THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

NSF International

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**STORMWATER TREATMENT TECHNOLOGY**	
APPLICATION:	**SEDIMENT REMOVAL**	
TECHNOLOGY NAME:	**ARKAL PRESSURIZED STORMWATER FILTRATION SYSTEM**	
TEST LOCATION:	**GREEN BAY, WISCONSIN**	
COMPANY:	**ZETA TECHNOLOGY, INC.**	
ADDRESS:	**416 Flamingo Avenue** **Stuart, Florida 34966**	PHONE: **(772) 781-7000** FAX: **(772) 781-7001**
WEB SITE:	**http://www.zetatechnology.com**	
EMAIL:	**zeta@zetatechnology.com**	

The U.S. Environmental Protection Agency (EPA) has created the Environmental Technology Verification (ETV) Program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV program is to further environmental protection by accelerating the acceptance and use of improved and more cost-effective technologies. ETV seeks to achieve this goal by providing high quality, peer-reviewed data on technology performance to those involved in the design, distribution, permitting, purchase, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations; stakeholder groups which consist of buyers, vendor organizations, and permitters; and with the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

NSF International (NSF), in cooperation with the EPA, operates the Water Quality Protection Center (WQPC), one of six centers under ETV. The WQPC recently evaluated the performance of the Arkal Pressurized Stormwater Filtration System distributed by Zeta Technologies, Inc., a system designed to remove solids from stormwater runoff. The system was installed at St. Mary's Hospital in Green Bay, Wisconsin. Earth Tech, Inc. and the United States Geologic Survey (USGS) performed the testing.

TECHNOLOGY DESCRIPTION

The following description of the Arkal Pressurized Stormwater Filtration (Arkal) System was provided by the vendor and does not represent verified information.

The key components of the Arkal system are the filtration processes, which are manufactured by Arkal. Ancillary components not manufactured by Arkal, including a splitter manhole and storage tank, were combined with the filtration processes to form a system designed to remove suspended solids from stormwater. Stormwater entered a sump where coarse solids settled and was then diverted either to a 9,200 ft^3 storage tank that fed the filtration processes, or an overflow bypass pipe that diverted water directly to the municipal storm sewer system without additional treatment.

The filtration processes consisted of two pressurized systems operating in series. The first filtration process consisted of four towers, each containing three "StarFilter" disk filter units designed to remove particles 50 microns and larger. The second filtration stage consisted of a series of five 48-inch diameter sealed sand filter tanks, designed to remove particles five microns and larger. Both filtration processes backwashed automatically when pressure differentials exceeded preset levels. The provision of multiple filters in each process allowed for filtration and backwash to occur simultaneously. The backwash wastewater was discharged to the municipal sanitary sewer, while the treated stormwater was discharged to the municipal storm sewer.

The vendor claims that the treatment system can remove 80 percent of the suspended solids greater than five microns in the stormwater.

VERIFICATION TESTING DESCRIPTION

Methods and Procedures

The test methods and procedures used during the study are described in the *Test Plan for Verification of the Arkal Filtration Systems, Inc. Pressurized Stormwater Filtration System, St. Mary's Hospital, Green Bay, WI* (Earth Tech, January 2001) (VTP). The Arkal system treats the hospital's 5.49-acre drainage area, which consists of paved parking areas, the building's roof, and landscaped areas. Green Bay receives an average of nearly 29 inches of precipitation, approximately 35 percent of which occurs during the summer months.

Verification testing consisted of collecting data during 15 qualified events that met the following criteria:

- The total rainfall depth for the event, measured at the site, was 0.2 inches (5 mm) or greater (snow fall and snow melt events do not qualify);
- Flow through the treatment device was successfully measured and recorded over the duration of the runoff period;
- A flow-proportional composite sample was successfully collected for both the influent and effluent over the duration of the runoff event;
- Each composite sample was comprised of a minimum of five aliquots, including at least two aliquots on the rising limb of the runoff hydrograph, at least one aliquot near the peak, and at least two aliquots on the falling limb of the runoff hydrograph; and
- There was a minimum of six hours between qualified sampling events.

Automated sample monitoring and collection devices were installed and programmed to collect composite samples from the influent, the treated effluent, and the untreated bypass during qualified flow events. Samples were analyzed for the following parameters:

Sediments
- total suspended solids (TSS)
- total dissolved solids (TDS)
- particle size analysis
- suspended sediment concentration (SSC)

Nutrients
- total phosphorus
- dissolved phosphorus
- nitrate and nitrite
- total Kjeldahl nitrogen (TKN)

Metals
- total calcium
- total magnesium
- total zinc

In addition to the flow and analytical data, operation and maintenance (O&M) data were recorded. Power consumption costs were calculated based on the manufacturer's rated pump specifications and length of operation during event periods.

VERIFICATION OF PERFORMANCE

Verification testing of the Arkal system lasted nearly 16 months. No bypassing occurred during the testing period, so all of the influent entering the system was treated and discharged as treated effluent to the storm sewer or as backwash filtrate to the sanitary sewer.

Test Results

The precipitation data for the 15 rain events are summarized in Table 1.

Table 1. Rainfall Data Summary

Event No.	Start Date	Start Time	Rainfall Depth (inches)	Rainfall Duration (hr:min)	Rainfall Volume[1] (ft^3)
1	6/2/01	3:45	0.81	7:24	16,070
2	6/10/01	12:26	0.41	2:54	6,307
3	6/11/01	22:38	0.20	1:49	2,367
4	6/15/01	10:20	0.38	1:50	5,374
5	8/25/01	2:45	0.34	6:52	4,467
6	12/12/01	22:18	0.39	2:55	5,495
7	4/18/02	4:27	0.40	3:32	4,959
8	4/24/02	15:07	0.63	3:39	8,044
9	4/27/02	20:15	1.13	10:33	16,332
10	5/1/02	22:19	0.22	3:12	2,557
11	5/25/02	8:31	1.27	35:40	16,114
12	6/13/02	23:48	0.31	14:01	4,640
13	6/21/02	17:15	0.36	1:05	4,985
14	7/25/02	17:39	0.40	1:08	5,728
15	9/19/02	4:48	0.23	2:24	2,929

[1] Rainfall volume was measured at the influent monitoring point.

The monitoring results were evaluated using event mean concentration (EMC) and sum of loads (SOL) comparisons.

The EMC or efficiency ratio comparison evaluates treatment efficiency on a percentage basis by dividing the effluent concentration by the influent concentration and multiplying the quotient by 100.

The efficiency ratio was calculated for each analytical parameter and each individual storm event. In order for efficiency ratio calculations to show a high treatment percentage, the influent parameter concentrations needed to be relatively high. This was not always the case because of the inherent variability of stormwater.

The SOL comparison evaluates the treatment efficiency on a percentage basis by comparing the sum of the influent and effluent loads (the product of multiplying the parameter concentration by the precipitation volume) for all 15 storm events. The calculation is made by subtracting the quotient of the total effluent load divided by the total influent load from one, and multiplying by 100. The analytical data ranges, EMC range and SOL reduction values are shown in Table 2.

Table 2. Analytical Data, EMC Range, and SOL Reduction Results

Parameter	Units	Influent Range	Effluent Range	EMC Range (percent)	SOL Reduction (percent)
TSS	mg/L	10 – 426	<2 – 61	47 – >94	82
SSC	mg/L	12 – 340	2 – 67	32 – 95	82
Total zinc	µg/L	24 – 210	<16 – 26	21 – 82	58
Total phosphorus	mg/L as P	0.023 – 0.32	<0.005 – 0.13	23 – >96	55
TKN	mg/L as N	0.32 – 2.2	0.35 – 1.0	-47 – 59	26
Dissolved phosphorus	mg/L as P	<0.005 – 0.17	<0.005 – 0.12	-75 – 50	13
Nitrate and nitrite	mg/L as N	0.29 – 1.7	0.67 – 2.1	-170 – 3.6	-76
TDS	mg/L	38 – 550	190 – 950	-1,100 – -31	-190
Total magnesium	mg/L	2.3 – 16	8.3 – 41	-570 – 53	-190
Total calcium	mg/L	6.5 – 64	19 – 77	-340 – -18	-210

The reductions in TSS and SSC exceeded the vendor's performance claim of 80 percent solids reduction, based on the SOL evaluation method. Additionally, constituents commonly found in particulate form or attached to sediment particles, such as phosphorus, TKN, and total zinc, were removed as sediments were removed. However, dissolved-phase parameters, such as TDS, phosphorus, nitrate, and nitrite, were not removed by the Arkal system. This is consistent with the vendor's performance claim.

The negative efficiencies for TDS, total calcium, and total magnesium were attributed to groundwater infiltration into the storm sewer system through cracks or poorly sealed joints. Calculation of the infiltration dilution effect, however, did not show the infiltration to have an impact on the TSS or SSC SOL evaluation. The infiltration issue is explained in greater detail in the verification report.

Particle size distribution analysis was conducted on the solids trapped in the sump and in samples when adequate sample volume was collected. Ninety percent of the particles trapped in the sump were larger than 250 microns, with 70 percent being larger than 2,000 microns. Twelve of the 15 qualified events had adequate influent sample volume to complete a sand\silt split (greater or less than 62 microns) analysis. None of the effluent samples had sufficient volume to complete the visual accumulator and pipette analyses.

The influent analysis indicated a sand/silt split of 25.8 percent to 74.2 percent, while the effluent had a sand/silt split of 16.2 percent to 83.8 percent. Furthermore, three events had adequate influent sample volume to conduct particle size analyses for particles as small as one micron. For these three events, the influent had a range of 17.3 to 38.9 percent of solids passing a four-micron sieve. In order for the Arkal system to achieve 82 percent sum of loads efficiency for these three events, it had to treat a portion of the

solids passing a four-micron sieve. This substantiates the vendor's performance claim of being able to treat particles five microns or larger.

System Operation

The Arkal system was installed prior to verification testing, so verification of installation procedures on the system was not documented.

Aside from routine monitoring and maintenance, eight maintenance events were performed during the testing period. Maintenance typically consisted of cleaning and disinfecting the StarFilter rings, which would develop microbial growth during long dry periods. A total of 84 hours of staff time and $260 in direct costs were used in maintaining the system during the testing period. No system downtime occurred as a result of maintenance activities.

Based on system operating time and equipment horsepower, electrical power consumption was calculated to be approximately 78 kWh per event.

Quality Assurance/Quality Control

NSF personnel completed a technical systems audit during testing to ensure that the testing was in compliance with the test plan. NSF also completed a data quality audit of at least 10 percent of the test data to ensure that the reported data represented the data generated during testing. In addition to QA/QC audits performed by NSF, EPA personnel conducted an audit of NSF's QA Management Program.

Original Signed By	*Original Signed By*
Lawrence W. Reiter, Ph. D. *July 27, 2004*	*Gordon E. Bellen* *August 4, 2004*
Lawrence W. Reiter, Ph.D. Date	Gordon E. Bellen Date
Acting Director	Vice President
National Risk Management Laboratory	Research
Office of Research and Development	NSF International
United States Environmental Protection Agency	

Availability of Supporting Documents

Copies of the *ETV Verification Protocol, Stormwater Source Area Treatment Technologies Draft 4.1, March 2002,* the verification statement, and the verification report (NSF Report Number 04/15/WQPC-WWF) are available from:

ETV Water Quality Protection Center Program Manager (hard copy)
NSF International
P.O. Box 130140
Ann Arbor, Michigan 48113-0140
NSF website: http://www.nsf.org/etv (electronic copy)
EPA website: http://www.epa.gov/etv (electronic copy)

Appendices are not included in the verification report, but are available from NSF upon request.