STORMWATER TREATMENT FIELD DEMONSTRATION AND EVALUATION

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Abstract. Pollution reduction in the Conasauga River is a high priority for Georgia due to the remaining biological diversity of the Conasauga. Home to 76 native species of fish, more than the Columbia and Colorado Rivers combined, the Conasauga serves residential, agricultural, and carpet industry needs in and around Dalton. Segments of the river are impaired due to sediment, nutrients, and fecal coliform bacteria from septic systems, agriculture, and stormwater runoff. As new stormwater regulations go into effect for Phase II communities, many agencies are asking for field performance data. A demonstration project was implemented in 2004 to reduce stormwater pollution by first using a hydrodynamic swirl separator and later by a mobile filter system, both manufactured by AquaShield^{TM}, Inc. The swirl system was installed at the 5-acre Whitfield County Public Works (WCPW) facility yard located within a 30-acre watershed. Automatic flow samplers collected runoff at the swirl separator during four storm events for analysis of oils and grease (O&G) and total suspended solids (TSS). The swirl separator captured 2 to 3 inches of sediment per month from the site. Field testing for an AquaShield^{TM} mobile filtration treatment system was also performed at the WCPW site. Grab samples collected during simulated storm events were analyzed for TSS and particle size distribution. The TSS removal efficiencies of the filtration system were greater than 90 percent. Success of this demonstration is measured by field observations of sediment captured by the swirl and by the high removal efficiencies of the filter system.

INTRODUCTION

Stormwater runoff is listed as a nonpoint source of pollution by Georgia Environmental Protection Division (EPD) for many of the impaired stream segments in the Conasauga River watershed. A General NPDES Stormwater Permit is listed as the watershed action to alleviate this source of nonpoint pollutants (Georgia EPD, 2004, 2006). Whitfield County was issued a Phase II General NPDES Stormwater Permit in December 2002. As Phase II requirements were being implemented, many questions were being raised by regulatory and regulated organizations concerning treatment options, field performance, maintenance of treatment systems, and best management practices (BMPs).

While this watershed strategy to address urban nonpoint source pollution was being implemented within a regulatory framework, the Conasauga River Alliance (CRA) was focusing on non-regulatory demonstration and education aspects of watershed protection strategies. In 2004, Whitfield County joined CRA to conduct a stormwater treatment demonstration workshop. Designers, planners, contractors, and regulators were invited to observe an installation of a stormwater treatment system to alleviate common apprehensions associated with implementation of new technologies. A manufactured hydrodynamic separator system manufactured by AquaShield^{TM} was selected to treat the runoff from the WCPW yard. Questions from participants covered a range of topics including design storm criteria for sizing, mechanics of treatment processes, inspections and maintenance needs. The demonstration site contained a mix of land cover types typical of commercial and industrial sites including roofs, and asphalt and gravel drives. Another objective of the demonstration was to monitor the system to gain field data about removal efficiencies and to establish guidance for system maintenance. Because the WCPW site was secure, it provided AquaShield^{TM} with a field testing location to also evaluate treatment alternatives and design modifications. This expanded the original scope of the demonstration and with the cooperation of the County, allowed quick field testing and evaluation of alternative designs. The WCPW test site successfully served to meet the objectives of this stormwater demonstration by (1) introducing a treatment option in the watershed, (2) gaining field data for selected pollutant removals, and (3) providing site-specific maintenance guidance.

MATERIALS & METHODS

Treatment Systems The first manufactured treatment system evaluated was an Aqua-Swirl^{TM} concentrator model AS-6. This in-ground system was used to treat runoff from a 3 acre drainage area having the most concentrated runoff within the site. Design parameters included a 25-year storm with a maximum flow rate of 20.4 cfs and a runoff coefficient of 0.8 in order to provide 80% reduction of TSS on a net annual basis.

Treatment targeted the first-flush in order to capture pollutants during the more numerous small runoff events, which make up 90% of the annual runoff volume. The Aqua-Swirl™ is made of high density polyethylene (HDPE) and is rated for H-20 traffic loading, a site consideration given heavy equipment use at the facility. An offline diversion was built in the upstream manhole to divert peak flows greater than 5.6 cfs through the system and to accommodate monitoring equipment placed after installation.

One year later, the mobile AquaShield ™ Go-Filter™ system was field tested. This trailer mounted system uses a "treatment train" approach consisting of two Aqua-Swirl™ units in series followed by a filter chamber using either a downflow or upflow configuration. The Aqua-Swirl™ units provide primary treatment while the filter chamber provides a secondary level of treatment to enhance removal efficiencies.

Field Sampling and Analyses. All field sampling was coordinated with the WCPW Director prior to sampling, and to coordinate simulated runoff events. Samples were collected in sterile, prepared bottles supplied by Analytical Industrial Research Laboratories Inc. (AIRL), a certified laboratory in Cleveland, Tennessee. Analytical procedures followed QA/QC methods required for commercial laboratory accreditation. Samples were analyzed for O&G using EPA method 1664, hexane extraction. The O&G analyses were performed on samples collected from both the in-ground Aqua-Swirl™ and the downflow Go-Filter™ units. The TSS analyses were performed using EPA Method 160.2 for the Aqua-Swirl™ and the downflow and upflow configurations of the Go-Filter™ for all sample events. Particle size distribution analyses were performed to characterize solids entering and leaving all three units.

Table 1 summarizes the sampling events and selected results of AquaShield™ treatment units evaluated at WCPW facility during 2006. During 2004-2005, ISCO™ flow activated automatic samplers were used to collect influent and effluent samples to the in-ground Aqua-Swirl™ AS-6 unit. Additionally, grab samples were taken from the in-ground unit in 2006 under low flow "dry" weather and runoff conditions. A single grab sample of 100 ml was collected at the invert of the inflow manhole to the AS-6 unit and at the outfall of the discharge pipe in the outlet manhole.

Another AquaShield™ system, the Go-Filter™ mobile unit, was evaluated for two designs: downflow (gravity)

Table-1 Selected Summary of WCPW Field Sampling

Date	AquaShield™ Unit	Event Type	Average TSS Removal
1-5-06	Aqua-Swirl™	dry weather	81
3-20-06	Aqua-Swirl ™	rainfall	51
3-24-06	Go-Filter ™ downflow	simulated	59
6-7-06	Go-Filter ™ upflow	simulated	86
6-17-06	Go-Filter ™ upflow	simulated	94

and upflow under three simulated runoff events.

Simulation of runoff was performed using WCPW tanker trucks to deliver 4,000 to 5,000 gallons of water to generate runoff from 0.57 acres of paving and gravel lanes on the site. This volume of water was delivered in 10 to 15 minutes. Sampling the mobile units required damming the inlet to the permanent in-ground AS-6 unit and pumping water from the inflow manhole. Head elevation from the manhole invert to the trailer was 10 feet. Using a pump rated capacity of 250 gpm, the estimated delivered flow rate to the Go-Filter™ mobile unit was about 125 gpm, or about 25 percent of the design capacity. Influent grab samples were collected at the opening of the inlet port on the first swirl. Effluent samples were collected at the outlet port of the filter chamber.

Field Inspections and Maintenance AquaShield™ recommends quarterly visual inspections for newly installed units to determine appropriate site specific inspection and maintenance protocols. The Aqua-Swirl™ AS-6 unit installed at WCPW was visually inspected quarterly by lifting the manhole cover to observe the extent of floatable oil and debris. A sludge-judge ™ was used to determine depth of sediment deposits in the unit. When deposits approached 30 inches in depth near the center of the cone of deposition, the unit was serviced with a vacuum pump truck, and deposits taken to a landfill in accordance with local guidelines. Quarterly inspections indicated a sediment deposition rate of 3 inches per month from the site. The unit has been pumped twice since installation in June 2004.

RESULTS AND DISCUSSION

Results and Field Observations of Sampling Events
Automated field sampling equipment problems were encountered during the 2004 monitoring of the Aqua-Swirl™ AS-6 in-ground system. Often the flow activated sensor in the effluent line did not trigger during runoff

Table 2. Summary of Selected Particle Size Distributions in WCPW Runoff Sampling

Date	Sample	Mean TSS, mg/L	Percent of Particles < 75 microns
1-5-06	Influent	2690	98
	Effluent	493	68
3-24-06	Influent	5013	93
	Effluent	1873	97
6-7-06	Influent	4240	76
	Effluent	511	78

events. As a result, paired datasets could not be obtained which results in uncertain removal efficiencies for TSS and O&G.

Table two summarizes particle size distribution of influent and effluent grab samples during selected runoff events. The January 2006 collection showed 98 percent of the influent and 68 percent of the effluent particles were less than 75 microns in diameter. Hydrodynamic separator efficiencies are limited with particle sizes less than 75 to 80 microns due to particles becoming neutrally buoyant. Since most of the particles in the runoff from WCPW were at or below this size range, swirl treatment alone would be limited, and reflected in lower removals of TSS. This eventually led to selection of the site for filtration system field testing.

Field observations during inspections of the in-ground Aqua-Swirl™ unit and servicing of the ISCO™ samplers revealed frequently occurring low flows more than 3 times per week regardless of antecedent rainfall runoff. Flow is typically less than 5 gpm at the site, but is sufficient to initiate hydrodynamic swirl action in the AS-6 unit. Runoff was often triggered by equipment washing at the WCPW site. This field observation combined with the automatic sampling equipment failures resulted in a need to change monitoring strategies and the scope of the demonstration. Influent and effluent grab samples would be collected from the unit under differing runoff conditions. Grabs samples were collected during one of the low flow "dry" weather events on January 5, 2006. Removal efficiency of the unit under very low flows showed removals of 82 percent TSS and 52 percent O&G.

The next condition sampled was a rainfall-runoff event on March 20, 2006. Two sets of grab samples were collected during the 0.50 inch rainfall event. The first set of influent and effluent grab samples was taken during "first flush" conditions. Rainfall at the time totaled 0.25 inches, and runoff to the AS-6 unit had initiated the "swirl" action. The second set of grab samples was taken 1.25 hours later after a total of 0.50 inches of rain. Runoff to the unit was steady and moderate. The TSS and O&G removals were 39 percent and 35 percent respectively. While removal rates appear to be low, the influent sample concentrations of each parameter during both runs were were low during this winter event: 647 ppm TSS and 18 ppm O&G in the "first flush" grab sample and 356 ppm TSS and 10.6 ppm O&G in the second grab sample set. Also, knowing the small particle size of TSS from this site is likely reflected in these removal rates.

Field testing of a downflow Go-Filter™ filter design was performed for a simulated runoff on March 24, 2006. Two county water trucks containing 2,000 gallons and 1,500 gallons sprayed over 0.5 acres of asphalt and gravel parking and drive areas of the yard to create a runoff event. Two sample runs were made on this day. During the first run, three truckloads of water totaling 5,500 gallons were delivered to the site in 25 minutes. During the second run, 4,000 gallons were delivered to the site in 20 minutes. During the first simulated run, influent to the swirl was observed to be foamy, and highly turbid and muddy. During the second run, the influent exhibited a more milky appearance. Water did not cascade over the entire length of the filter chamber during either run indicating that the runoff flow rate attained was on the low end of design capacity for the filter unit. Five sets of influent and effluent grab samples were collected over the two runs. Removals averaged 60 percent for TSS and 41 percent for O&G for the five sample sets.

Subsequent to the March 2006 sampling of the downflow Go-Filter unit, the system was modified with an upflow filter configuration and sampled under simulated runoff events on June 7 and June 16, 2006. Three simulated runoff events were sampled on June 7. The WCPW tanker truck used for this simulated event is rated to deliver 264 gpm. The truck delivered 2,000 gallons of water on 0.57 acre of pavement in 10 minutes. The WCPW pump used in the manhole was rated at 250 gpm. Given the 10-foot head elevation from the manhole and 3-inch line to the inlet of the first swirl on the mobile system train, it is estimated that 125 gpm were being delivered to the Go-Filter™ unit. The time increment between influent and effluent samples collection was about 2 minutes based on the observed interval between flows in swirl #1 and flows entering the filter chamber. The TSS removal efficiency for this simulated event averaged 86 percent. It was noted that the filter had not been surcharged with (clean) water or runoff prior to sampling. Removal efficiencies of a new filter are typically low in startup conditions; however, given influent TSS concentrations averaging 4,155 ppm and effluent concentrations averaging 536 ppm a dramatic reduction was still realized.

The upflow Go-Filter™ unit was sampled again on June 16, 2006, under three simulated runoff events. The unit was hydraulically static from the June 7 sampling event. By this time the filters had been "charged" with runoff water and deposits from the June 7 event. Using one WCPW tanker truck, 2,000 gallons of water were delivered to the 0.57 acre pavement in 10 minutes. A 600 gpm pump was used to vary the flow rate to the unit. Removal efficiencies averaged greater than 94 percent for TSS with one run approaching 99 percent. Influent concentrations averaged 3,066 ppm TSS and effluent concentrations averaged 117 ppm.

Comparison of Field Performance Data and Regulatory BMP Certifications The WCPW data were compared to field testing of AquaShield™ systems at other sites across the country. The University of New Hampshire (UNH) Stormwater Center conducted field testing on an Aqua-Filter™ model AF-4.2, comparable to the downflow filter unit on the mobile unit at WCPW (UNH 2005). A summary of the study reported a mean removal efficiency of 81 percent for TSS (AquaShield, 2006). The downflow Go-Filter™ unit at WCPW under simulated runoff conditions was 86 percent.

The WCPW field performance for TSS was compared to two nationally recognized certification protocol guidelines for manufactured stormwater treatment systems. Each program uses different approaches for TSS removal requirements. The Technology Acceptance and Reciprocity Partnership (TARP), an eight state consortium administered generally by the New Jersey Department of Environmental Protection NJDEP), requires that a filtration system should achieve 80 percent removal regardless of influent concentration and that designated field testing use a site exhibiting 100 to 300 ppm TSS with particle sizes of less than 100 microns in diameter (NJDEP Proposed TARP Revision 2006). The WCPC site meets the TSS removal and particle size requirement; however, the WCPW site had TSS influent concentrations in the 1000's ppm.

The other protocol program is the Technology Assessment Protocol-Ecology (TAPE) developed by the Washington State Department of Ecology and largely adopted by Texas. The TAPE protocol specifies 80 percent TSS removal if influent concentrations exceed 100 ppm (TAPE 2004). If influent concentrations are less than 100 ppm then the target effluent concentration is 20 ppm. The TAPE criteria are independent of particle size. All of the WCPW TSS influent data was above 100 ppm and none was below 100 ppm, thus the Aqua-Filter ™ on the Go-Filter™ system meets TAPE criteria for a manufactured system.

Policy Implications. As a site manager/operator, the WCPW field study raises several question. (1) What is the water quality and stream biological significance of small particles in runoff? (2) Does particle size have a role in numerical criteria? (3) Should site characterizations include particle size distribution for stormwater designs, and if so, how can this be handled for pre-project conditions?

CONCLUSIONS

As a watershed director, performance of the stormwater treatment system success is measured by the amount of sediment and pollutants that did not leave and enter the drainage network of the Conasauga River. Removing 3 inches (7 cubic feet, or 52 gallons) of sediment per month from this one 3-acre site provides encouragement for what is possible to treat hundreds of other sites in the larger Conasauga watershed. Sampling and analyses performed during this field demonstration and evaluation project provide field data and feedback on expectations of the tested manufactured stormwater treatment processes under various field conditions. Comprehensive and more controlled field performance evaluations are underway by AquaShield™ in other regions of the country.

As a site director, performance of this treatment system meets one significant goal of Phase II requirements: reducing pollutants in runoff. Quarterly inspections, and annual maintenance and servicing of the unit are not burdensome. Cost of service is nominal, which includes disposal of the pumped sediment by the local utility authority vacuum truck. This field demonstration project has resulted in another unit being used by the City of Dalton at the local airport which is adjacent to the Conasauga River. This spin-off demonstrates the value of the initial installation workshop and subsequent testing, as well as the commitment by the City and County to be good stewards of Georgia's water resources.

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