SEDIMENTATION CONTROL USING TWO BAFFLE BOXES IN SERIES

Gordon England, P.E.* and John Royal**
With special acknowledgement to Eric Winkler, Ph.D., University of Massachusetts - Amherst for peer review.

*Creech Engineers, Inc., 4450 W. Eau Gallie Blvd, #232, Melbourne, Fl. 32934; PH (321) 255-5434; Fax (321) 255-7751; email: gengland@mindspring.com
**Brevard County Surface Water Improvement, 2725 Judge Fran Jamieson Way, Viera, Fl. 34940; PH (321) 633-2014; FAX (321) 633-2081; email: surfacewater@yahoo.com

Abstract

For the last 8 years, the Brevard County Surface Water Improvement Program has used baffle boxes for stormwater sedimentation control at over 34 locations. As part of a Florida Department of Environmental Protection Demonstration Project for Indialantic Area Baffle Boxes, two baffle boxes were constructed in series on a 9.75 ha (24.1 ac) drainage basin in Sunset Park, near Indialantic. The first baffle box was installed in 1992 and long-term cleanout records have been documented on the performance of this baffle box. A second baffle box was installed in 1998 immediately upstream of the first baffle box to create a series configuration. Autosampler monitoring results for TSS, Total Phosphorus, COD, and BOD removal efficiencies are presented in this report for the second baffle box. In addition, the effectiveness of two baffle boxes in series is examined.

Introduction

Adverse impacts of sedimentation upon receiving water bodies has been well documented in recent years. In an effort to reduce sediment loadings from stormwater runoff, Brevard County's Stormwater Utility has had an active program of installing sediment traps, called baffle boxes, at stormwater pipe outfalls. A baffle box is an inline concrete or fiberglass box with two to three chambers for sediment to settle into. Weirs at pipe invert levels are used to partition the box allowing for 0.91 m (3 ft) deep chambers for sediment and debris storage. Screens hang from the ceiling to collect floating trash. These screens swivel up during high flows to minimize flow blockage and upstream flooding. An important advantage of using a baffle box is that no new land is required for construction of this Best Management Practice (BMP). It can be constructed in existing pipe easements or in street right-of-ways. Baffle boxes are cleaned out with vacuum trucks and their spoil is taken to a landfill. To date, 34 baffle boxes have been installed by Brevard County since 1992. Cleanout records have been maintained in a database for analysis of baffle box effectiveness.

In 1991 a Stormwater Masterplan was completed by Brevard County for a section of the barrier island north of the Town of Indialantic. This masterplan addressed water quality and quantity problems for this watershed. This area had few stormwater treatment facilities, and discharged into the Indian River Lagoon, an Estuary of National

Significance. In accordance with the masterplan recommendations, a baffle box was installed along Riverside Drive at Sunset Park in 1992, in Indialantic Basin H. This demonstration project was cost shared between the St. Johns River Water Management District and the National Estuary Program.

Basin H is a 9.75 ha (24.1ac) drainage basin with medium density residential land use. Soils in this basin are predominantly Galveston-Urban Land Complex, which is a well drained sandy soil containing shell fragments. There is significant sediment loading to the streets in this basin from airborne beach sand deposition. The topography is flat with a mixture of curbed and non-curbed streets. No swales are present in the drainage area. Many of the upstream pipes leading to the baffle box are perforated corrugated metal pipes installed to lower ground water. These pipes are not wrapped and allow considerable soil infiltration into the pipes. This causes constant base flows in the pipes with a heavy sediment load of large grain sand rolling along the bottom of the pipe during small storms.

Pollution from bed loads is not normally detected under typical storm event monitoring techniques. During large storm flows this material is suspended and is included in measurements of Total Suspended Solids. During interevent periods this material drops to the bottom of the pipe and is stored until the next high flow event. The significance of these bed loads is their confounding impact on mass balance relationships and buildup/wash-off models. These loads are essentially “invisible” and represent a significant pollution source to receiving waters. In the ensuing years approximately 13,279 kg (29,275 lbs) of sediment has been removed from this box, with a peak monthly loading of 816 kg (1,800 lbs) of sediment. Sediment removal was accomplished with a vacuum truck and a pipe plug was required to stop base flows during cleaning.

Using an FDEP 319(h) grant, 10 baffle boxes were installed in the Indialantic watershed in 1997 and 1998. The Sunset Park location was chosen for a baffle box in series where a new unit installed 4.6 m (15 ft) upstream of the original baffle box. This location was chosen because it had a proven sedimentation problem, and long term cleanout records. This study was designed to assess the effectiveness of two baffle boxes in series

Methods

Baffle box #1, the original baffle box had 3 chambers and was installed at a 90° bend of an existing 24” CMP, replacing an existing manhole. The 61 cm (24 in) pipe entered the first chamber of the box perpendicular to the length of the box, forcing the influent water to turn 90° before flowing in to the second chamber.

Baffle box #2 was installed in February 1998 at a cost of $23,421. This box was upstream of the first box with a 61 cm (24 in) CMP at each end of the box. The existing 61 cm pipe was about 1 meter below grade. This box had inside dimensions of 2.69 m (8.83 ft) long x 1.17 m (3.83 ft) wide x 1.86 m (6.12 ft) high, with weirs placed at 0.91 m (3 ft) and 1.96 m (6.42 ft) from the upstream wall of the box.

Automated samplers were set upstream and downstream of Baffle Box #2 at Sunset Park on December 9, 1999. Baffle Box #2 is located within the road right-of-way. In order to reduce potential aesthetic objections by a homeowner to having boxes in front of his home, the automated sampler enclosures were bolted to wood palettes and mounted on top of inlet grates on Baffle Box #1 that is to the south of the residence. Placement of sampling equipment presented unique challenges for the study due to community perceptions and emphasizes the importance of community involvement.

Confined space entry requirements were eliminated by mounting the suction strainers and flowmeter probe on 10.16 cm (4 in) wide by 45.7 cm (1.5 ft) long steel plate welded perpendicular to steel sign posts to form an "L" shape. The posts were then mounted with concrete anchor bolts to the inside walls such that the steel plates lay on the bottom of the pipes and extend into the pipes upstream and downstream. This method has been used successfully in the past where large debris is not present. A new ISCO model 4250 Doppler Velocity Flowmeter (Lincoln, Nebraska) was connected to the inflow side of Baffle Box #2 to record flow. No flowmeter was installed on the downstream side. One flowmeter initiated sampling of both inlet and outlet autosamplers. One grab sample and one sediment sample were collected as dry weather background samples to evaluate current background flow conditions and the accumulated sediment.

Previous sampling at this site indicated that many pollutant concentrations in the trapped sediments were higher than in the water samples. For this reason, more parameters were evaluated for the sediment samples than for the water samples. Sediment samples were collected from each of three chambers and analyzed for nutrients (N and P), BOD_5, metals, polynuclear aromatic hydrocarbons, and organochlorine pesticides. Discrete sampling for storm flows was used rather than composite sampling in an attempt to better understand the dynamics of the storm events.

The baffle boxes in this study had three chambers. Due to differences in the type of sediment collected in the three (3) chambers, sediment sampling required two (2) different collection devices. The first and second chambers collected heavier particles consisting mostly of coarse, large-grain sand. Because of the sediment's weight and coarseness, a PVC sampler was required that had adequate vacuum and seal for listing. A PVC sampler with valves was installed near the bottom of the PVC pipe in order to retain the sample. This allowed sampling of the first two chambers. The last chamber generally contained unconsolidated slurry of fine organic and metal-rich sediment with the consistency of pudding. The PVC core sampler was unable to hold such an unconsolidated sample long enough to allow retrieval. A syringe-type muck sampler was used for sampling this chamber.

Results

Cleanout records for Baffle Box # 2 indicated the box had been cleaned out three (3) times between the installation date and November 30, 1999. A total of 4,806 kg (10,574 lbs) of sediment had been removed from this box or 2,558 kg (5,639 lbs) per year. Due to the irregular frequency of cleanouts and seasonal variability of rainfall events and intensities, it was decided that annual loading rates would be the preferred method of reporting to compare BMPs.

Prior to this installation, 11,083 kg (24,433 lbs) of sediment were removed from Baffle Box #1, at a rate of 3,851 kg (8,490 lbs) per year. After installation of Baffle Box #2, only 487 kg (1,073 lbs) of sediment were collected in Baffle Box #1 over an 18 month period or, 324 kg (715 lbs) per year. The majority of settleable solids were trapped in the upstream baffle box, and only a small percentage of larger sediments was collected in the downstream baffle box. When comparing annual removal rates, it appeared that Baffle Box #2 was not as efficient as Baffle Box #1. It was surmised that the 90° bend in Baffle Box #1 resulted in lower linear velocities leading to greater settling than with the straight flow through design of Baffle Box #2. However, greater removal efficiencies may also be affected by concentration and sediment characteristics. This suggests that baffle boxes may have removal efficiencies that functional to a certain particle size or concentration of solids.

On December 11, 2000 a measurement of sediment accumulation in Baffle Box #2 showed 0.94 m^3 (33.09 cu ft) in chamber 1 (the furthest upstream chamber), 0.14 m^3 (4.82 cu ft) in chamber 2, and 0.04 m^3 (1.37 cu ft) in chamber 3. This is the typical pattern observed in the field and in other laboratory tests, with the first chamber filling fastest. The sediment gradation also followed a pattern of largest particles in chamber 1, and smallest in chamber 3 due to higher settling velocities of the larger particles.

Sediment concentrations found during the 1992 study for Baffle Box #1 are provided in Table 1. The sediment concentration results for Baffle Box #2, were presented in Table 2. In addition, the composition of the accumulated solids are analyzed. Based on the concentrations of each constituent and the mass of sediment removed, the weight of each constituent removed was calculated. The contaminant concentrations (on a mass basis, mg/kg) increased for almost all parameters from chamber 1 to chamber 2, and again from chamber 2 to chamber 3. With some parameters, the difference between chamber 1 and chamber 3 was several orders of magnitude. This increase in concentration corresponds to decreasing sediment size, with the highest concentrations in the mucky organic material in chamber 3. Chamber 1 had the largest particle sizes, mostly sand grains, and chamber 2 has a mixture of large and small particle sizes. For 50% of the parameters, the concentrations are below detectable limits in chamber 1. It is also noted that for most parameters, the highest pollutant mass loads are in chamber 2, with the next highest in chamber 3, and the lowest mass in chamber 1. This is probably due to the fact that there is a much higher percentage of large size particles from airborne beach sands than small sized particles in this area. The unusually high PAH values may have been the result of unauthorized oil being dumped into the pipe system.

Evaluation of the 1992 water sample results for Baffle Box #1, taken by grab samples, indicated a 70.6 percent TSS removal rate on average (mean). Approximately 50 percent of nutrient phosphorus is typically in particulate form. Consequently, an estimated 20 to 35 percent removal rate for phosphorus was expected. In the 1992 study, Total Phosphorus sample results showed a 38 percent average (median) reduction.

Approximately 25 percent of the suspended solids were organic in nature. Therefore, BOD and COD were measured. In the 1992 study, a 10 to 17 percent reduction in BOD_5 was anticipated. However, sample results indicated an average 39 percent BOD_5 reduction for two dates, and one date showed a 25 percent increase between inlet and outlet, likely due to resuspension.

	Metal Parameters (ug/kg)								
	Al	As	Cd	Cr	Cu	Hg	Pb	Ni	Zn
1st Chamber	32.1	1.13	ND	0.04	0.63	ND l	5.26	2.10	3.23
2nd Chamber	δ	6.70	0.28	10.05	0.84	δ	5.61	16.79	11.04
3rd Chamber	δ	64.80	0.28	8.22	30.60	δ	29.76	130.60	202.40

δ - not measured ND – Not detected

Table 1
Sediment Analysis Results for Indialantic Baffle Box #1 (1992)

		CHAMBER 1			CHAMBER 2			CHAMBER 3	
Parameter	mg/kg	kg Sediment Removed	mg Removed	mg/kg	kg Sediment Removed	mg Removed	mg/kg	kg Sediment Removed	mg Removed
% solids	66.60%	1,321		48.30%	193	93	19.90%	55	10.88
TKN	N/D			600		115,578	1,500		82,029
Total P	150		198,132	2,200		423,786	5,100		278,898
TOC	0.73%			5.30%			8.70%		
Mercury	0.0067		8.85	0.029		5.6	0.073		3.99
Aluminum	N/D			800		154,104	1,700		92,988
Arsenic	N/D			140		26,988	210		11,484
Barium	N/D			140		28,988	230		12,577
Chromium	N/D			7.8		1,502	15		820
Cadmium	1.9		2,509	N/D			N/D		
Iron	63		83,215	29,000		5,586,270	68,000		3,390,532
Lead	N/D			9.3		1,791	25		1,367
Nickel	N/D			2.7		520	4.6		251
Zinc	120		158,505	200		38,528	910		49,784
Copper	13		17,171	10		1,926	35		1,914
PAH (ug/kg)									
Acenaph-thylene	570		752,901	1,500		288,945	2,800		153,120
Benzo (A) Pyrene	N/D			120		23,115	N/D		
Benzo(ghi) Perylene	N/D			N/D			290		15,858
Fluoran-thene	N/D			160		30,820	290		18,585
Fluorene	200		264,176	560		107,872	2,500		1,36715
1-Methylnaph-thalen	1,200		1,585,056	11,000		2,118,930	14,000		765,804
Naphtha-lene	150		1,981	170		32,747	380		20,780
Pyrene	N/D			140		26,968	N/D		
Pesticides									
Dieldrin	N/D			12		2,311	N/D		

Table 2
Sediment Analysis for Indialantic Baffle Box #2 (2000)

The results of monitoring 3 storm events in 2000 at Baffle Box #2 with autosamplers are shown in Table 3. For the 7-17-00 storm there was a sampler malfunction at the inflow sample at time 10 minutes. Table 4 shows average removals for TSS, Total P, BOD, and COD.

At Time 0	Flow Rate cfs	Pipe Velocity fps	TSS mg/l	Total Phosphorus mg/l	BOD mg/l	COD mg/l
Inflow	0.37	0.70	14	0.54	3	47
Outflow			16	0.39	2	29
Change			+2	-0.15	-1	-18
% Change			+14.3	-27.8	-33.3	-38.3
At 10 Minutes	Flow Rate cfs	Pipe Velocity fps	TSS mg/l	Total Phosphorus mg/l	BOD mg/l	COD mg/l
Inflow	0.84	0.70	--	0.32	--	19
Outflow			7	0.39	2	23
Change			--	+0.07	--	+4
% Change			--	+21.9	--	+21.1
At 20 Minutes	Flow Rate cfs	Pipe Velocity fps	TSS mg/l	Total Phosphorus mg/l	BOD mg/l	COD mg/l
Inflow	1.04	0.50	50	1.7	5	45
Outflow			56	2.2	5	45
Change			+6	+0.5	0	0
% Change			+10.7	+29.4	0	0
At 30 Minutes	Flow Rate cfs	Pipe Velocity fps	TSS mg/l	Total Phosphorus mg/l	BOD mg/l	COD Mg/l
Inflow	0.85	0.30	28	1.2	3	26
Outflow			22	1.2	2	24
Change			-6	0	-1	-2
% Change			-27.3	0	-33.3	-7.7
Storm Average (mean)	**0.78**	**0.55**	**-0.58%**	**5.88%**	**-16.65%**	**-6.23%**

Indialantic Baffle Box Storm 7-17-00
Rainfall – (0.48”) in 30 minutes

At Time 0	Flow Rate cfs	Pipe Velocity fps	TSS mg/l	Total Phosphorus mg/l	BOD mg/l	COD mg/l
Inflow	0.35	1.23	50	0.59	12	85
Outflow			24	0.18	7	61
Change			-26	-0.41	-5	-24
% Change			-52.4	-69.5	-41.7	-28.2
At 10 Minutes	Flow Rate cfs	Pipe Velocity fps	TSS mg/l	Total Phosphorus mg/l	BOD mg/l	COD mg/l
Inflow	0.37	1.15	9	0.24	4	48
Outflow			14	0.17	5	50
Change			+5	-.07	+1	+2
% Change			+35.7	-29.2	+25	+4.2

At 20 Minutes	Flow Rate cfs	Pipe Velocity fps	TSS mg/l	Total Phosphorus mg/l	BOD mg/l	COD mg/l
Inflow	0.70	1.00	75	1.3	8	78
Outflow			44	0.57	6	55
Change			-31	-.73	-2	-23
% Change			-41.3	-56.2	-25	-29.5
At 30 Minutes	Flow Rate cfs	Pipe Velocity fps	TSS mg/l	Total Phosphorus mg/l	BOD mg/l	COD mg/l
Inflow	1.33	0.75	30	0.78	6	45
Outflow			30	0.64	6	50
Change			0	-0.14	0	+5
% Change			0	-17.9	0	+11.1
Storm Average (mean)	**0.69**	**1.03**	**-14.50%**	**-43.20%**	**-10.42%**	**-10.60%**

Indialantic Baffle Box Storm 7-21-00
Rainfall - (0.54") in 45 minutes

At Time 0	Flow Rate cfs	Pipe Velocity cfs	TSS mg/l	Total Phosphorus mg/l	BOD mg/l	COD mg/l
Inflow	0.37	1.0	5	0.77	4	32
Outflow			4	0.71	4	34
Change			-1	-.06	0	+2
% Change			-20	-7.8	0	+6.2
At 10 Minutes	Flow Rate cfs	Pipe Velocity cfs	TSS mg/l	Total Phosphorus mg/l	BOD mg/l	COD mg/l
Inflow	3.37	1.25	44	1.6	5	36
Outflow			35	1.5	4	35
Change			-9	-.1	-1	-1
% Change			-20.5	-6.2	-20	-2.8
At 20 Minutes	Flow Rate cfs	Pipe Velocity cfs	TSS mg/l	Total Phosphorus mg/l	BOD mg/l	COD mg/l
Inflow	4.33	1.50	30	1.5	3	30
Outflow			25	1.3	3	30
Change			-5	-0.2	0	0
% Change			-16.7	-13.3	0	0
At 30 Minutes	Flow Rate cfs	Pipe Velocity cfs	TSS mg/l	Total Phosphorus mg/l	BOD mg/l	COD Mg/l
Inflow	2.96	1.10	3	0.80	2	24
Outflow			2	0.73	2	26
Change			-1	-.07	0	+2
% Change			-33.3	-8.8	0	+8.3
Storm Average (mean)	**2.76**	**1.21**	**-22.62%**	**-9.02%**	**-5.00%**	**-2.92%**

Indialantic Baffle Box Storm 9-6-00
Rainfall - (1.08") in 60 minutes
Table 3

Parameter	TSS	Total Phosphorus	BOD	COD
% Removal (mean)	-13	-19	-11	-7

Table 4
Average Removals for All Storms

Discussion

As is typical in Florida, the rainfall amounts for the four monitored storms were short, low intensity events, ranging from 0.48” in 30 minutes to 1.08” in 60 minutes. This led to results which are applicable for normal Florida weather conditions, but may not be predictive for rainfall events in other regions of the country. These low rainfall events produced low velocities in the inflow pipes, and fairly low pollutant concentrations across the board. Velocities ranged from 0.09-0.45 m/s (0.3-1.5 f/s) and flow rates ranged from 0.01-0.12 m^3/s (0.35-4.33 cfs). There was a distinct correlation between removal rates and velocities as seen in Figure 1. The concentrations and removal rates for Total Phosphorus, BOD and COD were low, and therefore remainder of the discussion will focus on TSS.

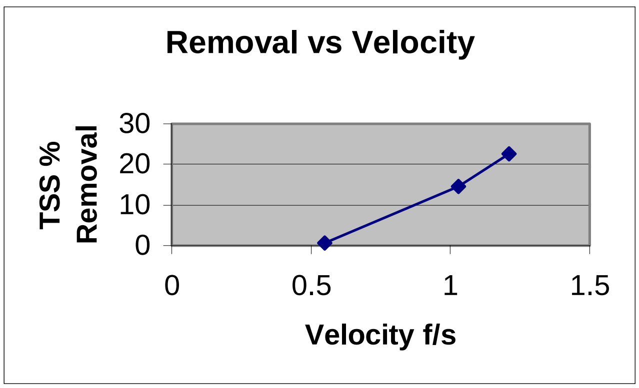

Figure 1

Discrete sampling demonstrated variable inflow concentrations, although only one storm exhibited a typical first flush effect. TSS removals ranged from 0.58% to 22.62%, with an average of 13%. These removal efficiencies were unexpectedly low in light of the large masses of sediment removed. Upon further analysis, it was noted that the high masses in chambers 1 and 2 consist of large sand particles that made up the bedload in the pipe. This bedload material was not detected as TSS by the autosamplers, but nevertheless was being flushed into the baffle box. Stahre and Urbonas, 1990, concluded that a relatively small number of large size particles can represent a relatively significant load by volume and weight of the total TSS measured in stormwater.

A study by Pandit, 1996, showed similar results with 86-90% removal rates for large grain sand and 20-30% removal for ultra fine sediment. Observations through clear pipes in a lab showed that upon initiation of flow, the fine sediment particles were rapidly flushed from the bedload, and the coarse particles required extended flow times to be completely flushed from the pipe. This phenomenon has been well documented in sanitary sewer studies by Berlamont, et.al, 2000, Nalluri and Ota, 2000 and many others.

It was attributed to variable shear stresses in partially filled pipes, particle sizes and shapes, pipe shape, settling velocities, and other unexplained variables. Therefore, the autosamplers were measuring only fine sediment particles capable of being suspended at very low velocities. At this location the majority of sediment particles were large coarse sands from infiltration pipes and beach wind deposits.

In a study of sedimentation basins, Kuo, 1976, concluded that the removal efficiency was independent of basin depth. He did find that removal efficiency increased with basin length. The baffle box length was arbitrarily chosen. Kuo's results indicate that using a baffle box as long as feasible will increase efficiency. Usually the precast box weight governs the box size. Large boxes require large cranes for lifting or necessitates laborious cast in place installations. Kuo also found that removal efficiencies varied from 12%-90% for a length/depth ratio of 5, depending upon particle size and flow rates.

Another conclusion from Pandit, 1996 was that the removal efficiency of a baffle box decreased with decreasing concentration. The TSS concentrations he used in laboratory analysis ranged from 50-1000 mg/l. Stahre and Urbonas, 1990, also concluded that TSS removal efficiencies in sedimentation tunnels were very poor when initial concentrations are around 10 mg/l. Concentration vs. concentration change for the discrete sampling events was plotted in Figure 2. It is apparent that as TSS concentration was reduced, the baffle box became less efficient, to the point of actually exporting sediment at concentrations below 20 mg/l.

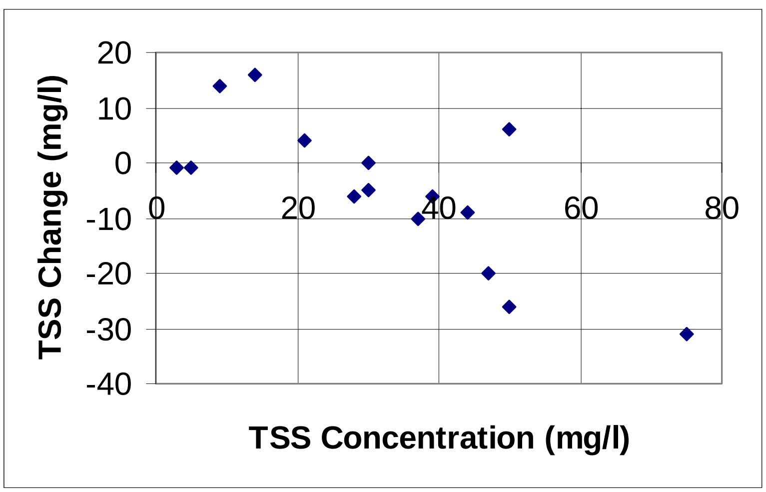

Figure 2
TSS Concentration vs. TSS Change

Conclusions

At this location, where sediment is predominantly large sand which settles rapidly, the use of two baffle boxes in series does not demonstrate cost effective treatment. At other locations in Brevard County with a higher percentage of fine sediments, the use of two boxes in series has been more effective than this location.

Heavy metal, PAH, and volatile solids concentrations were significantly higher in the fine, organic sediments than in heavy sand sediments, as evidenced by materials captured in successive treatment chambers. The relationship between increased concentration of these pollutants and particle size was not determined. However, this relationship was also observed by Sartor and Boyd, 1977.

Over 15,876 kg (35,000 lbs) of sediment was removed from the two baffle boxes during an 8-year period. Baffle boxes have been demonstrated to be effective BMPs for the removal of coarse sediments, trash, and debris. Due to low rainfall events and low pipe velocities encountered during the monitoring period, it was concluded that complete effectiveness of baffle boxes as BMPs was not determined. The removal efficiencies at velocities below 0.46 m/s (1.5 fps) and concentrations noted were estimated at 13% for TSS, 19% for Total Phosphorus, 11% for BOD, and 7% for COD. The removal efficiency for TSS is similar to previous testing by Pandit, 1996, in laboratory conditions for fine sediment. Therefore, the TSS removal rates of 89% for large grain sediment that Pandit measured is probably valid also. TSS removal was more effective at higher concentrations than lower concentrations. This conclusion is supported by Stahre, Stahre and Urbonas, 1990, who found that TSS sedimentation time increased significantly as particle volume in the water column increased.

The measured TSS removal rates were representative of fine organic sediments at very low concentrations and low velocities, but not for the larger sand sediments collected in the baffle boxes. Removal efficiencies for sediment traps will vary with velocity, particle size, and concentration. Therefore an estimate of TSS removal efficiencies for any type of sediment traps should include these variables. The inability of autosamplers to monitor bedloads prevents their use to determine the true TSS removal effectiveness of baffle boxes or any other type of sediment trapping BMPs that remove bedload materials. Additional testing with a different type of monitoring equipment, preferably in controlled laboratory conditions, should be used to measure TSS removals for BMPs. The use of autosamplers to measure other types of dissolved pollutants can still give valid results for those constituents.

References

Berlamont, Jean, Koen Trouw, and Gert Luyckx, (2000). “Shear Stress Distribution in Partially Filled Pipes and Its Effect on the Modeling of Sediment Transport in Storm Drains”. *ASCE 2000 Joint Conference on Water Resources Engineering*

Nalluri, Chandra and Jose J. Ota, (2000). “Non-Cohesive Sediment Transport in Clean Sewers and with Small Mobile Beds”. *ASCE 2000 Joint Conference on Water Resources Engineering*

Pandit, Dr. Ashok and Ganesh Gopatakrishnan, (1996). “Physical Modeling of a Stormwater Sediment Removal Box”. *Masters Thesis*

Sarter, J.D. and Boyd, G.B., “Water Pollutant Aspects of Street Surface Contaminants”. *U.S. EPA, EPA-600/2-77-047,1977.*

Stahre, Peter and Ben Urbonas, (1990). “Stormwater Detention for Drainage, Water Quality, and CSO Management”.

GRAIN SIZE DISTRIBUTION TEST DATA

ClientELAB, I N C .
Project: 001l-222
Project Number: 2000-00-1085

Sample Data

Sourcee **Chamber I**
Sample NO.: 0011-222-1
Elev or Depth Sample Length (in/cm):
Location t
Description:
bate: 12/29/00 PL: ● - - - IlLi - - - PT: - - -
USCS Classification - - - AASHTO Classification: - - -
Testing Remarks NOTE: AT CLIENTS REQUEST, SAMPLES WERE AIR DRIED AT ROOM TEMPERATURE BEFORE AND AFTER Washing

Mechanical Analysis Data

	Initial	After wash
Dry sample and tare-	930.25.	. 903.59
Tare a	'0.00	0.00
Dry sample weight =	930.25	903.59

Minus #200 from wash: 2.9. %
Tare for cumulative weight retained .OO

Sieve	Cumul. Wt. retained	Percent finer
# 4	7.51	99.2
# 10	11.70	98.7
# 20	. 41.31	95.6
# 40	277.16	70.2
# 60	636.74.	31.6.
# 90	797.57	14.3
# 100	865.62	7.0
# 200	902.02	3.0
# 325	903.59	2.9.

Fractional Components

Gravel/Sand based on #4
SandFines.based on #200
% COBBLES = % Gravel =
% SAND = 96.2 (% Coarse = 0.5 % medium = 28.5 % fine = 67.2)
% FINES = 3.0

D_{85}= 0.58 D_{60}= 0.37 D_{50}= 0.32
D_{30}= 0.84 D_{15}= 0.18 D_{10}= 0.16
C_c= 0.9955 C_u= 2.2497

MATERIALS ENGINEERING LABORATORY

Thompson Engineering

SURFACE WATER IMPRVMT 01/30/01 TUE 10:25 FAX 407 6932168

GRAIN SIZE DISTRIBUTION TEST DATA

Client E-LAB, **INC.**
Project: 0011-222
Project Number 2000-00-1085

Sample Data

Source CHAM BER 2
Sample No.: 0011-222-2
Elev, or Depth: sample Length **(in./cm.):**
Location:
Description:
Dater 12/29/00 pL*---- .. **LL:** --- **PI:** --‘-
USCS Classification --,.: AASHTO Classification - -,-
Testing Remarks: **NOTE:** AT **CLIENT'S REQUEST SAMPLE6 WERE AIR DRIED AT ROOM TEMPERATURE** BEFORE **AND AFTER WASHING.**

Mechanical Analysis Data

	Initial	After wash
Dry sample **and** tare-	749.80	717.14
Tare	**0.00**	**0.00**
Dry sample weight =	749.80	717.14

Minus #200 from **wash=** 4.4 %
Tare for cumulative weight retained=. -00

sieve	Cumul. ,wt. retained	Percent finer
#4	9.39	98.8
# 10	24.22	96.8
# **20**	**79.98**	**89.3**
# 40	240.41	67.9
# 60	401,26	46.5
# 80	'487.65	35.0
# 100	'578.26	22.9
# 200	701.11	6.5
# 325	717.14	4.4

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% **COBBLE8 -** % **GRAVEL =**
% SAND = 92.3 (% **coarse ▮ 2.0** % **medium = 28.9** % fine - 61.4)
% FINES = 6.5

D_{85}= 0.70 D_{60}= 0.35 D_{50}= 0.28
D_{30}= 0.17 D_{15}= 0.13 D_{10}= 0.11
C_c= 0.7223 C_u= 3.266

MATERIALS ENGINEERING LABORATORY

Thompson Engineering

GRAIN SIZE DISTRIBUTION TEST DATA

Client: ELAB, INC.
Project: 0011-222
Project Number: 2000-00-1085

Sample Data

Source: CHAMBER 3
Sample No: 0011-222-3
Elev. or Depth: Sampple Length (in./cm.):
Location:
bescripti6xl~
Date: 12/29/00 PL: - - LL!'--- **PI:** - - -
USCS Classification: - - AASHTO Classification: - - -
Testing **Remarks: NOTE: AT CLIENTS REQUEST, SAMPLES WERE** AIR **DRIED** AT **ROOM TEMPERATURE BEFORE** AND **AFTER** WASHING.

Mechanical Analysis Data

	Initial	After wash
Dry sample and tare=	207.42	175.34
Tare =	.0.00	0.00
Dry sample weight =	207.42	175.34

Minus #200 from wash= 15.5 %
Tare for cumulative weight retained= .00

sieve	cumul. wt. **retained**	Percent **finer**
#4,	4.28	97.9
# 10	14. 63	93.0
# 20	30.64	85.2
# 40	**44.11**	**78.7**
# 60	67.76	67.3
# 80	84.56	59.2
# 100	**101'64**	**51.0**
# 200	153.63	25.9
# 325	175.34	15.5

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = % GRAVEL =
% **SAND = 72.0 (% coarse = 4.9** % **medium** = 14.3 % fine = 52.8)
% FINES = **25.9**

D_{85}= 0.83 D_{60}= 0.18 D_{50}= 0.15
D_{30}= 0.09

MATERIALS ENGINEERING LABORATORY

Thompson Engineering