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NJCAT TECHNOLOGY VERIFICATION

BAYSAVER TECHNOLOGIES^{TM}, INC.

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1. Introduction

1.1 New Jersey Corporation for Advanced Technology (NJCAT) Program

NJCAT is a not-for-profit corporation to promote in New Jersey the retention and growth of technology-based businesses in emerging fields such as environmental and energy technologies. NJCAT provides innovators with the regulatory, commercial, technological and financial assistance required to bring their ideas to market successfully. Specifically, NJCAT functions to:

- Advance policy strategies and regulatory mechanisms to promote technology commercialization;
- Identify, evaluate, and recommend specific technologies for which the regulatory and commercialization process should be facilitated;
- Facilitate funding and commercial relationships/alliances to bring new technologies to market and new business to the state; and
- Assist in the identification of markets and applications for commercialized technologies.

The technology verification program specifically encourages collaboration between vendors and users of technology. Through this program, teams of academic and business professionals are formed to implement a comprehensive evaluation of vendor specific performance claims. Thus, suppliers have the competitive edge of an independent third party confirmation of claims.

Pursuant to N.J.S.A. 13:1D-134 et seq. (Energy and Environmental Technology Verification Program) the New Jersey Department of Environmental Protection (NJDEP) and NJCAT have established a Performance Partnership Agreement (PPA) whereby NJCAT performs the technology verification review and NJDEP certifies the net beneficial environmental effect of the technology. In addition, NJDEP/NJCAT work in conjunction to develop expedited or more efficient timeframes for review and decision-making of permits or approvals associated with the verified/certified technology.

The PPA also requires that:

- The NJDEP shall enter into reciprocal environmental technology agreements concerning the evaluation and verification protocols with the United States Environmental Protection Agency, other local required or national environmental agencies, entities or groups in other states and New Jersey for the purpose of encouraging and permitting the reciprocal acceptance of technology data and information concerning the evaluation and verification of energy and environmental technologies; and

- The NJDEP shall work closely with the State Treasurer to include in State bid specifications, as deemed appropriate by the State Treasurer, any technology verified under the Energy and Environment Technology Verification Program.

1.2 Technology Verification Report

On April 29, 2004, BaySaver Technologies, Inc., 1302 Rising Ridge Road, Unit 1, Mount Airy, MD 21771 submitted a formal request for participation in the NJCAT Technology Verification Program. The technology proposed – The BaySaver Separation System – is a patented stormwater treatment technology designed to remove sediments, oils, and debris from surface runoff. The system was developed in the early 1990's with the patent filed in 1997. Through research and field application, the technology has been refined to capture total suspended solids (TSS), sediments, oils and debris (including organics and trash). The request (after pre-screening by NJCAT staff personnel in accordance with the technology assessment guidelines) was accepted into the verification program. This verification report covers the evaluation based upon the performance claim of the vendor, BaySaver Technologies, Inc. (see Section 4). The verification report differs from typical NJCAT verification reports in that final verification of the BaySaver Separation System (and subsequent NJDEP certification of the technology) waits completed field testing that meets the full requirements of the Technology Acceptance and Reciprocity Partnership (TARP) – Stormwater Best Management Practice Tier II Protocol for Interstate Reciprocity for stormwater treatment technology. This verification report is intended to evaluate the BaySaver Separation System initial performance claim for the technology based primarily on carefully conducted laboratory studies. This claim is expected to be modified and expanded following completion of the TARP required field-testing.

A number of meetings, telephone discussions and email exchanges were conducted to solicit relevant materials and to refine specific claims from the vendor. This project included the evaluation of assembled reports, company manuals, literature, and a third party laboratory testing report to verify that the BaySaver Separation System meets the performance claim of BaySaver Technologies, Inc.

1.3 Technology Description

1.3.1 Technology Status: general description including elements of innovation/uniqueness/ competitive advantage.

In 1990 Congress established deadlines and priorities for EPA to require permits for discharges of stormwater that is not mixed or contaminated with household or industrial wastewater. Phase I regulations established that a NPDES (National Pollutant Discharge Elimination System) permit is required for stormwater discharge from municipalities with a separate storm sewer system that serves a population greater than 100,000 and certain defined industrial activities. To receive a NPDES permit, the municipality or specific industry has to develop a stormwater management plan and identify Best Management Practices for stormwater treatment and discharge. Best Management Practices (BMPs) are measures, systems, processes or controls that reduce pollutants at the source to prevent the pollution of stormwater runoff discharge from the site. Phase II stormwater discharges include all discharges composed entirely of stormwater, except those specifically classified as Phase I discharge.

The nature of pollutants emanating from differing land uses is very diverse. BaySaver Technologies, Inc. has developed a technology for separating and retaining floating and sinking pollutants including sediment, oil and debris under rapid flow conditions using two standard precast manholes and a separator unit. The two manholes allow the removal and storage of pollutants, while the separator unit acts as a dynamic flow control to route the flow through the most effective flow path for treatment. The BaySaver Separation System uses a combination of gravity separation and flow control to capture and retain pollutants. Maintenance is performed from above by a vacuum truck and without interference from internal components.

General

The BaySaver system is hydraulically designed to use gravitational separation as a means of capturing sediments, and free floating oils, trash, and debris.

The dual settling chambers and the internal flow splitter act in tandem to provide different levels of treatment for different runoff intensities. Coarse sediments are removed in the first structure, and finer sediments and floating pollutants are removed and trapped in the second. This is the case during the periods of low flow that comprise the majority of storm events.

During more intense storms, water is pushed up the T-pipes from below the surface in the first manhole. This water is free of floatable pollutants and large suspended sediments. At moderate flow rates, the T-pipes convey water from the center of the first manhole and discharge it directly downstream. Operating in conjunction with the T-pipes, influent water is diverted into the second manhole by the surface skimming trapezoidal weir. In this manner, the BaySaver Separation System continues to remove fine sediments and floatable pollutants in the second manhole as flow rates increase throughout the system.

The BaySaver Separator Unit includes an internal bypass that conveys high energy flows directly downstream. Bypass mode is effective when the flow rates begin approaching the peak design flow. By bypassing extreme flows, the BaySaver Separator Unit prevents the re-suspension and discharge of the pollutants that are already trapped within the system.

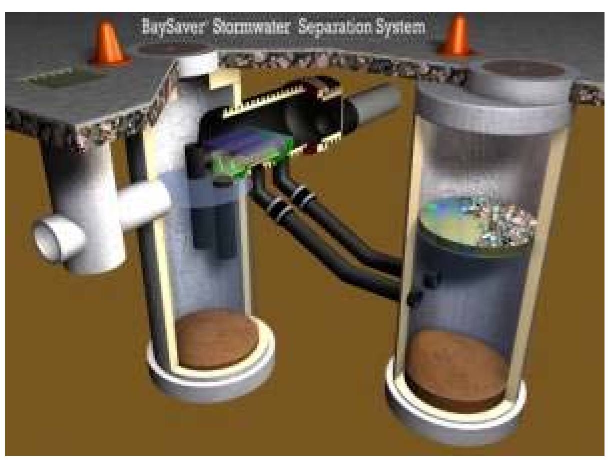

Figure 1. BaySaver Separation System

1.3.2 Specific Applicability

The BaySaver Separation System is a versatile and flexible BMP device that can be retrofitted into existing storm drains or incorporated into new designs and redevelopments. These systems can be used to improve the quality of stormwater runoff from high traffic areas, to contain potential oil spills, as a pretreatment step in a treatment train, and for other applications. Some specific potential uses include:

- Parking lots
- Gas and service stations
- Residential and commercial developments
- Airport taxi-way and runways
- Spill control for potential oil spills
- Industrial maintenance facilities
- Highway and bridge stormwater runoff
- Pretreatment practice to increase the longevity of sand filters, infiltration systems, ponds, or other water quality measures.

1.3.3 Range of Contaminant Characteristics

BaySaver Separation Systems have been shown to capture a wide range of pollutants of concern. These include: debris (including organic and trash); total suspended solids; sediments; and oil and grease.

1.3.4 Range of Site Characteristics

The BaySaver Separation System is designed to accommodate a wide range of flows and volumes (see Table 1). The BaySaver Separation System is manufactured in 5 different sizes using precast concrete manholes and can be custom designed as a model XK for any flow rate. Unit sizes and treatment capacities are listed in Table 1.

Table 1. Size and Treatment Capacities of BaySaver Separation System

Separator Unit	Unit Diameter	Manhole Size	Max. Treatment Flow	Peak Design Flow
1/2 K	24”	48”	0.8 cfs	6.8 cfs
1K	24”	48”	1.1 cfs	7.5 cfs
3K	36”	60”	3.3 cfs	23.1 cfs
5K	48”	72”	6.8 cfs	47.3 cfs
10K	>60”	120”	12.3 cfs	83 cfs
XK	Custom	Custom	Any flow rate	Custom

1.3.5 Material Overview, Handling and Safety

Site preparation, manholes delivery, pipe connection, and separation unit installation are all general construction practices. There is no handling of hazardous material.

Field personnel should take precautions while handling and installing manholes. Field personnel should use appropriate safety equipment, including hardhat and steel-toe boots. Personnel who operate field equipment during the installation process should have appropriate training, supervision, and experience.

The manholes are considered a confined space such that confined space training is needed to enter the structure. Entry also requires the use of a gas detector for safety. Standard OSHA confined space entry procedures should be followed (29 CFR 1910.146). Only persons who are certified by OSHA to make confined space entries should enter a BaySaver Separation System.

Safe and legal disposal of pollutants is the responsibility of the maintenance contractor. Solids recovered from the BaySaver Separation System can typically be land filled. It is possible that there may be some specific land use activities that create contaminated solids, which will be captured in the system. Such material would have to be handled and disposed of in accordance with hazardous waste management requirements.

1.4 Project Description

This project included the evaluation of assembled reports, company manuals, literature, and a third party laboratory testing report to verify that BaySaver Separation Systems meet the performance claims of BaySaver Technologies, Inc.

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2. Evaluation of the Applicant

2.1 Corporate History

BaySaver Technologies, Inc. was founded in 1997 by Tom Pank, owner of Accubid, a large commercial excavation firm located in Mount Airy, Maryland. Mr. Pank saw a need for a more effective and economical solution to the stormwater treatment requirements for his construction clients. He began experimenting with a 3-chamber box and quickly learned that a dual-manhole system with three treatment paths, as provided by the BaySaver Separation System, yields the most effective manner for treatment without re-suspension of sediments and debris.

Mr. Pank's first unit was installed in January 1997. The patent was officially awarded in 1998 for the BaySaver Stormwater Separation System (Pank 5,746,911). This system treats the influent water according to the rate of the flow removing sediment, debris and oil throughout the entire storm.

In late 2002, Mr. Pank made the commitment to develop BaySaver Technologies, Inc. into a major player in the stormwater treatment marketplace as Phase II of the Clean Water Act was quickly approaching. In early 2003, Mr. Pank recruited a veteran CEO, Kenneth Barksdale, to take control of BaySaver. Mr. Barksdale immediately created a vision for this rapidly growing company to become the most sought after provider of stormwater treatment solutions in the industry. To accomplish this, Mr. Barksdale is driving the company to expand and enhance its solutions for treatment devices to meet specific market demands.

In 2003, BaySaver Technologies, Inc. committed resources, time and capital to develop source data regarding the efficiency of the BaySaver model design. The company agreed to enter into several field studies and state run verification programs. Beginning early 2004, BaySaver Technologies, Inc. successfully negotiated an agreement with one of the premier hydraulic laboratories in the nation to perform in-depth third party analysis of the BaySaver Separation System in a full-scale laboratory setting. The University of Minnesota's Saint Anthony Falls Laboratory (SAFL) has been developing solutions for hydraulic and water resource problems for over 60 years.

2.2 Organization and Management

The company is headquartered in Mount Airy, Maryland, and has six regional sales offices throughout the United States located in Chicago, Atlanta, Northern California, Southern California, Boston and Baltimore. The BaySaver Regional Managers oversee 27 Independent Manufacturers Representatives and Distributors around the country. Continual growth of the distribution chain will continue until all areas around the U.S. and Canada are represented. The leadership consists of Ken Barksdale as the CEO, Austin Meyermann, Director of Engineering and Operations, Eric Fisher, Vice President of Sales, Paula Pike, Marketing Director and Robert Bitler, Director of Manufacturing. All components are manufactured at BaySaver's plant in Mount Airy, Maryland, and shipped to distributors around the country.

2.3 Operating Experience with Proposed Technology

In just six years, BaySaver Technologies, Inc. has experienced significant growth in sales and market share installing over 1,000 units around the U.S. and abroad. Growth for the last three years averaged 65% annually. The company grew out of the mid-Atlantic and north eastern regional areas. The states of Massachusetts, Connecticut, New Jersey, New York, Pennsylvania, Maryland, Virginia, and the District of Columbia, represent over 600 installations of the BaySaver Separation System.

2.4 Patents

BaySaver Technologies was granted its first patent on May 5, 1998 (U.S. Patent Number: 5,746,911), which protects the design of the standard BaySaver Separation System. This patent relies on the system having three distinct flow paths between two settling basins and a process by which the influent water is treated according to the rate of flow. Five other patents have been filed for new products to be introduced into the market in the upcoming months.

2.5 Technical Resources, Staff and Capital Equipment

BaySaver Technologies, Inc.'s corporate headquarters and manufacturing facilities are located in Mount Airy, Maryland. All design and technical support is also performed at the main office. BaySaver manufactures five base model sizes and can customize solutions for larger flow and treatment demands. The staff consists of an Engineering Team made up of two Applications Engineers and an outsourced Hydraulic Engineer, as well as a Plant Manager and four craftsmen.

In addition to the BaySaver Team we have added two consultants with engineering and physics backgrounds to work on product enhancements and new product design.

When a product is specified for a particular application, BaySaver Application Engineers provide shop drawings for independent concrete pre-casters chosen by the site contractors. The BaySaver Separation System is shipped directly to the site within two weeks of purchase order. The site contractor is responsible for installation. Complete installation guidelines are supplied at the time of delivery to the job site and include step-by-step instructions for installation. Each unit has flanged inlet and outlet pipes in order to assure the greatest flexibility for on-site adjustments. Installation is typically completed in one day.

BaySaver's representatives provide on-site support and guidance for installation upon request.

3. Treatment System Description

The BaySaver System is comprised of three main components: the BaySaver Separator Unit, the Primary Manhole, and the Storage Manhole. Figure 1 displays a simple schematic of the BaySaver Separation System. Influent flow containing pollutants enters the system by first passing through the Primary Manhole. In this structure, coarse sediment settles into a sump while the flow passes into the Separator Unit and is routed to the Storage Manhole. The influent flow, at this point, still contains pollutants of concern, such as fine sediments, oil and grease, floating trash, and other debris. Floatable trash, oils, and grease float to the surface of the Storage Manhole and the influent flow returns to the outfall of the system.

As the rate of flow increases through the system, the Separator Unit acts as a dynamic flow control to route the influent flow through the most effective flow path for treatment. For example, under low flow conditions the influent flow is treated as described in the previous paragraph. Under moderate flows and up to the maximum treatment flow, flow is continuously treated through both the Primary and Storage Manholes, with a portion of these flows diverted through the T-pipes and the remainder flowing across the weir of the Separator Unit. This flow path allows for full treatment of floatable pollutants, while still treating sediments under moderate flow conditions. During the condition of the design storm, the influent flow passes directly though the system.

The pre-cast manholes associated with the system are purchased from local pre-casters and are cast to applicable specifications. The BaySaver Separator Unit is fabricated out of High Density Polyethylene (HDPE) containing carbon black, making it UV resistant, and is manufactured using state of the art extrusion welding and butt-fusion techniques.

BaySaver Separation Systems are manufactured in five (5) standard sizes and can be made customized to treat a wide range of flows up to 100 cfs (44,850 gpm).

4. Technical Performance Claim

Claim - The BaySaver Separator Model 1K provides 51% Suspended-Sediment Concentration (SSC) removal efficiency (as per NJDEP treatment efficiency calculation methodology) for laboratory simulated stormwater runoff with an average influent concentration of 205 mg/L and an average d_{50} particle size of 85 microns. SSC removal testing was conducted with sediment pre-loaded in the lower chamber to 50% sediment capacity for the 1K unit.

5. Technical System Performance

A series of tests were conducted on a 1K Unit BaySaver Separation System at a full scale laboratory setting at the University of Minnesota, in their St. Anthony Falls Laboratory (SAFL) to determine the sediment removal efficiency of the system. The laboratory tests were completed for a NJDEP recommended particle size distribution (PSD) with particles ranging from 1 to 1,000 microns. Tests were performed with sediment influent concentrations ranging from 100 to 300 mg/L at various increments (i.e., 25%, 50%, 75%, 100%, and 125%) of the maximum treatment rate (1.1 cfs).

5.1 Laboratory Studies

SAFL conducted laboratory testing for BaySaver Technologies, Inc. to evaluate the Total Suspended Solids (TSS) removal efficiency of the 1K Unit Separator under the NJDEP TSS protocol. This section provides details of the laboratory system setup, test procedure, and test results.

System Description

The testing configuration of the BaySaver Separation System is illustrated in Figure 2. The facility setup consisted of two fiberglass manholes, an instrumented 1K model of the BaySaver Separation System, and the connection pipes. The setup also included a head tank connected by a 20 feet 18” diameter HDPE pipe at 2% slope to ensure normal flow conditions into the inlet pipe of the BaySaver 1K unit. Outflow from the unit was captured in a tail tank.

Inflow rates were measured using a sharp crested weir and a V-notch weir downstream of the tail tank. The weirs were equipped with two MassaSonic M-5000/220 Smart Ultrasonic Sensors connected to a PC to read the water level upstream of the weir for flow measurement. A sediment feeder was used to control sediment inflow rates and concentrations. The outflow sediment concentrations were measured by sampling the outflow from the discharge pipe into the tail tank. The samples were then filtered and dried following ASTM D3977-97.

Procedure

A series of tests were first performed to determine the 1K BaySaver Separation System maximum treatment flow rate and the maximum hydraulic rate.

The maximum treatment flow rate of the unit is when the water level reaches the crest of the internal bypass plate. When water flows over the plate, the untreated water passes through the system. The flow measured by the V-notch weir equipped with sonar showed that the maximum treatment rate of the BaySaver 1K model is 1.1 cfs. This was a significant finding, since prior to this testing BaySaver had been marketing the 1K Model as having a maximum treatment flow rate of 2.4 cfs. Based on this testing, BaySaver has amended the maximum treatment flow rates of all their units downward. Table 1 reflects these amendments. A pressure tab was connected to a wet well with a mark denoting the crest elevation of the bypass plate.

The maximum hydraulic rate is when the BaySaver unit is running full, i.e. the water level in the primary manhole is at the crown of the BaySaver unit. The flow measured by a sharp crested weir equipped with sonar showed that the maximum hydraulic rate of the BaySaver 1K model is 7.6 cfs.

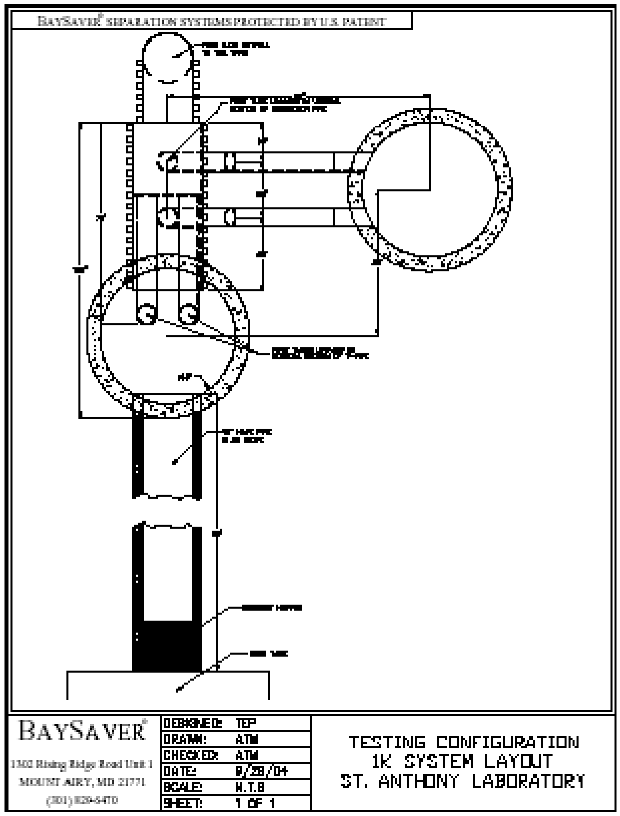

Figure 2. Testing Configuration of 1K BaySaver Separation System

To determine the sediment removal efficiency, the particle size distribution recommended by the NJDEP TSS Laboratory Testing Procedure was used. Sediments with 4 different specifications were mixed to create the recommended distribution and a mechanical mixer was used to mix the sediments. Since adding the clay particles would coagulate the samples and provide unrealistic distribution of the mix, it was decided not to add clay during the size distribution testing; instead the 5% clay was only added to the mix used for the removal efficiency testing. The samples with no clay were filtered, sieved, dried and weighed to determine their size distributions. The final particle size distribution (PSD) used for the testing is shown in Figure 3. The three distributions are from the same mix, but from different batches of that mix. Since some variability was observed within a mix, it was decided to extract three batches and to take one sample from each batch of the same mix. The PSD of the mix used in the testing was the average of the three PSDs shown in Figure 3. The average of these three PSDs is plotted as a dotted line to compare with the target distribution and shown in Figure 4. It is evident that between 100 microns and 1 mm, the mix and the target have very similar PSDs. Between 8 and 50 microns the mix used is about 5% coarser than the target. Below 8 microns, the mix used in the test has a slightly finer distribution than the target.

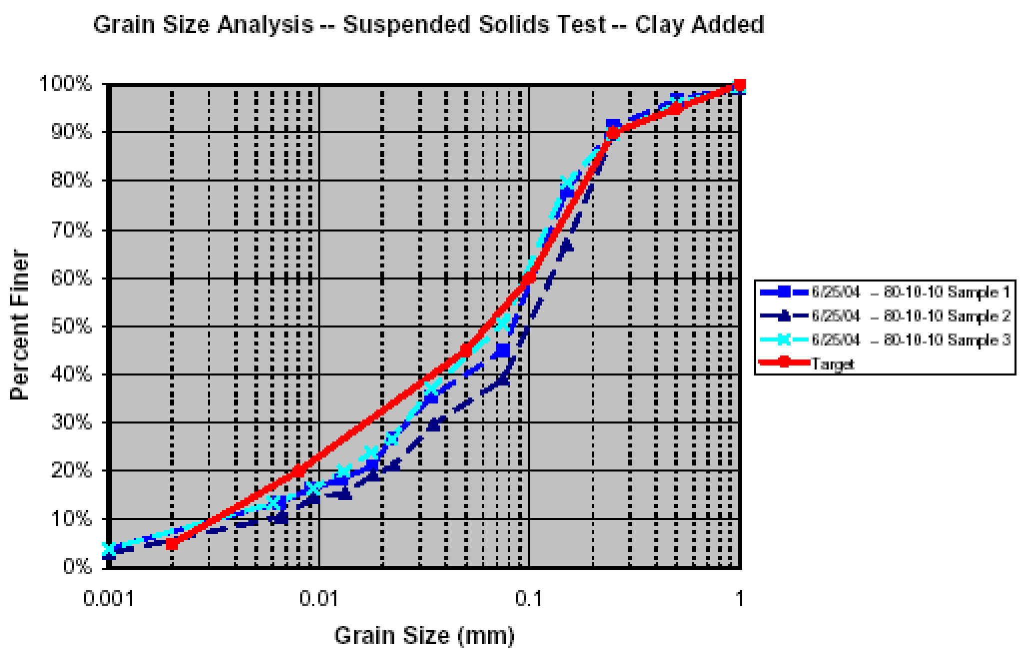

Figure 3. Comparison of the size distributions of three mixes (batches) with the target size distribution. The dashed lines are samples from three different mixes (batches) with similar proportions of sediments. The 5% clay was hypothetically added to the size distributions of the samples.

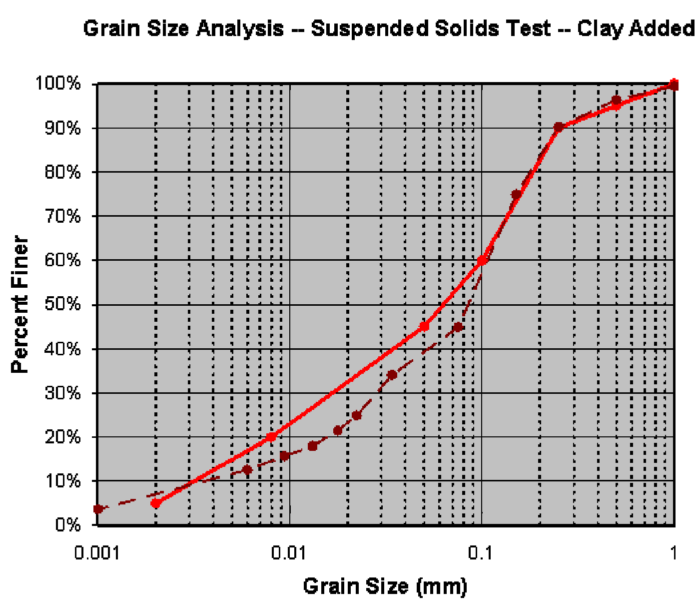

Figure 4. Comparison of the size distributions of the average of three mixes (batches) with the target size distribution.

To determine the removal efficiency of the 1K BaySaver unit, test runs were performed at constant (steady state) flow rates of 25, 50, 75, 100, and 125 percent of the maximum treatment flow rate (1.1 cfs). The test runs comprised 3 tests at each operating flow rate with influent concentrations of 100, 200 and 300 mg/l. In total 15 test conditions (19 tests) were carried out. The test duration varied with the flow rate. Prior to each test, the manholes were manually filled at 50% capacity (1 foot above the bed), i.e. the sediments were not deposited in the manholes through a natural process.

Mississippi River water was used in the tests. Prior to testing each day, water samples were collected in the head tank to determine the sediment concentration of the Mississippi River water. The measured concentrations during the two days of testing were 17.9 mg/l (day one) and 33.5 mg/l (a day several weeks later). Based on prior testing experience, river sediment consists primarily of fine silts and organics. Grab samples at the tail tank from the outflow pipe were collected to determine sediment removal efficiency. The samples were filtered, dried and weighed following ASTM D 3977-97 test methods.

TSS vs. SSC

In the preparation of the protocol for this study, BaySaver Technologies, Inc. reviewed laboratory tests for the determination of the total suspended solids concentration of the water samples to determine the most appropriate testing methodology. There are currently two recognized types of tests being used in the stormwater industry including:

1) APHA Method 2540 D, a traditional TSS test, where only a sub-sample of the overall sample for suspended solids content is tested; and
2) ASTM D 3977-97 (Re-approved 2002), "Suspended-Sediment Concentration (SSC)" test where the entire sample volume is tested.

The APHA Method 2540 D TSS protocol requires that a 500mL sample be agitated to homogenize the slurry. A 50mL sub-sample is then drawn and filtered to find the "total suspended sediment" concentration. In the case of analysis of sediment and water, maintaining a homogeneous mixture is difficult to achieve as particle dispersion is dependent on particle size and weight. As a result, extraction of a representative sample is challenging. Conversely, the SSC method uses the entire sample submitted to the laboratory for testing. By analyzing the entire sample, potential for error from agitation and sub-sample extraction is eliminated. NJDEP is currently funding a study to ascertain whether or not a correlation between TSS and SSC exists.

BaySaver and others regard the SSC, or "Bulk TSS", method as a more accurate indicator of the actual concentration of suspended solids of a given sample since the entire sample is used for analysis. These methods eliminate multiplying errors that can result from taking sub-samples; therefore, "Bulk TSS" analysis is BaySaver's preferred method for suspended solids measurement.

It is important to note that the NJDEP TSS removal criterion for stormwater management systems is based upon TSS, not SSC or "Bulk TSS". Through the definition of their TSS laboratory testing procedure, NJDEP has defined a particle size distribution that ranges from 1 to 1,000 microns. Since BaySaver Technologies, Inc. used the NJDEP recommended particle size distribution in their laboratory experiments, an argument can be made that the use of SSC or "Bulk TSS" would be appropriate for determining a system removal efficiency for TSS, since only TSS (as defined by NJDEP) were present in the experiment. If the particle size distribution used in the experiments had contained particles greater in size than 1,000 microns, these larger particles would have resulted in higher influent SSC concentrations, translating into higher removal efficiencies.

5.2 Verification Procedures

All the data provided to NJCAT were reviewed to fully understand the capabilities of the BaySaver Separation System. To verify the BaySaver Separation System claim, the laboratory data were reviewed and compared to the NJDEP Laboratory Testing Protocol. Only the data that closely compared to the NJDEP Laboratory Testing Protocol was used to verify the BaySaver Separation System claim. (Both grab sample and pitot tube effluent sample data were submitted. Only grab sample data were accepted for verification analysis.).

Claim - The BaySaver Separator Model 1K provides 51% Suspended-Sediment Concentration (SSC) removal efficiency (as per NJDEP treatment efficiency calculation methodology) for laboratory simulated stormwater runoff with an average influent concentration of 205 mg/L and an average d_{50} particle size of 85 microns. SSC removal testing was conducted with sediment pre-loaded in the lower chamber to 50% sediment capacity for the 1K unit.

5.2.1 NJDEP Recommended TSS Laboratory Testing Procedure

The NJDEP has prepared a Total Suspended Solids Laboratory Testing Procedure to help guide vendors as they prepare to test their stormwater treatment systems prior to applying for NJCAT verification. The Testing Procedure has three components:

1. Particle size distribution
2. Full scale laboratory testing requirements
3. Measuring treatment efficiency

<u>1. Particle size distribution:</u>

The following particle size distribution will be utilized to evaluate a manufactured treatment system (See Table 2), a natural/commercial soil representing U.S.D.A. definition of a sandy loam material. This hypothetical distribution was selected as it represents the various particles that would be associated with typical stormwater runoff from a post construction site.

Table 2. Particle Size Distribution

Particle Size (microns)	Sandy Loam (percent by mass)
500-1000 (coarse sand)	5.0
250-500 (medium sand)	5.0
100-250 (fine sand)	30.0
50-100 (very fine sand)	15.0
2-50 (silt)	(8-50 um, 25%) (2-8 um, 15%)*
1-2 (clay)	5.0

Notes:
1. Recommended density of particles ≤2.65 g/cm3

*The 8 um diameter is the boundary between very fine silt and fine silt according to the definition of American Geophysical Union. The reference for this division/classification is: Lane, E. W., et al. (1947). "Report of the Subcommittee on Sediment Terminology," Transactions of the American Geophysical Union, Vol. 28, No. 6, pp. 936-938.

2. Full Scale lab test requirements

A. At a minimum, complete a total of 15 test runs including three (3) tests each at a constant flow rate of 25, 50, 75, 100, and 125 percent of the treatment flow rate. These tests should be operated with initial sediment loading of 50% of the unit's capture capacity.
B. The three tests for each treatment flow rate will be conducted for influent concentrations of 100, 200, and 300 mg/L.
C. For an online system, complete two tests at the maximum hydraulic operating rate. Utilizing clean water, the tests will be operated with initial sediment loading at 50% and 100% of the unit's capture capacity. These tests will be utilized to check the potential for TSS re-suspension and washout.
D. The test runs should be conducted at a temperature between 73-79 degrees Fahrenheit or colder.

3. Measuring treatment efficiency

A. Calculate the individual removal efficiency for the 15 test runs.
B. Average the three test runs for each operating rate.
C. The average percent removal efficiency will then be multiplied by a specified weight factor (see Table 3) for that particular operating rate.
D. The results of the 5 numbers will then be summed to obtain the theoretical annual TSS load removal efficiency of the system.

Table 3. Weight Factors for Different Treatment Operating Rates

Treatment operating rate	Weight factor
25%	.25
50%	.30
75%	.20
100%	.15
125%	.10

Notes:
Weight factors were based upon the average annual distribution of runoff volumes in New Jersey and the assumed similarity with the distribution of runoff peaks. This runoff volume distribution was based upon accepted computation methods for small storm hydrology and a statistical analysis of 52 years of daily rainfall data at 92 rainfall gages.

5.2.2 Laboratory Testing

To determine the sediment removal efficiency of the unit, samples were collected and analyzed. The results of the sample analysis are summarized in Table 4.

To check for the repeatability of the sampling technique and the sample analysis, two samples were collected from the outflow pipe into the tail tank for 125% of the maximum treatment rate at 300 mg/l sediment concentration. The concentrations of the two samples were 202 and 187 mg/l, about 8% different. About 1 to 2 percent of this difference can be due to sample handling and the test procedure (see Method B of ASTM D3977-97). The rest is due to the sampling technique from the outflow pipe into the tail tank.

Table 4. Test Results Obtained from the Samples Collected from the Outflow into the Tail Tank

Target Concentration (mg/l)	Actual Flow (%)	Feed Concentration[1] (mg/l)	RW Concentration (mg/l)	Total Influent Concentration (mg/l)	Effluent Concentration (mg/l)	Removal Efficiency (%)	Average Removal Efficiency	Weight Factor
100	26.3	85.6	33.5	119.1	37.4	69		
100	26.3	85.6	33.5	119.1	31.3	74		
200	25.9	195.1	17.9	213.0	79.0	63		
300	25.9	280.9	17.9	298.8	112.2	62	66%	0.25
100	50.6	91.3	17.9	109.2	65.7	40		
200	50.6	201.2	17.9	219.1	89.9	59		
300	50.6	304.4	33.5	337.9	150.3	56		
300	50.6	304.4	33.5	337.9	154.2	54	51%	0.3
100	74.2	102.9	17.9	120.8	54.1	55		
200	77.2	196.8	17.9	214.7	125.4	42		
300	77.2	293.8	17.9	311.7	156.0	50	49%	0.2
100	100.1	101.4	17.9	119.3	58.1	51		
200	100.6	199.7	33.5	233.2	174.0	25		
200	100.6	199.7	33.5	233.2	175.8	25		
300	100.1	301.7	17.9	319.6	186.4	42	38%	0.15
100	122.8	99.9	17.9	117.8	77.2	34		
200	117.8	212.6	17.9	230.5	134.8	42		
300	117.8	315.9	17.9	333.8	202.3	39		
300	117.8	315.9	17.9	333.8	186.9	44	39%	0.1
% Removal							51%	

[1]Calculated from the mass feed rate of sediment and the actual flow rate

Three out of 16 samples obtained from the tail tank gave erroneous results. Only the sources of error of the sample with 300 mg/l concentration at 50% of the maximum treatment rate were identified. Therefore, those three tests were repeated (25%- 100 mg/l; 50%- 300 mg/l; and 100%- 200 mg/l), and for each test two new samples were collected from the outflow pipe into the tail tank. The Mississippi River sediment concentration for these three repeated tests was 33.5 mg/l.

Referring to Table 5, the average sediment removal efficiency, after applying the weight factors, became 51% for the sediment size distributions shown in Figure 4.

For re-suspension tests, the manholes were manually filled with sediment at 50% and 100% capacity. The river water was sampled to give the amount of suspended sediment before the re-suspension of the sediments in the manholes. The re-suspension tests were conducted under the maximum hydraulic rate, which was measured by the sharp crested weir to be 7.6 cfs. For each test a 1 gallon sample of water was collected in the tail tank. The results of the sample analysis are given in Table 5. The re-suspension concentrations at maximum hydraulic rate and at 50% and 100% capacity were 11 and 16 mg/l, respectively. The sediment concentration in the river has been considered in the calculation. For example, the average river water (RW) sediment concentration of the 2 runs is 4.33 mg/l. The sediment concentration of the 50% capacity 15.21 mg/l is obtained by dividing the weight of sediment (56.0 mg) by the volume of sample (3.68164 liters). Then, the 4.33 mg/l background concentration is subtracted to have the value shown in Table 5.

Table 5. Re-suspension Test Results

Capacity (%)	Weight of sample (g)			Weight of sample (g)			Concentration (mg/l)
	Gross	Tare	Net	Gross	Tare	Net	
RW	359.87	36.37	323.5	48.8116	48.8099	0.0017	5.26
RW	418.89	37.1	381.79	48.88	48.8787	0.0013	3.41
50	4087.20	405.56	3681.64			0.0560	10.88
100	3378.32	111.21	3267.11			0.0648	15.50

5.3 Inspection and Maintenance

The BaySaver Separation System requires minimal routine maintenance. However, since manholes receive and trap debris and sediment, periodical inspection for clogging and excessive debris and sediment accumulation is needed on a quarterly basis. The system needs to be cleaned, when necessary, to ensure optimum performance, typically every 12 months. The rate at which the system collects pollutants will depend more on site activities than the size of the unit, i.e., heavy winter sanding will cause the manhole to fill more quickly but regular sweeping will slow accumulation.

5.3.1 Inspection

Inspection is the key to effective maintenance and it is easily performed. BaySaver Technologies, Inc. recommends ongoing quarterly inspections of accumulated pollutants. Sediment accumulation may be especially variable during the first year after installation as construction disturbances and landscaping stabilizes. Quarterly inspections are typically sufficient to ensure that systems are cleaned out at the appropriate time. Inspections may need to be performed more often in the winter months in climates where sanding operations may lead to rapid accumulations or in other areas with heavy sediment loading. It is very useful to keep a record of each inspection.

The BaySaver Separation System should be cleaned when inspection reveals that 2 feet (0.6 meters) of sediment is accumulated at the bottom of either manhole or when visual inspection shows a large accumulation of debris or oil. This determination of sediment depth can be made by lowering a pole into the manhole until it hits the sediment and measuring the distance from the bottom of the pole to the water line mark on the pole. If this is less than 6 feet (1.8 meters), the system needs to be cleaned.

Note: To avoid underestimating the volume of sediment in the manholes, the measuring device must be lowered to the top of the sediment pile carefully. Finer, silty particles at the top of the pile may offer less resistance to the end of the rod than larger particles toward the bottom of the pile.

5.3.2 Maintenance

Maintaining the BaySaver Separation System is easiest when there is no flow entering the system. For this reason it is a good idea to schedule the cleanout during dry weather. Cleanout of the BaySaver Separation System with a vacuum truck is generally the most effective and convenient method of excavating all water, sediment, and debris in the manholes.

Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. In BaySaver Separation System installations where there is little risk of petroleum spills, liquid contaminants may not accumulate as quickly as sediment. However, any oil or gasoline spill should be cleaned out immediately. Trash can be netted out if it needs to be separated from the other pollutants.

Manhole covers should be securely seated following cleaning activities, to ensure that surface runoff does not leak into the unit from above.

5.3.3 Solids Disposal

Solids recovered from the BaySaver Separation System can typically be land filled or disposed of at an approved facility. Local regulations may prohibit the discharge of solid material into the sanitary sewer system. Check with the local sewer authority for permission to discharge the liquid. Many places treat the pollutants as leachate. Check with local regulators about disposal requirements.

5.3.4 Damage Due to Lack of Maintenance

It is unlikely that the BaySaver Separation System will become damaged due to lack of maintenance since there are no fragile internal parts. However, adhering to a regular maintenance plan ensures optimal performance of the system.

6. Technical Evaluation Analysis

6.1 Verification of Performance Claims

Based on the evaluation of the results from laboratory studies, sufficient data is available to support the BaySaver Separation System Claim: The BaySaver Separator Model 1K provides 51% Suspended-Sediment Concentration (SSC) removal efficiency (as per NJDEP treatment efficiency calculation methodology) for laboratory simulated stormwater runoff with an average influent concentration of 205 mg/L and an average d_{50} particle size of 85 microns. SSC removal testing was conducted with sediment pre-loaded in the lower chamber to 50% sediment capacity for the 1K unit.

6.2 Limitations

6.2.1 Factors Causing Under-Performance

If the BaySaver Separation System is designed and installed correctly, there is minimal possibility of failure. There are no moving parts to bind or break, nor are there parts that are particularly susceptible to wear or corrosion. Lack of maintenance may cause the system to operate at a reduced efficiency, and it is possible that eventually the system will become totally filled with sediment.

6.2.2 Pollutant Transformation and Release

The BaySaver Separation System will not increase the net pollutant load to the downstream environment. However, pollutants may be transformed within the unit. For example, organic matter may decompose and release nitrogen in the form of nitrogen gas or nitrate. These processes are similar to those in wetlands but probably occur at slower rates in the BaySaver Separation System due to the absence of light and mixing by wind, thermal inputs and biological activity. Accumulated sediment will not be lost from the system under normal operating conditions.

6.2.3 Sensitivity to Heavy Sediment Loading

The BaySaver Separation System requires no pretreatment. Heavy loads of sediment will increase the needed maintenance frequency.

6.2.4 Bypass Flow

The BaySaver Separation System has been designed for operating rates up to 100 cfs (44,850 gpm). Flow rates exceeding the treatment flow capacity of the system may cause re-suspension of previously captured material. The flow is designed to route peak flow through the separator and bypass the storage manhole to the downstream sewer.

6.2.5 Mosquitoes

The BaySaver Technologies, Inc. Separation System design incorporates standing water in the manholes, which can be a breeding site for mosquitoes.

7. Net Environmental Benefit

The NJDEP encourages the development of innovative environmental technologies (IET) and has established a performance partnership between their verification/certification process and NJCAT's third party independent technology verification program. NJDEP, in the IET data and technology verification/certification process, will work with any company that can demonstrate a net beneficial effect (NBE) irrespective of the operational status, class or stage of an IET. The NBE is calculated as a mass balance of the IET in terms of its inputs of raw materials, water and energy use and its outputs of air emissions, wastewater discharges, and solid waste residues. Overall the IET should demonstrate a significant reduction of the impacts to the environment when compared to baseline conditions for the same or equivalent inputs and outputs.

Once BaySaver Separation Systems have been verified and certified for interim use within the State of New Jersey, BaySaver Technologies, Inc. will then proceed to install and monitor systems in the field for the purpose of achieving goals set by the Tier II Protocol and final certification. At that time a net environmental benefit evaluation will be completed. However, it should be noted that the BaySaver Separation System requires no input of raw material, has no moving parts, and therefore, uses no water or energy.

8. References

BaySaver Technologies, Inc. (2004) BaySaver Separation System Installation Instructions.

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