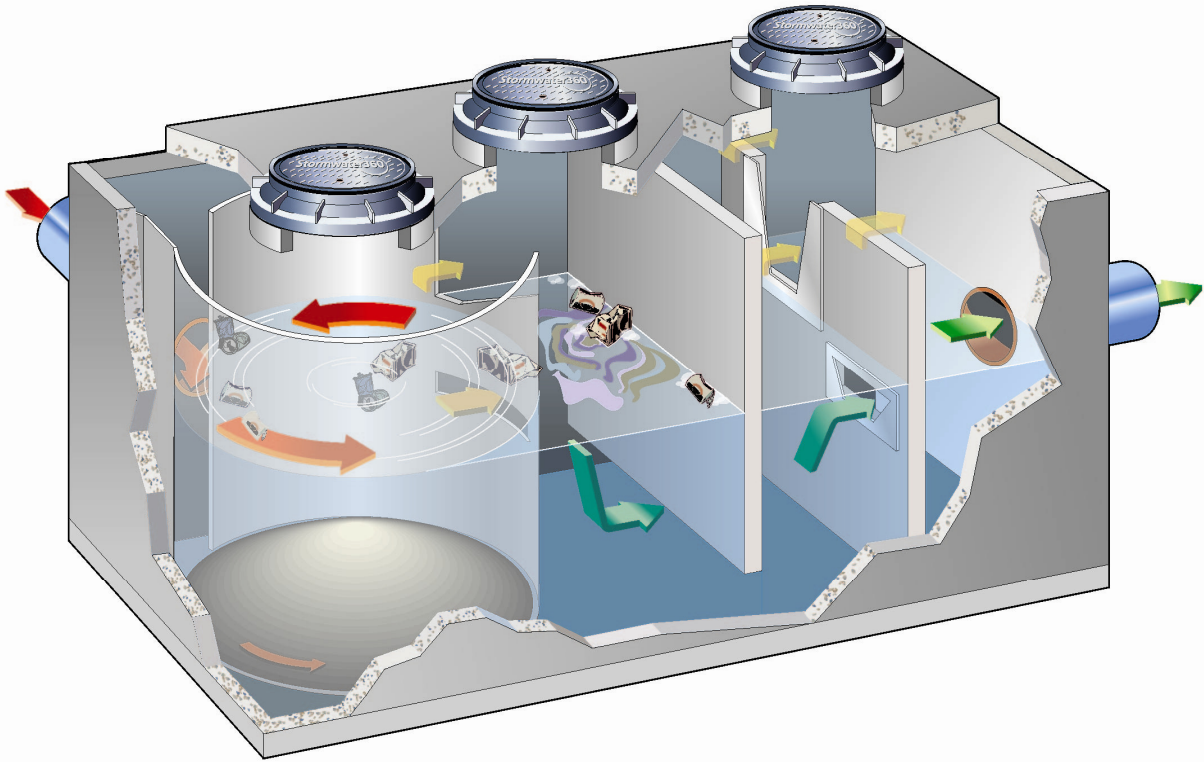


# Vortechs<sup>®</sup> System



## Technical Design Manual

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## **Vortechs System Contents**

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## Design and Operation

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### Basic Operation

The Vortechs<sup>®</sup> System is a hydrodynamic separator designed to enhance gravitational separation of floating and settling materials from stormwater flows. Stormwater flows enter the unit tangentially to the grit chamber, which promotes a gentle swirling motion. As polluted water circles within the grit chamber, pollutants migrate toward the center of the unit where velocities are the lowest. The majority of settleable solids are left behind as stormwater exits the grit chamber through two apertures on the perimeter of the chamber. Next, buoyant debris and oil and grease are separated from water flowing under the baffle wall due to their relatively low specific gravity. As stormwater exits the System through the flow control wall and ultimately through the outlet pipe, it is relatively free of floating and settling pollutants.

Over time a conical pile tends to accumulate in the center of the unit containing sediment and associated metals, nutrients, hydrocarbons and other pollutants. Floating debris and oil and grease form a floating layer trapped in front of the baffle wall. Accumulation of these pollutants can easily be accessed through manholes over each chamber. Maintenance is typically performed through the manhole over the grit chamber.

### Design Process

The Vortechs is typically sized to reduce the TSS concentration by a specific percentage at the water quality flow rate.

#### **Water Quality Flow Rate Method**

Stormwater360 typically selects the system that will provide an 80% annual TSS load reduction based on laboratory generated performance curves for 50-micron, 100-micron and 150-micron sediment particles. It can also be used to estimate annual hydrocarbon load reductions.

In many cases, a specific water quality design flow rate is required to be treated as a benchmark performance objective that will result in a system sized to meet a longer term performance objective. In many cases this water quality flow rate (WQQ) represents the peak flow rate from an event with a specific recurrence interval (i.e. the three-month storm) or it may represent the peak flow rate associated with a water quality depth (i.e. 10mm etc).

Once a System size is established, the internal elements of the System will be designed based on information provided by the site engineer. Flow control sizes and shapes, sump depth, spill storage capacity, sediment storage volume and inlet and outlet orientation are determined for each System. In addition, bypass weir calculations are made for off-line Systems.

### Flow Control Calculations

#### **The Orifice**

The lower flow control or “orifice” is typically sized to submerge the inlet pipe when the Vortechs System is operating at 20% of its’ treatment capacity. The orifice is typically a Cippoletti shaped aperture defined by its flat crest and sides which incline outwardly at a slope of 1 horizontal to 4 vertical.

$$\square \text{ Flow through orifice} = Q_{\text{orf}} = C_d \cdot A \cdot (2gh)^{0.5}$$

Where  $C_d$  = Orifice contraction coefficient = 0.56 (based on Stormwater360laboratory testing)

$A$  = Orifice flow area,  $\text{ft}^2$  (calculated by Stormwater360technical staff)

$h$  = Design head, ft (equal to the inlet pipe diameter)

The minimum orifice crest length is 3-inches and the minimum orifice height is 4-inches. If flow must be restricted beyond what can be provided by this size aperture, a Fluidic-Amp<sup>™</sup> hydro-brake flow control will be used. The

hydro-brake allows the minimum flow constriction to remain at 3-inches or greater while further reducing flow due to its unique throttling action.

### **The Weir**

The high flow control or “weir” is sized to pass the peak System capacity minus the peak orifice flow when the water surface elevation is at the top of the weir. This flow control is also a Cippoletti type weir.

The weir flow control is sized by solving for the crest length and head in the following equation:

$$\square \text{ Flow through weir} = Q_{\text{weir}} = C_d \cdot L \cdot (h)^{1.5}$$

Where  $C_d$  = Cippoletti Weir coefficient = 3.37 (based on Stormwater360laboratory testing)

$h$  = Available head, ft (height of weir)

$L$  = Design weir crest length, ft (calculated by Stormwater360technical staff)

### **Bypass Calculations**

In some cases, pollutant removal goals can be met without treating peak flow rates and it is most feasible to use a smaller Vortechs System configured with an external bypass. In such cases, a bypass design is recommended by Stormwater360for each off-line System. To calculate the bypass capacity, first subtract the System’s treatment capacity from the peak conveyance capacity of the collection system (minimum of 10 year recurrence interval). The result is the flow rate that must be bypassed to avoid surcharging the Vortechs System. Then use the following arrangement of the Francis formula to calculate the depth of flow over the bypass weir.

$$\square \text{ Flow over bypass weir} = H = (Q_{\text{bypass}} / (C_d \cdot L))^{2/3}$$

Where

$C_d$  = Discharge Coefficient = 3.3 for rectangular weir

$H$  = Depth of flow over bypass weir crest, ft

$L$  = Length of bypass weir crest, ft

The bypass weir crest elevation is then calculated to be the elevation at the top of the Cippoletti weir minus the depth of flow.

### **Hydraulic Capacity**

In the event that the peak design flow from the site is exceeded, it is important that the Vortechs System is not a constriction to runoff leaving the site. Therefore, each System is designed with enough hydraulic capacity to pass the 100-year flow rate. It is important to note that at operating rates above 68L/s of the grit chamber area (peak *treatment* capacity), captured pollutants may be lost.

When the System is operating at peak *hydraulic* capacity, water will be flowing through the gap over the top of the flow control wall as well as the orifice and the weir.

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## Maintenance

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The Vortechs System should be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more heavily on site activities than the size of the unit, e.g., unstable soils (construction sites) will cause the grit chamber to fill more quickly but regular sweeping will slow accumulation.

### Inspection

Inspection is the key to effective maintenance and is easily performed. Stormwater360 recommends ongoing quarterly inspections of the accumulated sediment. Pollutant deposition and transport may vary from year to year and quarterly inspections will help insure that systems are cleaned out at the appropriate time. It is very useful to keep a record of each inspection. A simple form for doing so is provided.

The Vortechs System should be cleaned when inspection reveals that the sediment depth has accumulated to within 150mm of the dry-weather water surface elevation. This determination can be made by taking 2 measurements with a stadia rod or similar measuring device; one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. The System should be cleaned out if the difference between the two measurements is 150mm or less. **Note:** to avoid underestimating the volume of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Finer, silty particles at the top of the pile typically offer less resistance to the end of the rod than larger particles toward the bottom of the pile.

### Cleaning

Maintaining the Vortechs 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 Vortechs system with a vacuum truck is generally the most effective and convenient method of excavating pollutants from the system. If such a truck is not available, a "clamshell" grab may be used, but it is difficult to remove all accumulated pollutants with such devices.

In installations where the risk of large petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, an oil or gasoline spill should be cleaned out immediately. Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use adsorbent pads since they are usually cheaper to dispose of than the oil water emulsion that may be created by vacuuming the oily layer. Trash can be netted out if you wish to separate it from the other pollutants.

Accumulated sediment is typically evacuated through the manhole over the grit chamber. Simply remove the cover and insert the vacuum hose into the grit chamber. As water is evacuated, the water level outside of the grit chamber will drop to the same level as the crest of the lower aperture of the grit chamber. It will not drop below this level due to the fact that the bottom and sides of the grit chamber are sealed to the tank floor and walls. This "Water Lock" feature prevents water from migrating into the grit chamber, exposing the bottom of the baffle wall. Floating pollutants will decant into the grit chamber as the water level there is drawn down. This allows most floating material to be withdrawn from the same access point above the grit chamber.

If maintenance is not performed as recommended, sediment may accumulate outside the grit chamber. If this is the case, it may be necessary to pump out all chambers. It is a good idea to check for accumulation in all chambers during each maintenance event to prevent sediment build up there.

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

## Vortechs System Inspection & Maintenance Log – Sample

Model: 5000			Location: Smith Superstores, Sydney		
Date	Water Depth to Sediment <sup>1</sup>	Floatable Layer Thickness <sup>2</sup>	Maintenance Performed	Maintenance Personnel	Comments
12/1/01	900	0	N/A	B. Johnson	Installed
3/1/02	700	Sheen	None	B. Johnson	Swept parking lot
6/1/02	600	Heavy Sheen	None		
9/1/02	500	25	Sorbent pads deployed to remove captured oil	S. Riley	Oil spill
12/1/02	300	Sheen	None	S. Riley	
4/1/03	150	10	Clean-out scheduled	S. Riley	Heavy floating debris
4/15/03	900	0	Grit Chamber evacuated	ACE Environmental Services	Cleanout completed
<b>SAMPLE SHEET</b>					

1. The water depth to sediment is determined by taking two measurements with a stadia rod: one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. When the difference between the two measurements is 150mm or less, the system should be cleaned out.
2. For optimum performance, the system should be cleaned out when the floating hydrocarbon layer accumulates to an appreciable thickness. In the event of a spill, the system should be cleaned immediately.

## Vortechs System Inspection & Maintenance Log

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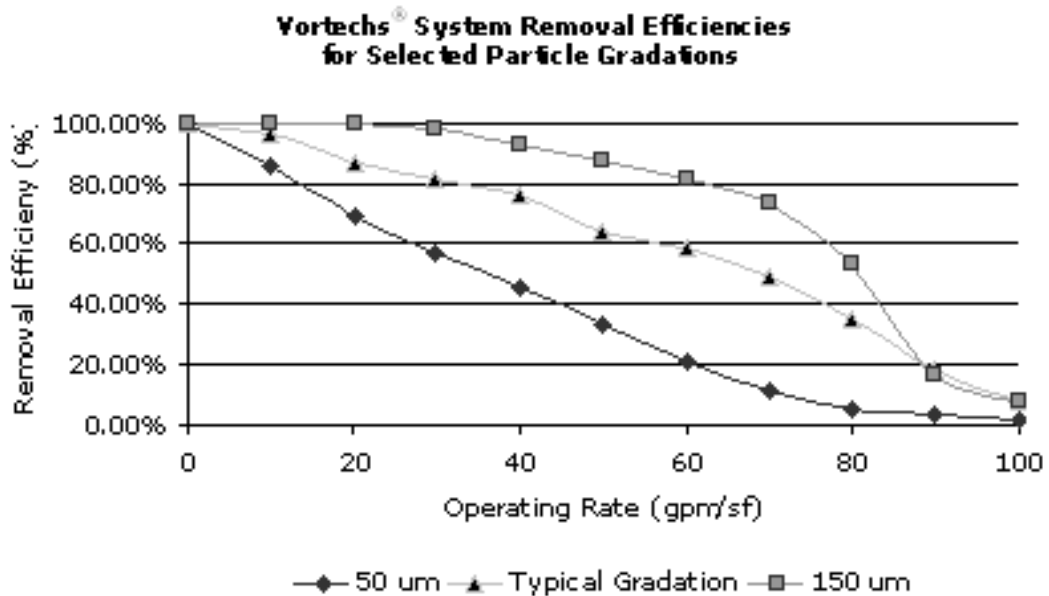
# Laboratory and Field Testing

## Introduction

Stormwater360 is an established leader in the stormwater treatment industry, marketing the Vortechs Stormwater Treatment System as a technology capable of removing a high percentage of floating and settling pollutants from stormwater flows. Extensive testing in both the laboratory and in the field has produced a comprehensive set of data describing the relationship between flow rate, particle size, and removal efficiency.

Sections 1 and 2 contain the results of laboratory and field-testing. Section 1 shows the results of full-scale testing with a Vortechs Model 2000 at a CONTECH Stormwater Solutions laboratory in Portland, Maine. Section 2 includes long term monitoring results from several Vortechs Systems installed on typical projects.

Figure 1. Laboratory Testing - Vortechs Stormwater Treatment System



### Performance

These performance curves are based on laboratory tests using a full scale Vortechs Model 2000. The testing protocol used is described on the following pages. The 150-micron curve demonstrates the results of tests using particles that passed through a 100-mesh sieve and were retained on a 150-mesh sieve. The 50-micron curve is based on tests of particles passing through a 200-mesh sieve and retained on a 400-mesh sieve. A slurry representing an average stormwater sediment gradation, with the particle size gradation shown in table 1 page 9, was also tested in our laboratory.

As the graph clearly shows, Vortechs Systems maintain positive total suspended solids (TSS) removal efficiencies over the full range of operating rates, allowing the system to effectively treat all runoff from large infrequent design storms as well as runoff from the more frequent low intensity storms. Precast Vortechs Systems are designed to treat peak flows from 45L/s up to 708L/s without bypassing. Peak flows that exceed rated treatment capacities can be conveyed around the system with an external bypass. Internal bypasses can be configured to direct low flows from the last chamber of the Vortechs system to polishing treatment when more stringent water quality standards are imposed. In all configurations, high removal efficiencies are achieved during the lower intensity storms, which constitute the majority of annual rainfall volume.



## Laboratory Quality Control Brief

The following protocol summarizes standard operating procedures for Total Suspended Solids (TSS) testing in the CONTECH Stormwater Solutions Laboratory. These guidelines were followed in the creation of the preceding performance curves.

### ***Sediment Source***

Sediment samples are sorted according to ASTM Special Technical Publication 477 B, which establishes sieve analysis procedures. U.S. Standard Sieves in a Gilson SS-15 sieve shaker are used to separate particles to the various fractions required for our tests. To ensure uniformity of those fractions, an unsorted sample is sieved until less than 1% of that sample passes through the sieve in one minute. All sediment recovered after a test is dried and sent back through a sieve before reuse. Unless otherwise specified, mineral sediments with a density of 2.65 g/cm<sup>3</sup> are used.

The following table describes the particle size distribution of samples tested by CONTECH Stormwater Solutions to represent TSS Loading in typical urban runoff.

Table 1.	
Particle Size Distribution	Percentage of Sample Make-up
< 63 mm	42%
63 – 75 mm	4%
75 – 100 mm	9%
100 – 150 mm	7%
150 – 250 mm	11%
> 250 mm	27%

### ***Flow Calibration and Regulation***

Flow calibration is accomplished by calculating the head at the baffle wall required to produce a given flow rate through the orifice and the weir in the flow control wall. Flow is regulated by a 300mm butterfly valve located upstream of the Vortechs system. In order to simulate field conditions, flow rates are changed gradually to avoid flow surges through the system. The test flow rate is set by observing the head in the Vortechs system and adjusting the regulating valve accordingly. Before any samples are collected, the valve must remain fixed for a period equal to half of the detention time so that flow equalizes throughout the system. Each test group is planned so that flow rates increase incrementally in consecutive tests.

### ***Sediment Metering***

All sediment is injected into the inlet pipe via a 6mm flexible hose using a Watson Marlow 5058 peristaltic metering pump. For TSS tests, a known gradation of sediment and water are combined in approximately a 1/2 pound/gallon ratio in a holding tank and homogenized by a mixing propeller powered by a 1/3 horsepower motor. The mixer is activated at least 5 minutes before testing commences and runs continuously throughout the test. The metering pump is activated for a period of time equal to at least half of the detention time of the Vortechs

system at the test flow rate, before the first influent sample is taken. The pump must run continuously until the last effluent sample is taken.

### **Sample Collection**

All influent samples are taken from a 150mm gate valve located upstream of the Vortechs system. A collection bin housing a 500 mL sample container is positioned beneath the valve. Five seconds before each sample is taken the valve is quickly opened and closed to eliminate any interference from particles that have settled in the low velocity region of the gate. This eliminates artificially high influent readings. The time that the influent sample was taken is recorded and the corresponding effluent sample is collected after a period of time equal to the detention time. Effluent grab samples are collected at the discharge pipe, by sweeping the mouth of a 500 mL bottle through the exiting flow stream. Samples are annotated and refrigerated until they can be analyzed.

### **Sample Analysis**

TSS samples are analyzed in the Stormwater360 laboratory, following EPA method 160.2, a method for the measurement of total non-filterable solids. Volume measurements are accurate to 0.6 mL using a 500 mL graduated cylinder and an Acculab V-1 analytical balance with a readability of 0.001 g is used to measure mass.

## **Field Testing - Vortechs System Field Monitoring Summary**

Stormwater360 has become a leader in the stormwater industry in large part because of the company's unwavering long-term commitment to research and development. In addition to performing their own field tests, Stormwater360 has diligently pursued opportunities to work with third party organizations to test their products. In fact, the Vortechs system has been subjected to the most comprehensive third party testing in the industry. These independent studies have allowed Stormwater360 to corroborate their lab and field data to ensure that actual performance of the Vortechs system matches their claims.

**Following are brief summaries of the field tests completed to date. Please contact Stormwater360 for the full reports. In addition, all reports are available for download on Stormwater360 web site at [www.stormwater360.com.au](http://www.stormwater360.com.au).**

### **DeLorme Mapping Company - Yarmouth, ME CONTECH Stormwater Solutions**

Prior to this premier field test of the Vortechs system, Stormwater360 developed an extensive body of laboratory data to document total suspended solids (TSS) removal efficiency. Stormwater360 performed this field study in order to compare the performance predicted using laboratory data to the performance of a correctly sized system in the field.

The study site was the headquarters of DeLorme Mapping in Yarmouth, Maine. The building, driveway, parking lot and ancillary facilities were constructed in 1996. A Vortechs Model 11000 was installed to treat runoff from the 300-space, 4-acre parking lot.

<b>Testing Period</b>	May 1999 to Dec. 1999
<b># of Storms Sampled</b>	20
<b>Mean Influent Concentration</b>	328 mg/L

<b>Mean Effluent Concentration</b>	60 mg/L
<b>Removal Efficiency</b>	82%

The main purpose of the DeLorme study was to verify that the sizing methodology developed from our full-scale laboratory testing was valid and an accurate means of predicting field performance. The results of the study confirmed our sizing methodology.

**Village Marine Drainage - Lake George, NY**  
**New York State Department of Environmental Conservation, Division of Water**

The New York State DEC used funds obtained in a Section 319 grant to initiate a study of the effectiveness of the Vortechs system to remove sediment and other pollutants transported by stormwater to Lake George, Lake George Village, New York. "Since the 1970s, when there was a rapid increase in the rate and concentration of development along the southwestern shores of Lake George, we have been concerned about the impact of stormwater discharges into the lake," said Tracy West, co-author of the study.

<b>Testing Period</b>	Feb. 2000 to Dec. 2000
<b># of Storms Sampled</b>	13
<b>Mean Influent Concentration</b>	801 mg/L
<b>Mean Effluent Concentration</b>	105 mg/L
<b>Removal Efficiency</b>	88%

The study concluded that the Village and Town of Lake George should consider installing additional Vortechs Systems in areas where sedimentation and erosion have been identified as non-point source pollution problems.

**Harding Township Rest Area - Harding Township, NJ**  
**RTP Environmental Associates**

This third party evaluation was performed under a U.S. Environmental Protection Agency grant, administered by the New Jersey Department of Environmental Protection. A. Roger Greenway, principal of RTP Environmental Associates, Inc., conducted the study in conjunction with Thonet Associates, which assisted with data analysis and helped develop best management practices (BMP) recommendations.

The Vortechs Model 4000 was sized to handle a 100-year storm from the three-acre paved parking area at the Harding Rest Stop, located off the northbound lane of I-287 in Harding Township, New Jersey.

<b>Testing Period</b>	May 1999 to Nov. 2000
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<b># of Storms Sampled</b>	5
<b>Mean Influent Concentration (TSS)</b>	493 mg/L
<b>Mean Effluent Concentration (TSS)</b>	35 mg/L
<b>Removal Efficiency (TSS)</b>	93%
<b>Mean Influent Concentration (TPH)</b>	16 mg/L
<b>Mean Effluent Concentration (TPH)</b>	5 mg/L
<b>Removal Efficiency (TPH)</b>	67%

The study concluded that truck rest stops and similar parking areas would benefit from installing stormwater treatment systems to mitigate the water quality impacts associated with stormwater runoff from these sites.

**Timothy Edwards Middle School - South Windsor, CT**  
**UCONN Department of Civil & Environmental Engineering**

Susan Mary Board published this study of the Vortechs system as a thesis as part of the requirements for a Master of Science degree from the University of Connecticut. Her objective was to determine how well the Vortechs system retained pollutants from parking lot runoff, including total suspended solids (TSS), nutrients, metals, and petroleum hydrocarbons.

A Vortechs Model 5000 was installed in 1998 to treat runoff from the 82-space parking lot of Timothy Edwards Middle School. The entire watershed was approximately 2 acres, and was 80% impervious.

<b>Testing Period</b>	July 2000 to April 2001
<b># of Storms Sampled</b>	Weekly composite samples taken
<b>Mean Influent Concentration</b>	324 mg/L
<b>Mean Effluent Concentration</b>	73 mg/L
<b>Removal Efficiency</b>	77%

Additionally, the Vortechs system was particularly effective in removing zinc (85%), lead (46%), copper (56%), phosphorus (67%) and nitrate (54%).

The study concluded that the Vortechs Stormwater Treatment system significantly reduced effluent concentrations of many pollutants in stormwater runoff.