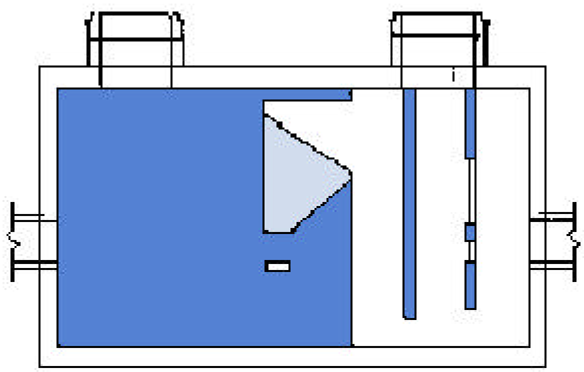
FINAL REPORT

A Study of the Effectiveness of a Vortechs™ Stormwater Treatment System for Removal of Total Suspended Solids and Other Pollutants in the Marine Village Watershed, Village of Lake George, New York



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Disclaimer

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Abstract

Aerial photographs indicate that a significant increase in the size of stream deltas in Lake George has occurred over the past 50 years, an increase that greatly exceeds the normal rate of geologic and hydrologic processes. The 1983 National Urban Runoff Program (NURP) concluded that Lake George would be directly affected by the rapid rate of commercial and residential development along its shorelines, resulting in water quality decline. In an effort to reduce in-Lake sedimentation, a Vortechs™ Stormwater Treatment System was installed in a 3.78-hectare subcatchment in the Village of Lake George in 1997. The Vortechs™ System is a concrete, underground structure comprised of three chambers – an initial grit chamber that concentrates and deposits sediments, an oil chamber and baffle wall that traps floatables, and a flow control chamber. The current study evaluates the effectiveness of the Vortechs™ System in removing sediment and other pollutants from stormwater runoff. The pollutants requiring evaluation under the SPDES General Permit 93-06 include total suspended solids, total phosphorus, total nitrogen and biological oxygen demand. In addition, specific conductance and fecal coliform bacteria are being monitored. Samples collected from the inflow and outflow of the Vortechs™ System during different types of events are compared. The purpose of this study is to define, more specifically, the Vortechs™ System's performance and efficiency in removing different pollutants over a range of different types of storm events.

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Acknowledgements

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Mayor Robert M. Blais and the Village of Lake George Trustees for their foresight, stewardship and considerable effort in implementing a stormwater management plan for the Marine Village watershed. These same individuals were instrumental in getting the monitoring station installed near the Lake George Junior-Senior High School and the Village continues to pay for the electric power that operates the station.

Robert Bombard from the New York State Department of Environmental Conservation directed the installation of monitoring equipment at the site and provided upkeep at the station, lab assistance, and guidance.

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Vaikko Allen, an Environmental Scientist for Vortechnics, Inc., provided technical assistance with the study design and rating curve information for the Model 11000 Vortechs™ System installed at Canada Street.

Alexandra Rhodes of C.T. Male Associates, P.C. provided site plan drawings prepared for the installation of the Vortechs™ System.

The administration of the Lake George Junior-Senior High School allowed the station and its equipment to be installed on the property.

Reggie Burlingame, Superintendent of the Village of Lake George Sanitation Department, and his staff provided time and effort with the regular cleanouts of the Vortechs™ System and also allowed access to the Village Wastewater Treatment facility so that inoculums for the biological oxygen demand (BOD) testing could be collected.

Finally, the Lake George Association provided use of the CatchVac to the Village of Lake George to clean the Vortechs™ System.

SECTION I. INTRODUCTION

Lake George is the largest body of water located entirely in the Adirondack Park in New York State. Historically, it is known as the "Queen of American Lakes" for its crystal clear waters and inherent natural beauty, and the Lake has been a tourist attraction since the late 1800's. The construction of the Adirondack Northway, Interstate 87, in the 1960's greatly facilitated travel to the region, and as a result, there was a surge in tourism and recreation in the Lake George region during the early 1970's. The extreme rate and concentration of development along the southwestern shores of Lake George, particularly in Lake George Village, has led to many environmental problems, including high sedimentation rates from streams. As the tourism industry rapidly grew, so did concern for the health of Lake George water quality.

Initiated in 1977, the five-year National Urban Runoff Program (NURP) demonstrated that stormwater discharges from land surfaces contain various pollutants and loading rates depending on land use and climatological factors. Lake George, located in Warren County, New York, was one of the original sites selected for this study (Sutherland et al. 1983). As a result of the NURP Program and other studies, the National Pollutant Discharge Elimination System (NPDES) program was initiated at the national level and delegated to most individual states.

On 1 August 1993, the New York State Department of Environmental Conservation (NYSDEC) issued General Permit GP-93-06 for storm water discharges from construction activities. GP-93-06 requires the preparation of a Storm Water Pollution Prevention Plan that addresses three areas of concern: erosion control during construction, increased volume and rate of runoff after construction, and increased pollutant load and wash off due to the proposed land use changes. The permit requires an applicant to evaluate the impacts of total phosphorus (TP), total nitrogen (TN), biological oxygen demand (BOD), total suspended solids (TSS), and potential thermal changes to receiving water bodies. The results of this evaluation lead to designed mitigation practices to reduce the increased load to acceptable levels.

Environmental concern about non-point sources of pollution and the regulation of these discharges has led to a rapid increase in the number and types of products and systems that are marketed to reduce the impacts from developed areas on water quality. The Vortechs™ Stormwater Treatment System is one of many devices available. In 1997, two separate Vortechs™ Systems were installed in the Village of Lake George as part of a comprehensive stormwater management design that was prepared for a highly urbanized watershed (Marine Village) that drains directly to Lake George.

There are no known independent studies in the northeastern region of the United States that demonstrate the effectiveness of the Vortechs™ System in mitigating the pollutant concerns noted in the SPDES permit system. The manufacturer's literature does discuss the ability of the units to remove sediment over certain ranges of flow as a result of studies conducted in the lab, but similar studies have not been conducted in the field. As in the case of Lake George, many of these units have been installed in urbanized settings to retrofit a site for water quality improvements. However, specific water quality performance evaluation over a range of pollutants is lacking.

During 1998, the NYSDEC Division of Water was awarded a grant from Section 319 (Non-point Source Implementation) funds to evaluate the Vortechs™ System installed adjacent to Canada Street in the Marine Village Watershed. The Warren County Soil and Water Conservation District (WCSWCD) administered the study through a contract with the NYS Department of Agriculture and Markets. The period of the contract for the Study was from 1 April 1999 through 15 May 2000. Due to delays, however, the contract was not executed until August 1999 and sampling did not start until February 2000. The period of the contract was extended until 31 December 2000 so that the sampling objectives of the project could be accomplished.

A monitoring program was established to determine the effectiveness of the Vortechs™ System in removing sediment and other pollutants from stormwater runoff. The pollutants requiring evaluation under the SPDES GP-93-06 include TSS, TP, TN and BOD. In addition, specific conductance (SpC) and fecal coliform bacteria (FC) were monitored. Samples were collected from the inflow and outflow of the Vortechs™ System during different types of events, analyzed for the pollutants identified above, and then compared to each other.

SECTION II. BACKGROUND

Description of Previous Studies in the Marine Village Watershed

The Marine Village watershed was studied intensively in the early 1980's during the Lake George Urban Runoff Study (Sutherland et al., 1983) and again in the early 1990's as part of a Section 314 (Clean Water Act) Phase 2 Implementation Project (Sutherland, 1999) and a Stormwater Retrofitting Project (Hyatt et al., 1995). Results from these studies clearly show that this watershed is a significant contributor of pollutants to Lake George. Of seven watersheds studied during these investigations, Marine Village ranked 3rd or higher based on the total load per unit area of primary runoff pollutants, including total Kjeldahl nitrogen, total phosphorus, lead, chloride, and suspended sediment, to Lake George. The table below summarizes baseflow concentrations, the total load and the load per unit area of major pollutants in the average springtime runoff from the Marine Village watershed. These data are compared with the forested and undeveloped segment of Prospect Mountain Brook west of Interstate 87.

Table 1. Baseflow concentrations, load, and load per unit area of major pollutants in the average springtime runoff from the Marine Village watershed.

	Pollutants				
	TKN	TSS	Cl	Pb	TOTP
Marine Village					
Baseflow	0.23 mg/L	4 mg/L	82 mg/L	7 ìg/L	14 ìg/L
Load	70 kg	31,049 kg	13,155 kg	4,505 g	10,875 g
Load/unit area	28.34 kg/ha	12570.45 kg/ha	5325.91 kg/ha	1823.88 g/ha	4402.83 g/ha
Undeveloped*					
Baseflow	0.11 mg/L	1 mg/L	2 mg/L	5 ìg/L	3 ìg/L
Load	35 kg	2,002 kg	76 kg	127 g	2,839 g
Load/unit area	14.17 kg/ha	810.53 kg/ha	30.77 kg/ha	51.42 g/ha	1149.39 g/ha

* Prospect Mountain Brook west of Interstate 87 used as undeveloped watershed for comparison

Description of Stormwater Management in the Marine Village Watershed

The Village of Lake George retained C.T. Male Associates, P.C. during 1989 to investigate stormwater flooding and pollution within the Marine Village watershed. In 1990, following this investigation, a report entitled *Marine Village Subbasin Stormwater Management Design Report* presented four major components for stormwater management in the Marine Village watershed. Two management structures identified in the report were grit separators to treat street runoff before it enters the main watershed conveyance pipe west of the Lake. Unfortunately, when the report was issued, funding was not available for implementation of the stormwater management recommendations.

In 1993, the Village of Lake George was awarded an Intermodal Surface Transportation Efficiency Act (ISTEA) Program grant from the New York State Department of Transportation (NYSDOT). Funds from the grant were used to implement several components of the Marine Village watershed stormwater runoff management plan. The Vortechs™ System was chosen as the grit separation device to treat stormwater runoff from major transportation corridors in the watershed. Two Vortechs™ Systems were purchased and installed during 1997; one unit adjacent to Ottawa Street, and the other unit adjacent to Canada Street (Route 9).

Description of the Vortechs™ Stormwater Treatment System

The Vortechs™ System is a large capacity, precast concrete structure installed below grade to receive surface runoff. The chambered design of the System combines swirl-concentrator and flow-control technologies to eliminate turbulence. A brief description of the Vortechs™ System features and operation is as follows (also refer to Figure 1):

- Grit chamber (#1) – the swirling motion created by the tangential inlet directs settleable solids towards the center of the chamber. Sediment is caught in the swirling flow path and settles back onto the pile after the storm event is over.
- Oil chamber (#2) and baffle wall – the center baffle traps floatables in the oil chamber.
- Flow control chamber (#3) – the weir and orifice flow controls a) raise level and volume in the System as flow rate increases, and b) gradually drain the System as flow rate subsides.

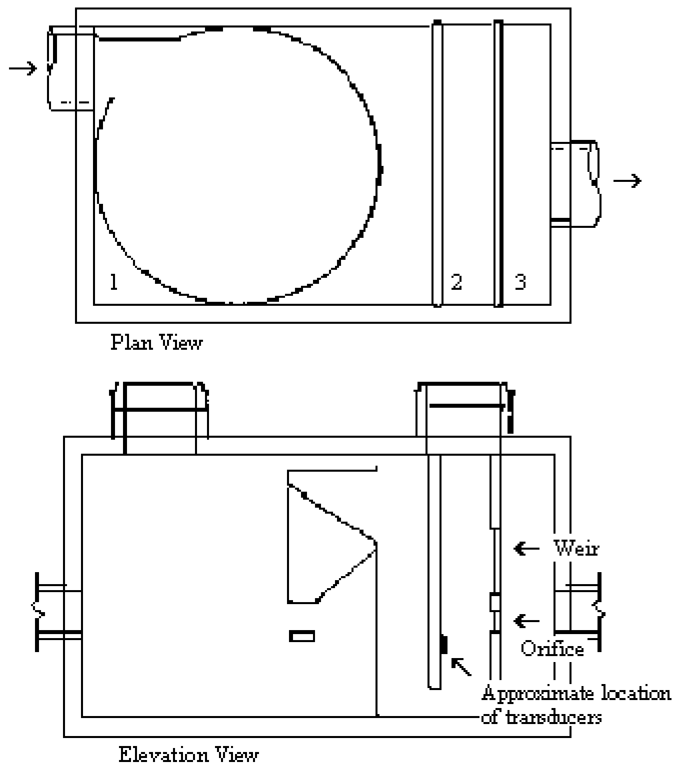
According to the manufacturer's literature, the System is designed to provide 80% TSS removal on a net annual basis.

SECTION III. DESCRIPTION OF THE AREA

Marine Village Watershed

The Marine Village watershed is located on the west side of Lake George near the south end of the Lake and has a surface area of 95.55 hectares (0.96 km^2). About one-half (47 percent) of the watershed is located west of Interstate 87 (Figure 2) and is almost totally forested (Hyatt et al., 1995). The portion of the watershed east of Interstate 87 is about 85 percent developed (urbanized) and has an impervious area of 12.42 ha. Road and highway surfaces, primarily Canada and Ottawa Streets and Interstate 87, cover 6.39 ha in this watershed and comprise about 50 percent of the total impervious area.

Figure 1. Schematic of the Vortechs™ Stormwater Treatment System.



A natural channel conveys runoff from the forested portion of the watershed west of Interstate 87 (Figure 2). This channel has no baseflow during the late summer and early fall of dry years. Flow from the western watershed is directed under Interstate 87 via paved channels and culverts with some detention occurring in a structure that was installed recently between the northbound exit # 22 ramp and the northbound travel lane of Interstate 87. Flow from the Interstate 87 area is directed eastward through culverts that drain the berm of an abandoned railroad right-of-way. Below this point, flow is conveyed in an open swale to the developed portions of the watershed near Jogues Farm Road. Jogues Farm Pond is the only continuous source of flow in the Marine Village system. Once in the developed area, flow from the west combines with flows from the northwest (Jogues Farm Pond) and is carried via culverts directly to Lake George.

Study Area

The Canada Street Vortechs™ Stormwater Treatment System is located on the west side of Canada Street, on property occupied by the Lake George Junior-Senior High School (Figure 3). The main axis of the subwatershed extends in a north-south direction and includes a 670-meter section of Canada Street and adjacent properties that are primarily commercial and residential. The total surface area of the subwatershed draining to the Vortechs™ System is 3.78 hectares; Canada Street comprises 30 percent (1.21 ha) of this total area. Only 5 percent (0.19 ha) of the subwatershed is pervious surface.

The minimum surface elevation in the subwatershed, about 104 m, occurs at the Vortechs™ System site while the maximum elevation, 113 m, occurs at the northern extent of the drainage area, at the intersection of Canada Street and Lake Avenue. The surface elevation along the southern boundary of the subwatershed, south of Amherst Street and west to Ottawa Street, is about 108 m.

The Vortechs™ System installed at the Canada Street site is a Model 11000. Some of the specifications of the Model 11000 are listed below.

Grit Chamber Diameter/Area (m/m²)	Peak Design Flow (m^3/s)	Sediment Storage (m³)	Oil storage (m³)	Approximate Size, L x W (m)
3.1/7.34	0.496	4.21	6.81	4.88 x 3.05

The inlet/outlet configuration of the Vortechs™ System is shown in Figure 1. The side inlet optimizes grit chamber swirling action and is the preferred configuration.

Surface runoff in the subwatershed is collected in a series of drop inlets and culverts along Canada Street and adjacent areas. Subsurface runoff approaching the Vortechs™ System from the north and south is diverted to an interceptor chamber and then routed to the System through a 61 cm HDPE culvert. Runoff leaves the System through a 61 cm HDPE and is discharged to a culvert that carries runoff from the remainder of the Marine Village Watershed.

SECTION IV. METHODOLOGY

A monitoring station established at the site of the Marine Village Storm Sewer in the early 1980's (Lake George NURP Study) and then re-established in 1991 (Lake George Stormwater Management Feasibility Study and Section 319 Monitoring) was used to house the instrumentation for the current study. The station is located adjacent to the Lake George Junior-Senior High School, on the west side of Canada Street, and consists of an insulated fiberglass shelter (Kenco Plastics Company) that has AC power, lighting, and heat. The shelter, 1.37 m wide x 0.76 m deep x 2.13 m high, is situated on a wooden platform about 11 m from the northeast corner of the Vortechs™ System.

Instrumentation

The following equipment was installed at the monitoring station for the Vortechs™ System study:

- A Telog Instruments Inc. Model WLS-2109e Level Tracker equipped with an 1830 series Druck 5.0 psi submersible transducer (strain gauge differential pressure type) with 50 mV output.
- A Keller Psi 5.0 psi submersible transducer (strain gauge differential pressure type) with 4-20 mA output.
- Two Manning Environmental, Inc. 4901 Portable Vacuum Priority Contaminant™ Samplers that collect stormwater runoff samples based either on time or level.

Figure 4 is a schematic diagram of the equipment setup at the monitoring station and the Vortechs™ System. The Druck and Keller Psi submersible transducers were mounted next to each other on the wall of the Vortechs™ System between the Grit Chamber (#1) and the Oil Chamber (#2), facing the wall of the Flow Control Chamber (#3) that contains the weir and orifice (see Figures 1 and 4).

Figure 2. Map of the Marine Village Watershed

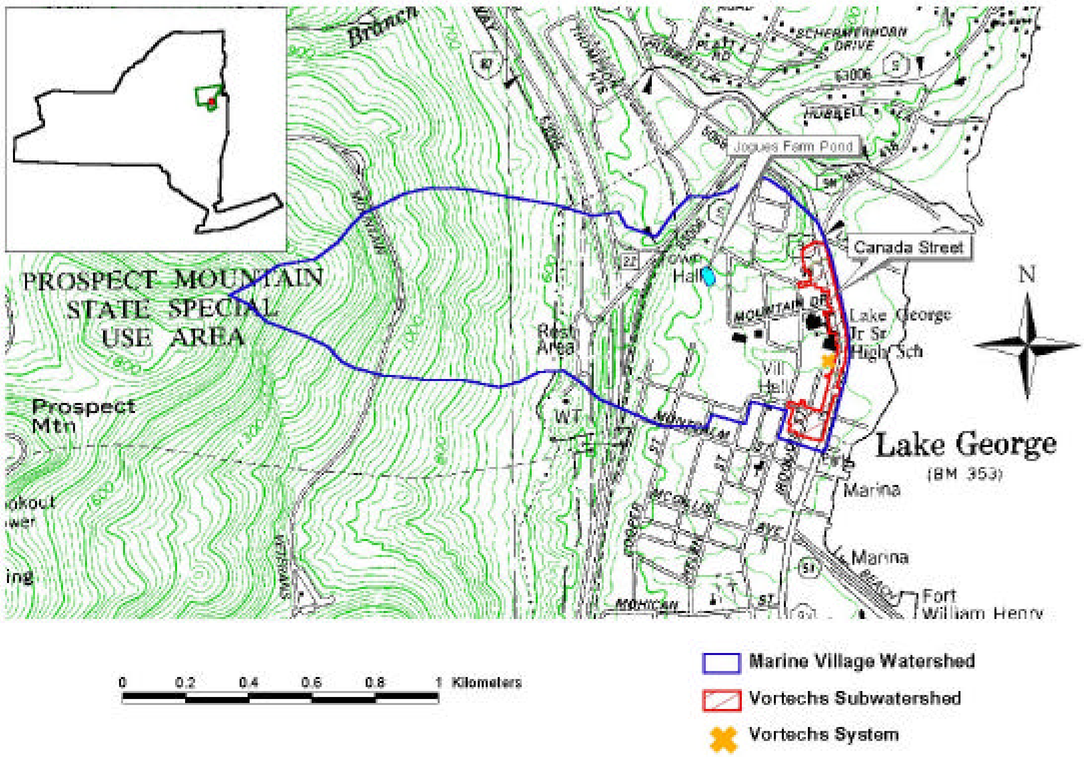
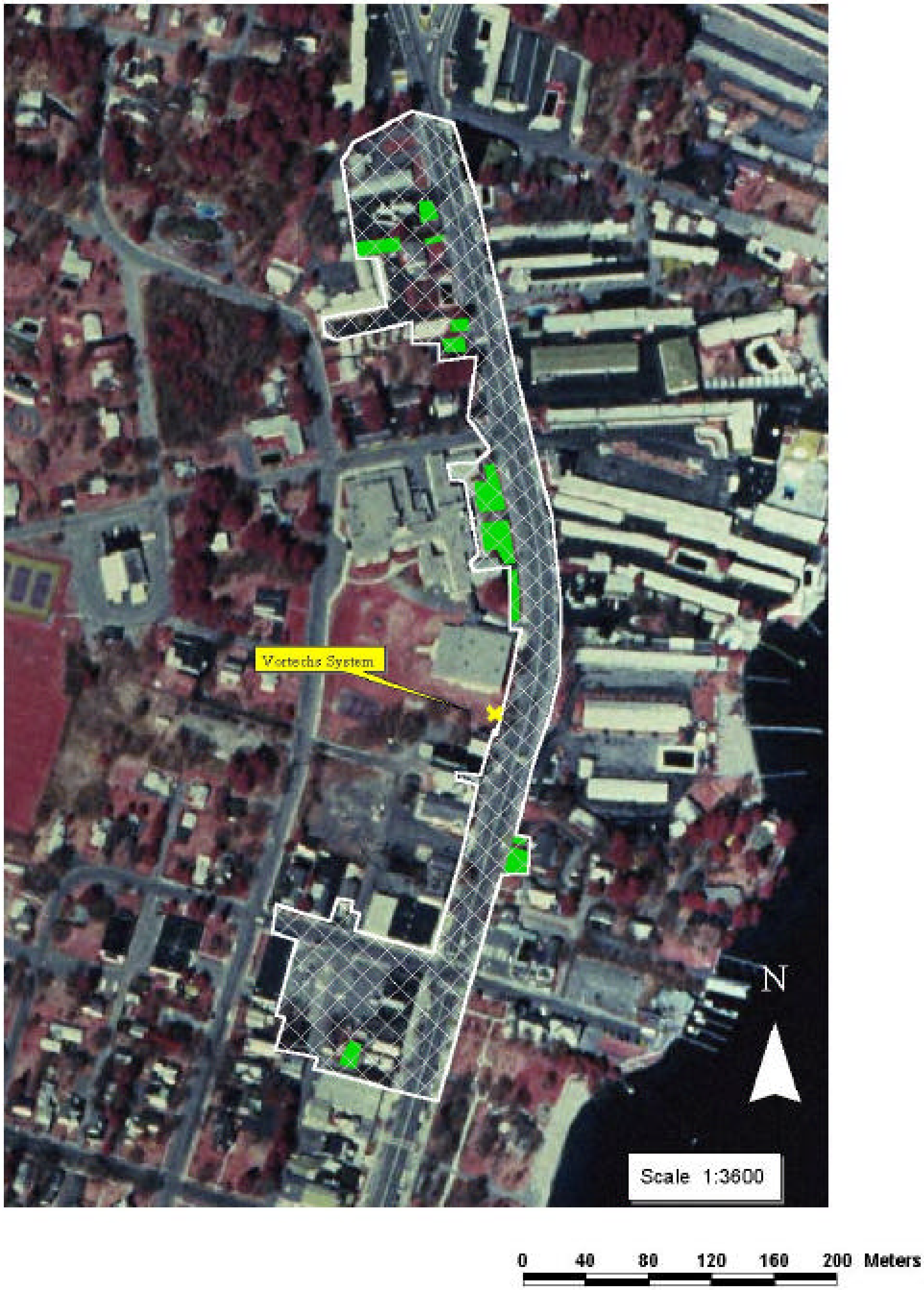
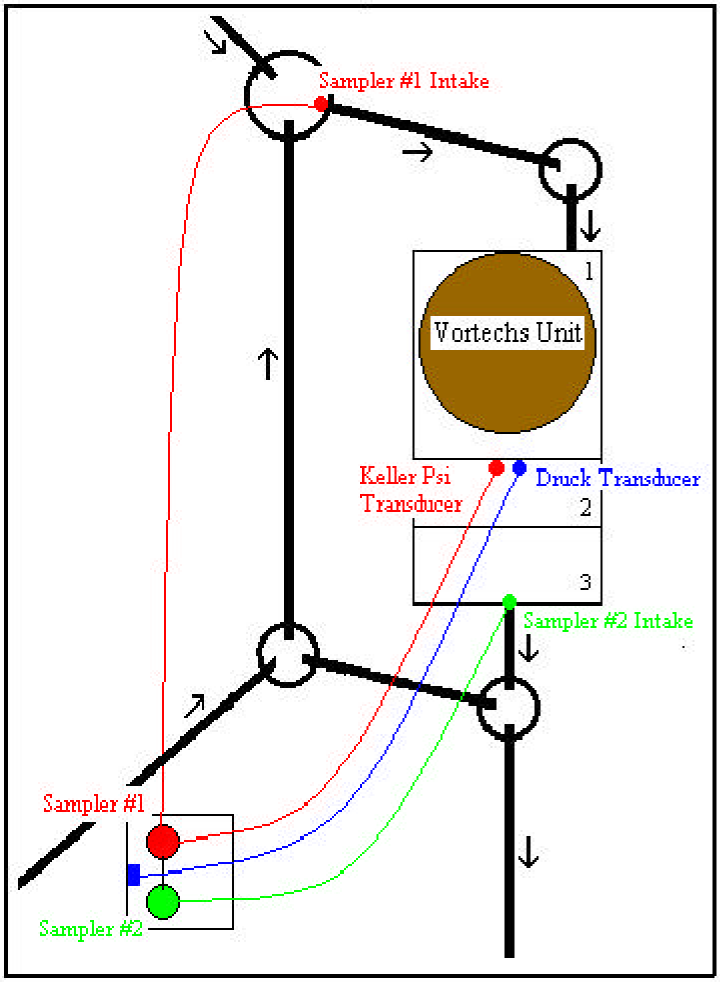


Figure 3. Canada Street Vortechs™ System Subcatchment



White hatch – subcatchment area = 3.78 hectares
Green blocks – pervious areas = 0.19 hectares

Figure 4. Schematic of the Vortechs™ System with instrumentation installed for the study



The transducer wires exit the Vortechs™ System through the sidewall and run underground, enclosed in PVC conduit, to the shelter. The Druck transducer was wired to the WLS-2109e recorder (Level Tracker) installed in the shelter. The recorder was programmed to process the input signal from the transducer, as percentage of the full-scale reading (3.59 meters), once each minute. At the end of a five-minute interval, the recorder averages the previous five values, and stores this value. The recorder was scaled to save data continuously at five-minute intervals for readout in feet.

The Keller Psi transducer was wired to a Manning 4901 sampler equipped with a controller that can accept input from an external device, such as a transducer, that outputs a 4-20mA signal representing water level in the System. This optional analog input allowed the sampler to be used in *09 mode to initiate stormwater runoff sampling during the rising and falling water levels of storm events in the Vortechs™ System.

The intake for the Manning sampler equipped with the Keller transducer (Sampler #1) is located in the runoff interceptor chamber, where the culverts carrying stormwater from Canada Street converge (Figure 4). The intake for the other sampler (Sampler #2) was located in the Flow Control Chamber (#3) of the Vortechs™ System, just below the invert level of the outlet pipe. The sampler hoses were buried below grade in PVC conduit and wrapped with heat tape and pipe insulation to keep the lines from freezing in cold weather.

Prior to an event, the samplers were programmed for collection based on the anticipated intensity and duration of the event. Sampler #1 was set either for 'Flow Mode' or 'Time

Mode', and was connected to Sampler #2 via a contact closure connection. Sampler #1 collected a sample when the signal for a preset level was received from the transducer or a preset time interval had elapsed. A contact closure output from Sampler #1 signaled completion of each sampling sequence from the System inflow and activated collection of a sample from the System outflow by Sampler #2. In this way, corresponding inflow and outflow samples were collected from the Vortechs™ System during storm events.

Sampler #1 was equipped with a controller that had data logging capability and would record the specific time that discrete stormwater runoff samples were collected during an event. This information could be downloaded from the sampler to a PC in ASCII format using a HyperTerminal link.

Stage Discharge Relationships

The stage discharge curve for the Canada Street Vortechs™ System was received through personal communication with Vortechnics, Inc. personnel. The sensors of the Druck and Keller Psi transducers were mounted about 78 cm above the floor of the Vortechs™ System on the baffle, and about 6 cm below the crest of the orifice (Figure 1). Knowing the elevation relationship between the transducer sensors and the crest of the orifice, flow calculations could be computed for the System by subtracting 0.06 m from the level, in m, recorded by the Level Tracker. The flow equations are shown in Appendix 1.

Sample Methodology

Stormwater runoff samples were collected from the inflow and outflow of the Vortechs™ System along the entire duration of a hydrologic event. Refer to Appendix 2, Marine Village Vortechs™ System Storm Hydrographs, for the sampling start/stop times in relation to the precipitation start/stop times. The frequency of sample collection during each event was determined by the anticipated duration and intensity of the event runoff.

Personnel would visit the monitoring station every 12-24 hours during an event to check equipment, change sampler bases (and bottles) as required, download sample collection information from the Manning sampler and collect water level information from the Vortechs™ System recorder. The stormwater runoff samples were transported to the Darrin Fresh Water Institute (Rensselaer Polytechnic Institute) Field Station in Bolton Landing, NY (~ 16 kilometers north of the study site) for processing.

Water level information collected from the Vortechs™ System recorder was exported as an event hydrograph. The 'Inflow' and 'Outflow' samples were plotted along the hydrograph according to the date and time of collection. Samples were selected from different portions of the event hydrograph for processing. The total number of samples selected for processing was based upon the duration and intensity of each runoff event.

Stormwater runoff samples were processed as discrete samples for TP, TN, TSS, BOD, and FC bacteria. A summary of the processing, preservation, sample volume, storage containers, and holding times for the parameters is listed in Table 2.

Table 2. Summary of processing, preservation, sample volume, storage containers and holding times for study parameters.					
Parameter	Processing	Preservation	Volume (mL)	Container	Holding Time
Total phosphorus	raw sample	freeze	100 mL	125 mL PE	28 days
Total soluble phosphorus	filter sample	freeze	100 mL	125 mL PE	28 days
Total nitrogen	raw sample	freeze	100 mL	125 mL PE	28 days
Total soluble nitrogen	filter sample	freeze	100 mL	125 mL PE	28 days
Total suspended solids	raw sample	cool to 4ºC	500-1000 mL	1000 mL PE	7 days
Biological Oxygen Demand	raw sample	cool to 4ºC	1000 mL	1000 mL PE	48 hours
Fecal coliform bacteria	raw sample	cool to 4ºC	100 mL	125 mL PE	6 hours
Chloride	filter sample	cool to 4ºC	50 mL	50 mL PE	28 days
PE = polyethylene					

Specific conductance (as µS/cm at 25º C) was analyzed on all samples selected for TP, TN and TSS analysis.

Almost all sample analyses were performed at the Darrin Fresh Water Institute (DFWI) field station. Table 3 is a summary of the analytical procedures for parameters included in this study. Samples processed for TP and TN were stored frozen until analysis, while the FC bacteria samples were processed immediately and incubated within the 6-hour holding time. TSS samples generally were run on the same day as collection.

The BOD samples either were 1) processed and incubated at the field lab immediately following collection or 2) shipped on ice (4°C) overnight to the NYS Department of Health, Wadsworth Center for Laboratories and Research in Albany, NY for processing and incubation within the 48-hour holding time. The results of the two different procedures used to assess BOD were determined to be comparable.

Table 3. Summary of analytical procedures utilized in the Vortechs™ System study.	
Parameter	**Method**
Total Phosphorus	Colorimetric – Persulfate Oxidation (SM 4500-P)
Total soluble phosphorus	Colorimetric – Persulfate Oxidation, w/filtration (SM 4500-P)
Total Nitrogen	Colorimetric – Persulfate Oxidation (SM 4500-N)
Total soluble nitrogen	Colorimetric – Persulfate Oxidation, w/filtration (SM 4500-N)
Total Suspended Solids	Total Suspended Solids Dried at 103-105º C (SM 2540 D)
Fecal Coliform Bacteria	Membrane Filtration (SM 9222 D)
Biological Oxygen Demand	NYSDOH Lab - 5-day BOD test (SM 5210 B)
	Field Lab – 5-day BOD test (BOD Trak™ Instrument, Hach® Company) (Appendix 3)
Chloride	Ion Chromatography (EPA Method 300)
Specific Conductance	Instrumental (SM 2510 B)

<u>Precipitation monitoring</u>

Wetfall and frozen precipitation that occurred during the study were monitored at the Cedar Lane Atmospheric Deposition Station. The station is located in the Lake George Beach and Battlefield State Park, Town of Lake George, about 1.5 km from the site of the Canada Street Vortechs™ System. Precipitation data at the station are collected with a Qualimetrics, Inc. Model 6021A tipping bucket rain-snow gauge that tips once for each 0.0254 centimeters of wetfall. The gauge is equipped with heaters to allow the accurate measurement of frozen precipitation. The tipping mechanism in the gauge is associated with a mercury-reed switch that sends a signal to a Telog Instruments, Inc. Model R-2107 event recorder for each tip that occurs. The event recorder provides a continuous record of precipitation at the Cedar Lane station and is programmed to summarize and store the information at 5-minute intervals.

Visual Land Survey

A survey of the Vortechs™ System subcatchment was conducted on 13 and 16 October 2000. A sample survey sheet is shown in Appendix 4. Village of Lake George tax map information was used to determine property boundaries and approximate building dimensions on each lot. Based on the survey and aerial photography of the subwatershed, the impervious and pervious area draining to the Vortechs™ System was determined.

Pollutant Loading Calculations

The total discharge (in m^3) for each event was calculated by summing the individual instantaneous five-minute values for discharge through the System. Pollutant loadings were calculated by the method used by Longabucco and Rafferty (1998). Discrete chemistry data for TSS, TP and TN were linearly interpolated to produce concentrations at five-minute intervals for each storm. These values were multiplied by the instantaneous discharge and summed to produce the event mass loading for each constituent. If there were discharges at the end of an event and no chemistry sample for a constituent, the last chemistry value was used to estimate the five-minute concentrations for the "tail" of the event. This assumption affected the calculations for TP and TN for two events (03/28/00 and 04/3/00).

SECTION V. RESULTS AND DISCUSSION

Total Suspended Solids

Figure 5 shows the TSS event mean concentration values of the inflow versus the outflow for the various storm events sampled during the study. Figure 6 shows the TSS percent removal for each storm event. Appendix 5 lists the TSS values in mg/L at the specific date and time they were collected. Event mean concentration data for TSS, TP, and TN (inflow and outflow) are presented in Appendix 6.

The chemical loading graphs for TSS in Appendix 7 show that the inflow had a greater amount of TSS than the outflow, indicating removal of TSS in all storm events except one (the 03/25/00 event). Furthermore, all of the storms with removal had at least a 50 percent removal rate with many of the storms having removals of well over 80 percent (Figure 6 and Table 4).

Figure 5. Event Mean Concentration for TSS.

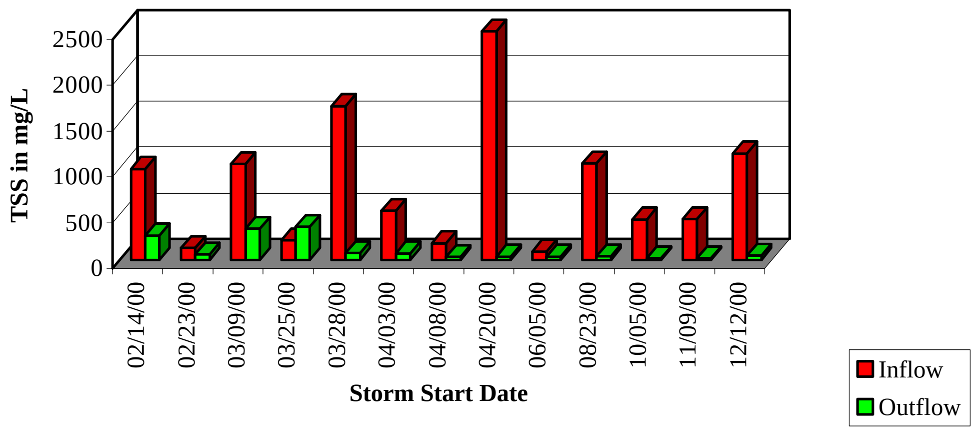


Figure 6. Percent Removal of TSS.

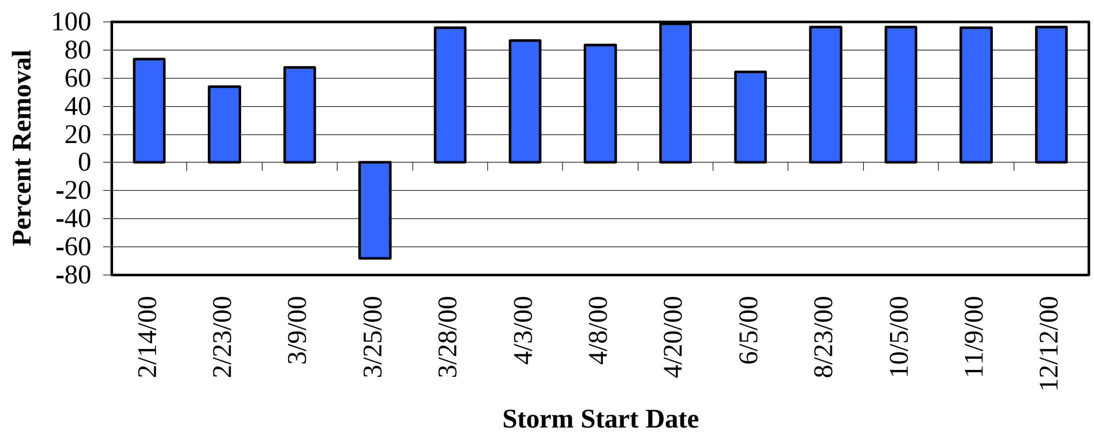


Table 4. Percent removal of TSS, TP and TN from Vortechs™ System during the study.

	Percent Removal		
Storm Start Date	TSS	TP	TN
02/14/00	73.35	11.56	-9.13
02/23/00	53.99	25.02	9.88
03/09/00	67.51	11.30	22.30
03/25/00	-68.03		
03/28/00	95.73	5.05	30.19
04/03/00	86.89	-26.94	20.07
04/08/00	83.54		
04/20/00	98.58		
06/05/00	64.46		
08/23/00	96.46	-118.95	-52.48
10/05/00	96.23	2.85	-113.64
11/09/00	96.10	5.70	18.95
12/12/00	96.13	3.30	-6.47

The 03/25/00 storm event was low intensity and short duration. The total rainfall for the storm was 0.10 cm in a 40-minute period (Table 5). This is the only storm sampled where the TSS loading for the outflow was greater than that of the inflow.

Table 5. Summary of runoff events that were sampled during the study.

Event Summary							**Vortechs™ Summary**
Start Day	Start Time	Stop Day	Stop Time	Duration (minutes)	Depth (centimeters)	Mean (cm/hr)	Event Volume Thru Unit (meters^3)
02/13/00	2225	02/14/00	1345	920	3.51	0.23	1192.54
02/24/00	1340	02/25/00	1740	1680	0.84	0.03	285.17
02/27/00	2335	02/28/00	0720	465	0.99	0.13	337.02
02/28/00	1355	02/28/00	1400	5	0.03	0.00	8.64
03/01/00	1855	03/01/00	2230	215	0.08	0.03	25.93
							*4209.41
03/09/00	1115	03/09/00	2245	690	0.53	0.05	181.47
03/11/00	0755	03/12/00	1610	1935	2.39	0.08	812.31
03/25/00	2015	03/25/00	2055	40	0.10	0.00	34.56
03/27/00	2330	03/28/00	1505	935	2.95	0.18	1002.42
04/03/00	0850	04/03/00	1425	335	0.51	0.10	172.83
04/03/00	2145	04/04/00	1420	995	3.58	0.23	1218.46
04/08/00	1910	04/09/00	1750	1360	1.83	0.08	622.19
04/20/00	2010	04/21/00	1630	1220	2.21	0.10	751.82
06/05/00	2000	06/06/00	2355	1675	5.51	0.20	1780.86
08/23/00	1045	08/23/00	1650	365	1.85	0.30	599.09
10/05/00	1440	10/06/00	0910	1110	2.90	0.15	935.57
11/09/00	2240	11/10/00	1640	1080	2.41	0.13	779.64
12/11/00	2155	12/12/00	0945	710	1.78	0.15	**604.91

* 3552.65 m^3 = volume due to snowmelt and 656.76 m^3 = volume precipitation
** volume based on ground being frozen

Thirteen events were sampled from 02/14/00 to 12/11/00 and represent 38.5 cm of runoff. Since this subwatershed is approximately 95% impervious area and the average annual precipitation in the Lake George region is just over 100 cm/yr, about 40% of the annual runoff was sampled during this study. By subtracting the inflow and outflow TSS loads, it was determined that the System removed 7.2 metric tons of suspended solids during the 304-day study period. Using a bulk density of 2 g/cm^3, this is equivalent to 3.6 m^3, or just below the System's rated storage capacity of 4.2 m^3. This would indicate that the System probably should be cleaned twice per year.

Total Phosphorus and Total Nitrogen

Figure 7 shows the TP event mean concentration values of the Vortechs™ System inflow versus the outflow. Figure 8 shows the percent removal of TP for each storm event that was sampled. Appendix 5 lists the phosphorus values in ìg/L at the specific date and time they were collected.

Figure 7. Event Mean Concentration for TP.

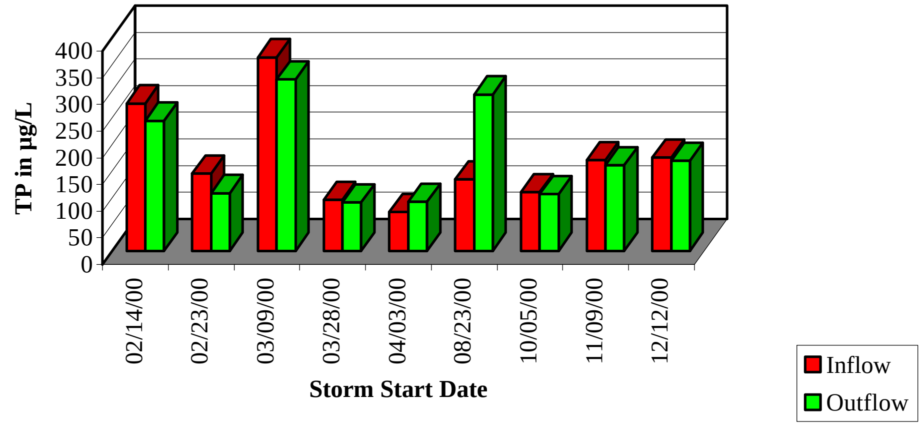
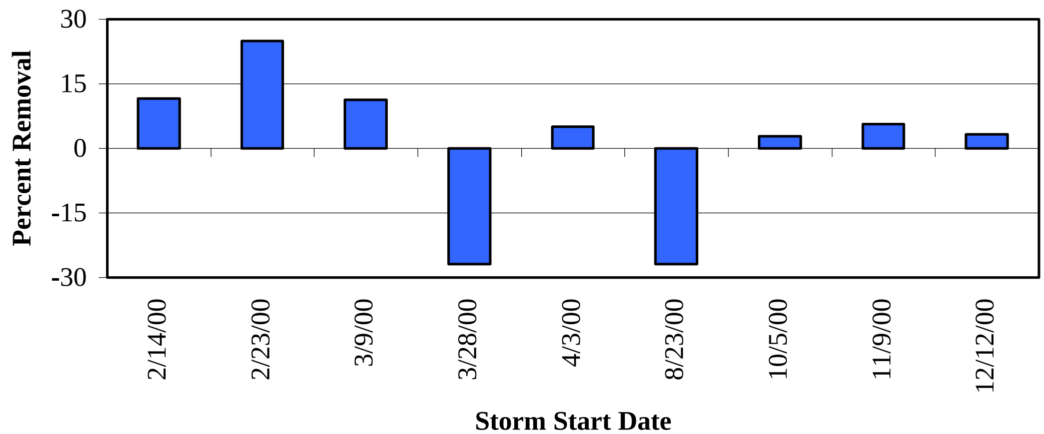


Figure 8. Percent Removal of TP.



Total phosphorus values from the DFWI Offshore Chemistry Program indicate that the mean level of phosphorus in Lake George at the Lake George Village station for the period 1996-1999 was 6.2 ìg/L. The phosphorus levels of stormwater in the Vortechs™ System are significantly higher, ranging from a low of 37 ìg/L to a high of 2229 ìg/L.

Figure 9 shows the TN event mean concentration values of the Vortechs™ System inflow versus the outflow. Figure 10 shows the percent removal of TN for each storm event that was sampled. Appendix 5 lists the nitrogen values in mg/L at the specific date and time that they were collected.

Total nitrogen values from the DFWI Offshore Chemistry Program, 1996-1999, indicate that the mean nitrogen level at the Lake George Village station for the three-year period was 0.20 mg/L. The nitrogen levels of stormwater that leaves the Vortechs™ System range from a low of 0.0 mg/L to a high of 56.8 mg/L.

Figure 9. Event Mean Concentration for TN.

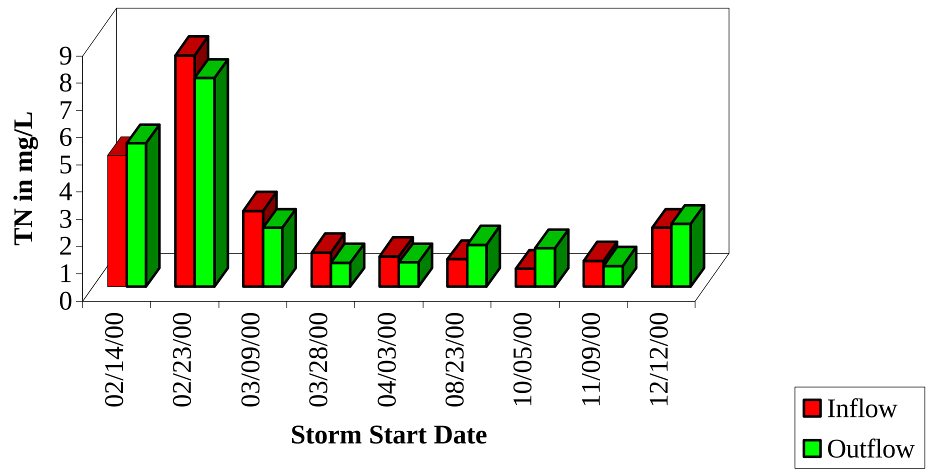
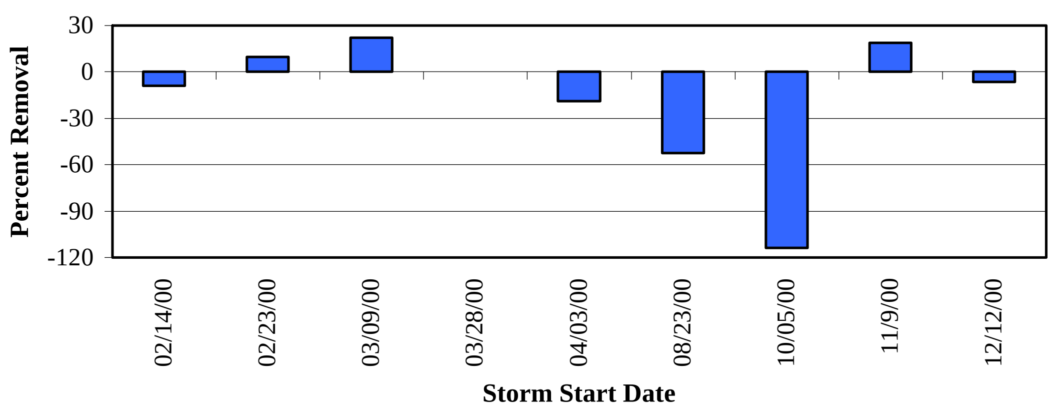
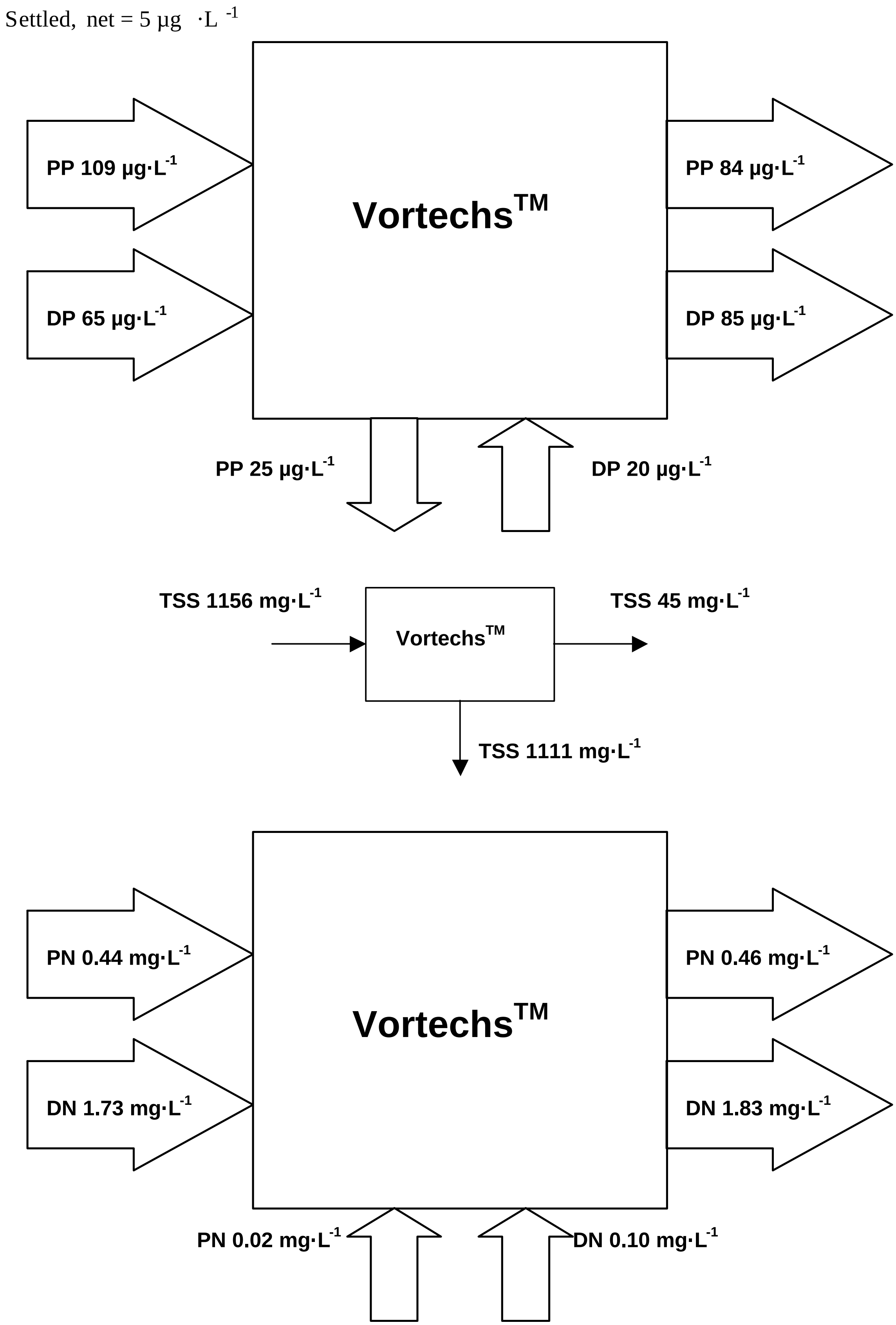


Figure 10. Percent Removal of TN.



On 12/11/00, a five-hour runoff event occurred that produced 503 m^3 (resulting from a 1.3 cm rainfall) of runoff. During this storm eleven samples were analyzed for total suspended sediment and seven for nitrogen and phosphorus. Filtered samples were also analyzed for nitrogen and phosphorus. Although the Vortechs™ System removed 96.1% of the TSS, it removed only 23% of the particulate phosphorus, which corresponds to a removal of 3.3% for total phosphorus. The System did not remove either total or particulate nitrogen. Figure 11 summarizes the flow-weighted concentrations for TSS and the forms of nitrogen and phosphorus for the 12/11/00 event. The reason that the System removes very little phosphorus and no nitrogen is because removals are confined to sand-sized (minus #200 sieve) particles that are low in nitrogen and phosphorus. For example, the TSS removed by the System (Coarse Particulate Phosphorus, CPP) has a phosphorus content of only 0.002%, while the outflow TSS has a phosphorus level (Fine Particulate Phosphorus, FPP) of 0.188%, or almost 100 times greater. Since the System does not remove particulate nitrogen, it is not possible to do a similar calculation, but the nitrogen level in the outflow TSS is 1.089%. In summary, at least for the one event sampled during the 2000 field season, it is clear that the sand-sized material removed by the System has very low levels of both nitrogen and phosphorus and hence overall nutrient removal is also small. The fine-grained material and the dissolved fraction that pass through the System contain almost all of the nitrogen and phosphorus. These observations need to be confirmed by additional sampling during 2001.

Figure 11. A summary of the flow-weighted concentrations for TSS and the forms of nitrogen and phosphorus for the 12/11/00 event.



Sutherland et al. (1983) developed an equation that compared areal unit phosphorus loading (gP/ha/day) to percent land development in selected Lake George Urban Runoff Study (NURP) catchments. If the equation were applied to a theoretical Lake George catchment that was 100 percent developed (equivalent to 25 percent impervious area for the NURP catchments), the areal unit phosphorus loading rate would be 0.959 gP/ha/day. Since the Vortechs™ System subwatershed is approximately 95% impervious area, using a straight multiplier, one could estimate the areal unit phosphorus loading rate as 3.800 gP/ha/day. With a subwatershed area of 3.78 ha, the annual NURP TP load to the Vortechs™ System would be 5,243 g TP/yr. The events that were sampled for TP represented about 38.5 cm, or about one third of the annual runoff. The annual TP load to the Vortechs™ System, based on the events that were sampled, is 6,005 g TP/yr, which is similar to the NURP number.

In May 1998, the Vortechs™ System was cleaned and samples of sediment in the unit were analyzed for TP, TN, metals and grain size (Table 6). About 90 percent of the material was sand-sized, with equal amounts of larger (gravel) and smaller (silt and clay) particles. The material was 0.02 percent P and 0.16 percent N. Stormwater samples collected from the entire Marine Village watershed (which includes less developed upland areas) from 1991-1993 exhibited TP/TSS and TN/TSS ratios of 0.15 percent and 0.16 percent, respectively. These results indicate that the material trapped in the Vortechs™ System appears to be similar in nitrogen content but depleted in phosphorus content when compared to stormwater samples from the entire watershed.

Table 6. Results of Vortechs™ System Sediment Chemistry Evaluation

Sample	Matrix	Date	Dry Wt (grams)	Volume (mL)	TP (mg/Kg)	TN (mg/Kg)	Ca (mg/Kg)	Mg (mg/Kg)	Na (mg/Kg)	K (mg/Kg)	Pb (mg/Kg)
V1A	sediment	5/1/98	1.166	50		580.6	20798	7504	223	169	7
V1B	sediment	5/1/98	1.1292	50			26567	11114	522	228	40
V2A	sediment	5/1/98	1.0698	50	204.6	2616	6637	4674	939	362	87
V2B	sediment	5/1/98	1.17	50			4188	4444	1030	361	62
				average	**205**	**1598**	**14548**	**6934**	**679**	**280**	**49**
				fraction	0.0002	0.0016	0.01455	0.00693	0.00068	0.00028	0.000049

Sample	Matrix	Date	Dry Wt (grams)	Volume (mL)	Fe (mg/Kg)	Cu (mg/Kg)	Mn (mg/Kg)	Zn (mg/Kg)	LOI (mg/Kg)	LOI (%)
V1A	sediment	5/1/98	1.166	50	227	3	44	6	10000	1.0%
V1B	sediment	5/1/98	1.1292	50	7527	18	161	58		
V2A	sediment	5/1/98	1.0698	50	8460	332	432	457	380000	38.0%
V2B	sediment	5/1/98	1.17	50	9658	397	523	567		
				average	**6468**	**188**	**290**	**272**	**195000**	**19.5%**
				fraction	0.00647	0.00019	0.00029	0.00027	0.195	

Fecal Coliform

Appendix 5 presents the FC data in CFU/100mL. Due to the difficulty of proper sampling procedures, very few samples were analyzed for FC. The levels of FC for contact recreation, set by the NYSDEC (NYSCR&R, Title 6, Chapter X, Parts 700-706), require that a five-sample geometric mean be 400/100mL per sample, or less. In February 2000, FC results ranged from less than 10 to a high of 90/100mL. In August and October 2000 the FC numbers rose to a low of 60/100mL and a high of 100,000/100mL. Several of the higher values violate the standard stated above. It is expected that the fecal coliform levels are lower in the winter and colder months and higher in the summer and warmer months.

Biological Oxygen Demand

The BOD values in mg/L are listed in Appendix 5. The BOD values for inflow and outflow are comparable. For the seven samples taken, the inflow averaged 24 mg/L and the outflow averaged 16 mg/L. There does not seem to be a significant removal rate.

Conductivity

Appendix 5 shows the Vortechs™ System conductivity values in ìS. Table 7 shows a comparison of Marine Village conductivity data collected in 1992 to Vortechs™ System conductivity data collected in 2000.

The conductivity levels in the samples from the Vortechs™ System vary greatly from conductivity results for the entire Marine Village watershed. Because the Vortechs™ System subwatershed is 95 percent impervious, the conductivity values are expected to be higher than those of the 95.55 ha Marine Village watershed (which is 47 percent forested), especially in the winter months when salting and sanding take place. Both data sets in Table 7 clearly show that there are seasonal variations in conductivity levels. The Vortechs™ System results indicate that there are significant seasonal variations in conductivity levels and that the average levels are significantly higher than those of the entire Marine Village watershed.

Table 7. Average conductance values for the Marine Village watershed and Vortechs™ System subwatershed.

	Conductivity in µS		
	Annual average	Winter average	Summer average
Marine Village (1992 data)	230	522	144
Vortechs™ (2000 data)			
Inflow	2569	3571	95
Outflow	2751	3916	268

DFWI water chemistry data (1996) show that the summer mean chloride concentration in Lake George has risen 33 percent over a 12-year period, from 6.71 mg/L for the period 1981-1984, to 7.55 mg/L for the period 1985-1989, to 8.94 mg/L for the period 1990-1993. Although chloride was not one of the parameters included in this study, it was added to the list of analytes for the 12/11/00 storm event. The chloride event mean concentrations for the Vortechs™ System inflow and outflow were 1224.97 mg/L and 1093.08 mg/L, respectively, for the single runoff event. These data emphasize the dramatic impact of human influence on the water quality of Lake George and corroborate the DFWI data that increased chloride concentrations are the result of road and highway deicing practices.

Sediment Sieve Analysis

Sediment samples were collected from the Vortechs™ System in 1998 and 2000 during the cleanout procedure. These 18-kg samples were transported to Parrot-Wolff Labs in East Syracuse, New York, where grain size, distribution analysis and tests for organic content were carried out. Based upon these analyses, the two samples were very close in character. The grain size distribution analysis shows that the samples are predominantly sand (Appendix 8). The Vortechs™ System did capture fine material (minus #200 sieve) to the degree that 5.2 percent finer by weight of the 1998 sample and 3.3 percent of the 2000 sample were realized. The organic content for the two samples also were very close. The

1998 sample contained 2.2 percent organic content while the 2000 sample contained 2.8 percent.

Since the watershed contributing to this unit is 95 percent impervious, the fact that well over 50 percent of the sediment is medium to fine sand is consistent with what would be expected in this location.

SECTION VI. CONCLUSIONS AND RECOMMENDATIONS

The subwatershed that drains to the Canada Street Vortechs™ Stormwater Treatment System has a surface area of 3.78 ha and is 95 percent impervious. The Vortechs™ System was evaluated in this study by comparing inflow samples to outflow samples and calculating pollutant loadings for TSS, TP, and TN. Conductivity was measured for samples that were collected and analyzed for TSS. Very few samples were analyzed for FC and BOD because of restrictive sampling procedures and holding times, respectively.

The evaluation of the Vortechs™ System through the comparison of the inflow to the outflow shows that the System removes at least 60 percent of total suspended solids from stormwater for individual storms under most flow conditions. The TSS removal efficiency for the entire study period was calculated to be 88 percent, exceeding the manufacturer's estimated annual removal efficiency (80 percent).

About 3.6 m^3 of sediment was removed from the Vortechs™ System in June 2000, an amount just below the rated storage capacity of 4.2 m^3, indicating that the clean out of the System probably should be increased from once to twice a year. Sediment sieve analysis indicates that the majority of sediment trapped in the System is sand-sized particles. The System also captured fine material (minus #200 sieve), an average of 4.25 percent finer by weight. Less than 3 percent of the total sediment from the sieve analysis was organic.

Estimates from this study show that the Vortechs™ System removes some coarse particulate nutrients (phosphorus and nitrogen). However, the bulk of the phosphorus and nitrogen in stormwater runoff is in fine particulate and dissolved forms and passes through the System. A more complete data set is necessary to verify this finding and additional data will be collected during 2001.

Conductivity levels in the Vortechs™ System vary seasonally as a result of salt compounds being applied to roads and highways during winter deicing practices. Although chloride was not one of the analytes included in the present study, chloride concentrations were measured during a December 2000 runoff event and demonstrate the high loading of this substance to the Lake from a single developed catchment. These data corroborate the DFWI data (1996) that show a significant increase in annual average summer chloride values in Lake George during 12 years of water chemistry monitoring.

In spite of the small number of samples analyzed during the study, it is apparent that the FC levels vary with the seasons of the year, tending to be lower in colder months and higher in warmer months. BOD levels were low, indicating low organic content in material entering the Vortechs™ System.

The following recommendations are offered as a result of the present study:

1. The Canada Street Vortechs™ System should be cleaned at least two times each year to maintain its high sediment removal efficiency. By adhering to this frequency of cleanouts, it will be possible to greatly reduce the amount of total suspended solids that enter Lake George from this subcatchment. The load of other pollutants will be greatly reduced by a regular cleanout schedule (e.g. Pb [adsorbed to sediment] and Ca [dissolved in water that will be removed during cleanout]). One of the cleanouts should occur during mid-winter to maximize sediment removal efficiency during the period of high and (usually) sustained runoff during spring snowmelt. The mid-winter cleanout will reduce the load of dissolved pollutants, such as Ca and Cl, which enter the Lake as a result of winter deicing practices.

2. The Village and Town of Lake George should consider installing additional Vortechs™ Stormwater Treatment Systems in locations adjacent to the Lake where sedimentation and erosion have been identified as non-point source pollution problems. Potential watersheds for these installations include Prospect Mountain Brook, West Brook and English Brook and areas where there is drainage directly from impervious surfaces to Lake George (e.g. Beach Road along the south end of the Lake). The installation of these units and regular maintenance would greatly reduce the annual load of sediment and other pollutants that currently enter Lake George.

3. The Village of Lake George should retain the services of an engineering consultant to investigate the possibility of retrofitting the Canada Street Vortechs™ System with some structure or device (BMP) to remove the fine particulate and dissolved forms of phosphorus and nitrogen that are bypassing the System and entering Lake George.

4. Due to the highly sensitive situation involving highway corridors adjacent to the shoreline within the Village and Town of Lake George and the impact of stormwater runoff from these areas on water quality of the Lake, the New York State Department of Transportation and local highway departments should consider using a road salt substitute during winter de-icing practices to reduce the loading of Ca and Cl.

5. The Darrin Fresh Water Institute should summarize and analyze Lake George water chemistry data for the entire period 1980-2000 to determine whether there has been a significant increase in calcium concentrations since the previous analysis was conducted (1996). This information is particularly important in view of the potential calcium loading to Lake George from stormwater runoff during and after winter de-icing practices and the recent discovery of zebra mussels (*Dreissena polymorpha*) in the Lake George ecosystem.

SECTION VII. REFERENCES

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Appendix 1

Vortechs^{TM} System flow equations

The equation for flow through the orifice is:

$$Q = C_d A \sqrt{2gh}$$

where Q = flow rate (cfs)
C_d = coefficient of discharge (=0.58)
A = area of orifice (ft^2)
g = acceleration due to gravity
h = head measured from the center of the orifice to the water level elevation

The equation for flow through the weir is:

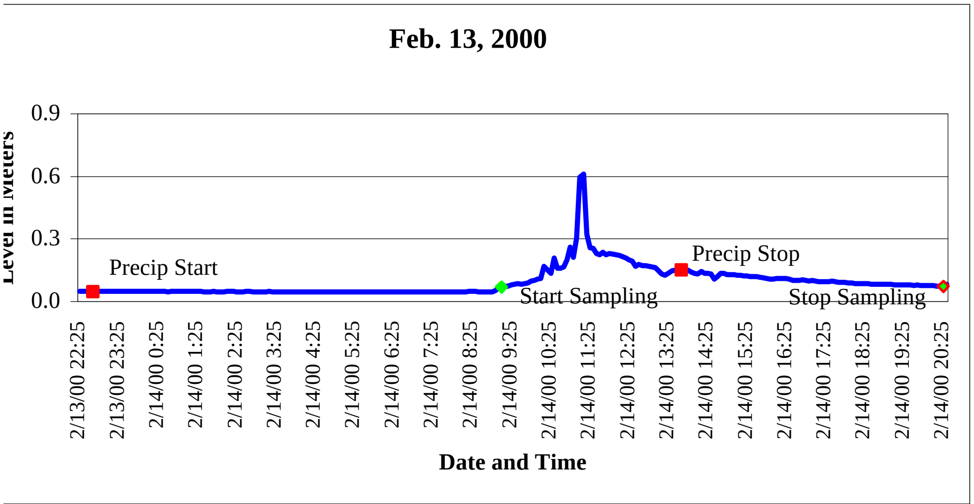
$$Q = C_d L (h)^{3/2}$$

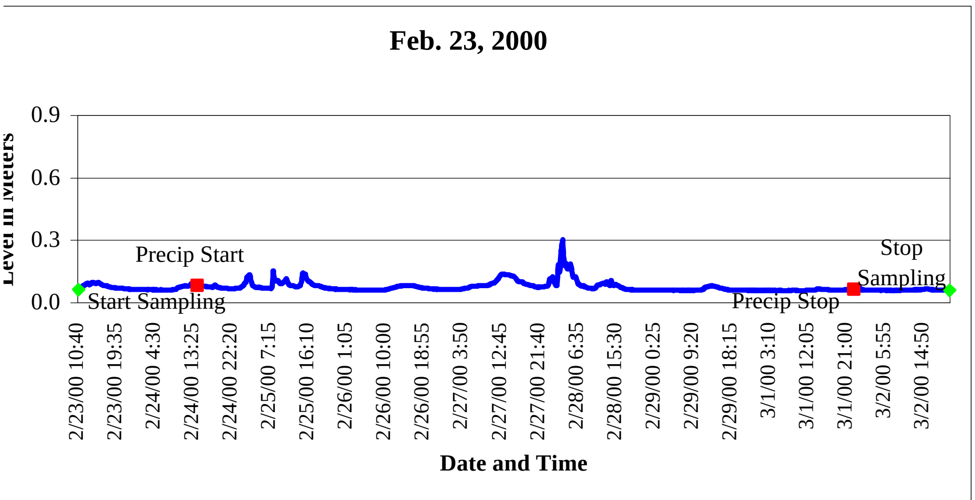
where Q = flow rate (cfs)
C = coefficient of discharge
L = length of weir crest
h = head measured from the crest of the weir to the water level elevation

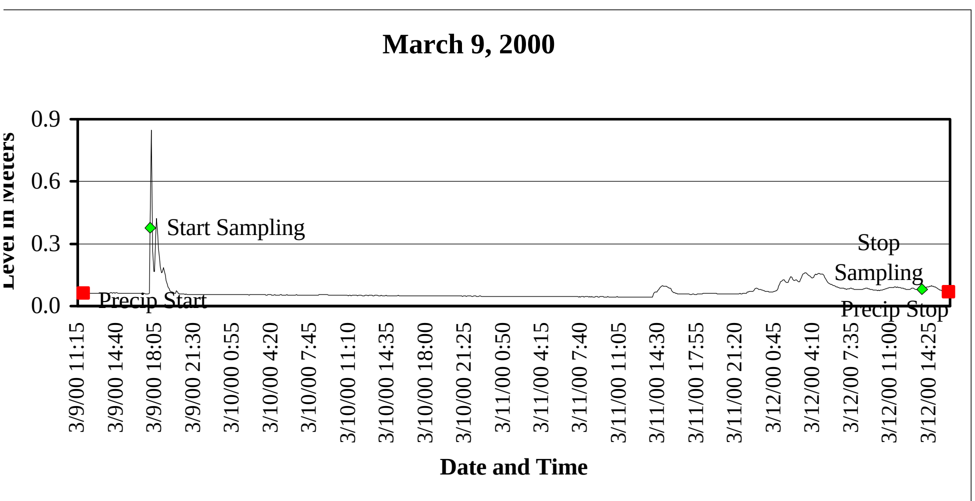
Appendix 2

Storm hydrographs showing precipitation start/stop times in relation to sampling start/stop times

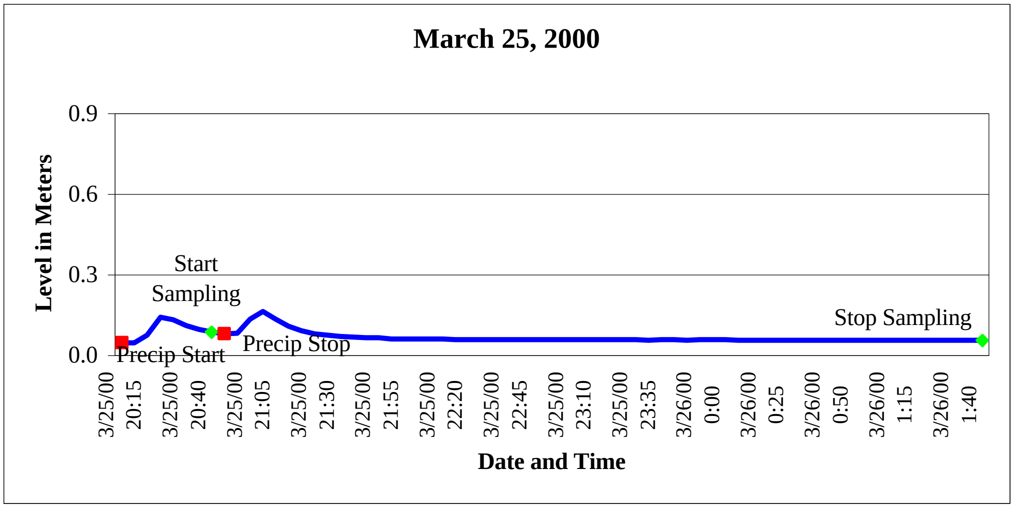
Marine Village Vortechs™ System Hydrographs

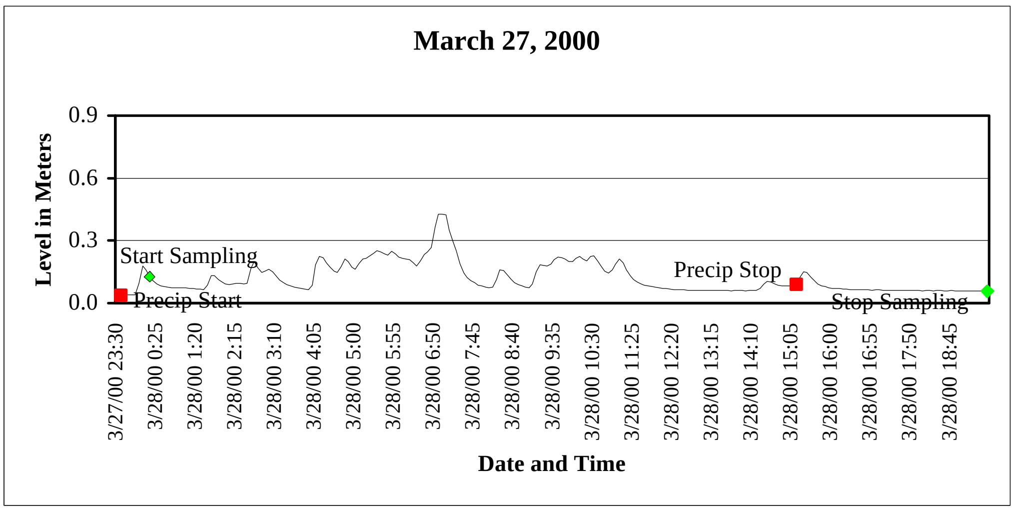


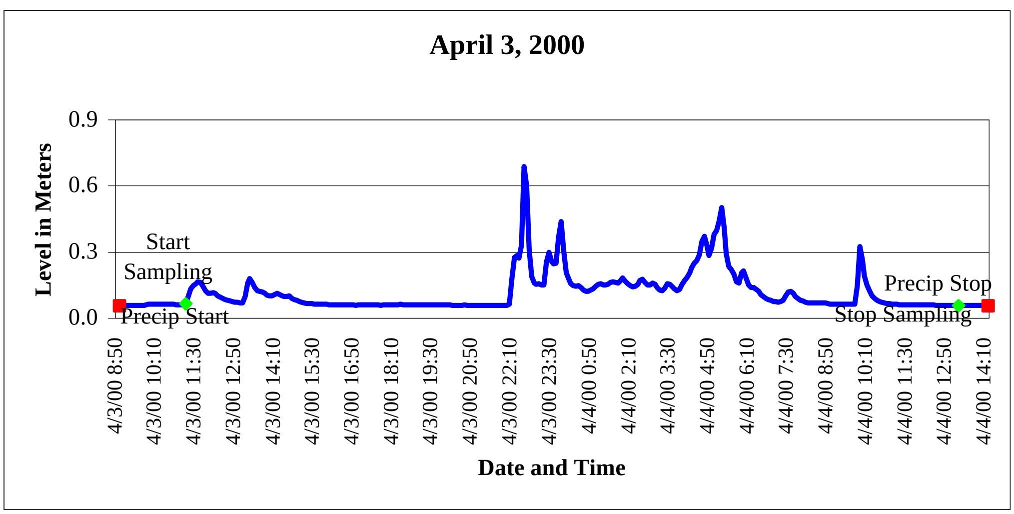




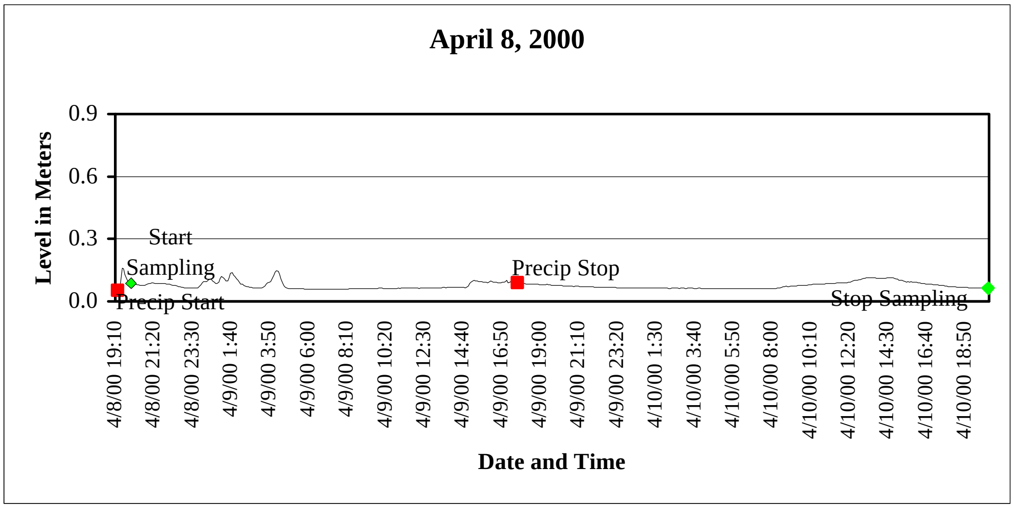
Marine Village Vortechs™ System Hydrographs

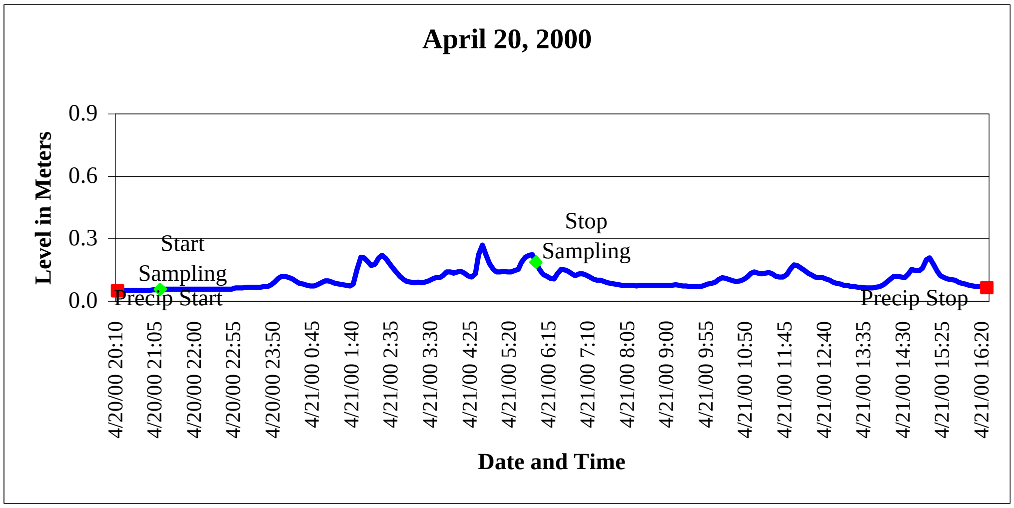


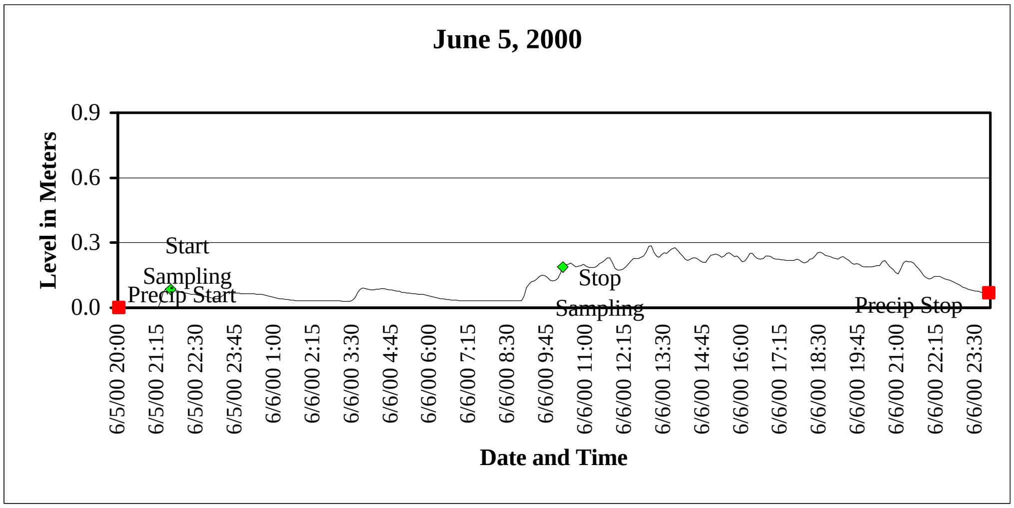




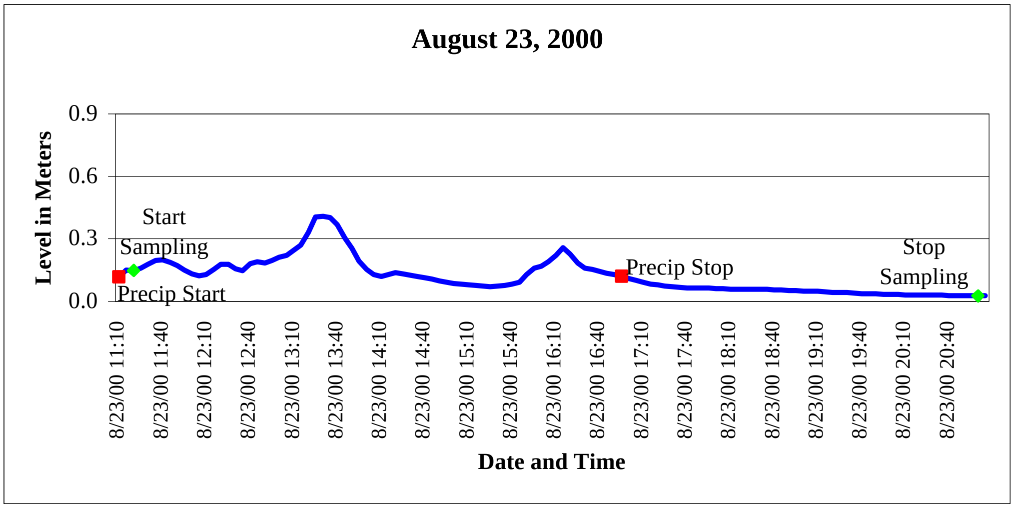
Marine Village Vortechs™ System Hydrographs

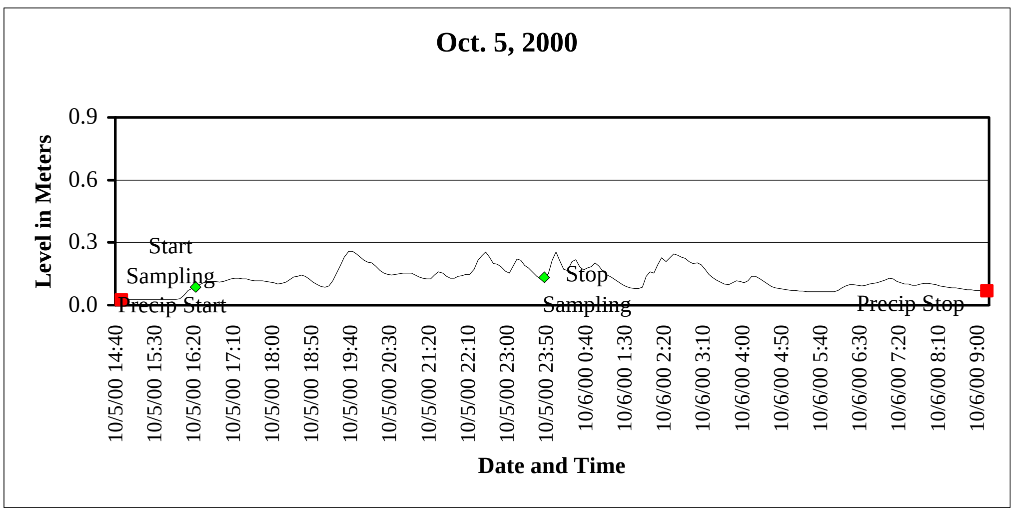


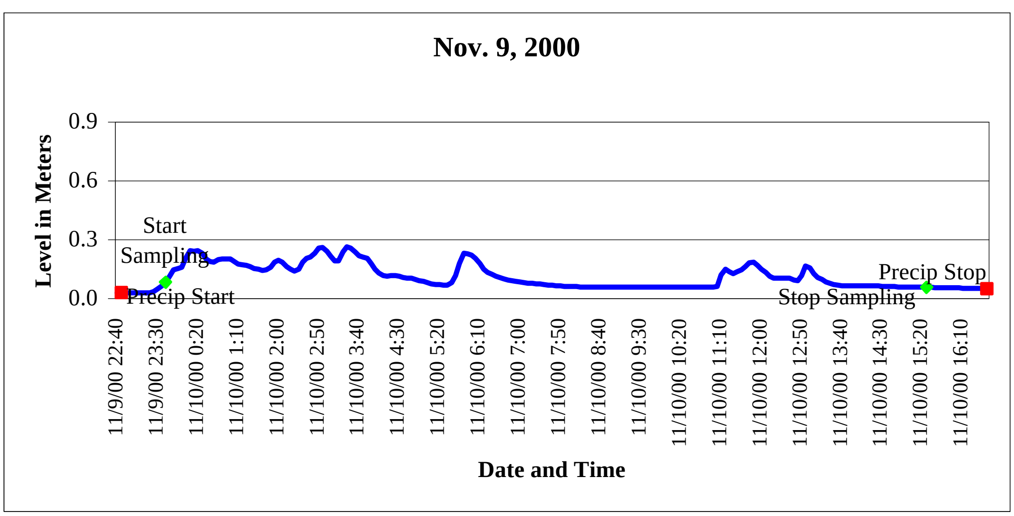




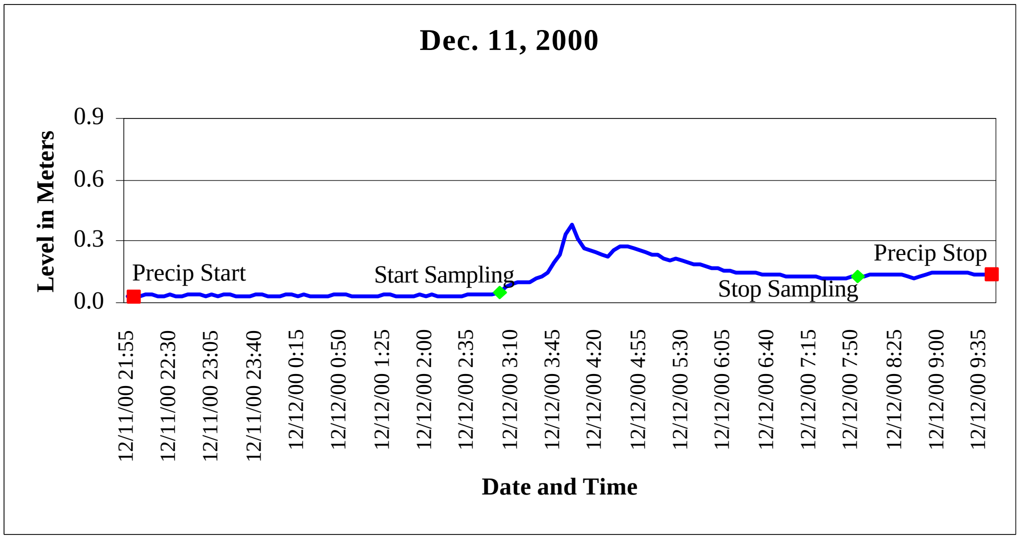
Marine Village Vortechs™ System Hydrographs







Marine Village Vortechs™ System Hydrographs



Appendix 5

Marine Village Subcatchment Survey Sheet

Marine Village Subcatchment Survey

Name of Surveyors	
Date	

Lot #			
Tax Map #			
Land Use Type			
Town	Village of Lake George		
Street Address			
Commercial Address			
Lot Dimensions			

Structures	1	2	3	4
Building Type				
Dimensions (ft x ft)				
Gutters (ft)				
Drains to…				

Other Impervious Areas					
Area Type					
Dimensions (ft x ft)					
Drains to…					
Material					

Lawn Dimension (ft x ft)					
% Bare Ground					
% Shrubs, Gardens, Etc.					

Comments:

Appendix 6

Marine Village Vortechs ^{TM} System Inflow and Outflow Data for conductivity, TP, TN, TSS, FC, and BOD

Vortechs™ System Inflow										
DATE + TIME	ACCESSION NUMBER	LEVEL IN FEET	TP (μg/L)	TN (mg/L)	TSS (mg/L)	COND μS/cm	BOD (mg/L)	FC #/100mL	TFP (μg/L)	TSN (mg/L)
2/14/00 9:00	VTI 00-01	0.36	202	7.0	186.89	28500		<10*		
2/14/00 9:30	VTI 00-02	0.47	260	6.5	266.47	22500		<10*		
2/14/00 10:00	VTI 00-03	0.53	339	5.0	352.60	15600		<10*		
2/14/00 10:30	VTI 00-04	0.88	388	5.6	558.72	12400		10*		
2/14/00 11:00	VTI 00-05	0.89	439	8.4	1231.30	11000		<10*		
2/14/00 11:30	VTI 00-06	1.03	318	4.4	3785.20	9900		<10*		
2/14/00 12:00		0.94			1153.95	7600				
2/14/00 13:00		0.74			434.19	9600				
2/14/00 14:00	VTI 00-07	0.66	133	3.5	523.91	8470		<10*		
2/14/00 15:30		0.59			163.97	16720				
2/14/00 16:30	VTI 00-08	0.55	276	4.5	227.29	11920		30*		
2/14/00 18:30		0.48			73.00	14130				
2/14/00 20:30	VTI 00-09	0.43	207	4.5	58.32	12570		90*		
2/23/00 10:40		0.39			48.82	13940				
2/23/00 12:40		0.50			204.10	7260				
2/23/00 15:40		0.51			114.87	5200				
2/23/00 18:40		0.43			59.00	6730				
2/24/00 4:40		0.39			25.71	6610				
2/24/00 11:20		0.46			90.36	4110				
2/24/00 14:20		0.47			159.23	6200				
2/24/00 16:20		0.45			102.31	4970				
2/24/00 18:20		0.48			282.96	4890				
2/24/00 20:20	VTI 00-14	0.42	172	3.8	68.81	3800				
2/25/00 0:20		0.42			41.18	3260				
2/25/00 1:20	VTI 00-16	0.51	205	6.6	125.93	2060				
2/25/00 2:20	VTI 00-17	0.64	265	4.3	349.83	1060				
2/25/00 3:20	VTI 00-18	0.46	165	3.7	140.18	1010				
2/25/00 4:20		0.43			57.17	1390				
2/25/00 7:20	VTI 00-20	0.42	114	3.4	11.70	1740				
2/25/00 8:20	VTI 00-21	0.56	244	4.5	148.57	1090				
2/25/00 12:20	VTI 00-22	0.46	140	56.8	55.77	3040				
2/25/00 15:20	VTI 00-23	0.65	225	13.3	53.82	1061				
2/25/00 18:20		0.47			92.12	1206				
2/25/00 21:20	VTI 00-25	0.41	105	37.5	59.69	1572				
2/26/00 6:20	VTI 00-26	0.39	50	43.5	11.74	1942				
2/26/00 12:20		0.44			45.24	1403				
2/26/00 15:20	VTI 00-28	0.46	163	18.3	68.84	1190				
2/26/00 18:20		0.43			37.08	1090				
2/26/00 21:20		0.41			24.38	1114				
2/27/00 6:20	VTI 00-30	0.45	94	16.5	33.85	893				
2/27/00 9:20		0.46			38.41	788				
2/27/00 13:20	VTI 00-31	0.65	227	1.3	219.56	530				
2/27/00 16:20		0.57			83.33	492				
2/27/00 19:20	VTI 00-33	0.48	96	2.8	36.79	511				
2/27/00 22:20	VTI 00-34	0.44	795	0.2	19.55	558				
2/28/00 1:20		0.50			69.85	549				
2/28/00 4:20	VTI 00-36	0.73	126	0.5	965.23	179				
2/28/00 7:20		0.46	5748		325.54	220				

Vortechs^{TM} System Inflow

DATE + TIME	ACCESSION NUMBER	LEVEL IN FEET	TP (µg/L)	TN (mg/L)	TSS (mg/L)	COND µS/cm	BOD (mg/L)	FC #/100mL	TFP (µg/L)	TSN (mg/L)
BLANK	VTI 00-38		<1	<0.05						
2/28/00 10:45	VTI 00-39	0.42	78	0.2	147.81	352				
2/28/00 12:45	VTI 00-40	0.50	152	0.2	126.46	277				
2/28/00 14:45		0.48			96.42	424				
2/28/00 16:45		0.43			59.38	333				
2/28/00 18:45		0.40			22.54	351				
2/28/00 20:45	VTI 00-41	0.39	99	5.5	22.96	404				
2/29/00 8:50		0.39			7.78	555				
2/29/00 12:50	VTI 00-42	0.44	164	0.9	58.74	427				
2/29/00 14:50		0.44			51.50	298				
2/29/00 16:50		0.40			31.84	296				
2/29/00 18:50		0.39			22.94	334				
2/29/00 22:50		0.39			15.78	357				
3/1/00 4:55		0.38			12.02	374				
3/1/00 12:50	VTI 00-44	0.39	64	2.8	11.30	532				
3/1/00 14:50		0.41			37.11	455				
3/1/00 16:50	VTI 00-45	0.39	132	0.0	26.21	365				
3/1/00 20:50		0.40			18.31	430				
3/1/00 22:50	VTI 00-46	0.46	258	28.0	138.99	1573				
3/2/00 0:50	VTI 00-47	0.39	164	21.8	68.70	1470				
3/2/00 2:50		0.39			40.95	1402				
3/2/00 4:50	VTI 00-48	0.39	109	22.8	34.15	1361				
3/2/00 8:50		0.38			28.87	1334				
3/2/00 12:50		0.40			20.58	1156				
3/2/00 14:50		0.40			21.10	747				
3/2/00 16:50		0.40			42.29	437				
3/2/00 18:50		0.39			30.98	386				
3/2/00 20:55	VTI 00-49	0.39	170	0.7	24.04	387				
3/9/00 17:40	VTI 00-50	2.97	1976	7.3	4160.85	312				
3/9/00 17:45	VTI 00-51	2.06	1911	4.4	2586.87	233				
3/9/00 17:50	VTI 00-52	1.08	428	3.4	1701.54	221				
3/9/00 17:55	VTI 00-53	0.74	918	2.7	1753.13	209				
3/9/00 18:05	VTI 00-54	1.36	1068	2.7	4903.03	225				
3/10/00 0:05	VTI 00-55	0.38	338	2.4	2063.43	203				
3/10/00 6:05	VTI 00-56	0.37	137	2.6	345.77	230				
3/11/00 14:45	VTI 00-57	0.51	291	6.1	221.52	12160				
3/11/00 15:45	VTI 00-58	0.42	326	4.1	152.50	8220				
3/11/00 17:45		0.38	8783		61.28	6210				
3/11/00 21:45	VTI 00-59	0.39	n/a	1.8	36.58	11010				
3/11/00 22:45	VTI 00-60	0.43	105	2.5	60.94	18280				
3/11/00 23:45		0.44			72.80	22400				
3/12/00 1:45	VTI 00-61	0.57	129	1.2	92.44	9570				
3/12/00 2:45		0.59			45.70	6900				
3/12/00 3:45	VTI 00-62	0.68	86	1.5	71.43	3810				
3/12/00 4:45	VTI 00-63	0.70	72	0.4	301.37	1910				
3/12/00 5:45	VTI 00-64	0.54	67	1.7	417.61	2700				
3/12/00 6:45		0.48			178.90	5680				
3/12/00 9:45	VTI 00-65	0.45	69	1.2	59.55	7630				

Vortechs™ System Inflow

DATE + TIME	ACCESSION NUMBER	LEVEL IN FEET	TP (µg/L)	TN (mg/L)	TSS (mg/L)	COND µS/cm	BOD (mg/L)	FC #/100mL	TFP (µg/L)	TSN (mg/L)
3/12/00 11:45	VTI 00-66	0.49	84	1.2	63.75	3160				
3/12/00 13:45	VTI 00-67	0.46	57	0.8	62.17	1450				
BLANK	VTI 00-68		2	<0.05						
3/25/00 20:50		0.48	669		382.50	6650				
3/25/00 21:50		0.41			238.75	3300				
3/26/00 1:50		0.38			55.00	2910				
3/28/00 0:08	VTI 00-69	0.72	572	6.6	1111.09	851				
3/28/00 0:18	VTI 00-70	0.55	382	3.8	628.92	99				
3/28/00 1:30	VTI 00-71	0.40	125	2.9	57.72	1179				
3/28/00 1:45	VTI 00-72	0.63	185	2.8	1241.85	415				
3/28/00 2:30	VTI 00-73	0.51	167	2.7	536.56	365				
3/28/00 2:40	VTI 00-74	0.85	201	3.0	1587.66	223				
3/28/00 3:30	VTI 00-75	0.46	93.9	2.4	795.09	196				
3/28/00 4:08	VTI 00-76	0.93	260	2.0	1175.08	150				
3/28/00 4:20	VTI 00-77	0.83	148	1.6	8947.81	132				
3/28/00 4:45	VTI 00-78	0.89	89	1.1	4163.23	88				
3/28/00 5:10	VTI 00-79	0.89	68	0.9	2889.70	58				
BLANK	VTI 00-80		<1	<0.05						
3/28/00 11:10		0.83	2290.9		468.78	56				
3/28/00 11:35		0.50			217.44	79				
3/28/00 14:05		0.39			20.86	156				
3/28/00 14:30		0.54			86.42	263				
3/28/00 14:55		0.46			84.76	226				
3/28/00 15:20		0.69			178.89	162				
3/28/00 15:45		0.47			91.48	131				
3/28/00 16:35		0.40			38.05	165				
3/28/00 19:35		0.38			29.24	196				
4/3/00 11:20	VTI 00-81	0.63	378	2.3	176.67	241				
4/3/00 11:25	VTI 00-82	0.68	356	2.3	361.88	185				
4/3/00 12:00	VTI 00-83	0.56	126	1.2	148.28	102				
4/3/00 13:20	VTI 00-84	0.78	138	1.3	537.78	99				
4/3/00 13:50	VTI 00-85	0.56	81	0.8	178.28	84				
4/3/00 15:50	VTI 00-86	0.40	62	1.1	72.36	115				
4/3/00 20:25		0.38	1141		27.01	179				
4/3/00 22:20		1.13			5022.20	69				
4/3/00 22:40		2.17			1385.68	43				
4/3/00 23:00		0.70			587.93	39				
4/3/00 23:30		1.04			1403.37	33				
4/3/00 23:50		1.63			827.98	28				
4/4/00 0:05		0.77			483.37	31				
4/4/00 0:30		0.65			110.96	43				
4/4/00 8:15		0.42			37.07	75				
4/4/00 10:15		0.60			48.40	57				
4/4/00 10:45		0.42			28.22	64				
4/4/00 11:15		0.39			13.21	77				
4/4/00 14:15		0.38			16.52	93				
4/8/00 19:50		0.51			47.73	162				
4/9/00 0:20		0.53			28.64	83				

Vortechs™ System Inflow										
DATE + TIME	ACCESSION NUMBER	LEVEL IN FEET	TP (µg/L)	TN (mg/L)	TSS (mg/L)	COND µS/cm	BOD (mg/L)	FC #/100mL	TFP (µg/L)	TSN (mg/L)
4/9/00 7:45		0.38			10.58	37				
4/9/00 15:20		0.52			139.26	20100				
4/9/00 22:45		0.41			820.00	12700				
4/10/00 10:05		0.45			60.12	8880				
4/10/00 12:05		0.49			38.29	6680				
4/10/00 14:05		0.56			100.85	5580				
4/10/00 16:05		0.50			65.19	4120				
4/10/00 20:05		0.40			11.49	3520				
4/20/00 21:00		0.37			67.86	737				
4/20/00 23:00		0.40			25.31	504				
4/21/00 0:00		0.59			99.25	205				
4/21/00 1:00		0.52			28.64	158				
4/21/00 2:00		0.76			11526.13	115				
4/21/00 2:30		0.72			7062.22	57				
4/21/00 3:00		0.49			2310.12	73				
4/21/00 4:30		0.93			398.16	61				
4/21/00 5:30		0.81			391.10	59				
4/21/00 6:30		6.05			119.02	55				
6/5/00 20:10					*1251.43*	*339*				
6/5/00 21:40	VTI 00-87	0.47	238	4.1	66.88	185				
6/5/00 23:10		0.33			30.39	169				
6/6/00 0:40		0.39			22.68	156				
6/6/00 3:40		0.43			20.53	145				
6/6/00 8:55		0.30			26.84	143				
6/6/00 10:25		0.85			292.28	71				
8/23/00 11:10	VTI 00-93	0.58	1229	8.9	3254.31	307				
8/23/00 11:45	VTI 00-90/94	0.81	729	3.7	1310.53	123	58	800?		
8/23/00 12:45		0.82			1270.24	69				
8/23/00 13:40	VTI 00-91/95	1.40	94	0.8	527.92	28	9	60?		
8/23/00 14:10		0.59			146.38	37				
8/23/00 15:40	VTI 00-92/96	0.46	69	1.2	26.08	75	11	1000?		
8/23/00 16:10		0.92			12427.75	54				
8/23/00 16:40		0.67			3155.19	45				
8/23/00 18:05		0.39			446.91	66				
8/23/00 21:05	VTI 00-97	0.28	46	0.7	9.27	75	12	7900		
10/5/00 16:15	VTI 00-98	0.45	297	0.7	87.50	310	54	25200		
10/5/00 18:15		0.56			22.96	71				
10/5/00 19:50	VTI 00-99	0.95	96	0.8	78.23	32	17	29100		
10/5/00 20:50		0.70			396.10	34				
10/5/00 22:15		0.76			1363.78	35				
10/5/00 23:50	VTI 00-100	0.69	43	0.4	120.58	29	5	100000		
11/9/00 23:45	VTI 00-101	0.57	505	5.9	160.29	244				
11/10/00 0:20	VTI 00-102	1	304	2.1	287.91	78				
11/10/00 1:30	VTI 00-103	0.7	201	0.9	193.38	49				
11/10/00 2:40		0.89			1257.44	35				
11/10/00 3:50	VTI 00-104	0.87	115	0.4	935.51	28				

Vortechs™ System Inflow										
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11/10/00 4:25		0.58			172.52	35				
11/10/00 5:35	VTI 00-105	0.46	134	0.7	27.67	62				
11/10/00 6:10	VTI 00-106	0.78	115	0.6	72.27	35				
11/10/00 7:20		0.44			11.55	47				
11/10/00 9:05	VTI 00-107	0.39	159	0.8	4.92	75				
BLANK	VTI 00-108		<1	<0.05						
11/10/00 12:20	VTI 00-109	0.53	91	0.4	356.81	56				
11/10/00 15:20	VTI 00-110	0.38	165	0.6	18.73	65				
12/12/00 3:00	VTI 00-111		259	4.7	251.90	15480			63	3.5
12/12/00 3:30	VTI 00-112		353	4.3	292.35	9400			20	2.7
12/12/00 4:00	VTI 00-113		162	2.7	2297.74	6180			41	2.0
12/12/00 4:30	VTI 00-114		189	2.0	3706.93	3060			55	1.6
12/12/00 5:00					332.20	1720				
12/12/00 5:30					171.36	1260				
12/12/00 6:00	VTI 00-115		127	1.6	145.41	1060			70	1.4
12/12/00 6:30					72.80	1000				
12/12/00 7:00					36.52	900				
12/12/00 7:30	VTI 00-116		154	1.8	36.36	920			130	1.7
12/12/00 8:00	VTI 00-117		192	2.1	80.73	1790			129	1.7
BLANK	VTI 00-118		6	lt 0.05					lt 1.0	lt 0.5
Results marked with a "*" were tested outside of the six hour holding time and are not certifiable as per DFWI.										
Fecal Coliform results marked with a "?" refers to a count with high background.										

Vortechs^{TM} System Outflow										
DATE + TIME	ACCESSION NUMBER	LEVEL IN FEET	TP (µg/L)	TN (mg/L)	TSS (mg/L)	COND µS/cm	BOD (mg/L)	FC #/100mL	TFP (µg/L)	TSN (mg/L)
2/14/00 9:00	VTO 00-01	0.36	41	6.85	23.94	30600		<10*		
2/14/00 9:30	VTO 00-02	0.47	39	7.69	21.79	30400		<10*		
2/14/00 10:00	VTO 00-03	0.53	120	8.08	121.64	26600		<10*		
2/14/00 10:30	VTO 00-04	0.88	392	7.79	483.17			10*		
2/14/00 11:00	VTO 00-05	0.89	490	6.56	775.85	11500		30*		
2/14/00 11:30	VTO 00-06	1.03	284	4.54	396.90	9600		10*		
2/14/00 12:00		0.94			188.73	7800				
2/14/00 13:00		0.74			136.76	9000				
2/14/00 14:00	VTO 00-07	0.66	176	3.81	147.50	8500		<10*		
2/14/00 15:30		0.59			140.00	15700				
2/14/00 16:30	VTO 00-08	0.55	188	4.99	132.00	12600		30*		
2/14/00 18:30		0.48			81.41	14300				
2/14/00 20:30	VTO 00-09	0.43	48	7.35	28.03	29500		<10*		
2/23/00 10:40		0.39			80.66	13610				
2/23/00 12:40		0.50			182.39	8910				
2/23/00 15:40		0.51			125.54	5640				
2/23/00 18:40		0.43			72.61	6540				
2/24/00 4:40		0.39			36.09	6570				
2/24/00 11:20		0.46			94.24	4710				
2/24/00 14:20		0.47			104.14	4750				
2/24/00 16:20		0.45			118.36	5800				
2/24/00 18:20		0.48			89.25	4700				
2/24/00 20:20	VTO 00-14	0.42	227	5.72	149.20	4600				
2/25/00 0:20		0.42			54.94	3770				
2/25/00 1:20	VTO 00-16	0.51	156	4.99	73.33	3280				
2/25/00 2:20	VTO 00-17	0.64	278	5.33	202.50	1800				
2/25/00 3:20	VTO 00-18	0.46	167	15.75	108.72	1080				
2/25/00 4:20		0.43			68.96	1080				
2/25/00 7:20	VTO 00-20	0.42	107	33.75	25.66	1540				
2/25/00 8:20	VTO 00-21	0.56	280	19.25	24.00	1510				
2/25/00 12:20	VTO 00-22	0.46	144	3.23	80.65	2700				
2/25/00 15:20	VTO 00-23	0.65	212	17.25	164.15	1264				
2/25/00 18:20		0.47			48.03	1126				
2/25/00 21:20	VTO 00-25	0.41	89	23.75	31.50	1309				
2/26/00 6:20	VTO 00-26	0.39	73	26.75	21.77	1496				
2/26/00 12:20		0.44			21.22	1501				
2/26/00 15:20	VTO 00-28	0.46	78	37.25	20.26	1660				
2/26/00 18:20		0.43			59.55	1289				
2/26/00 21:20		0.41			49.04	1109				
2/27/00 6:20	VTO 00-30	0.45	96	1.8	27.31	1150				
2/27/00 9:20		0.46			23.77	1100				
2/27/00 13:20	VTO 00-31	0.65	78	9.5	27.95	865				
2/27/00 16:20		0.57			121.07	975				
2/27/00 19:20	VTO 00-33	0.48	133	4.25	72.43	595				
2/27/00 22:20	VTO 00-34	0.44	91	1.24	33.42	556				
2/28/00 1:20		0.50			24.83	582				
2/28/00 4:20	VTO 00-36	0.73	130	5.75	64.18	686				
2/28/00 7:20		0.46			50.86	214				

Vortechs^{TM} System Outflow										
DATE + TIME	ACCESSION NUMBER	LEVEL IN FEET	TP (µg/L)	TN (mg/L)	TSS (mg/L)	COND µS/cm	BOD (mg/L)	FC #/100mL	TFP (µg/L)	TSN (mg/L)
BLANK	VTO 00-38		<1	<0.05						
2/28/00 10:45	VTO 00-39	0.42	69.4	0.8	26.67	279				
2/28/00 12:45	VTO 00-40	0.50	151	0.54	48.83	307				
2/28/00 14:45		0.48			88.64	436				
2/28/00 16:45		0.43			69.10	409				
2/28/00 18:45		0.40			57.19	379				
2/28/00 20:45	VTO 00-41	0.39	161	0.78	55.20	373				
2/29/00 8:50		0.39			44.40	379				
2/29/00 12:50	VTO 00-42	0.44	145	2.25	36.55	397				
2/29/00 14:50		0.44			51.57	394				
2/29/00 16:50		0.40			46.67	349				
2/29/00 18:50		0.39			42.68	343				
2/29/00 22:50		0.39			38.86	343				
3/1/00 4:55		0.38			36.83	348				
3/1/00 12:50	VTO 00-44	0.39	145	0.3	33.76					
3/1/00 14:50		0.41			29.67					
3/1/00 16:50	VTO 00-45	0.39	114	0.3	29.28					
3/1/00 20:50		0.40			25.60					
3/1/00 22:50	VTO 00-46	0.46	121	0.3	24.00					
3/2/00 0:50	VTO 00-47	0.39	132	4.75	37.72	645				
3/2/00 2:50		0.39			36.80	682				
3/2/00 4:50	VTO 00-48	0.39	121	6.75	36.47	697				
3/2/00 8:50		0.38			35.49	694				
3/2/00 12:50		0.40			35.69	700				
3/2/00 14:50		0.40			35.54	729				
3/2/00 16:50		0.40			40.94	858				
3/2/00 18:50		0.39			35.34	945				
3/2/00 20:55	VTO 00-49	0.39	113	10.25	36.83	937				
3/3/00 1:35					*33.26*	*935*				
3/3/00 4:55					*32.64*	*932*				
3/3/00 ?					*33.15*	*940*				
3/9/00 17:40	VTO 00-50	2.97	1837	5.8	3397.16	454				
3/9/00 17:45	VTO 00-51	2.06	2229	4.5	2367.43	296				
3/9/00 17:50	VTO 00-52	1.08	1566	6.3	1571.13	263				
3/9/00 17:55	VTO 00-53	0.74	1459	4.9	1214.29	251				
3/9/00 18:05	VTO 00-54	1.36	828	4.6	955.94	238				
3/10/00 0:05	VTO 00-55	0.38	165	1.6	116.49	128				
3/10/00 6:05	VTO 00-56	0.37	119	1	57.30	122				
3/11/00 14:45	VTO 00-57	0.51	110	1.2	30.29	868				
3/11/00 15:45	VTO 00-58	0.42	264	3.9	104.32	11180				
3/11/00 17:45		0.38			101.97	11500				
3/11/00 21:45	VTO 00-59	0.39	206	2.8	91.59	10670				
3/11/00 22:45	VTO 00-60	0.43	185	3.1	81.29	10230				
3/11/00 23:45		0.44			100.46	15430				
3/12/00 1:45	VTO 00-61	0.57	139	1.9	152.65	12390				
3/12/00 2:45		0.59			61.16	9090				
3/12/00 3:45	VTO 00-62	0.68	108	0.4	52.62	3950				

Vortechs™ System Outflow										
DATE + TIME	ACCESSION NUMBER	LEVEL IN FEET	TP (µg/L)	TN (mg/L)	TSS (mg/L)	COND µS/cm	BOD (mg/L)	FC #/100mL	TFP (µg/L)	TSN (mg/L)
3/12/00 4:45	VTO 00-63	0.70	74	1.6	39.84	2210				
3/12/00 5:45	VTO 00-64	0.54	77	1.7	44.66	2470				
3/12/00 6:45		0.48			27.44	2760				
3/12/00 9:45	VTO 00-65	0.45	64	1.4	33.77	8410				
3/12/00 11:45	VTO 00-66	0.49	79	0.4	53.80	4090				
3/12/00 13:45	VTO 00-67	0.46	182	3.6	52.84	2110				
BLANK	VTO 00-68		1.3	0.1						
3/25/00 20:50		0.48			621.96	8600				
3/25/00 21:50		0.41			337.78	4430				
3/26/00 1:50		0.38			204.51	4040				
3/28/00 0:08	VTO 00-69	0.72	552	4.9	303.73	4000				
3/28/00 0:18	VTO 00-70	0.55	348	4.9	351.32	2260				
3/28/00 1:30	VTO 00-71	0.40	147	2.8	154.87	1597				
3/28/00 1:45	VTO 00-72	0.63	194	3.6	132.50	1585				
3/28/00 2:30	VTO 00-73	0.51	389	2.9	87.57	885				
3/28/00 2:40	VTO 00-74	0.85	392	2.7	151.03	818				
3/28/00 3:30	VTO 00-75	0.46	223	2.4	47.95	583				
3/28/00 4:08	VTO 00-76	0.93	128	2.1	71.48	578				
3/28/00 4:20	VTO 00-77	0.83	196	1.4	157.03	698				
3/28/00 4:45	VTO 00-78	0.89	126	1.1	97.95	525				
3/28/00 5:10	VTO 00-79	0.89	46	0.4	56.88	367				
BLANK	VTO 00-80		12	<0.05						
3/28/00 11:10		0.83			48.80	70				
3/28/00 11:35		0.50			44.11	74				
3/28/00 14:05		0.39			26.78	88				
3/28/00 14:30		0.54			25.76	98				
3/28/00 14:55		0.46			39.54	189				
3/28/00 15:20		0.69			57.88	273				
3/28/00 15:45		0.47			76.31	226				
3/28/00 16:35		0.40			66.55	211				
3/28/00 19:35		0.38			58.68	211				
4/3/00 11:20	VTO 00-81	0.63	87	1.9	32.22	376				
4/3/00 11:25	VTO 00-82	0.68	122	2.2	59.68	527				
4/3/00 12:00	VTO 00-83	0.56	172	2.4	91.30	244				
4/3/00 13:20	VTO 00-84	0.78	136	1.3	64.41	166				
4/3/00 13:50	VTO 00-85	0.56	108	1.2	60.68	107				
4/3/00 15:50	VTO 00-86	0.40	87	0.8	41.21	111				
4/3/00 20:25		0.38			35.77	112				
4/3/00 22:20		1.13			30.83	113				
4/3/00 22:40		2.17			188.64	74				
4/3/00 23:00		0.70			343.37	45				
4/3/00 23:30		1.04			168.37	42				
4/3/00 23:50		1.63			156.74	43				
4/4/00 0:05		0.77			131.18	38				
4/4/00 0:30		0.65			53.70	34				
4/4/00 8:15		0.42			22.47	73				
4/4/00 10:15		0.60			47.20	50				
4/4/00 10:45		0.42			35.16	54				
4/4/00 11:15		0.39			32.17	54				

Vortechs^{TM} System Outflow										
DATE + TIME	ACCESSION NUMBER	LEVEL IN FEET	TP (µg/L)	TN (mg/L)	TSS (mg/L)	COND µS/cm	BOD (mg/L)	FC #/100mL	TFP (µg/L)	TSN (mg/L)
4/4/00 14:15		0.38			24.18	55				
4/8/00 19:50		0.51			76.63	224				
4/9/00 0:20		0.53			20.56	148				
4/9/00 7:45		0.38			5.76	43				
4/9/00 15:20		0.52			16.41	3440				
4/9/00 22:45		0.41			22.90	16600				
4/10/00 10:05		0.45			51.08	8580				
4/10/00 12:05		0.49			43.56	6710				
4/10/00 14:05		0.56			47.91	5170				
4/10/00 16:05		0.50			39.89	4350				
4/10/00 20:05		0.40			24.07	4040				
4/20/00 21:00		0.37			19.69	205				
4/20/00 23:00		0.40			14.38	208				
4/21/00 0:00		0.59			14.38	208				
4/21/00 1:00		0.52			34.95	410				
4/21/00 2:00		0.76			28.02	317				
4/21/00 2:30		0.72			18.84	285				
4/21/00 3:00		0.49			148.46	492				
4/21/00 4:30		0.93			35.44	109				
4/21/00 5:30		0.81			13.80	82				
4/21/00 6:30		6.05			26.70	71				
6/5/00 21:40	VTO 00-87	0.47	254	3.6	38.72	888				
6/5/00 23:10		0.33			36.44	571				
6/6/00 0:40		0.39			29.29	379				
6/6/00 3:40		0.43			29.09	338				
6/6/00 8:55		0.30			16.94	201				
6/6/00 10:25		0.85			48.37	236				
8/23/00 11:10	VTO 00-93	0.58	39.8	0.4	5.82	151				
8/23/00 11:45	VTO 00-90/94	0.81	884	1.2	80.63	129	57	1600?		
8/23/00 12:45		0.82			40.43	92				
8/23/00 13:40	VTO 00-91/95	1.40	152	2.6	38.07	74	21	17100?		
8/23/00 14:10		0.59			39.86	68				
8/23/00 15:40	VTO 00-92/96	0.46	169	0.7	54.59	30	3	1200?		
8/23/00 16:10		0.92			19.78	30				
8/23/00 16:40		0.67			13.08	42				
8/23/00 18:05		0.39			10.76	47				
8/23/00 21:05	VTO 00-97	0.28	37	0.5	9.17	48	10	7200		
10/5/00 16:15	VTO 00-98	0.45	230	5.7	2.42	4900	4	23500		
10/5/00 18:15		0.56			17.72	285				
10/5/00 19:50	VTO 00-99	0.95	105	0.8	42.89	62	8	8600		
10/5/00 20:50		0.70			8.86	39				
10/5/00 22:15		0.76			6.85	40				
10/5/00 23:50	VTO 00-100	0.69	50	0.4	4.22	29	6	9100		
11/9/00 23:45	VTO 00-101	0.57	228	1.0	13.20	179				
11/10/00 0:20	VTO 00-102	1	295	2	44.79	80				
11/10/00 1:30	VTO 00-103	0.7	223	1	8.20	50				

Vortechs™ System Outflow										
DATE + TIME	ACCESSION NUMBER	LEVEL IN FEET	TP (µg/L)	TN (mg/L)	TSS (mg/L)	COND µS/cm	BOD (mg/L)	FC #/100mL	TFP (µg/L)	TSN (mg/L)
11/10/00 2:40		0.89			10.88	36				
11/10/00 3:50	VTO 00-104	0.87	99	0.4	5.92	27				
11/10/00 4:25		0.58			3.50	31				
11/10/00 5:35	VTO 00-105	0.46	120	0.3	3.40	38				
11/10/00 6:10	VTO 00-106	0.78	106	0.5	7.92	33				
11/10/00 7:20		0.44			4.30	39				
11/10/00 9:05	VTO 00-107	0.39	126	0.4	3.68	42				
BLANK	VTO 00-108		<1	<0.05						
11/10/00 12:20	VTO 00-109	0.53	117	0.5	36.79	72				
11/10/00 15:20	VTO 00-110	0.38	158	0.8	36.33	78				
12/12/00 3:00	VTO 00-111		74	1.3	7.78	2110			24	1.5
12/12/00 3:30	VTO 00-112		295	3.3	85.08	8690			131	2.4
12/12/00 4:00	VTO 00-113		158	3.1	89.29	6380			60	2.2
12/12/00 4:30	VTO 00-114		175	2.7	57.64	3300			62	1.8
12/12/00 5:00					26.67	1900				
12/12/00 5:30					20.33	1370				
12/12/00 6:00	VTO 00-115		134	1.6	16.72	1170			100	1.7
12/12/00 6:30					20.57	1100				
12/12/00 7:00					18.79	1040				
12/12/00 7:30	VTO 00-116		171	1.5	27.83	990			122	1.6
12/12/00 8:00	VTO 00-117		255	1.9	46.29	1440			124	1.3
BLANK			6	lt 0.05					lt 1.0	lt 0.5

Results marked with a "*" were tested outside of the six hour holding time and are not certifiable as per DFWI.

Fecal Coliform results marked with a "?" refers to a count with high background.

Appendix 7

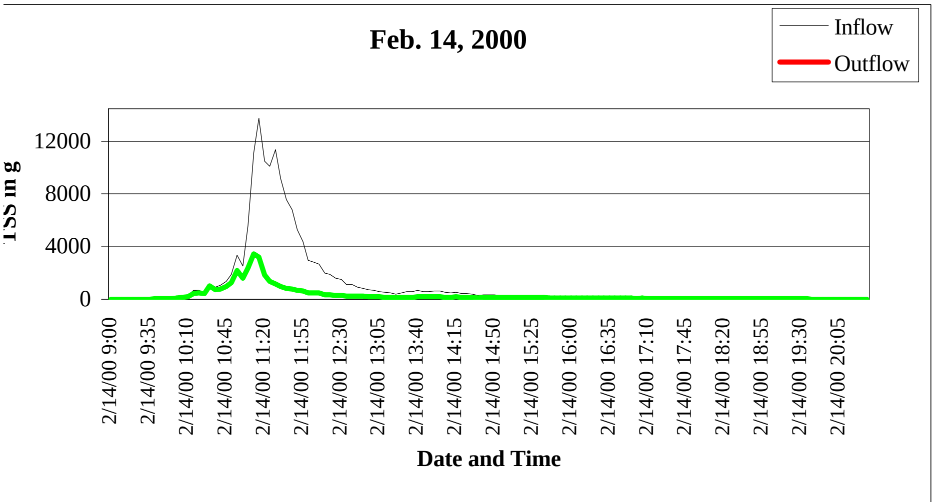
Event Mean Concentration data for TP, TN, and TSS

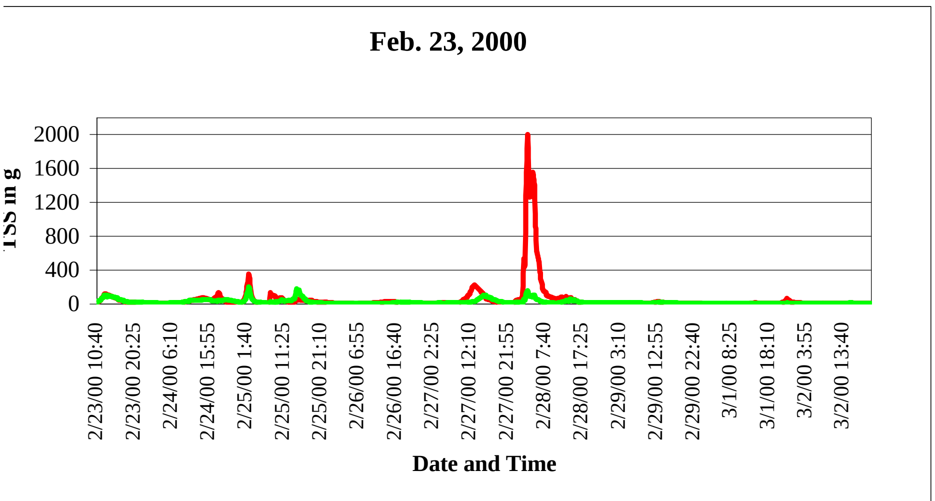
	Event Mean Concentrations			Event Mean Concentrations		
	Inflow			Outflow		
Storm Start Date	TP in µg/L	TN in mg/L	TSS in mg/L	TP in µg/L	TN in mg/L	TSS in mg/L
02/14/00	276.04	4.82	987.48	244.13	5.26	263.18
02/23/00	144.43	8.50	128.73	108.30	7.66	59.23
03/09/00	362.62	2.78	1040.04	321.66	2.16	337.87
03/25/00			213.73			359.14
03/28/00	95.19	1.25	1673.57	90.38	0.88	71.39
04/03/00	72.42	1.12	535.16	91.94	0.90	70.14
04/08/00			180.81			29.76
04/20/00			2491.55			35.41
06/05/00			89.99			31.98
08/23/00	133.82	1.01	1047.02	293.00	1.54	37.08
10/05/00	109.64	0.66	439.45	106.51	1.41	16.57
11/09/00	169.86	0.95	445.19	160.17	0.77	17.36
12/12/00	174.53	2.16	1156.16	168.76	2.30	44.72

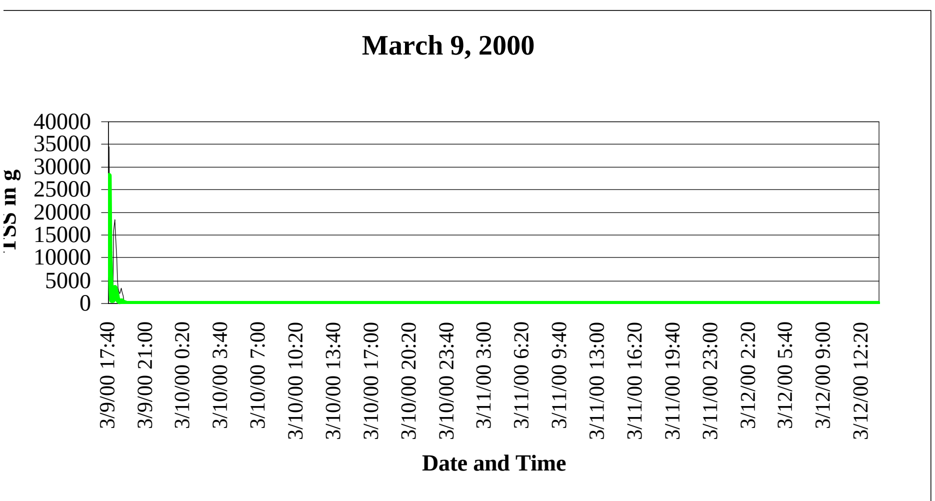
Appendix 8

Total Suspended Solids Chemical Loading Graphs for each storm sampled

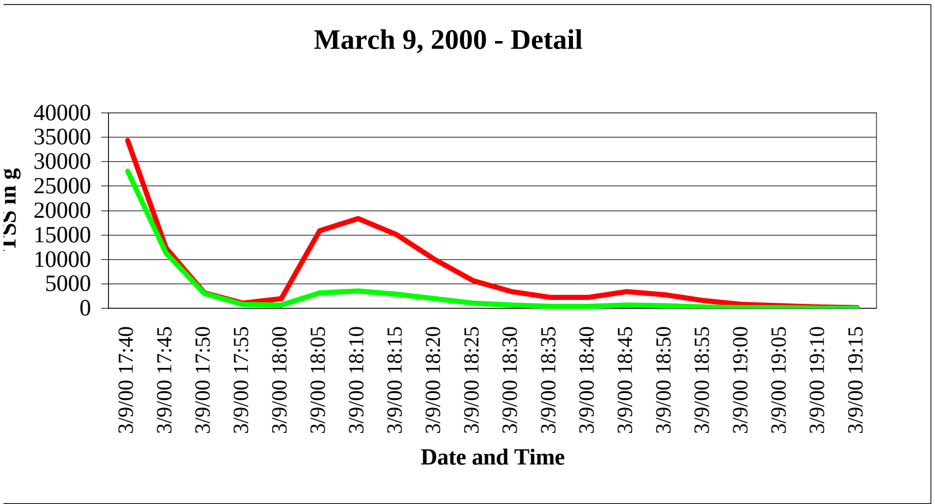
Total Suspended Solids Chemical Loading

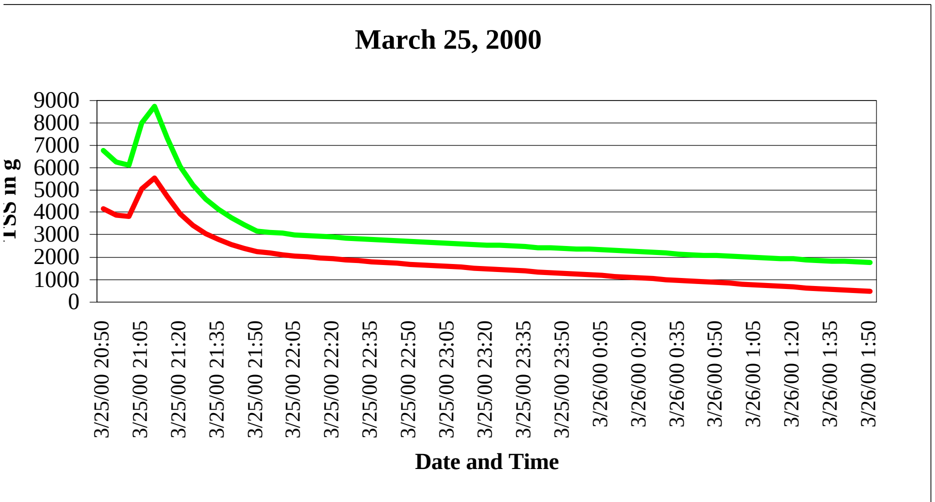


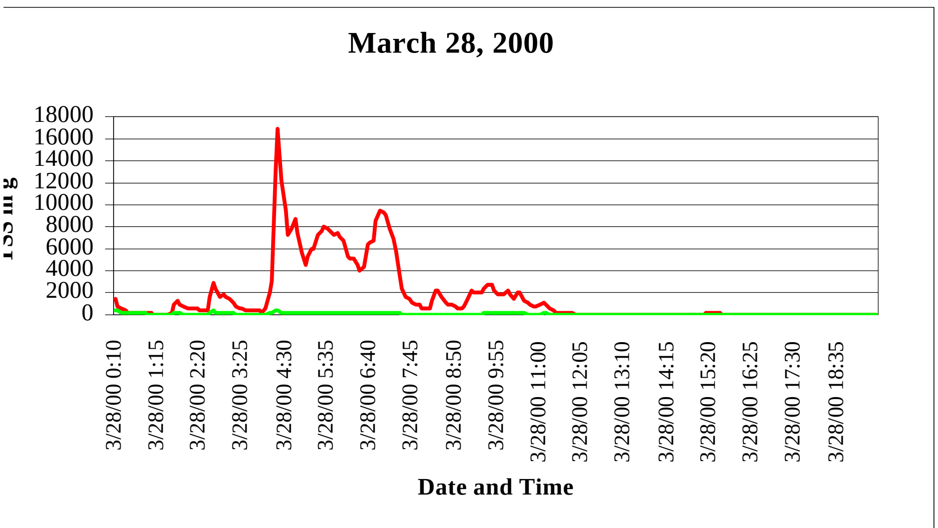




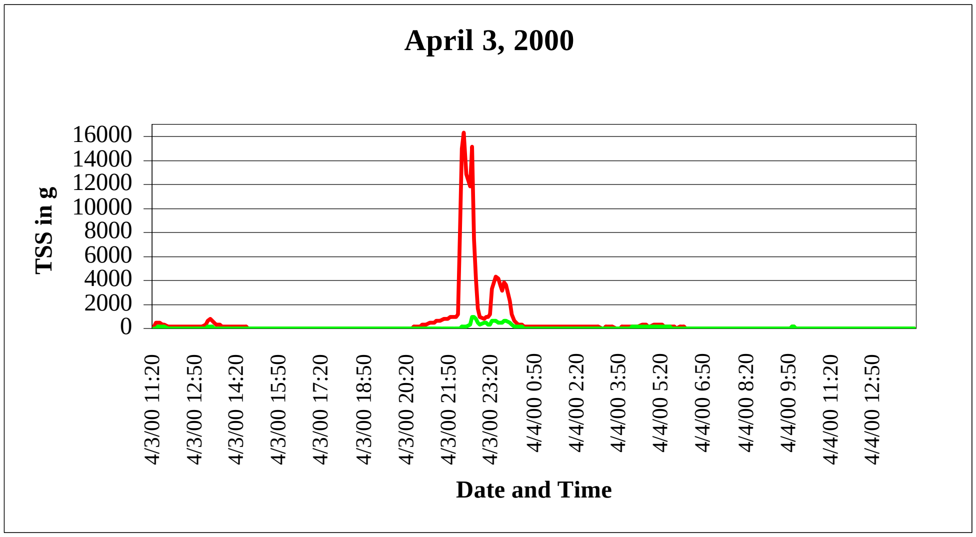
Total Suspended Solids Chemical Loading

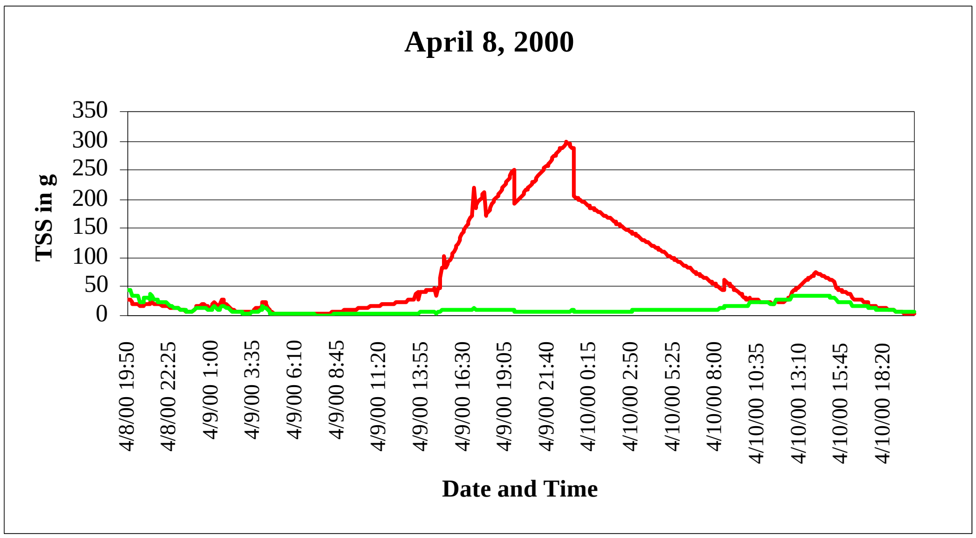


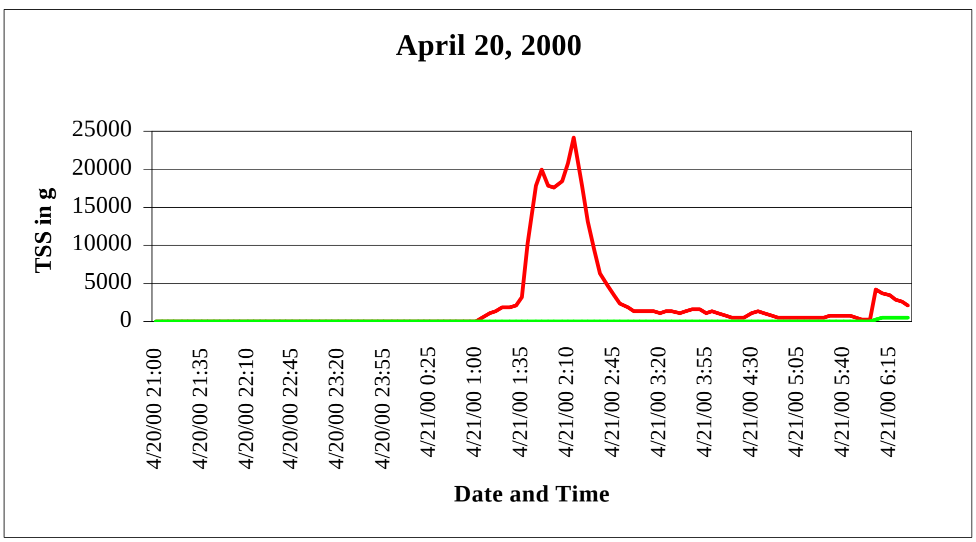




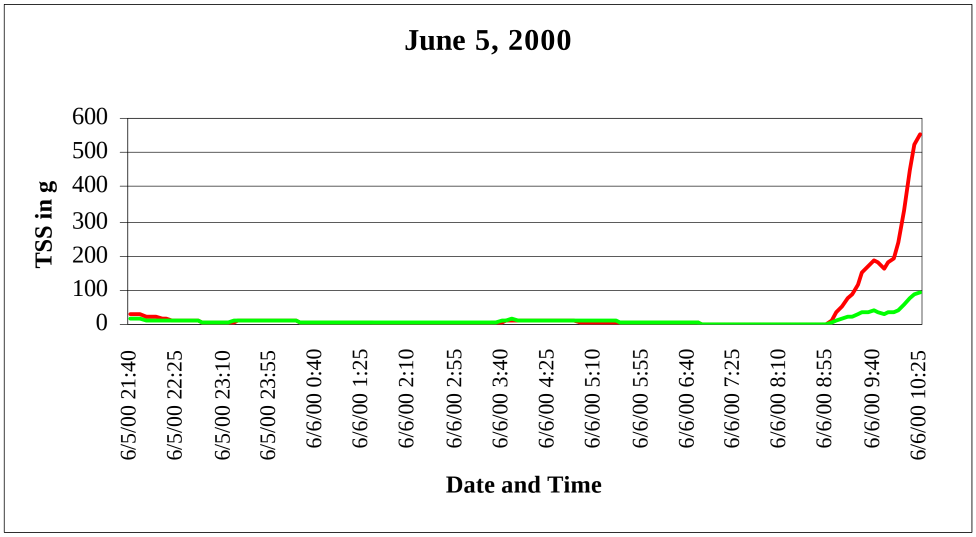
Total Suspended Solids Chemical Loading

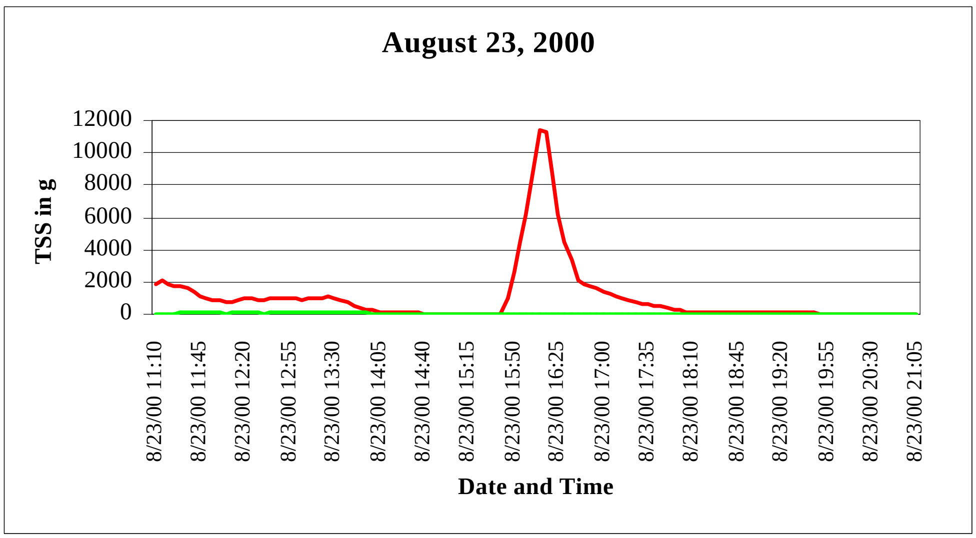


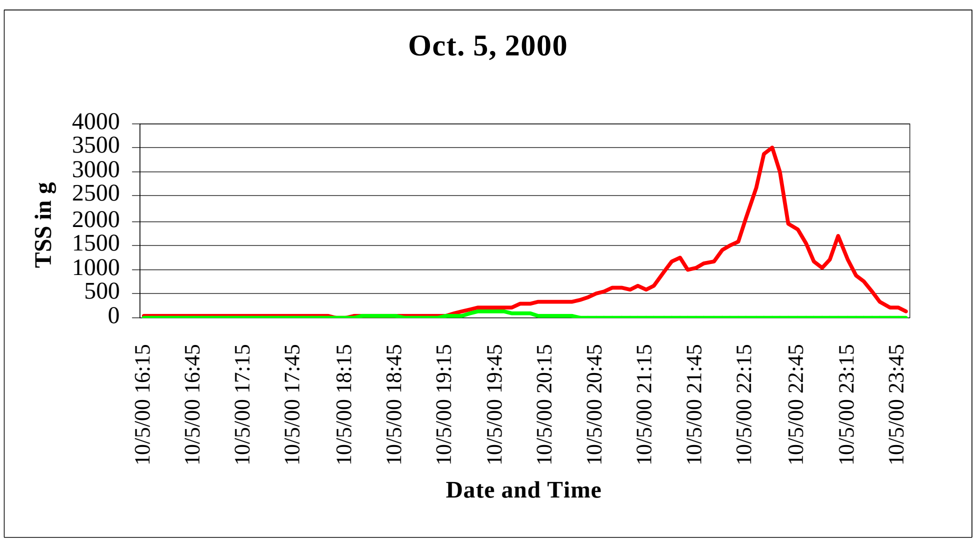




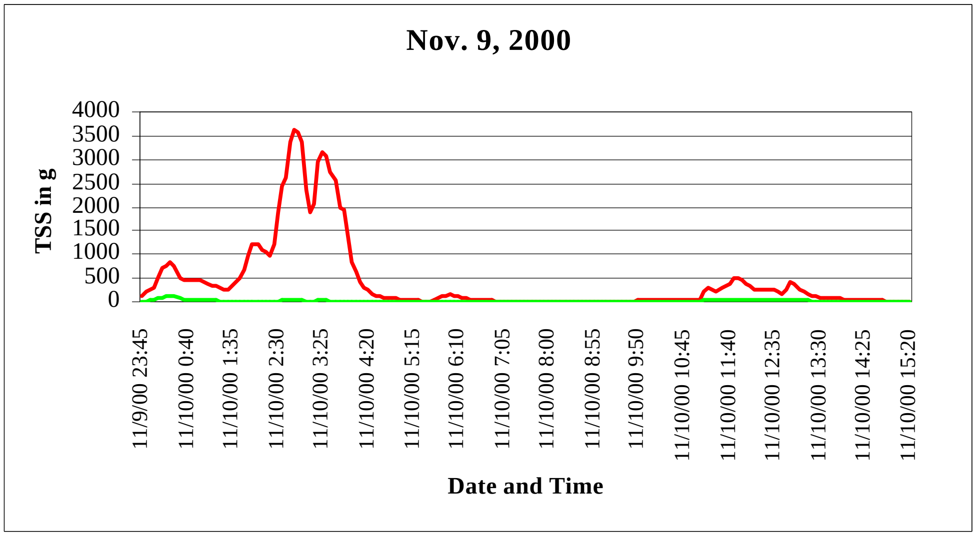
Total Suspended Solids Chemical Loading

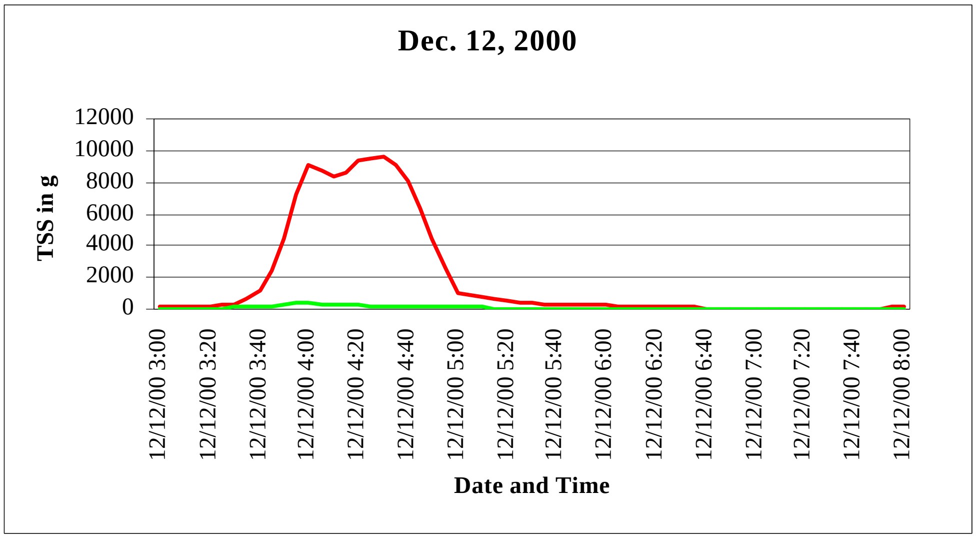






Total Suspended Solids Chemical Loading





Appendix 9

Grain size distribution graph from Vortechs^{TM} Systems cleanouts
in 1998 and 2000

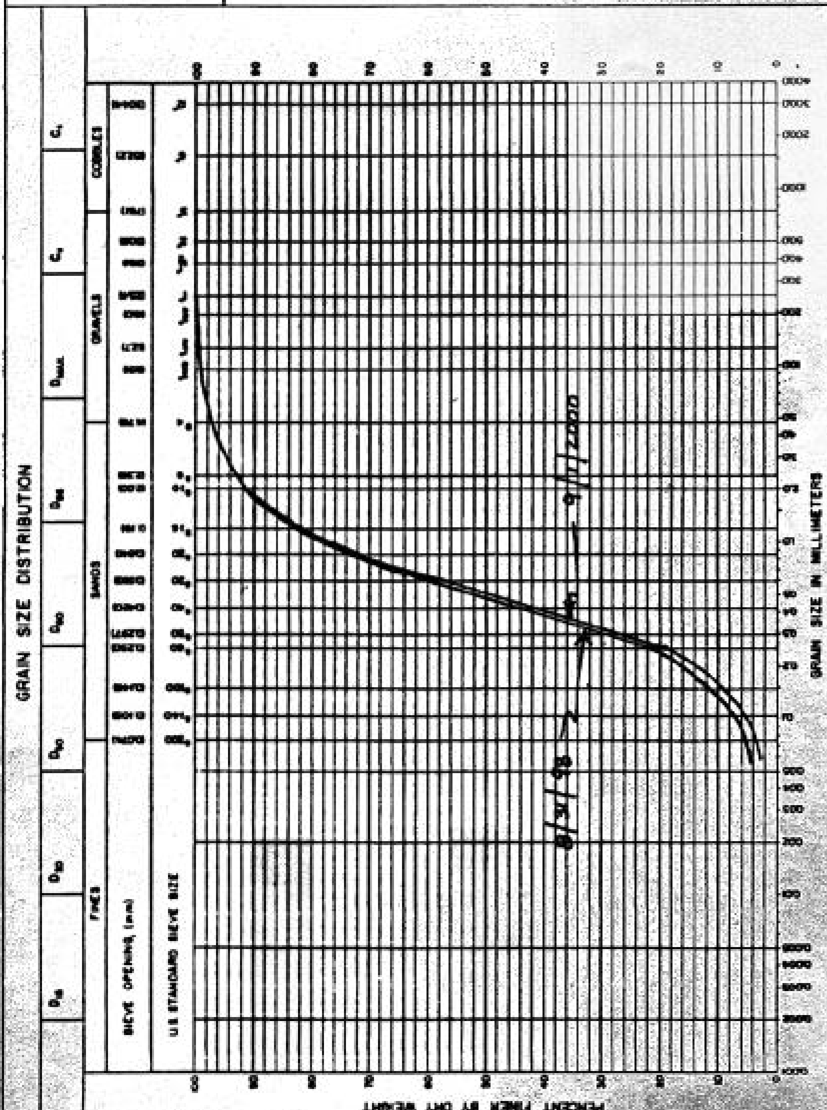
SCS-ENG-353A
Rev. 11-71

LABORATORY NO. ______

MATERIALS TESTING REPORT	U. S. DEPARTMENT of AGRICULTURE SOIL CONSERVATION SERVICE	SOIL CLASSIFICATION

PROJECT and STATE: VORTECHS STUDY – LAKE GEORGE VILLAGE		SAMPLE LOCATION: CANADA STREET
FIELD SAMPLE NO.: AS SHOWN	DEPTH: CHAMBER	GEOLOGIC ORIGIN: STORM WATER WASH OFF
TYPE OF SAMPLE:	TESTED AT: PARROTT-WOLFF	APPROVED BY: / DATE: AS SHOWN
SYMBOL	DESCRIPTION	

GRAIN SIZE DISTRIBUTION



UNDISTURBED CONDITION: MOISTURE %; DRY UNIT WEIGHT g/cc, pcf

SHRINKAGE LIMIT %

SOLUBLE SALTS %

ATTERBERG LIMITS: NATURAL MOISTURE LL, PI; AIR DRY LL, PI; OVEN DRY LL, PI

SPECIFIC GRAVITY (G_s): (−) #4; (+) #4

REMARKS

GPO : 1971 O - 100-348