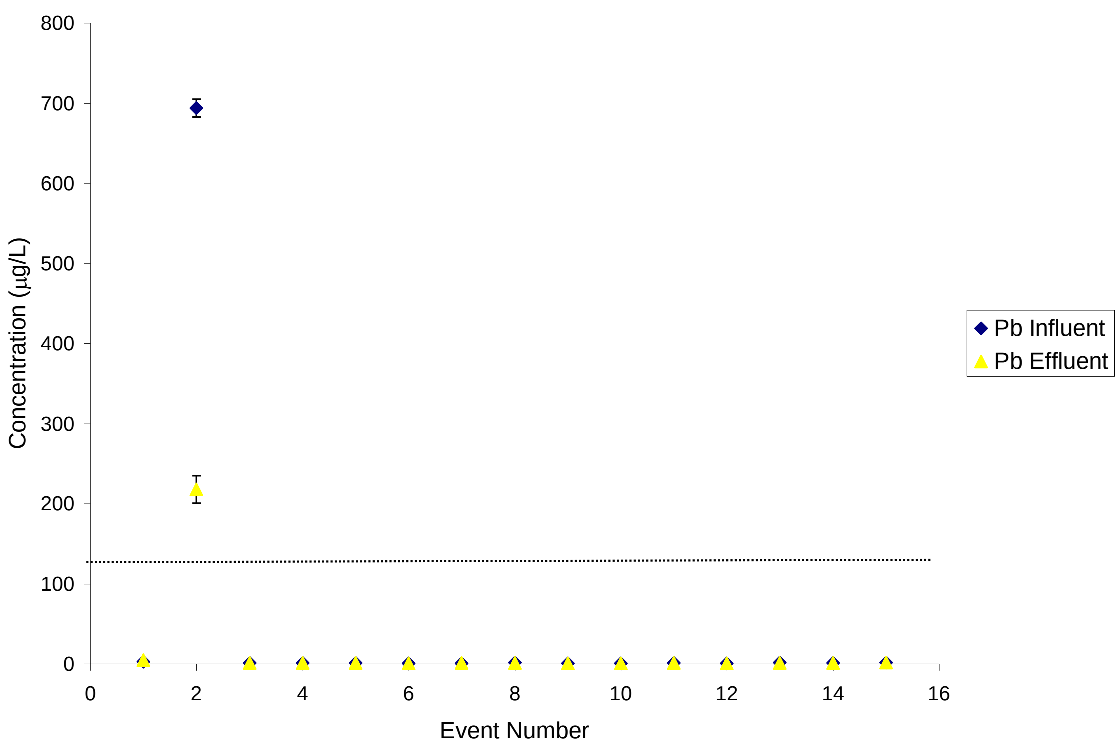
11. Storm event number, date of event, and zinc concentration values.

Storm No	Date	Zn Influent (ug/L)	St. Dev	Zn Effluent (ug/L)	St. Dev.
1	2/14/2005	44.1	0.9	30.1	1.2
2	2/24/2005	153.1	22.0	86.9	2.1
3	3/8/2005	23.9	1.2	11.3	0.7
4	3/20/2005	55.9	1.1	16.2	0.6
5	3/24/2005	31.0	0.7	23.5	1.3
6	4/4/2005	26.4	1.7	43.0	0.7
7	4/8/2005	74.0	0.5	65.6	0.2
8	4/22/2005	109.5	0.2	101.3	1.8
9	4/29/2005	53.8	2.9	46.5	2.9
10	5/16/2005	82.0	1.9	47.8	31.8
11	5/20/2005	45.6	0.3	40.8	1.0
12	5/24/2005	78.7	0.4	44.1	2.1
13	6/3/2005	80.8	0.1	64.5	0.5
14	6/7/2005	85.2	0.4	63.0	0.8
15	6/30/2005	104.4	0.4	89.7	0.5



12. Storm event number, date of event, and lead concentration values.

Storm No	Date	Pb Influent (ug/L)	St. Dev	Pb Effluent (ug/L)	St. Dev.
1	2/14/2005	2.5	0.1	4.7	0.1
2	2/24/2005	693.6	11.2	217.8	17.1
3	3/8/2005	1.2	0.1	1.1	0.3
4	3/20/2005	1.0	0.2	1.0	0.0
5	3/24/2005	1.1	0.1	0.8	0.0
6	4/4/2005	0.7	0.1	0.6	0.1
7	4/8/2005	0.5	0.0	0.9	0.0
8	4/22/2005	1.3	0.0	0.8	0.0
9	4/29/2005	0.5	0.0	0.5	0.0
10	5/16/2005	0.7	0.0	0.4	0.0
11	5/20/2005	0.8	0.0	0.9	0.0
12	5/24/2005	0.6	0.1	0.5	0.0
13	6/3/2005	1.5	0.1	1.1	0.0
14	6/7/2005	0.8	0.0	1.2	0.0
15	6/30/2005	1.5	0.0	1.3	0.0



PAH Measurements

Compounds Measured for:

1 Indeno (1,2,3 - cd)pyrene
2 Benzo(ghi)perylene
3 Dibenzo(a,h)anthracene
4 Benzo(a)Pyrene
5 Benzo(k)Flouranthene
6 Chrysene
7 Benzo(a)Anthracene
8 Pyrene
9 Flouranthene
10 Anthracene
11 Phenanthrene
12 Acenaphthylene
13 Napthalene
14 Benzo(b)flouranthene

Events and the Compounds with concentrations above 0.5 ppb in at least one sample

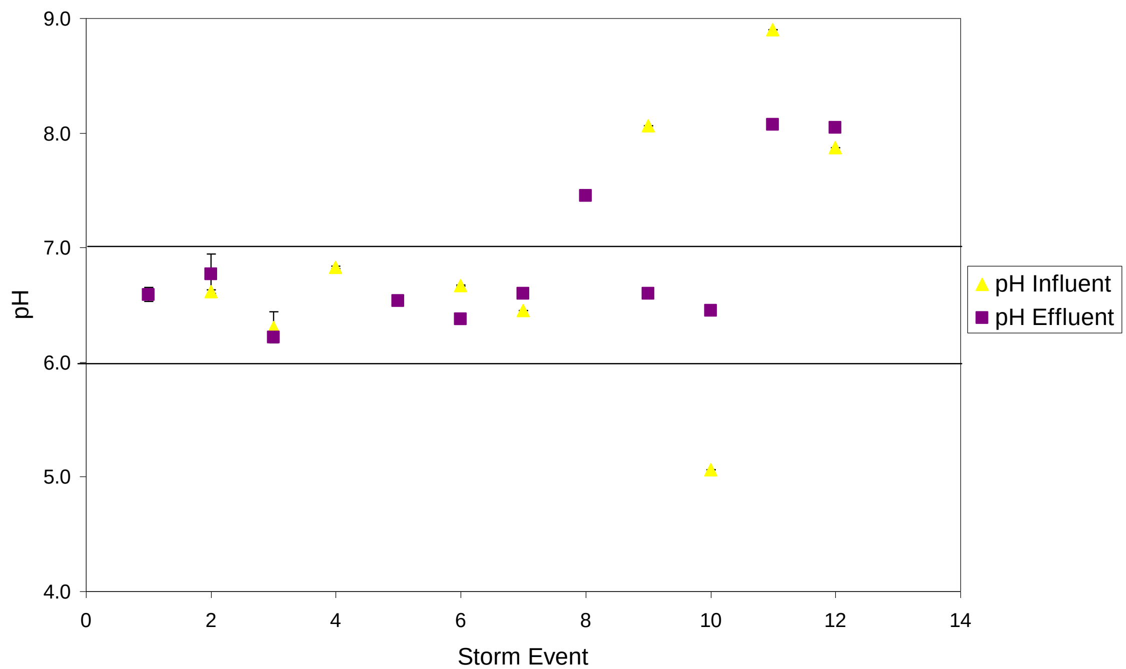
Storm event 2		Nothing over 1 ppb	
Storm event 5		Nothing over 1 ppb	
Storm event 6			
3	**Dibenzo(a,h)anthracene**		
	IN6 A	0.29	1.44
	IN6 average	0.29	**1.4**
	OUT6 C	20.09	100
	Out6 average	20.09	**100.5**
13	**Napthalene**		
	OUT6 B	0.0868	0.434
	OUT6 C	0.8763	4.3815
	Out6 average	0.48155	**2.41**
Storm Event 7			
7	**Benzo(a)Anthracene**		
	IN7 A	0.4427	2.2135
	IN7 B	0.2448	1.224
	IN7 C	0.2574	1.287
	IN7 average	0.315	**1.6**
	Out7 average	NA	NA
12	**Acenaphthylene**		
	IN7 A	0.2168	1.084
	IN7 B	0.0196	0.098
	IN7 average	0.1182	**0.59**
	OUT7 A	0.0002	0.001
	OUT7 B	0.0003	0.0015
	Out7 average	0.00025	**0.00**
Storm event 8			
1	**Indeno (1,2,3 - cd)pyrene**	**HPLC conc.**	**Actual conc. (ppb)**

	IN8 average	NA	NA
	OUT8 B	11.3326	56.7
	Out8 average	11.3326	**56.7**
5	**Benzo(k)Flouranthene**		
	OUT8 A	0.2142	1.071
	Out8 average	0.2142	**1.07**
Storm event 10		Nothing over 1 ppb	
Storm event 11			
1	**Indeno (1,2,3 - cd)pyrene**	**HPLC conc.**	**Actual conc. (ppb)**
	IN11 average	NA	NA
	OUT11 A	2.0227	10.1135
	Out11 average	2.0227	**10.11**
Storm event 12			
3	**Dibenzo(a,h)anthracene**		
	IN12 average	NA	NA
	OUT12 B	0.1309	0.6545
	Out12 average	0.1309	**0.65**
Storm event 13		Nothing over 1 ppb	
Storm event 14			
1	**Indeno (1,2,3 - cd)pyrene**	**HPLC conc.**	**Actual conc. (ppb)**
	IN14 B	2.6042	13.0
	IN14 average	2.6042	**13.0**
	Out14 average	NA	NA
Storm event 15			
13	**Napthalene**		
	IN15 B	0.0561	0.3
	IN15 average	0.0561	**0.3**
	OUT15 A	0.008	0.0
	OUT15 B	0.6336	3.2
	OUT15 C	0.0016	0.0
	Out15 average	0.2144	1.1

Results for the DC Sand Filter Site

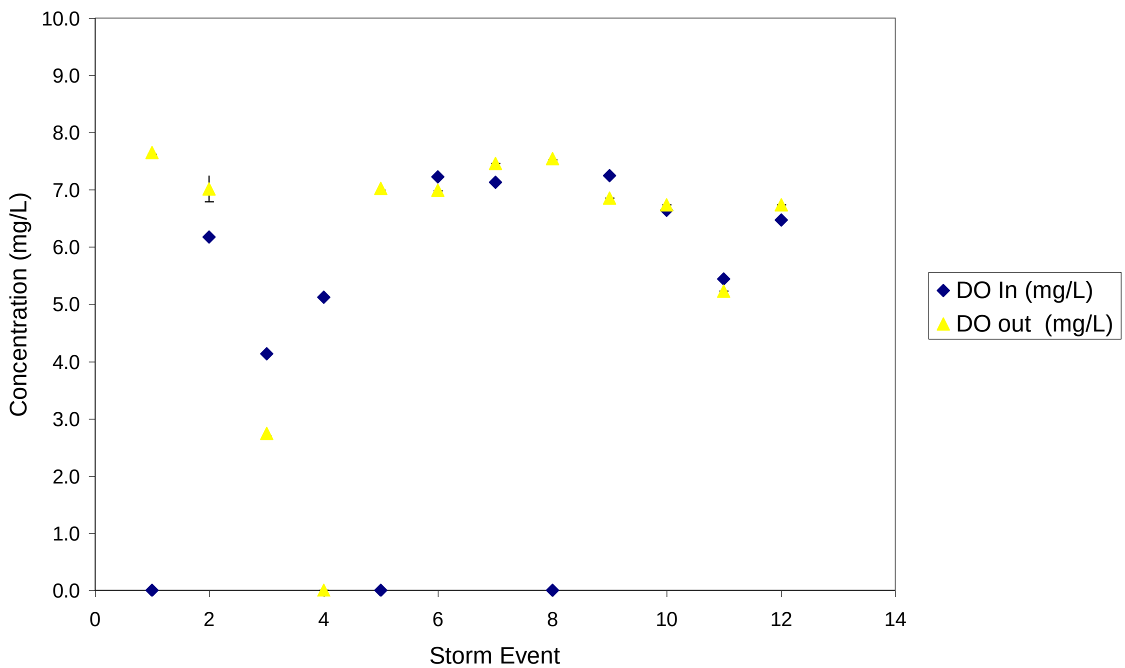
DDOT project - Site # 2 -DC village
pH

Storm #	pH Influent	St. Dev	pH Effluent	St. Dev.
1	NS	NS	6.6	0.1
2	6.6	0.0	6.8	0.2
3	6.3	0.1	6.2	0.0
4	6.8	0.0	NS	NS
5	NS	NS	6.5	0.0
6	6.7	0.0	6.4	0.0
7	6.5	0.0	6.6	0.0
8	NS	NS	7.5	0.0
9	8.1	0.0	6.6	0.0
10	5.1	0.0	6.5	0.0
11	8.9	0.0	8.1	0.0
12	7.9	0.0	8.0	0.0
Average	7.0	0.0	6.9	0.0
Std. Dev.	1.1	0.0	0.7	0.1



DDOT project - Site # 2 -DC village
DO

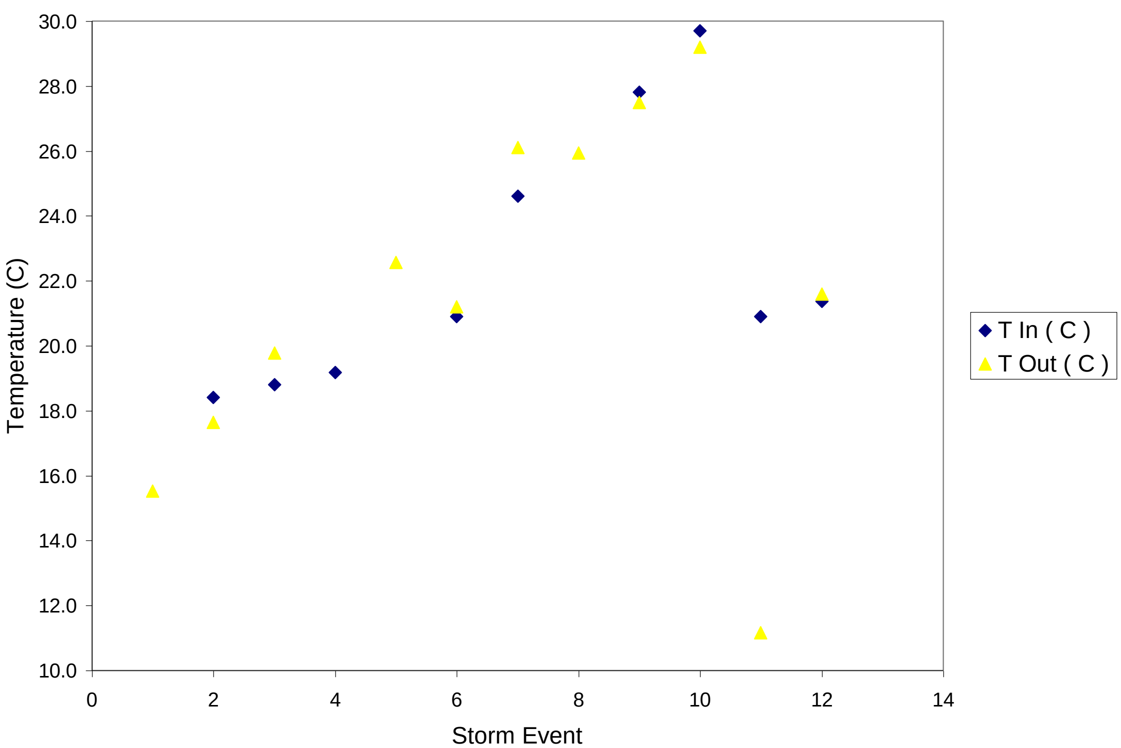
Storm #	DO In (mg/L)	St. Dev	DO out (mg/L)	St. Dev.
1	NS	NS	7.7	0.0
2	6.2	0.0	7.0	0.2
3	4.1	0.0	2.7	0.0
4	5.1	0.0	NS	NS
5	NS	NS	7.0	0.0
6	7.2	0.0	7.0	0.0
7	7.1	0.0	7.5	0.0
8	NS	NS	7.5	0.0
9	7.3	0.0	6.9	0.0
10	6.6	0.0	6.7	0.0
11	5.4	0.0	5.2	0.0
12	6.5	0.0	6.7	0.0
Average	6.2	0.0	6.5	0.0
Std. Dev.	1.1	0.0	1.4	0.1



DDOT project - Site # 2 -DC village

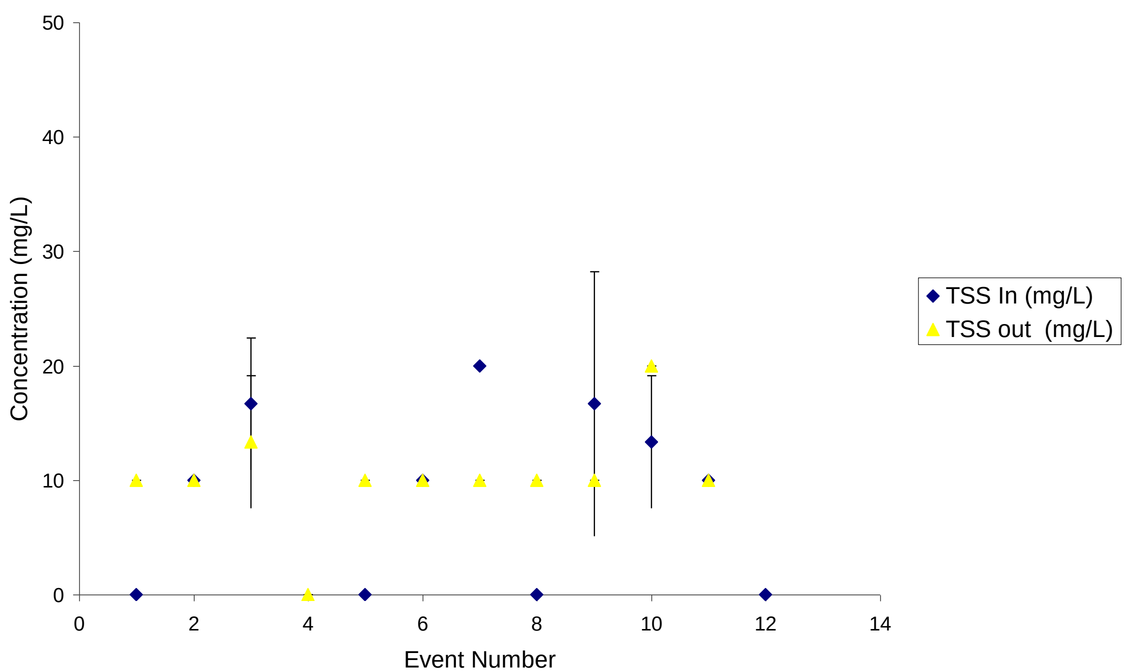
Temperature

Storm #	T In (C)	St. Dev	T Out (C)	St. Dev.
1	NS	NS	16	0
2	18	0	18	0
3	19	0	20	0
4	19	0	NS	NS
5	NS	NS	23	0
6	21	0	21	0
7	25	0	26	0
8	NS	NS	26	0
9	28	0	28	0
10	30	0	29	0
11	21	0	11	0
12	21	0	22	0
Average	22.4	0.0	21.7	0.1
Std. Dev.	4.1	0.1	5.5	0.1



DDOT project - Site # 2 -DC village
TSS

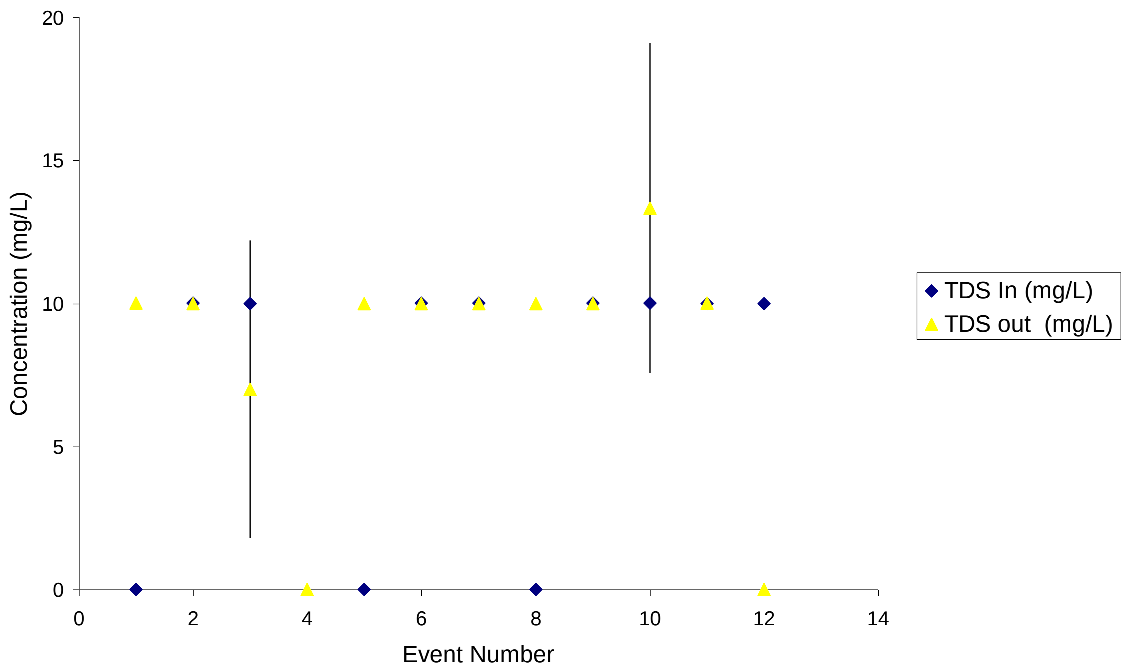
Storm #	TSS In (mg/L)	St. Dev	TSS out (mg/L)	St. Dev.	% Removal
1	NS	NS	10	0	
2	10	0	10	0	
3	17	6	13	6	
4	670	52	NS	NS	
5	NS	NS	10	0	
6	10	0	10	0	
7	20	0	10	0	
8	NS	NS	10	0	
9	17	12	10	0	
10	13	6	20	0	
11	10	0	10	0	
12	NS	NS			
Average	95.8	9.4	11.3	0.6	0.88
Std. Dev.	232.0	17.7	3.2	1.8	



DDOT project - Site # 2 -DC village

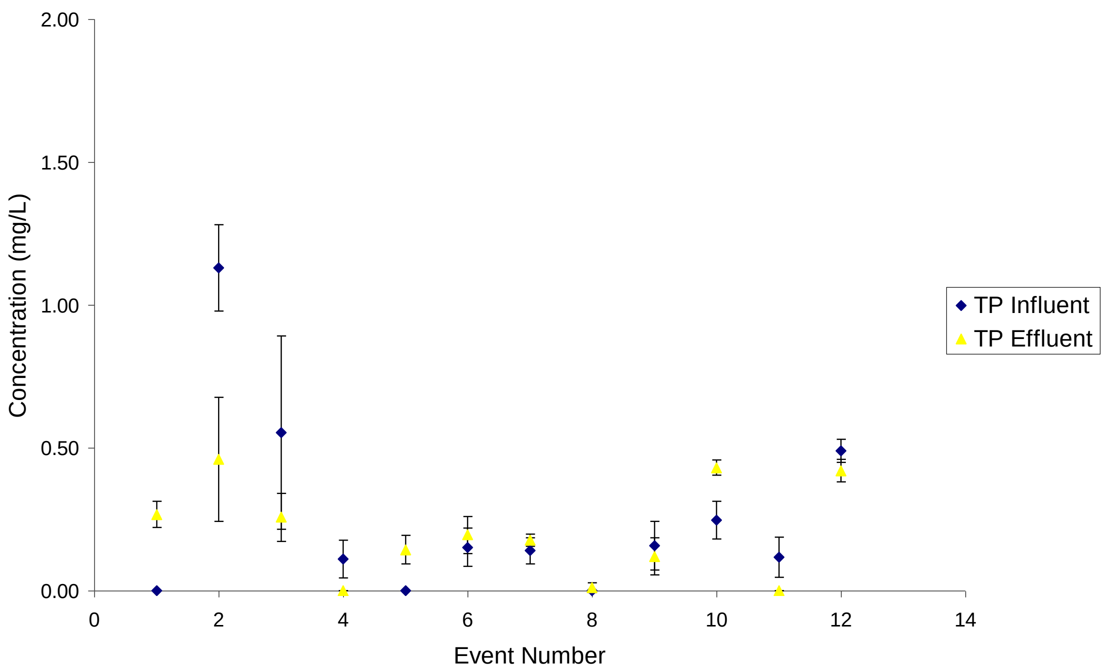
TDS

Storm #	TDS In (mg/L)	St. Dev	TDS out (mg/L)	St. Dev.	
1	NS	NS	10.0	0.0	
2	10.0	0.0	10.0	0.0	
3	10.0	0.0	7.0	5.2	
4	363.3	37.9	NS	NS	
5	NS	NS	10.0	0.0	
6	10.0	0.0	10.0	0.0	
7	10.0	0.0	10.0	0.0	
8	NS	NS	10.0	0.0	
9	10.0	0.0	10.0	0.0	
10	10.0	0.0	13.3	5.8	
11	10.0	0.0	10.0	0.0	
12	10.0	0.0	0.0	0.0	
					% Removal
Average	49.3	4.2	9.1	1.0	0.81
Std. Dev.	117.8	12.6	3.3	2.2	



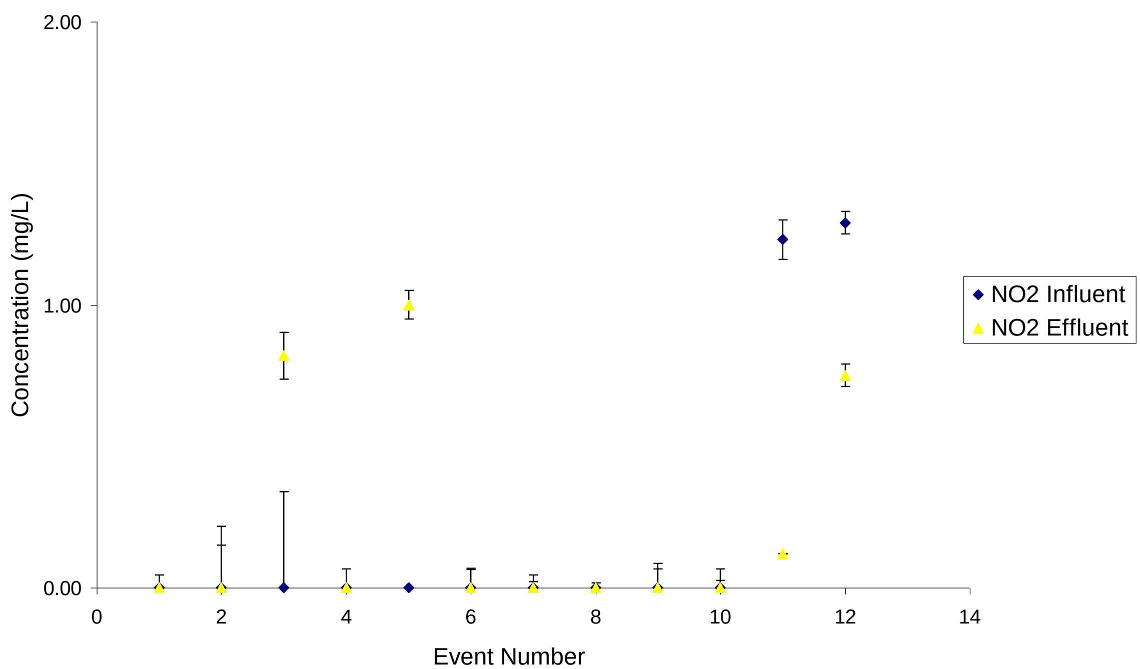
DDOT project - Site # 2 -DC village
TP

Storm #	TP mg/L TP Influent	St. Dev	TP mg/L TP Effluent	St. Dev.	
1	NS	NS	0.27	0.05	
2	1.13	0.15	0.46	0.22	
3	0.55	0.34	0.26	0.08	
4	0.11	0.07	NS	NS	
5	NS	NS	0.14	0.05	
6	0.15	0.07	0.20	0.07	
7	0.14	0.05	0.18	0.02	
8	NS	NS	0.01	0.02	
9	0.16	0.09	0.12	0.07	
10	0.25	0.07	0.43	0.03	
11	0.12	0.1	0.0	0.0	
12	0.5	0.0	0.4	0.0	
					% Removal
Average	0.3	0.1	0.2	0.1	0.34
Std. Dev.	0.3	0.1	0.2	0.1	

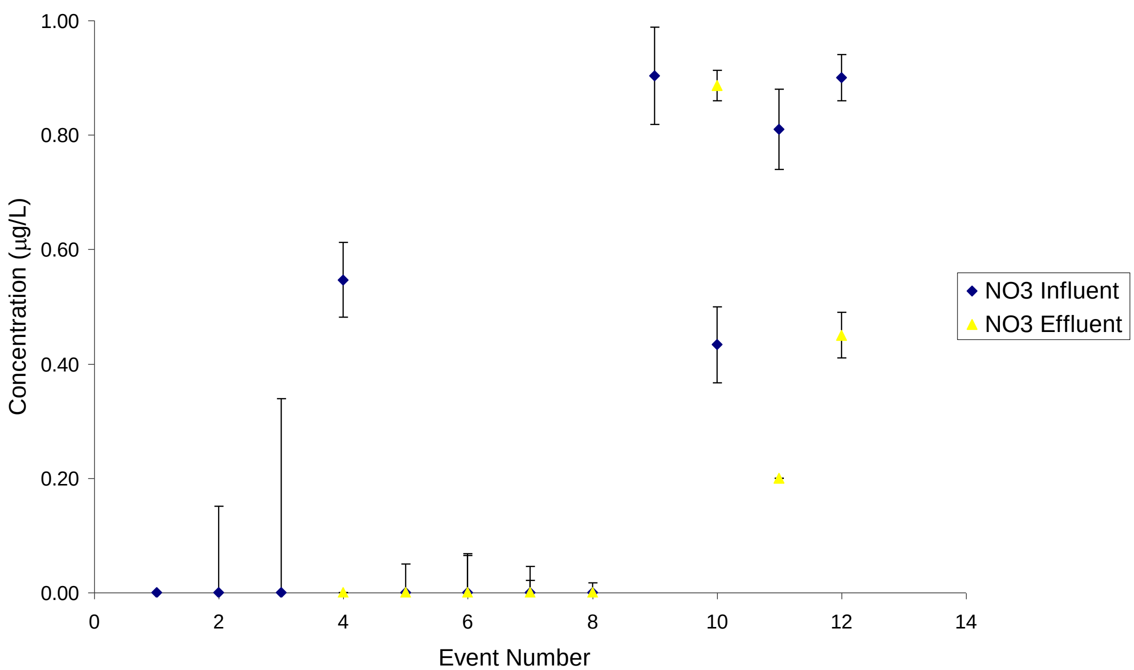


DDOT project - Site # 2 -DC village
NO2

Storm #	NO2 mg/L NO2 Influent	St. Dev	NO2 mg/L NO2 Effluent	St. Dev.	
1	NS	NS	0.00	0.00	
2	0.00	0.00	0.00	0.00	
3	0.00	0.00	0.82	0.16	
4	0.00	0.00	NS	NS	
5	NS	NS	1.00	0.00	
6	0.00	0.00	0.00	0.00	
7	0.00	0.00	0.00	0.00	
8	NS	NS	0.00	0.00	
9	0.00	0.00	0.00	0.00	
10	0.00	0.00	0.00	0.00	
11	1.23	0.10	0.12	0.03	
12	1.3	0.0	0.8	0.0	
					% Removal
Average	0.3	0.0	0.2	0.0	0.13
Std. Dev.	0.6	0.0	0.4	0.0	

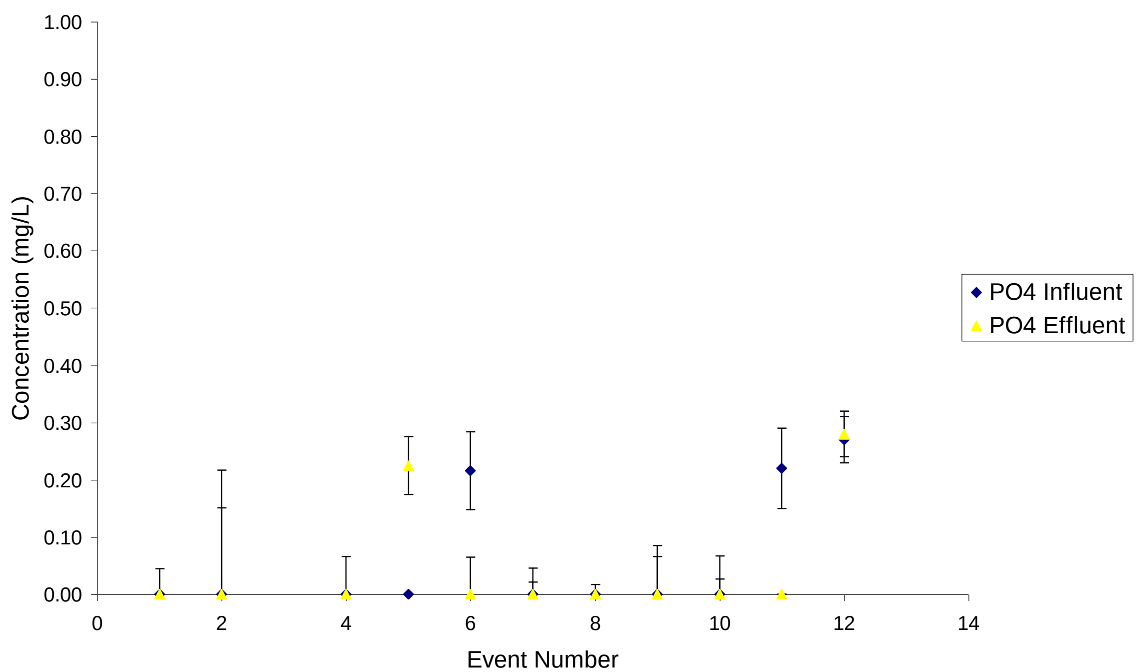


DDOT project - Site # 2 -DC village					
NO3					
	NO3 mg/L		NO3 mg/L		
Storm #	NO3 Influent	St. Dev	NO3 Effluent	St. Dev.	
1	NS	NS	3.43	0.75	
2	0.00	0.00	3.80	1.51	
3	0.00	0.00	1.13	0.12	
4	0.55	0.15	NS	NS	
5	NS	NS	0.00	0.00	
6	0.00	0.00	0.00	0.00	
7	0.00	0.00	0.00	0.00	
8	NS	NS	0.00	0.00	
9	0.90	0.01	1.17	0.09	
10	0.43	0.03	0.89	0.44	
11	0.81	0.55	0.20	0.15	
12	0.9	0.0	0.5	0.1	
					% Removal
Average	0.4	0.1	1.0	0.3	-1.52
Std. Dev.	0.4	0.2	1.4	0.5	



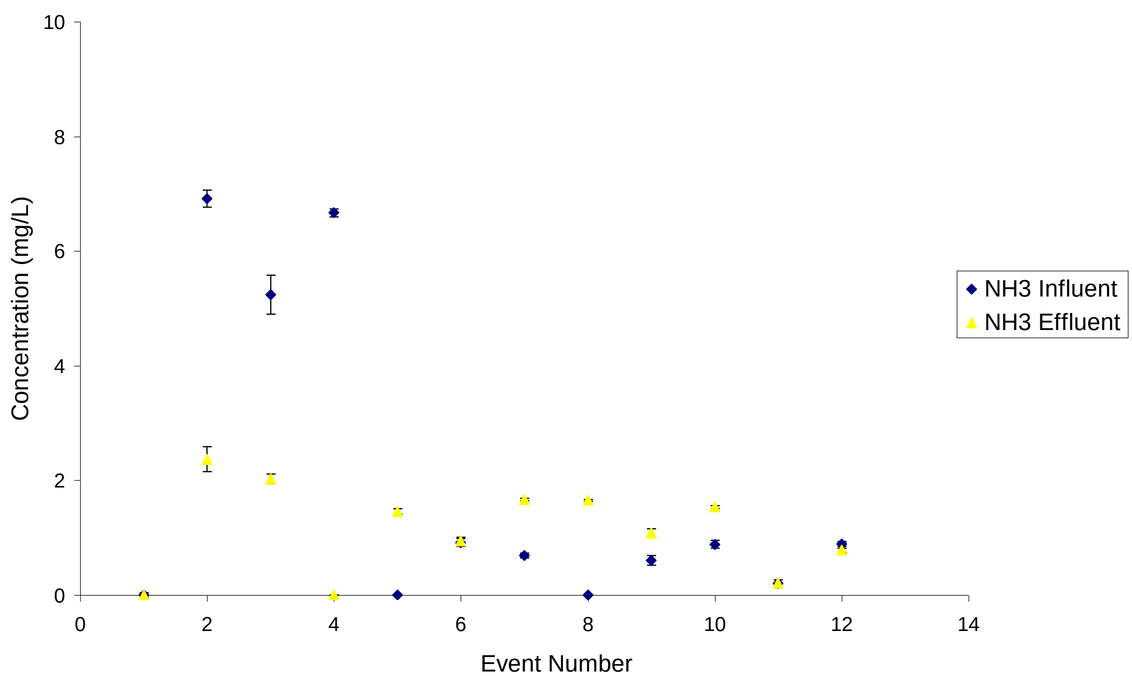
DDOT project - Site # 2 -DC village
PO4

Storm #	PO4 mg/L PO4 Influent	St. Dev	PO4 mg/L PO4 Effluent	St. Dev.	
1	NS	NS	0.00	0.00	
2	0.00	0.00	0.00	0.00	
3	1.55	0.17	2.02	0.11	
4	0.00	0.00	NS	NS	
5	NS	NS	0.22	0.00	
6	0.22	0.01	0.00	0.00	
7	0.00	0.00	0.00	0.00	
8	NS	NS	0.00	0.00	
9	0.00	0.00	0.00	0.00	
10	0.00	0.00	0.00	0.00	
11	0.2	0.0	0.0	0.0	
12	0.3	0.0	0.3	0.0	
					% Removal
Average	0.3	0.0	0.2	0.0	0.09
Std. Dev.	0.5	0.1	0.6	0.0	



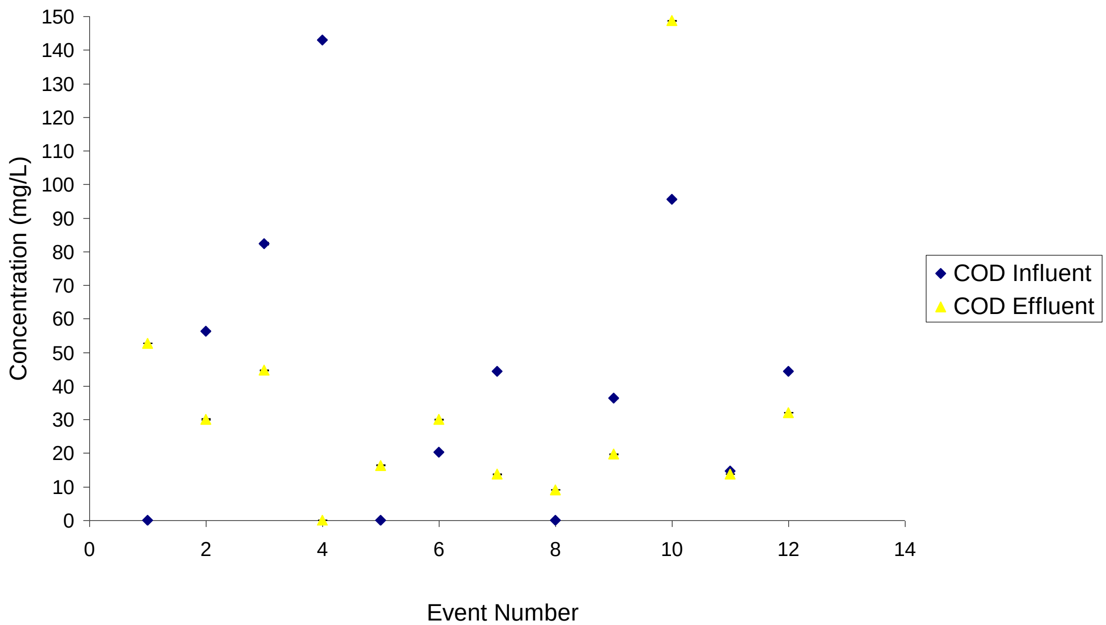
DDOT project - Site # 2 -DC village
NH3

Storm #	NH3 mg/L NH3 Influent	St. Dev	NH3 mg/L NH3 Effluent	St. Dev.	
1	NS	NS	0.00	0.00	
2	6.92	0.05	2.37	0.065	
3	5.24	0.50	2.03	0.248	
4	6.67	0.45	NS	NS	
5	NS	NS	1.46	0.06	
6	0.92	0.04	0.95	0.04	
7	0.69	0.00	1.67	0.06	
8	NS	NS	1.65	0.09	
9	0.60	0.08	1.09	0.16	
10	0.88	0.06	1.54	0.13	
11	0.20	0.01	0.21	0.01	
12	0.9	0.0	0.8	0.0	
					% Removal
Average	2.6	0.1	1.2	0.1	0.51
Std. Dev.	2.8	0.2	0.7	0.1	



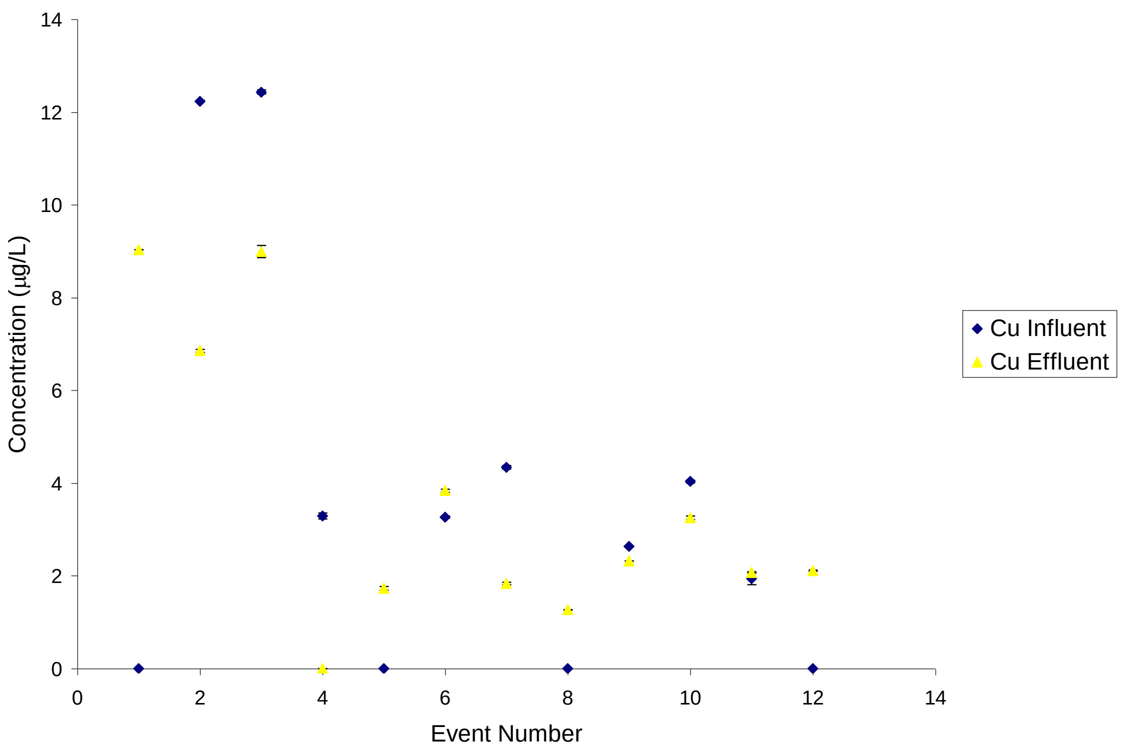
DDOT project - Site # 2 -DC village
COD

Storm #	COD mg/L COD Influent	St. Dev	COD mg/L COD Effluent	St. Dev.	
1	NS	NS	52.7	0.6	
2	56.3	0.6	30.0	1.0	
3	82.3	2.1	44.7	0.6	
4	143.0	6.1	NS	NS	
5	NS	NS	16.3	0.6	
6	20.3	0.6	30.0	1.0	
7	44.3	2.5	13.7	0.6	
8	NS	NS	9.0	0.0	
9	36.3	0.6	19.7	1.5	
10	95.5	43.1	148.7	7.2	
11	14.7	0.3	13.7	0.1	
12	44.3	3.1	32.0	1.0	
					% Removal
Average	60	6.5	37	1.3	0.37
Std. Dev.	41	13.8	39	2.0	



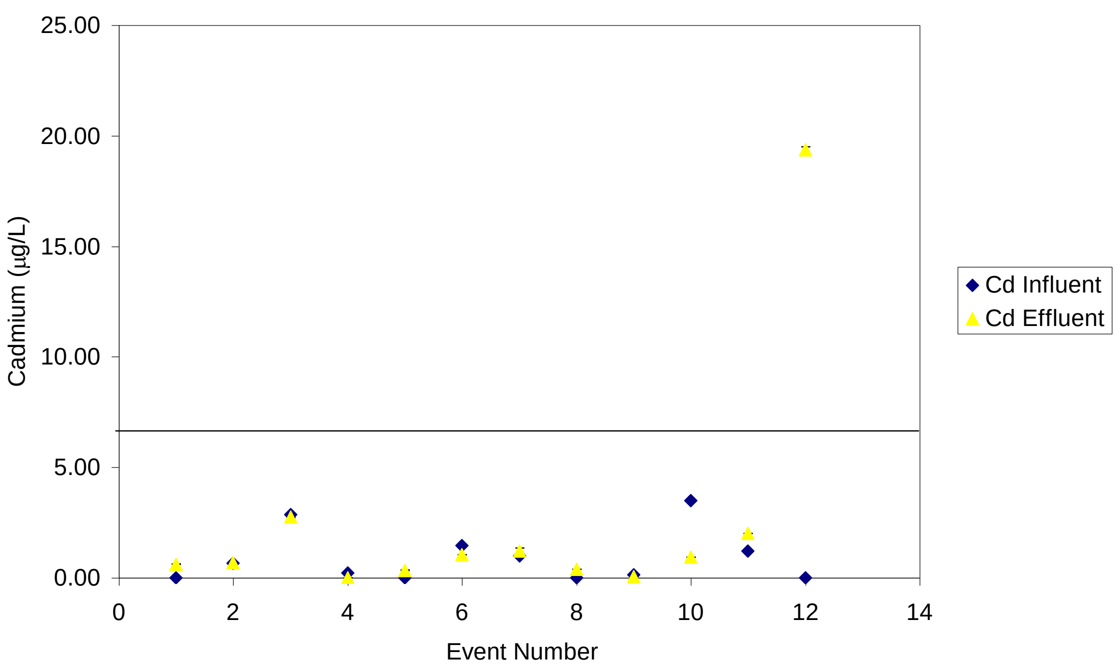
DDOT project - Site # 2 -DC village
Cu

Storm #	(ug/L) Cu Influent	St. Dev	(ug/L) Cu Effluent	St. Dev.	
1	NS	NS	9.0	0.0	
2	12.2	0.0	6.9	0.0	
3	12.4	0.0	9.0	0.1	
4	3.3	0.1	NS	NS	
5	NS	NS	1.7	0.0	
6	3.3	0.0	3.8	0.0	
7	4.3	0.0	1.8	0.0	
8	NS	NS	1.3	0.0	
9	2.6	0.0	2.3	0.0	
10	4.0	0.0	3.2	0.0	
11	1.9	0.1	2.1	0.0	
12	NS	NS	2.1	0.0	
					% Removal
Average	5.5	0.0	3.9	0.0	0.29
Std. Dev.	4.3	0.0	2.9	0.0	



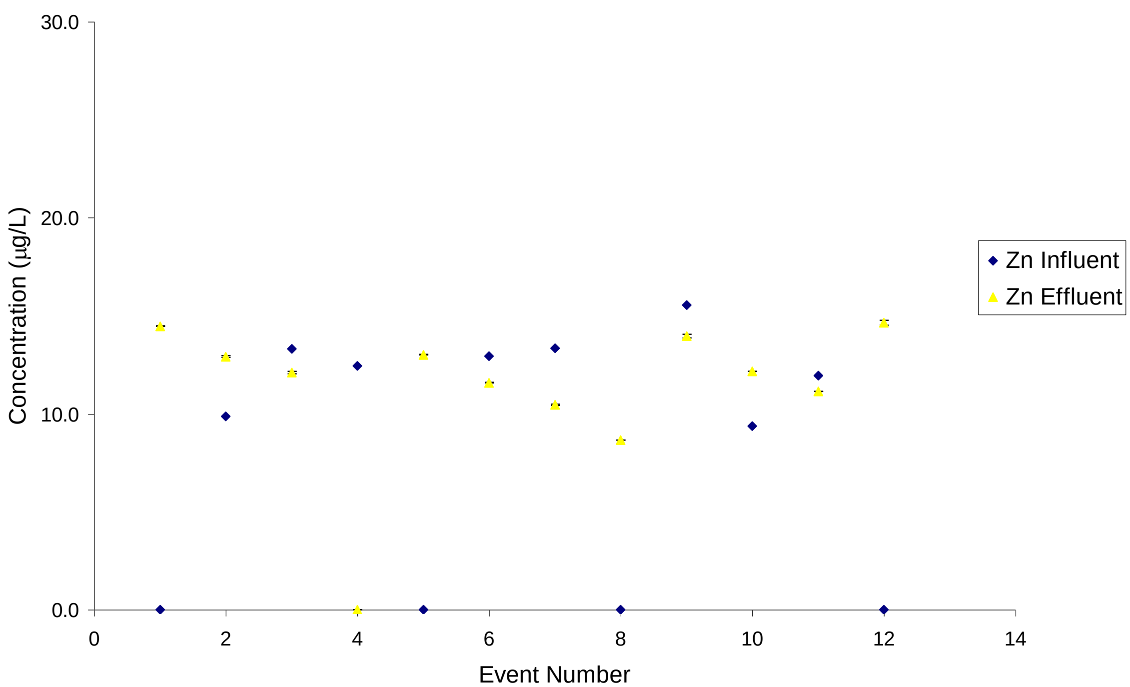
DDOT project - Site # 2 -DC village
Cd

Storm #	(ug/L) Cd Influent	St. Dev	(ug/L) Cd Effluent	St. Dev.	
1	NS	NS	0.6	0.0	
2	0.6	0.0	0.7	0.0	
3	2.9	0.0	2.7	0.0	
4	0.2	0.0	NS	NS	
5	NS	NS	0.3	0.0	
6	1.5	0.0	1.0	0.0	
7	1.0	0.0	1.2	0.1	
8	NS	NS	0.4	0.0	
9	0.1	0.0	0.1	0.0	
10	3.5	0.1	0.9	0.0	
11	1.2	0.0	2.0	0.0	
12	NS	NS	19.4	0.1	
					% Removal
Average	1.4	0.0	2.7	0.0	-0.94
Std. Dev.	1.2	0.0	5.6	0.1	



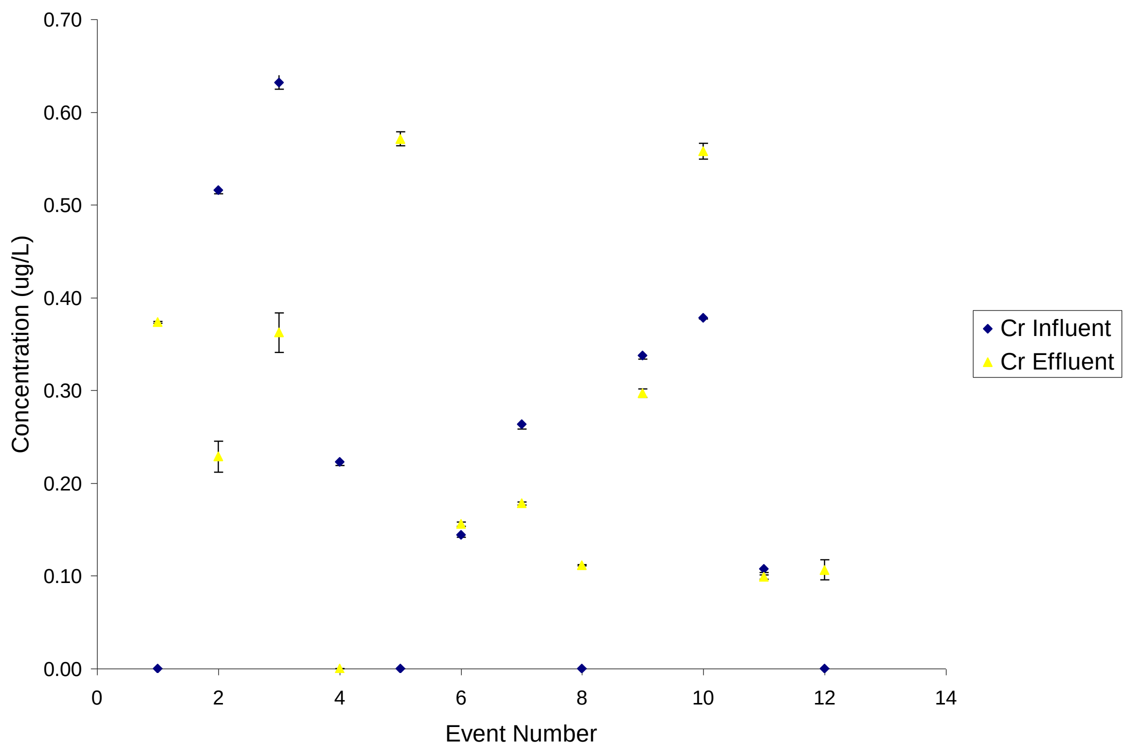
DDOT project - Site # 2 -DC village
Zn

Storm #	(ug/L) Zn Influent	St. Dev	(ug/L) Zn Effluent	St. Dev.	
1	NS	NS	14.5	0.0	
2	9.9	0.1	12.9	0.0	
3	13.3	0.0	12.1	0.1	
4	12.4	0.1	NS	NS	
5	NS	NS	13.0	0.0	
6	12.9	0.0	11.6	0.0	
7	13.3	0.0	10.5	0.0	
8	NS	NS	8.6	0.0	
9	15.5	0.0	14.0	0.1	
10	9.4	0.1	12.2	0.0	
11	11.9	0.0	11.1	0.0	
12	NS	NS	14.6	0.1	
					% Removal
Average	12.3	0.0	12.3	0.0	0.01
Std. Dev.	2.0	0.0	1.8	0.0	



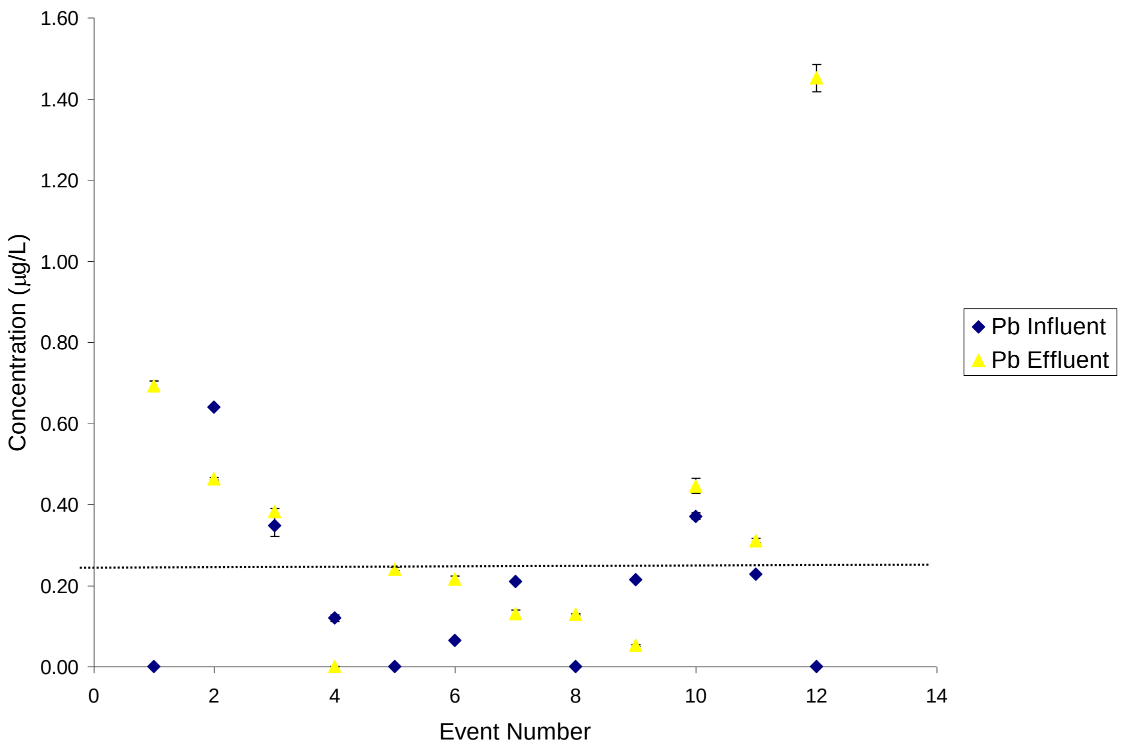
DDOT project - Site # 2 -DC village
Cr

Storm #	(ug/L) Cr Influent	St. Dev	(ug/L) Cr Effluent	St. Dev.	
1	NS	NS	0.4	0.0	
2	0.5	0.0	0.2	0.0	
3	0.6	0.0	0.4	0.0	
4	0.2	0.0	NS	NS	
5	NS	NS	0.6	0.0	
6	0.1	0.0	0.2	0.0	
7	0.3	0.0	0.2	0.0	
8	NS	NS	0.1	0.0	
9	0.3	0.0	0.3	0.0	
10	0.4	0.0	0.6	0.0	
11	0.1	0.0	0.1	0.0	
12	NS	NS	0.1	0.0	
					% Removal
Average	0.3	0.0	0.3	0.0	0.15
Std. Dev.	0.2	0.0	0.2	0.0	



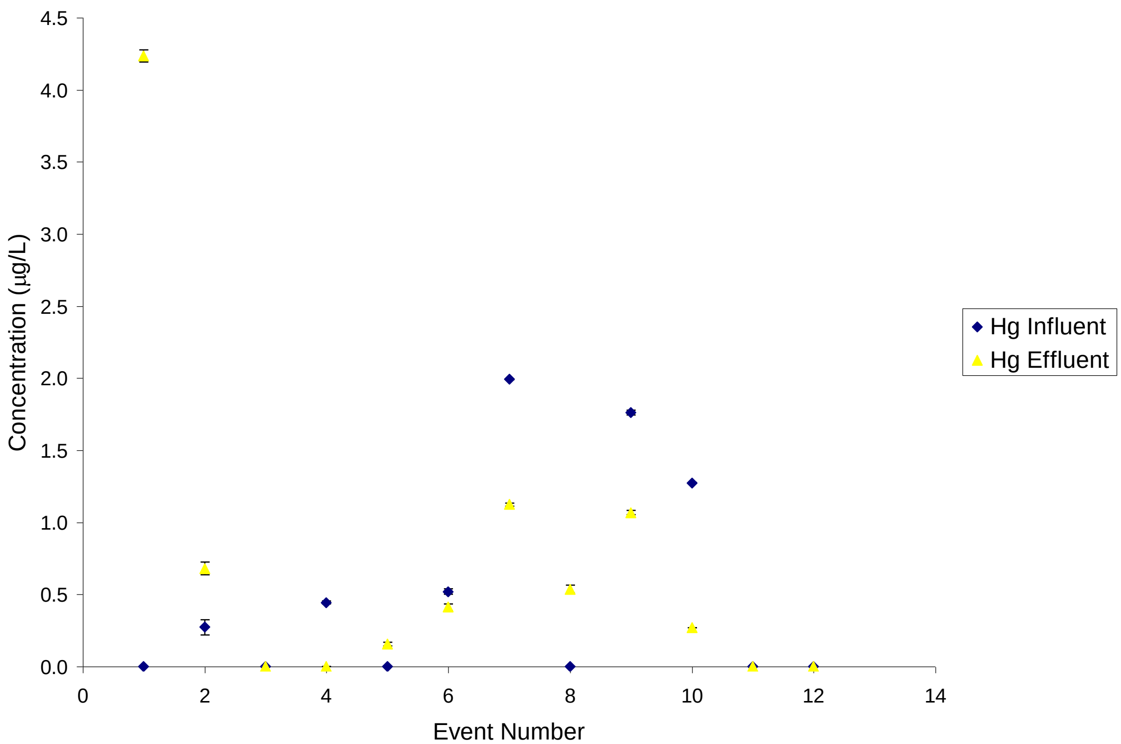
DDOT project - Site # 2 -DC village
Pb

Storm #	(ug/L) Pb Influent	St. Dev	(ug/L) Pb Effluent	St. Dev.	
1	NS	NS	0.7	0.0	
2	0.6	0.0	0.5	0.0	
3	0.3	0.0	0.4	0.0	
4	0.1	0.0	NS	NS	
5	NS	NS	0.2	0.0	
6	0.1	0.0	0.2	0.0	
7	0.2	0.0	0.1	0.0	
8	NS	NS	0.1	0.0	
9	0.2	0.0	0.1	0.0	
10	0.4	0.0	0.4	0.0	
11	0.2	0.0	0.3	0.0	
12	NS	NS	1.5	0.0	
					% Removal
Average	0.3	0.0	0.4	0.0	-0.50
Std. Dev.	0.2	0.0	0.4	0.0	



DDOT project - Site # 2 -DC village
Hg

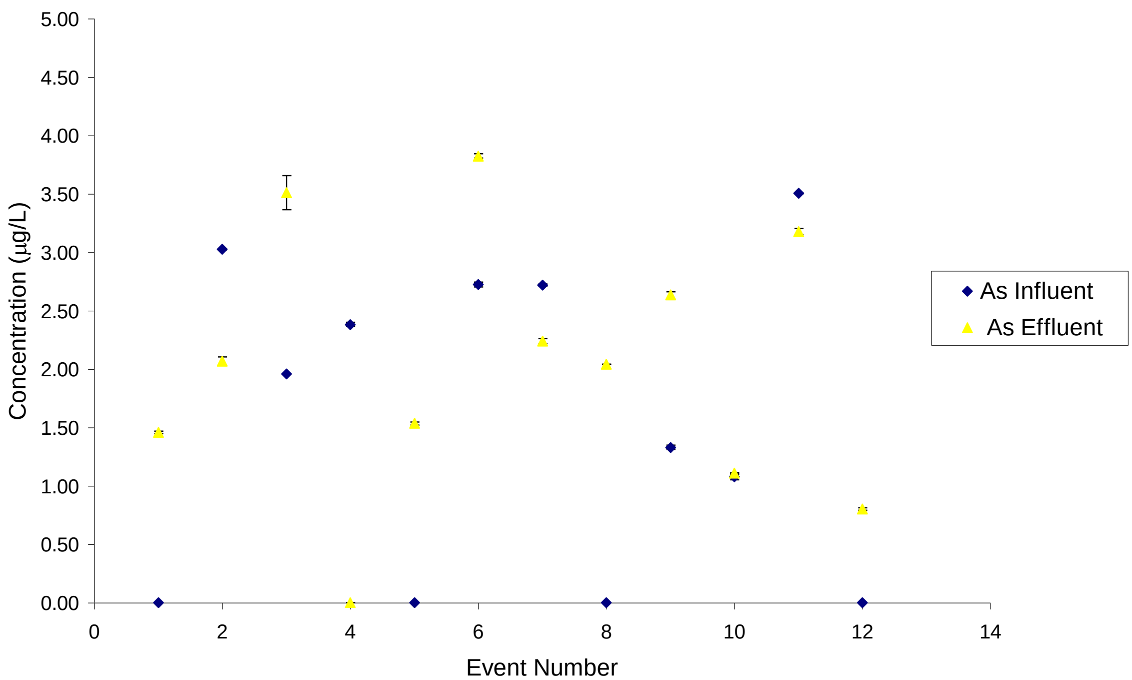
Storm #	Influent ug/L Hg Influent	St. Dev	Effluent ug/L Hg Effluent	St. Dev.	
1	NS	NS	4.2	0.0	
2	0.3	0.1	0.7	0.0	
3	0.0	0.0	0.0	0.0	
4	0.4	0.0	NS	NS	
5	NS	NS	0.2	0.0	
6	0.5	0.0	0.4	0.0	
7	2.0	0.0	1.1	0.0	
8	NS	NS	0.5	0.0	
9	1.8	0.0	1.1	0.0	
10	1.3	0.0	0.3	0.0	
11	0.0	0.0	0.0	0.0	
12	NS	NS	0.0	0.0	
					% Removal
Average	0.8	0.0	0.8	0.0	0.02
Std. Dev.	0.8	0.0	1.2	0.0	



DDOT project - Site # 2 -DC village
As

Storm #	As Influent	St. Dev	As Effluent	St. Dev.
1	NS	NS	1.5	0.0
2	3.0	0.0	2.1	0.0
3	2.0	0.0	3.5	0.1
4	2.4	0.0	NS	NS
5	NS	NS	1.5	0.0
6	2.7	0.0	3.8	0.0
7	2.7	0.0	2.2	0.0
8	NS	NS	2.0	0.0
9	1.3	0.0	2.6	0.0
10	1.1	0.0	1.1	0.0
11	3.5	0.0	3.2	0.0
12	NS	NS	0.8	0.0

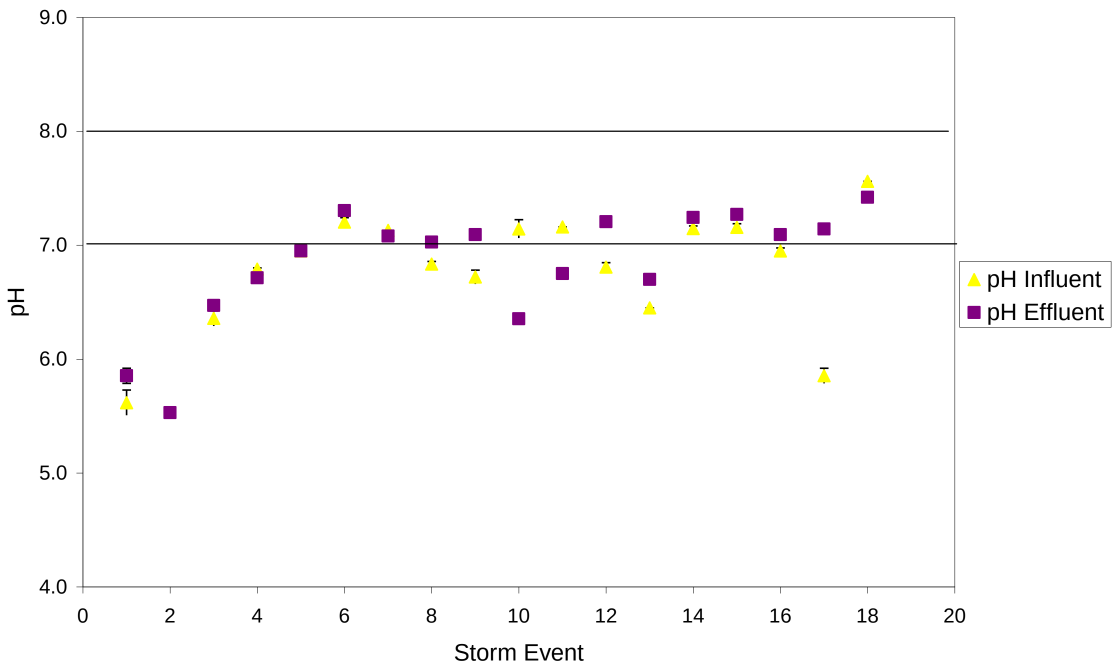
					% Removal
Average	2.3	0.0	2.2	0.0	0.05
Std. Dev.	0.8	0.0	1.0	0.0	



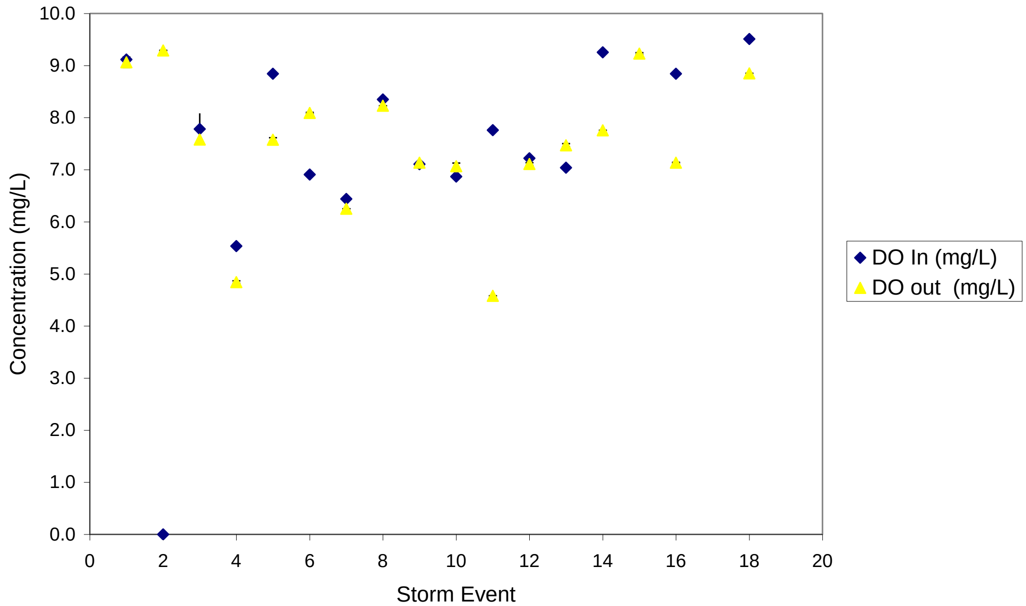
W Street BaySaver

1. Storm event number, date of event, pH, DO, and temperature values.

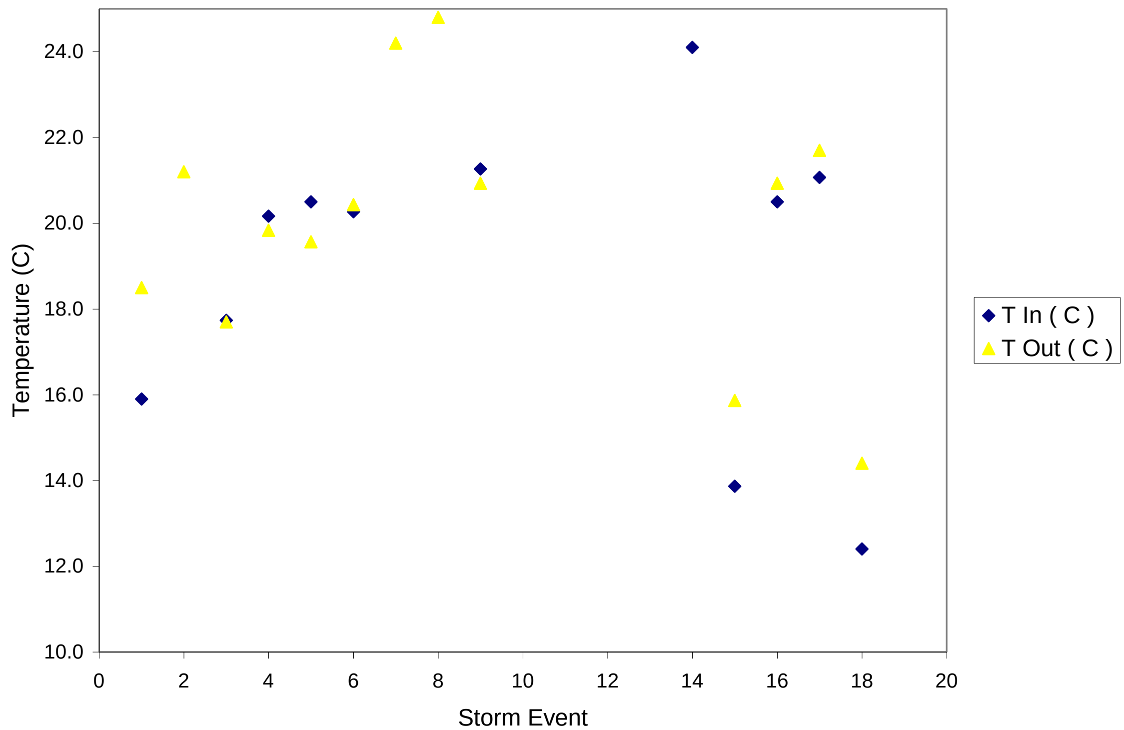
Storm #	pH Influent	St. Dev	pH Effluent	St. Dev.
1	5.6	0.1	5.9	0.1
2	NS	NS	5.5	0.0
3	6.4	0.1	6.5	0.0
4	6.8	0.0	6.7	0.0
5	7.0	0.0	7.0	0.0
6	7.2	0.0	7.3	0.0
7	7.1	0.0	7.1	0.0
8	6.8	0.0	7.0	0.0
9	6.7	0.1	7.1	0.0
10	7.1	0.1	6.4	0.0
11	7.2	0.0	6.8	0.0
12	6.8	0.0	7.2	0.0
13	6.5	0.0	6.7	0.0
14	7.1	0.0	7.2	0.0
15	7.2	0.0	7.3	0.0
16	7.0	0.0	7.1	0.0
17	5.9	0.1	7.1	0.1
18	7.6	0.0	7.4	0.0
Samples 1-15				
Average	6.8	0.0	6.8	0.0
Std. Dev.	0.4	0.0	0.5	0.0
Samples 16-18				
Average	6.8	0.0	7.2	0.0
Std. Dev.	0.9	0.0	0.2	0.0



Storm #	DO In (mg/L)	St. Dev	DO out (mg/L)	St. Dev.
1	9.1	0.0	9.1	0.1
2	NS	NS	9.3	0.0
3	7.8	0.3	7.6	
4	5.5	0.0	4.8	0.0
5	8.8	0.1	7.6	0.0
6	6.9	0.0	8.1	0.0
7	6.4	0.0	6.3	0.0
8	8.4	0.0	8.2	0.0
9	7.1	0.0	7.1	0.0
10	6.9	0.0	7.1	0.1
11	7.8	0.0	4.6	0.0
12	7.2	0.1	7.1	0.0
13	7.0	0.0	7.5	0.0
14	9.3	0.0	7.8	0.0
15	11.6	0.0	9.2	0.0
16	8.8	0.1	7.1	0.0
17				
18	9.5	0.0	8.9	0.0
Samples 1-15				
Average	7.8	0.0	7.4	0.0
Std. Dev.	1.5	0.1	1.4	0.0
Samples 16-18				
Average	9.2	0.0	8.0	0.0
Std. Dev.	0.5	0.0	1.2	0.0

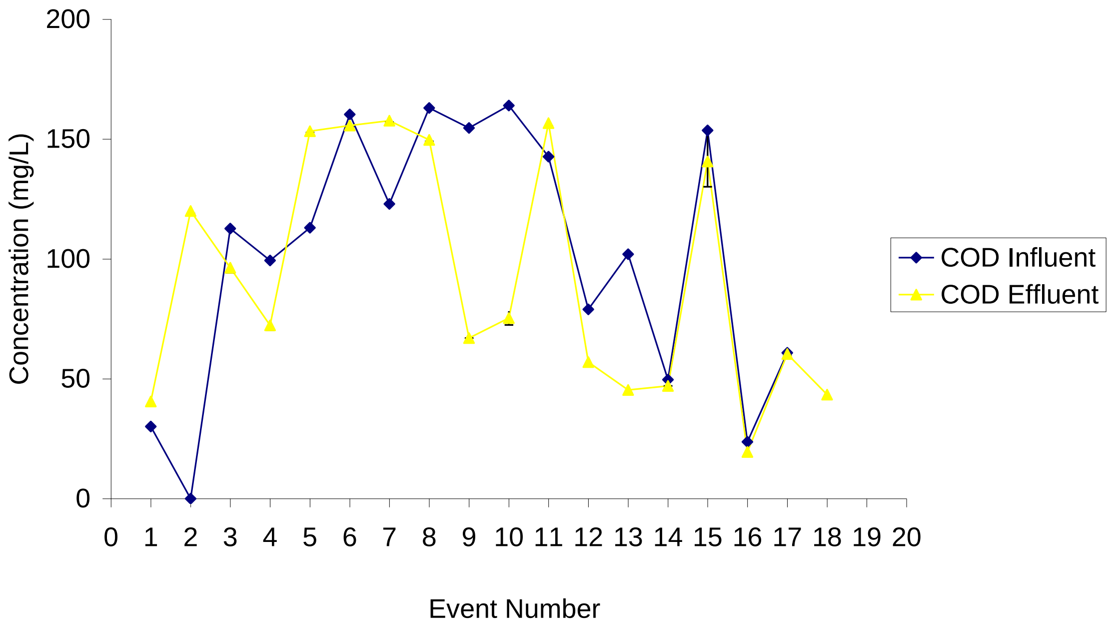


Storm #	T In (C)	St. Dev	T Out (C)	St. Dev.
1	15.90	0.26	18.5	0.0
2	NS	NS	21.2	0.0
3	17.7	0.3	17.7	0.0
4	20.2	0.1	19.8	0.1
5	20.5	0.0	19.6	0.1
6	20.3	0.1	20.4	0.1
7	27.5	0.0	24.2	0.0
8	25.9	0.0	24.8	0.0
9	21.3	0.1	20.9	0.1
10	30.5	0.1	27.8	0.0
11	27.0	0.0	26.8	0.0
12	27.6	0.1	26.2	0.1
13	27.9	0.0	28.5	0.0
14	24.1	0.1	27.0	0.2
15	13.9	0.1	15.9	0.1
16	20.5	0.0	20.9	0.1
17	21.1	0.2	21.7	0.1
18	12.4	0.0	14.4	0.0
Samples 1-15				
Average	22.9	0.1	22.6	0.0
Std. Dev.	5.1	0.1	4.1	0.0
Samples 16-18				
Average	18.0	0.1	19.0	0.1
Std. Dev.	4.8	0.1	4.0	0.1



2. Storm event number, date of event, chemical oxygen demand values.

Storm #	COD mg/L COD Influent	St. Dev	COD mg/L COD Effluent	St. Dev.
1	30.1	2.5	41	2
2	NS	NS	120	1
3	113	6	96	2
4	99	1	72	2
5	113	22	153	1
6	160	1	156	1
7	123	2	158	1
8	163	0	150	1
9	155	2	67	0
10	164	1	75	3
11	143	2	157	1
12	79	1	57	2
13	102	2	45	1
14	50	0	47	0
15	154	1	141	11
16	24	1	19	2
17	61	0	60	1
18	45	1	43	2
Samples 1-15				
Average	117.6	3.0	102.3	1.8
Std. Dev.	42.8	5.6	46.7	2.5
Samples 16-18				
Average	43.3	0.9	41.1	1.4
Std. Dev.	18.7	0.8	20.5	0.6

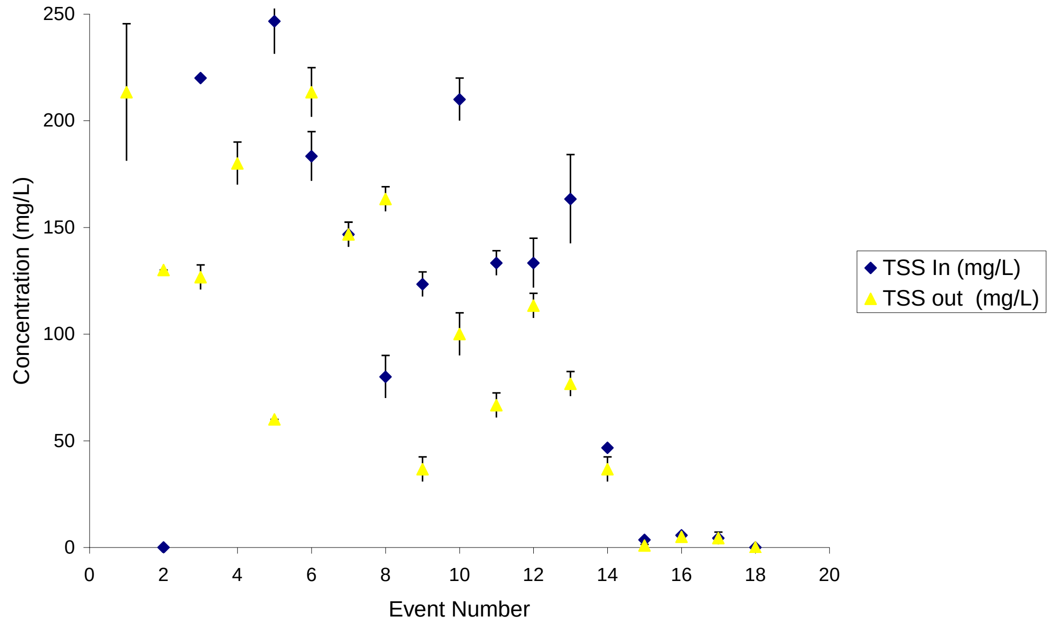


3. Storm event number, date of event, total suspended and total dissolved solid values.

Storm #	TSS In (mg/L)	St. Dev	TSS out (mg/L)	St. Dev.
1	1993	271	213	32
2	NS	NS	130	0
3	220	0	127	6
4	380	26	180	10
5	247	15	60	0
6	183	12	213	12
7	147	6	147	6
8	80	10	163	6
9	123	6	37	6
10	210	10	100	10
11	133	6	67	6
12	133	12	113	6
13	163	21	77	6
14	47	6	37	6
15	4	46	1	0
16	6	1	5	1
17	4	5	4	3
18	0	0	0	0

					% Removal
Samples 1-15					
Average	290	31.8	111	7.4	0.62
Std. Dev.	499	69.7	65	7.7	
					% Removal
Samples 16-18					

Average	3.3	1.9	3.1	1.2	0.07
Std. Dev.	3.0	2.6	2.7	1.5	

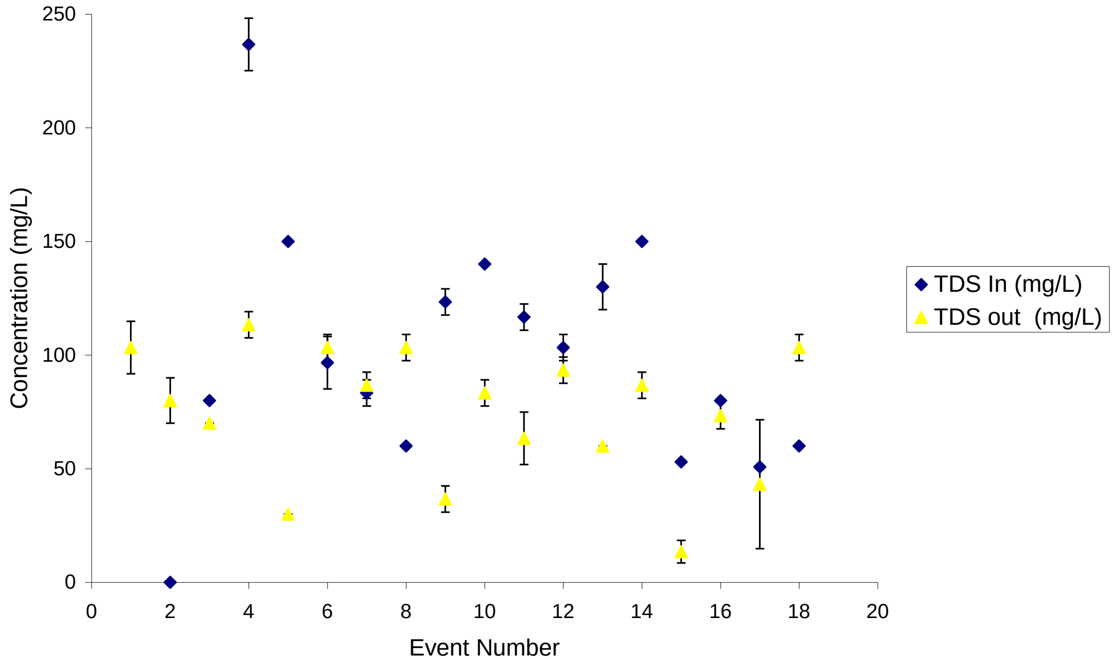


Storm #	TDS In (mg/L)	St. Dev	TDS out (mg/L)	St. Dev.
1	1700	184	103	12
2	NS	NS	80.000	10.000
3	80	0	70	0
4	237	12	113	6
5	150	0	30	0
6	97	12	103	6
7	83	6	87	6
8	60	0	103	6
9	123	6	37	6
10	140	0	83	6
11	117	6	63	12
12	103	6	93	6
13	130	10	60	0
14	150	0	87	6
15	53	56	14	5
16	80	10	73	6
17	51	48	43	28
18	60	0	103	6

Samples 1-15					% Removal
Average	230	21	75	6	0.67
Std. Dev.	426	49	30	4	

Samples 16-18	% Removal

Average	64	19	73	13	-0.15
Std. Dev.	15	26	30	13	

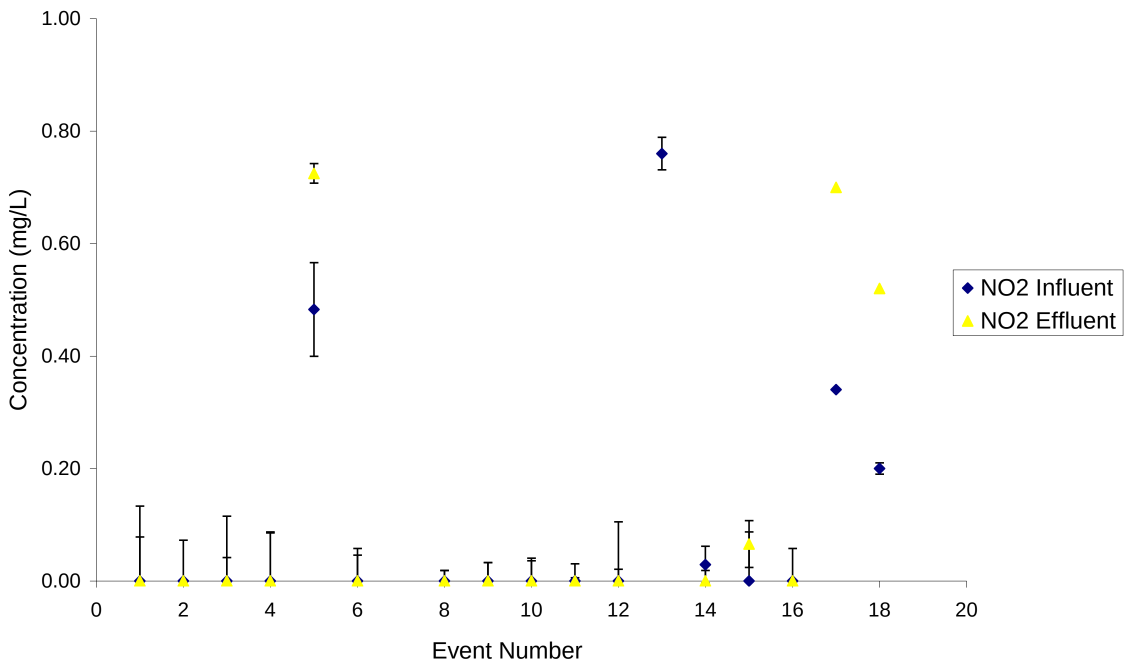


4. Storm event number, date of event, NH_3, NO_2, NO_3, and PO_4 concentration values

Storm #	NO2 mg/L NO2 Influent	St. Dev	NO2 mg/L NO2 Effluent	St. Dev.
1	0.0	0.0	0.0	0.0
2	NS	NS	0.0	0.0
3	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0
5	0.5	0.1	0.7	0.2
6	0.0	0.0	0.0	0.0
7	20.0	1.0	8.3	0.6
8	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
13	0.8	0.2	2.7	1.0
14	0.0	0.0	0.0	0.0
15	0.0	0.0	0.1	0.1
16	0.0	0.0	0.0	0.0
17	0.3	0.2	0.7	0.0
18	0.2	0.0	0.5	0.0

Samples 1-15					% Removal
Average	1.5	0.1	0.8	0.1	0.48

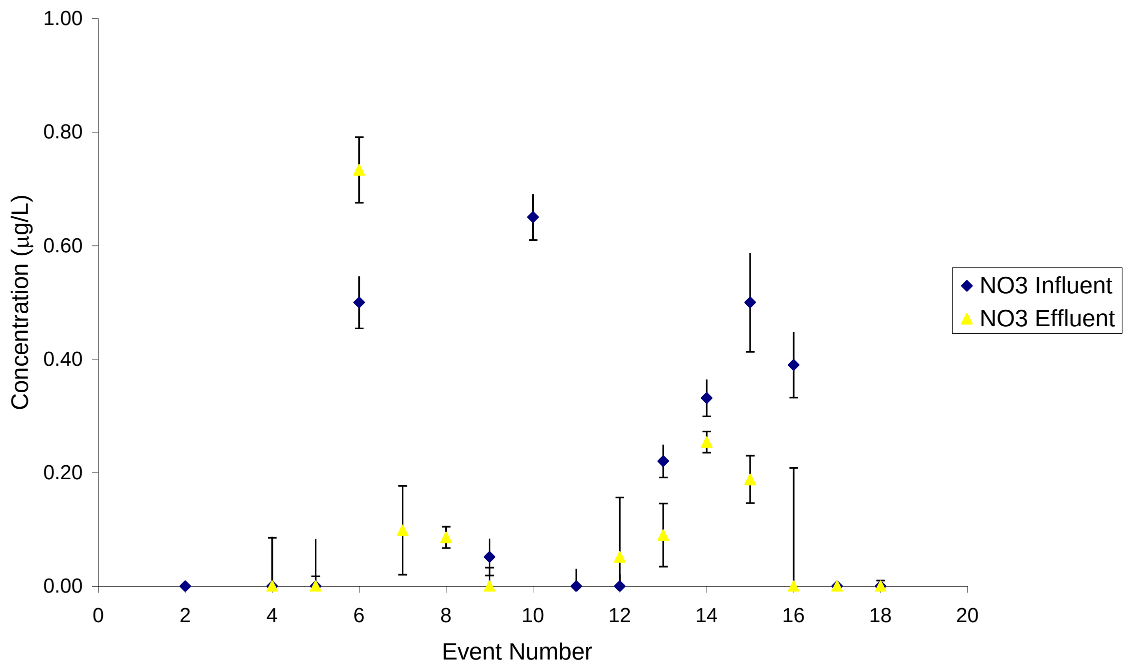
Std. Dev.	5.3	0.3	2.2	0.3	
					% Removal
Samples 16-18					
Average	0.2	0.1	0.4	0.0	-1.26
Std. Dev.	0.2	0.1	0.4	0.0	



Storm #	NO3 mg/L NO3 Influent	St. Dev	NO3 mg/L NO3 Effluent	St. Dev.
1	1.2	2.0	9.5	0.9
2	NS	NS	3.7	1.0
3	1.7	0.3	7.6	0.5
4	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0
6	0.5	0.1	0.7	0.2
7	4.8	0.3	0.1	0.0
8	1.7	0.0	0.1	0.1
9	0.1	0.1	0.0	0.0
10	0.7	0.1	1.4	0.6
11	0.0	0.0	2.1	0.8
12	0.0	0.0	0.1	0.1
13	0.2	0.0	0.1	0.0
14	0.3	0.1	0.3	0.0
15	0.5	0.1	0.2	0.1
16	0.4	0.1	0.0	0.0
17	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0

					% Removal
Samples 1-15					
Average	0.8	0.2	1.7	0.3	-1.07

Std. Dev.	1.3	0.5	3.0	0.4	
					% Removal
Samples 16-18					
Average	0.1	0.0	0.0	0.0	1.00
Std. Dev.	0.2	0.1	0.0	0.0	

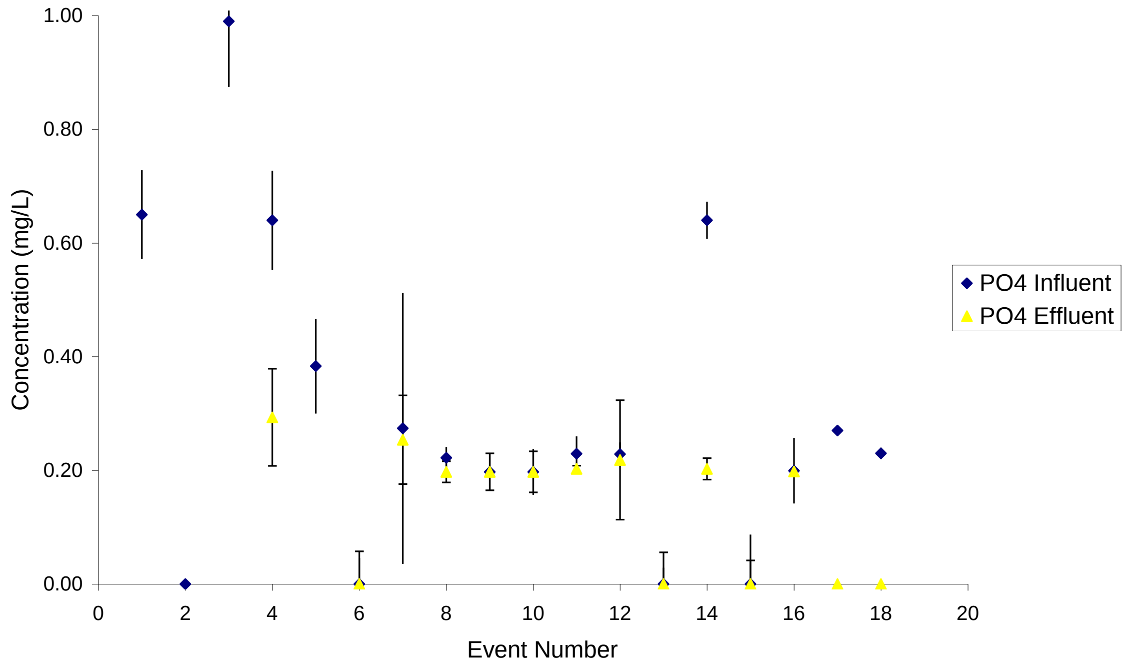


Storm #	PO4 mg/L PO4 Influent	St. Dev	PO4 mg/L PO4 Effluent	St. Dev.
1	0.65	0.61	48.14	0.14
2	NS	NS	45.60	0.96
3	0.99	0.23	47.45	1.08
4	0.64	0.13	0.29	0.12
5	0.38	0.08	48.33	7.09
6	0.00	0.00	0.00	0.00
7	0.27	0.04	0.25	0.00
8	0.22	0.02	0.20	0.00
9	0.20	0.00	0.20	0.00
10	0.20	0.00	0.20	0.00
11	0.23	0.05	0.20	0.00
12	0.23	0.00	0.22	0.00
13	0.00	0.00	0.00	0.00
14	0.64	0.13	0.20	0.00
15	0.00	0.00	0.00	0.00
16	0.20	0.00	0.20	0.00
17	0.27	0.03	0.00	0.00
18	0.23	0.05	0.00	0.00

Samples 1-15 %

					Removal
Average	0.3	0.1	12.8	0.6	-37.38
Std. Dev.	0.3	0.2	21.6	1.8	

					% Removal
Samples 16-18					
Average	0.2	0.0	0.1	0.0	0.72
Std. Dev.	0.0	0.0	0.1	0.0	



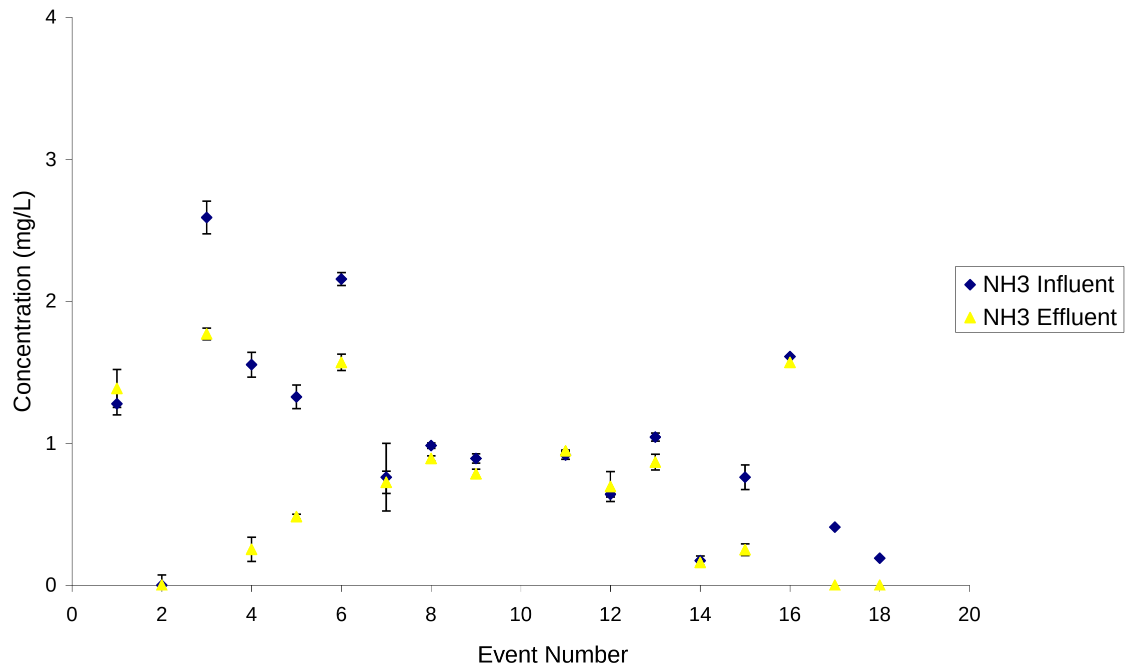
5. Storm event number, date of event, and ammonia concentration values.

Storm #	NH3 mg/L NH3 Influent	St. Dev	NH3 mg/L NH3 Effluent	St. Dev.
1	1.3	0.2	1.4	0.1
2	NS	NS	0.0	0.0
3	2.6	0.1	1.8	0.1
4	1.6	0.1	0.3	0.0
5	1.3	0.2	0.5	0.1
6	2.2	0.1	1.6	0.1
7	0.8	0.0	0.7	0.0
8	1.0	0.0	0.9	0.0
9	0.9	0.0	0.8	0.0
10	4.9	0.8	4.8	0.4
11	0.9	0.0	0.9	0.0
12	0.6	0.2	0.7	0.1
13	1.0	0.1	0.9	0.1
14	0.2	0.0	0.2	0.0
15	0.8	0.0	0.3	0.1
16	1.6	0.1	1.6	0.1

17	0.4	0.2	0.0	0.0
18	0.2	0.0	0.0	0.0

Samples 1-15					% Removal
Average	1.4	0.1	1.0	0.1	0.27
Std. Dev.	1.2	0.2	1.2	0.1	

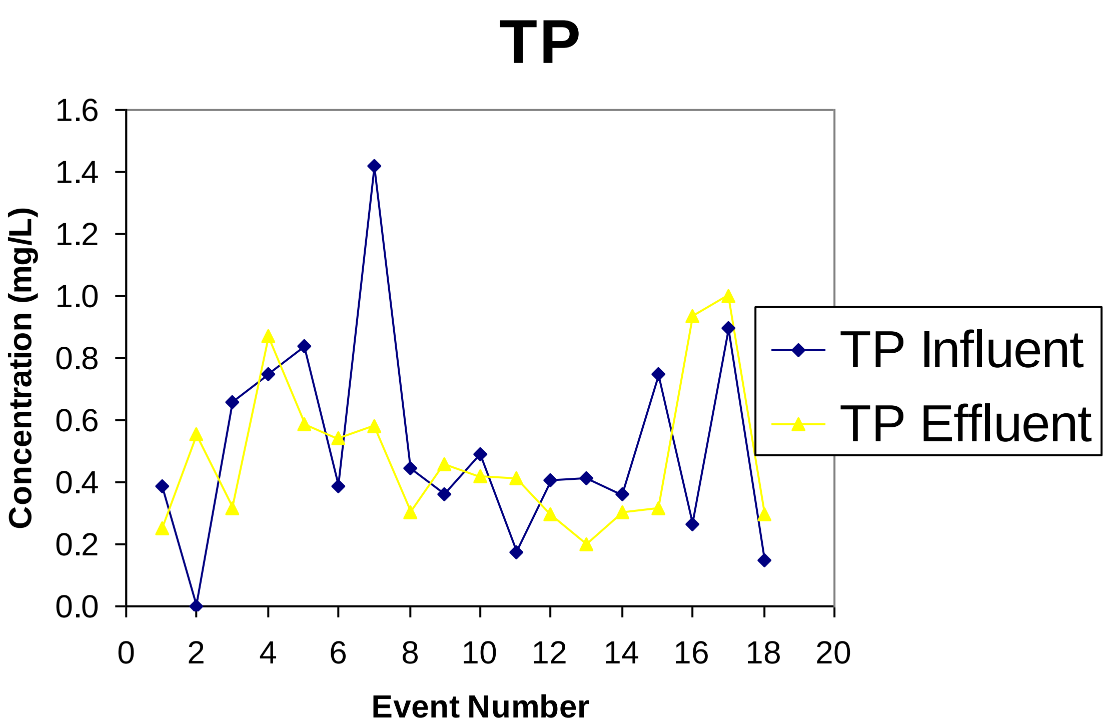
Samples 16-18					% Removal
Average	0.7	0.1	0.5	0.0	0.29
Std. Dev.	0.8	0.1	0.9	0.1	



6. Storm event number, date of event, and TP concentration values.

Storm #	TP mg/L TP Influent	St. Dev	TP mg/L TP Effluent	St. Dev.
1	0.4	0.1	0.3	0.1
2	NS	NS	0.6	0.1
3	0.7	0.1	0.3	0.0
4	0.8	0.1	0.9	0.1
5	0.8	0.1	0.6	0.0
6	0.4	0.0	0.5	0.1
7	1.4	0.2	0.6	0.1
8	0.4	0.0	0.3	0.0
9	0.4	0.0	0.5	0.0
10	0.5	0.0	0.4	0.0
11	0.2	0.0	0.4	0.0
12	0.4	0.0	0.3	0.1
13	0.4	0.0	0.2	0.1

14	0.4	0.0	0.3	0.0	
15	0.8	0.1	0.3	0.0	
16	0.3	0.1	0.9	0.2	
17	0.9	0.0	1.0	0.0	
18	0.2	0.0	0.3	0.0	
					% Removal
Samples 1-15					
Average	0.6	0.1	0.4	0.1	0.24
Std. Dev.	0.3	0.1	0.2	0.0	
					% Removal
Samples 16-18					
Average	0.4	0.0	0.7	0.1	-0.70
Std. Dev.	0.4	0.0	0.4	0.1	



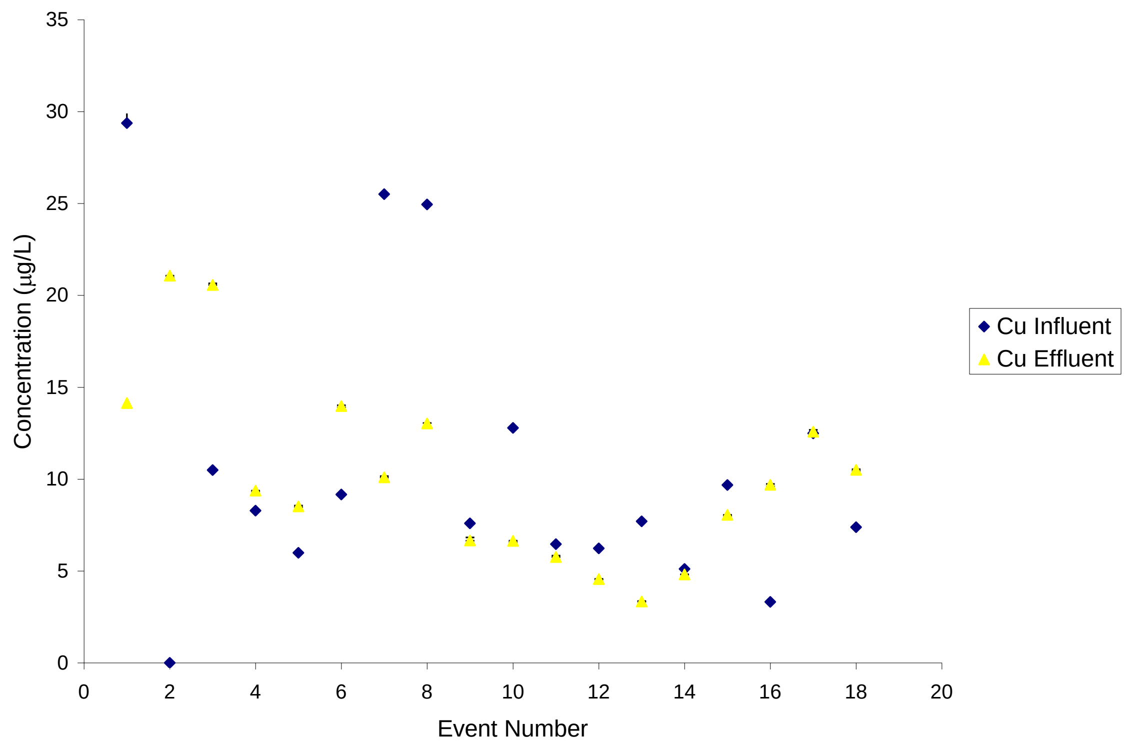
7. Storm event number, date of event, and copper concentration values.

Storm #	(ug/L) Cu Influent	St. Dev	(ug/L) Cu Effluent	St. Dev.
1	29.38	0.10	14.14	0.52
2	NS	NS	21.07	0.01
3	10.5	0.0	20.6	0.1
4	8.3	0.0	9.4	0.0
5	6.0	0.1	8.5	0.3
6	9.2	0.0	14.0	0.0
7	25.5	0.2	10.1	0.1
8	25.0	0.0	13.0	0.0
9	7.6	0.1	6.7	0.0
10	12.8	0.0	6.6	0.0

11	6.5	0.0	5.8	0.0
12	6.2	0.0	4.6	0.0
13	7.7	0.0	3.3	0.0
14	5.1	0.0	4.8	0.0
15	9.7	0.1	8.1	0.1
16	3.3	0.0	9.7	0.0
17	12.5	0.1	12.6	0.1
18	7.4	0.1	10.5	0.1

Samples 1-15					% Removal
Average	12	0	10	0	0.17
Std. Dev.	8	0	6	0	

Samples 16-18					% Removal
Average	8	0	11	0	-0.41
Std. Dev.	5	0	1	0	



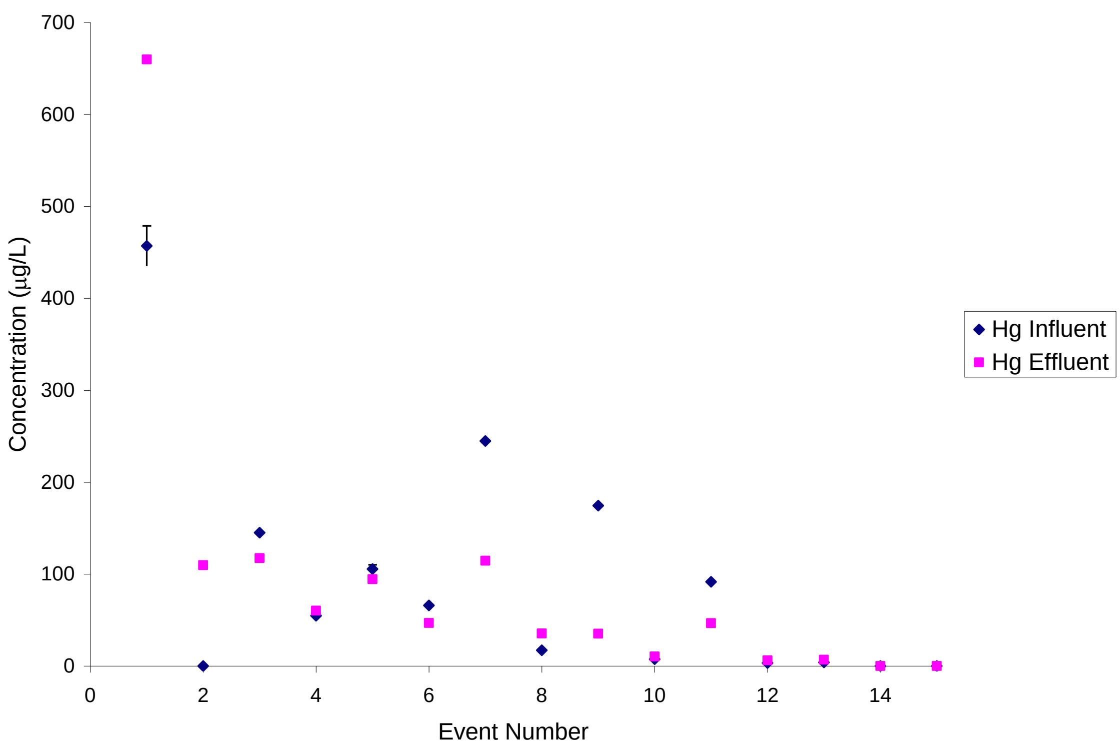
8. Storm event number, date of event, and mercury concentration values.

Storm #	Influent ug/L Hg Influent	St. Dev	Effluent ug/L Hg Effluent	St. Dev.
1	457	22	660	7
2	NS	NS	110	0
3	145	0	117	1
4	55	0	60	1
5	106	5	94	2
6	66	1	47	1
7	245	1	114	0

8	17	0	35	0
9	174	0	35	0
10	7	0	10	0
11	92	0	47	0
12	3	0	6	0
13	4	0	7	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	0	0	0	0

Samples 1-15					% Removal
Average	97.9	2.2	89.5	0.8	0.09
Std. Dev.	128.1	5.8	163.4	1.8	

Samples 16-18					% Removal
Average	0.0	0.0	0.0	0.0	#DIV/0!
Std. Dev.	0.0	0.0	0.0	0.0	



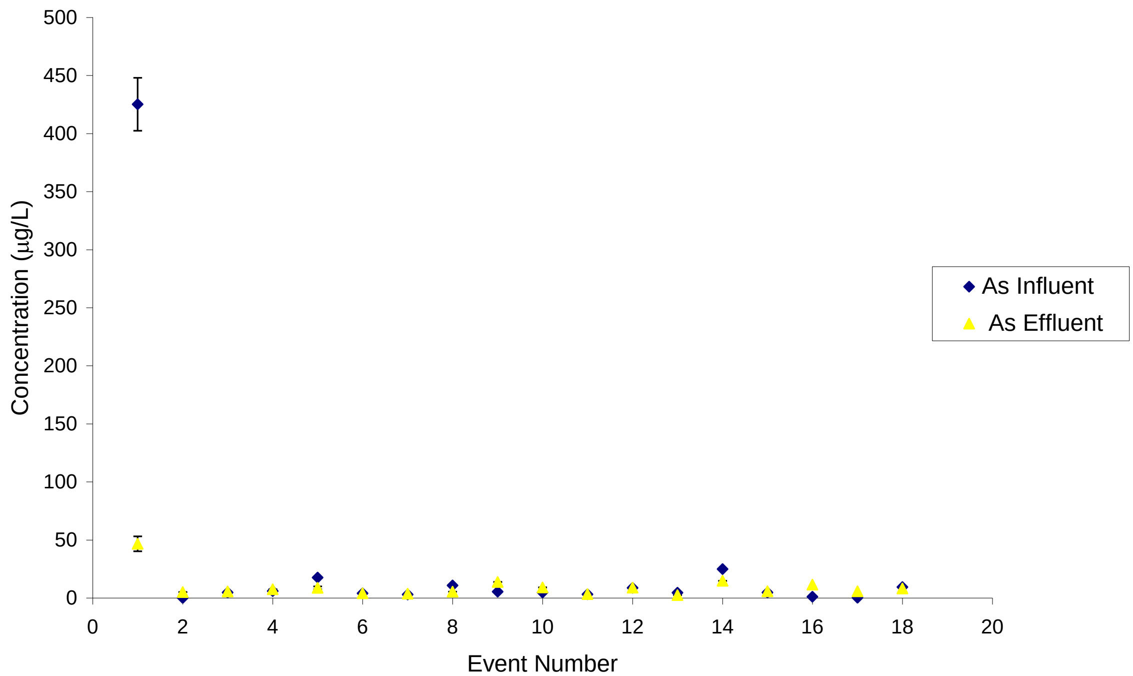
9. Storm event number, date of event, and arsenic concentration values.

Storm #	As Influent	St. Dev	As Effluent	St. Dev.
1	425.2	22.8	46.6	6.4
2	NS	NS	5.0	0.0
3	4.7	0.0	5.5	0.0
4	5.9	0.0	7.5	0.1
5	17.6	0.7	8.7	1.3

6	4.0	0.1	4.0	0.0
7	3.0	0.0	3.6	0.0
8	10.8	0.0	5.4	0.0
9	5.3	0.0	13.8	0.0
10	4.6	0.0	9.0	0.0
11	3.2	0.0	3.3	0.0
12	8.7	0.1	8.9	0.1
13	4.5	0.0	2.5	0.0
14	24.9	0.1	14.7	0.0
15	4.8	0.1	5.7	0.1
16	1.0	0.0	11.4	0.0
17	0.1	0.0	5.7	0.1
18	9.4	0.1	8.2	0.1

Samples 1-15					% Removal
Average	37.7	1.7	9.6	0.5	0.74
Std. Dev.	111.7	6.1	10.8	1.6	

Samples 16-18					% Removal
Average	3.5	0.0	8.4	0.1	-1.41
Std. Dev.	5.1	0.0	2.9	0.0	



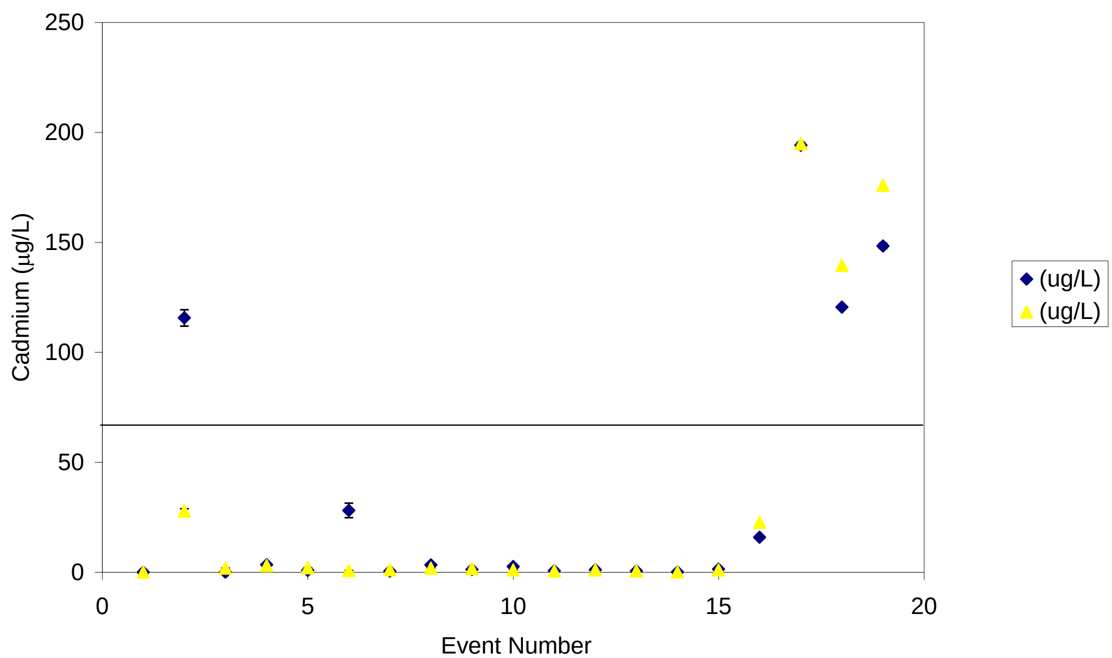
10. Storm event number, date of event, and cadmium concentration values.

Storm #	(ug/L) Cd Influent	St. Dev	(ug/L) Cd Effluent	St. Dev.
1	115.6	3.7	27.9	0.9
2	NS	NS	1.84	0.00
3	3.4	0.0	3.1	0.0

4	0.8	0.0	2.0	0.0
5	28.1	3.3	0.7	0.0
6	0.5	0.0	1.1	0.0
7	3.3	0.0	1.8	0.0
8	1.2	0.0	1.7	0.0
9	2.5	0.0	1.0	0.0
10	0.6	0.0	0.6	0.0
11	1.1	0.0	1.0	0.0
12	0.5	0.0	0.5	0.0
13	0.1	0.0	0.0	0.0
14	1.4	0.0	1.0	0.0
15	15.8	0.0	22.6	0.6
16	194.1	1.3	194.8	1.3
17	120.5	0.6	139.5	0.7
18	148.3	1.2	176.0	3.3

Samples 1-15					% Removal
Average	12	1	4	0	0.64
Std. Dev.	31	1	9	0	

Samples 16-18					% Removal
Average	154	1	170	2	-0.10
Std. Dev.	37	0	28	1	



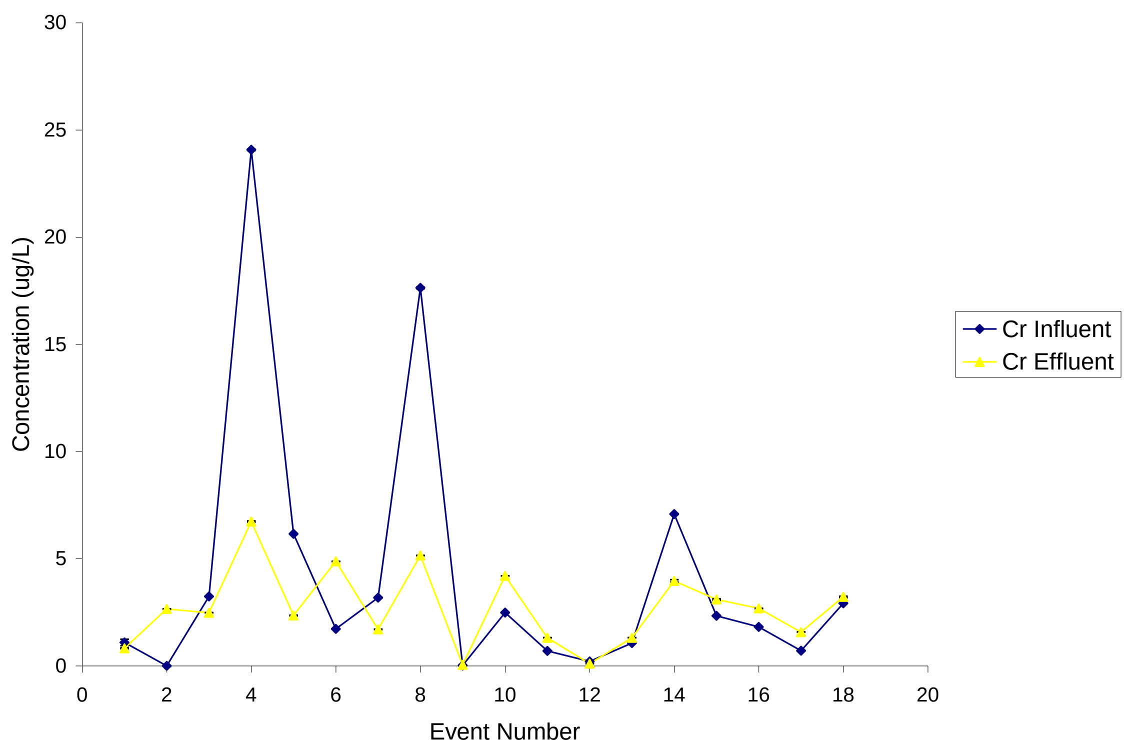
11. Storm event number, date of event, and chromium concentration values.

Storm #	(ug/L) Cr Influent	St. Dev	(ug/L) Cr Effluent	St. Dev.

1	1.1	0.2	0.8	0.0
2	NS	NS	2.66	0.00
3	3.2	0.0	2.5	0.0
4	24.1	0.0	6.7	0.0
5	6.2	0.0	2.4	0.0
6	1.7	0.0	4.9	0.0
7	3.2	0.0	1.7	0.0
8	17.6	0.0	5.1	0.0
9	0.0	0.0	0.0	0.0
10	2.5	0.0	4.2	0.0
11	0.7	0.0	1.3	0.0
12	0.2	0.0	0.1	0.0
13	1.1	0.0	1.3	0.0
14	7.1	0.0	4.0	0.1
15	2.3	0.0	3.1	0.0
16	1.8	0.0	2.7	0.0
17	0.7	0.0	1.6	0.0
18	2.9	0.0	3.2	0.0

Samples 1-15					% Removal
Average	5.1	0.0	2.7	0.0	0.46
Std. Dev.	7.1	0.0	2.0	0.0	

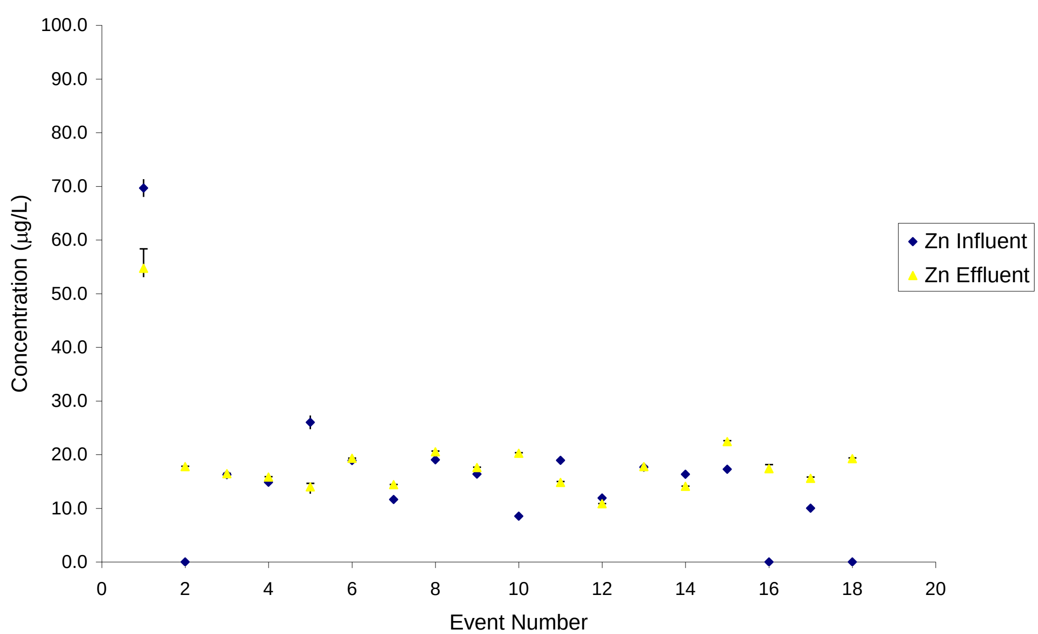
Samples 16-18					% Removal
Average	1.8	0.0	2.5	0.0	-0.37
Std. Dev.	1.1	0.0	0.8	0.0	



12. Storm event number, date of event, and zinc concentration values.

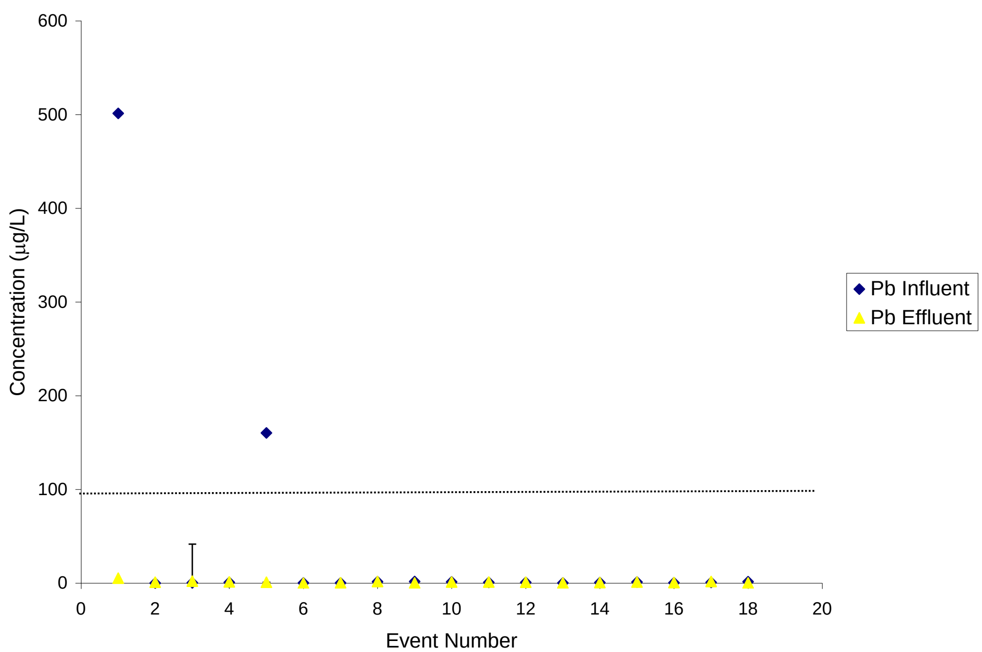
Storm #	Zn Influent	St. Dev	Zn Effluent	St. Dev.
1	69.7	1.7	54.7	3.6
2	NS	NS	17.8	0.1
3	16.3	0.1	16.4	0.1
4	14.8	0.0	15.8	0.1
5	26.0	1.3	14.0	0.7
6	18.9	0.1	19.3	0.1
7	11.7	0.2	14.4	0.0
8	19.0	0.0	20.5	0.2
9	16.4	0.2	17.6	0.1
10	8.5	0.1	20.2	0.1
11	18.9	0.0	14.8	0.2
12	11.9	0.0	10.9	0.0
13	17.7	0.0	17.7	0.0
14	16.4	0.1	14.1	0.0
15	17.3	0.2	22.4	0.2
16	0.0	0.0	17.4	0.8
17	10.0	0.0	15.6	0.2
18	0.0	0.0	19.2	0.2

Samples 1-15					% Removal
Average	20	0	19	0	0.04
Std. Dev.	15	1	10	1	
Samples 16-18					% Removal
Average	3	0	17	0	-4.22
Std. Dev.	6	0	2	0	



13. Storm event number, date of event, and lead concentration values.

Storm #	(ug/L) Pb Influent	St. Dev	(ug/L) Pb Effluent	St. Dev.	
1	501.3	39.5	5.3	0.3	
2	NS	NS	1.0	0.0	
3	0.5	0.0	2.1	0.0	
4	0.7	0.0	1.4	0.0	
5	160.2	0.4	0.8	0.0	
6	0.2	0.0	0.0	0.0	
7	0.1	0.0	0.3	0.0	
8	1.5	0.0	1.7	0.0	
9	1.8	0.0	0.2	0.0	
10	1.4	0.0	1.1	0.0	
11	0.8	0.0	1.2	0.0	
12	0.7	0.0	0.9	0.0	
13	0.3	0.0	0.2	0.0	
14	0.5	0.0	0.6	0.0	
15	1.2	0.0	1.1	0.1	
16	0.4	0.0	0.6	0.0	
17	0.7	0.0	1.8	0.0	
18	1.4	0.0	0.2	0.0	
Samples 1-15					% Removal
Average	47.9	2.9	1.2	0.0	0.97
Std. Dev.	137.2	10.5	1.3	0.1	
Samples 16-18					% Removal
Average	0.8	0.0	0.8	0.0	0.00
Std. Dev.	0.5	0.0	0.8	0.0	



14. PAH Measurements

Compounds Measured for:

1 Indeno (1,2,3 - cd)pyrene
2 Benzo(ghi)perylene
3 Dibenzo(a,h)anthracene
4 Benzo(a)Pyrene
5 Benzo(k)Flouranthene
6 Chrysene
7 Benzo(a)Anthracene
8 Pyrene
9 Flouranthene
10 Anthracene
11 Phenanthrene
12 Acenaphthylene
13 Napthalene
14 Benzo(b)flouranthene

Events and the Compounds with concentrations above 0.5 ppb in at least one sample

PAH REPORT (15 Events)

	INLET Conc. (ppb)	OUTLET Conc. (ppb)	Rem. Eff.	EPA Priority Pollutant (ppb)
Naphthalene	0.09	2.90	-3164%	0
Anthracene	1.23	0.43	65%	8,300
Flouranthene	55.67	73.07	-31%	130
Pyrene	93.88	18.77	80%	830
Chrysene	0.58	0.70	-21%	3.8
Benzo(a)anthracene	0.01	1.23	-12192%	3.8
Benzo(b)flouranthene	0.36	0.82	-131%	3.8
Benzo(k)flouranthene	0.38	0.04	90%	3.8
Benzo(a)pyrene	0.39	0.01	97%	3.8
Dibenzo(a,h)anthracene	4.62	2.46	47%	3.8
Benzo(ghi)perylene	3.65	1.67	54%	0
Ideno(1,2,3-cd)pyrene	0.27	0.03	90%	3.8

Summary of Storm Event # 1 (2/13/2006)

	HPLC conc.	Actual conc. (ppb)
Chrysene		
In average	0.07	0.33
Out average	0.00	0.01
Pyrene		
In average	0.01	0.06
Out average	0.04	0.22
Flouranthene		
In average	10.86	54.32
Out average	0.00	0.00
Anthracene		

In average	0.21	1.04
Out average	0.00	0.00
Napthalene		
In average	0.01	0.03
Out average	0.00	0.00
Benzo(b)flouranthene		
In average	0.06	0.30
Out average	0.08	0.38

Summary of Storm Event # 2 (4/4/2006)

Flouranthene		
In average	0.00	0.00
Out average	11.97	59.85
Pyrene		
In average	13.79	68.95
Out average	0.00	0.00
Benzo(k)flouranthene		
In average	0.00	0.01
Out average	0.00	0.00
Benzo(a)pyrene		
In average	0.01	0.05
Out average	0.00	0.00
Dibenzo(a,h)anthracene		
In average	0.01	0.06
Out average	0.00	0.00

Summary of Storm Event # 3 (4/8/2006)

Chrysene		
In average	0.00	0.01
Benzo(b)flouranthene		
In average	0.00	0.00
Out average	0.00	0.01
Dibenzo(a,h)anthracene		
In average	0.12	0.60
Out average	0.00	0.00
Benzo(ghi)perylene		
In average	0.67	3.36
Out average	0.00	0.02
Ideno(1,2,3-cd)pyrene		
In average	0.00	0.01
Out average	0.00	0.00

Summary of Storm Event # 4 (4/22/2006)

Chrysene		
In average	0.02	0.12
Out average	0.00	0.00
Benzo(a)anthracene		
In average	0.00	0.00
Out average	0.00	0.01
Benzo(b)flouranthene		

In average	0.00	0.01
Out average	0.00	0.00
Benzo(k)flouranthene		
In average	0.00	0.00
Out average	0.00	0.01
Dibenzo(a,h)anthracene		
In average	0.03	0.17
Out average	0.16	0.80
Benzo(ghi)perylene		
In average	0.00	0.00
Out average	0.00	0.01

Summary of Storm Event # 5 (5/8/2006)

Chrysene		
In average	0.00	0.02
Out average	0.00	0.00
Dibenzo(a,h)anthracene		
In average	0.27	1.37
Out average	0.31	1.54
Benzo(ghi)perylene		
In average	0.01	0.06
Out average	0.00	0.00

Summary of Storm Event # 6 (5/11/2006)

NAPHTHALENE		
In average	0.00	0.01
Out average	0.00	0.01
Anthracene		
In average	0.00	0.01
Out average	0.00	0.00
Benzo(b)flouranthene		
In average	0.00	0.02
Out average	0.00	0.00
Benzo(k)flouranthene		
In average	0.03	0.15
Out average	0.00	0.00
Benzo(a)pyrene		
In average	0.07	0.34
Out average	0.00	0.00
Dibenzo(a,h)anthracene		
In average	0.13	0.67
Out average	0.00	0.00
Benzo(ghi)perylene		
In average	0.02	0.10
Out average	0.00	0.00
Ideno(1,2,3-cd)pyrene		
In average	0.02	0.10
Out average	0.00	0.00

Summary of Storm Event #7 (5/26/2006)

Anthracene		
In average	0.02	0.11
Out average	0.00	0.00
Pyrene		
In average	1.93	9.63
Out average	0.00	0.00
Benzo(b)flouranthene		
In average	0.00	0.01
Out average	0.00	0.00
Benzo(k)flouranthene		
In average	0.00	0.02
Out average	0.00	0.00
Dibenzo(a,h)anthracene		
In average	0.00	0.00
Out average	0.04	0.10
Benzo(ghi)perylene		
In average	0.00	0.01
Out average	0.00	0.01
Ideno(1,2,3-cd)pyrene		
In average	0.00	0.01
Out average	0.01	0.03

Summary of Storm Event #8 (6/09/2006)

NAPHTHALENE		
In average	0.00	0.01
Out average	0.57	2.85
Anthracene		
In average	0.01	0.04
Out average	0.05	0.25
Flouranthene		
In average	0.00	0.00
Out average	1.27	6.35
Pyrene		
In average	0.02	0.11
Out average	0.87	4.35
Chrysene		
In average	0.00	0.00
Out average	0.04	0.22
Benzo(a)anthracene		
In average	0.00	0.00
Out average	0.04	0.19
Benzo(b)flouranthene		
In average	0.00	0.00
Out average	0.02	0.09
Dibenzo(a,h)anthracene		
In average	0.01	0.04
Out average	0.00	0.01
Benzo(ghi)perylene		
In average	0.00	0.00
Out average	0.00	0.01

Summary of Storm Event #9   (6/12/2006)

NAPHTHALENE		
In average	0.00	0.01
Out average	0.00	0.00
Anthracene		
In average	0.00	0.00
Out average	0.03	0.16
Flouranthene		
In average	0.01	0.05
Out average	1.37	6.87
Pyrene		
In average	2.11	10.57
Out average	0.36	1.78
Benzo(b)flouranthene		
In average	0.00	0.00
Out average	0.06	0.32
Benzo(k)flouranthene		
In average	0.00	0.00
Out average	0.01	0.03
Dibenzo(a,h)anthracene		
In average	0.00	0.00
Out average	0.00	0.01

Summary of Storm Event #10   (6/19/2006)

NAPHTHALENE		
In average	0.00	0.02
Out average	0.00	0.01
Anthracene		
In average	0.01	0.03
Out average	0.00	0.01
Flouranthene		
In average	0.26	1.30
Out average	0.00	0.00
Pyrene		
In average	0.89	4.46
Out average	2.41	12.06
Chrysene		
In average	0.05	0.23
Out average	0.09	0.47
Benzo(a)anthracene		
In average	0.00	0.00
Out average	0.21	1.03
Benzo(b)flouranthene		
In average	0.00	0.01
Out average	0.01	0.03
Benzo(k)flouranthene		
In average	0.01	0.06
Out average	0.00	0.00
Dibenzo(a,h)anthracene		

In average	0.21	1.03
Out average	0.00	0.00
Benzo(ghi)perylene		
In average	0.00	0.02
Out average	0.00	0.00

Summary of Storm Event # 14   (9/1/2006)

NAPHTHALENE		
In average	0.00	0.00
Out average	0.00	0.02
Pyrene		
In average	0.00	0.00
Out average	0.07	0.36
Benzo(a)pyrene		
In average	0.00	0.00
Out average	0.00	0.01
Benzo(ghi)perylene		
In average	0.00	0.00
Out average	0.32	1.62
Ideno(1,2,3-cd)pyrene		
In average	0.01	0.05
Out average	0.00	0.00

Summary of Storm Event # 15   (9/14/2006)

NAPHTHALENE		
In average	0.00	0.01
Out average	0.00	0.01
Anthracene		
In average	0.00	0.01
Out average	0.00	0.00
Benzo(b)flouranthene		
In average	0.00	0.02
Out average	0.00	0.00
Benzo(k)flouranthene		
In average	0.03	0.15
Out average	0.00	0.00
Benzo(a)pyrene		
In average	0.07	0.34
Out average	0.00	0.00
Dibenzo(a,h)anthracene		
In average	0.13	0.67
Out average	0.00	0.00
Benzo(ghi)perylene		
In average	0.02	0.10
Out average	0.00	0.00
Ideno(1,2,3-cd)pyrene		
In average	0.02	0.10
Out average	0.00	0.00

Summary of Storm Event # 16   (10//2006)

Benzo(b)flouranthene

In average	0.00	0.00
Out average	0.01	0.04

Summary of Storm Event # 17   (10/16/2006)

0.00

Summary of Storm Event # 18   (10/27/2006)

0.00

Conclusions

Benning Road Bioretention

In this study grab samples of the influent and effluent water for 15 storm events have been monitored for the bioretention site located adjacent to the Benning Road Bridge. This water quality monitoring project is concluded well. The methodology and protocols for the sampling of the storm water at the site reached the point of routine for Dr. Glass and his four students. With confidence we entered the rainy season for the Washington D.C. area with the belief that sampling for this first site would be completed by this month, July 2005. Preparatory work for the second site has neared completion. The housing is in place and we are finalizing the plans for withdrawing the water from the inlet and outlet of the sand filter to be monitored at D.C. Village.

Unfortunately it is the belief of this project team that the Benning Road bioretention site was poorly designed, constructed, maintained, or all of the above. From visual inspection of the catch basins one of the inlets to the bioretention did not operate properly for the length of the project. Only a trickle of storm water reaches the bioretention site from the clogged inlet, the majority of the storm water proceeds directly into the combined sewer system with no diversion to the bioretention cell from one of the two catch basins. This is most likely a maintenance problem.

In addition, this site seems to be too small for the watershed that it is theoretically supposed to be treating. For seven of the fifteen storm events monitored the overflow of the bioretention was reached. This bioretention system seems to overflow for relatively small storms and it is only treating the inflow of one of the two pipes that are connected to it. Pollutants that are dissolved pass through the system with little potential for removal when overflow occurs.

In summary, when evaluating the average values of the parameters in the inlet and outlet from this bioretention, it must be concluded that it is not representative of the capability of this technology when properly designed, built, and maintained. Only total suspended solids and total dissolved solids were removed on a semi-consistent basis from the system, at 86% and 91% removal efficiencies. Most of the dissolved constituents were removed at no better than 50% efficiency. These values are much less than removal percentages of bioretention systems in the literature or the performance of other bioretention systems monitored by this investigator in the past.

DC Village Sand Filter

In this study 12 storm events were monitored to evaluate the efficiency of a DC Sand Filter on one of the parking lots serving the DC Village facility. The site was equipped with two ISCO Automatic Samplers with a submerged flow monitor, a strainer, and a rain gauge. This site seems to treat the relatively light load of pollutants found in this parking lot very well. The efficiency of solids removal was almost 90% and because this parking lot was not loaded with heavy metals and oil and greases none of the other parameters was found to be excessive. The system did not remove the low concentrations of nutrients or organic carbon at a high percentage; however they are not designed to remove those pollutants. There were several problems with the use of the samplers.

In the future, Dr. Glass and his students will have to receive training to enter into the sewer system with out the assistance of DC DOE staff so that regular maintenance and upkeep of the subsurface installation can be achieved. In addition, sampling equipment that is left in the open space without security is destined to be vandalized by the public. The sampling equipment was destroyed during the 12th event at the site as a result of someone running over the metal conduit that protected the submerged probes electrical wiring and the tube that connected the strainer to the pump in the automatic sampler.

W Street Parking Facility BaySaver

A BaySaver is designed to remove solids, some suspended solids, and oils and grease from ordinary, normal traffic parking lots. The BaySaver website states that the device should remove 80% of TSS for a 1 inch per hour rainfall event. The storm events for this study were not limited to 1 inch of rainfall, which showed only a 62% removal rate for TSS. There is no readily available information at the BaySaver website, however there is no doubt that the system was not designed to receive the level of pollutant input from the industrial site for the intense storms that we receive here in the D.C. metropolitan area.

When first viewing the two chambers of the BaySaver at the W Street parking facility, it was known that the site needed to be cleaned. Given the contractual nature of the project we could not wait to sample when the system was cleaned, so we began sampling immediately upon determining how we would take the grab samples and transport them to the laboratory. The facility was not designed for proper monitoring with automatic samplers, just as the bioretention at Benning Road had not been. The monitoring revealed that there is very poor removal of the water quality pollutants of interest by the BaySaver. The BaySaver is designed to store oil and grease, solid matter, and floatables until a pump truck can come to empty the chamber. In addition, they are designed to overflow at a given flowrate. It is the belief of this research team that when the BaySaver overflows some of the pollutants that have been stored inside of the device flow out of the system, resulting in pollution and the poor efficiency that was measured throughout this project.