Robert Pitt, Ph.D., P.E., DEE **Environmental Engineer**

2137 Farley Rd Birmingham, AL 35226 **(205) 979-1073**

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Subject: Hydro-Kleen flow test report

This is the letter report, as requested, that summarizes our flow tests with the Hydro-Kleen Storm Water Filtration System.

Our initial flow tests, using your standard set of media, began on September 9th. Our test apparatus included a 75 ft^3 water storage tank, a 100 gal/min rated submersible pump, and 1-1/2 inch plastic hose to connect the pipe to the test apparatus. The Hydro-Kleen unit was supported by lumber across the top of a plastic laminate-lined waterproofed wooden box, 34 inches square and 48 inches tall. Water entered the top of the unit from the test rig header, entered a plastic tub mixing chamber (used later during the sediment tests to ensure mixing of the test mixtures) and then flowed through large holes in the bottom of the mixing chamber and entered the Hydro-Kleen unit. The water drained from the media chamber of the Hydro-Kleen and fell into the bottom of the large wooden box that acted like an inlet structure and catchbasin sump. The water filled the box to the 14 inch level, and then poured out through a 4 inch diameter orifice. The exiting water entered a short length of 6 inch PVC pipe where it was directed back into the storage tank. This enabled re-circulating tests to be conducted for some time.

With this flow test arrangement, maximum flows of 60 to 65 gpm are possible. This initial test day was used to assemble the equipment on the portable trailer and to construct the necessary brackets and supports. During these tests, the maximum flow using clean water did not cause any overflow/bypass of the Hydro-Kleen test unit. The flow was measured by capturing the discharged water from the inlet box in a 5 gallon bucket for a set period of time, and then carefully measuring the captured water in a smaller measuring cup. In these tests, we captured 21 quarts of water in 5 seconds, for a flow rate of 63 gpm.

Tests were continued on September 11, 13, 20, and 23 using the Hydro-Kleen insert in the inlet box placed on a small utility trailer. Water from Star Lake, a detention pond in Hoover, Alabama, was pumped to the apparatus from the floating pump. Figures 3 and 4 show this setup, including the commercial fish feeder that was used to slowly add the test material to the water. This device (from Aquatic Ecosystems, FL) allows us to add up to 20 pounds of fine sediment to the water over a 12 hour period.

The test sediment we used was a combination of materials in order to match the particle size distribution found in stormwater as closely as possible. For the first test, we used mixture containing 45% Si-Co-Sil 106 ground silica (available from U.S. Silica, WV), 10% fine sand (sand blasting grade from Porter-Wagner), and 45% of a mixture of intermediate industrial abrasives (aluminum oxide). Our initial analyses showed the Si-

Co-Sil had a particle size distribution centered around 5 mm (U.S. Silica's specifications indicated 75% smaller than 45 mm), the fine sand was centered at about 300 mm, and the abrasive mixture was evenly distributed between 10 and 80 mm. The combination was very close to typical stormwater particle size distributions. The second test used a mixture 90% Si-Co-Sil 250 ground silica (50% passing 45 mm) and 10% of the fine sand. Our supplemental report will have more information on the particle sizes when the confirmation laboratory measurements are completed.

The particle size distribution plot from the Monroe St detention pond monitoring program conducted over many years by the USGS and the WI DNR. This plot includes bed-load samples, in addition to suspended solids. Although there is a relatively wide range of distributions found at this site, this distribution is similar to the size ranges found in most other outfall studies. It is important to note that only about 30% of stormwater particles are in the clay particle size range ($\leq$ 2 mm). Testing using all clay would lead to unusual results that would not be indicative of actual stormwater.

The first test ran over 3 days (Sept 11, 13, and 20) and used a total of 20 pounds of the initial test sediment mixture. We pumped for 6.6 hours at a 19.7 gal/min flow on the first day, 4.2 hours at 20.5 gal/min on the second day, and 6.3 hours at 21.4 gal/min on the third day. A total of 21,056 gallons (about 80 m^3) of lake water was therefore pumped over the 3 test days. The lake water solids concentrations are shown in Table 1. The suspended solids content was measured to be 12 mg/L. Therefore, the total solids added to the test for the first test series was 20 pounds (9.08 kg) of added sediment, plus another 2.1 pounds (0.95 kg) added from the lake sediment, for a total of 22.1 lb (10.03 kg).

Table 1. Lake Water Solids Content

Particulate Size		mg/L
All	Total Solids	69
Passing 0.47 µm	Total dissolved solids	59
Retained on 0.47 µm filter	Suspended solids	12

At the end of the third day of the test, the Hydro-Kleen still had not overflowed, or bypassed. The maximum water level was about 1 inch from the overflow. At a lower flow of 18.0 gal/min, less than an inch of water ponded on top of the upper media bag. There was about 3.5 inches of ponding at the last incremental test flow rate of 21.8 gal/min.

The second test used higher sediment loads to see if the Hydro-Kleen would clog faster at higher concentrations. September 23 tests used 45 pounds (20.4 kg) of the sediment. The tests ran for 5.3 hours at an average flow of 28.2 gal/min. The total water pumped was therefore 8970 gallons (34 m^3). With a lake SS concentration of 12 mg/L, 0.90 lbs (0.41 kg) of lake SS was also added during the test. Therefore, a total of 45.9 lbs (20.8 kg) was added to the Hydro-Kleen during this test.

During the last hour of the second test, the Hydro-Kleen was within and inch of overflowing, so the flow rate was reduced to about 15 gal/min (from the 28 gal/min that was used for most of the test). The head immediately dropped to zero (less than an inch of ponding noted on top of the upper media bag). After each 5 lb increment of material was added, the flow was then increased back to the 28 gal/min flow rate. The head would increase to close to overflowing, but would then suddenly drop. This was repeated 3 times, with the same behavior. It was likely that the sediment was being washed further down and through the media and into the catch basin sump during the periods of the higher flows. After the test, the top media bag was cut open and examined (after drying and weighing). There was a thick layer of the sediment material on top of the media. This was not found on the first test, where much more lake debris was accumulated on the media (due to the greater amount of lake water pumped). The larger debris (water-logged small branches and leaves) apparently was the cause for clogging during the first test. This material was not as evident during the second test, and it was thought that the Hydro-Kleen could function for an extended period without clogging, unless enough of this larger material accumulated on top of the media bag.