

TECHNICAL BULLETIN // **UP-FLO™ FILTER**

EVALUATION OF SIL-CO-SIL 106 REMOVAL PERFORMANCE
USING FILTER SAND MEDIA

© 2006 Hydro International

94 Hutchins Drive • Portland, ME 04102

Tel: 207.756.6200 • Fax: 207.756.6212

www.hydrointernational.biz

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EVALUATION OF SIL-CO-SIL 106 REMOVAL PERFORMANCE USING FILTER SAND MEDIA

INTRODUCTION

The Up-Flo™ Filter is a high rate, modular filtration system designed to meet the most stringent stormwater treatment regulations. It incorporates multiple elements of a treatment train design into a single, small-footprint device. The Up-Flo™ Filter is engineered to remove over 80% of fine TSS and associated pollutants. Filter Media can be customized to target site-specific pollutants. This test evaluated the TSS removal performance of the Up-Flo™ Filter with Filter Sand at the operating filtration rate of 23 gpm per Filter Module. The feed pollutant used was Sil-Co-Sil 106, a commercially available ground silica gradation having 100% of particles smaller than 212 microns in diameter and 75% of particles smaller than 45 microns in diameter. The particle size distribution for Sil-Co-Sil 106 can be found in **Figure 1**.

TESTING ARRANGEMENT AND PROCEDURES

A full-scale, Catch Basin configuration Up-Flo™ Filter equipped with one Filter Module was used for this test. The Filter Module contained two (2) media bags of Filter Sand.

A 3-inch Flygt pump delivered influent from the 23,000 gallon clean water reservoir to the Up-Flo™ Filter through an 8-inch PVC pipe network. The pipe network was equipped with a Hershey VP-820 butterfly valve to return flows in excess of the desired influent flow rate to the feed reservoir. A slurry supply tank containing Sil-Co-Sil 106 and clean water was continuously mixed and fed to the delivery line with a Watson Marlow 704 S/R peristaltic pump at 80 rpm. The slurry was fed to the delivery line three (3) feet upstream of the Up-Flo™ Filter. The

Sil-Co-Sil 106 Particle Size Distribution

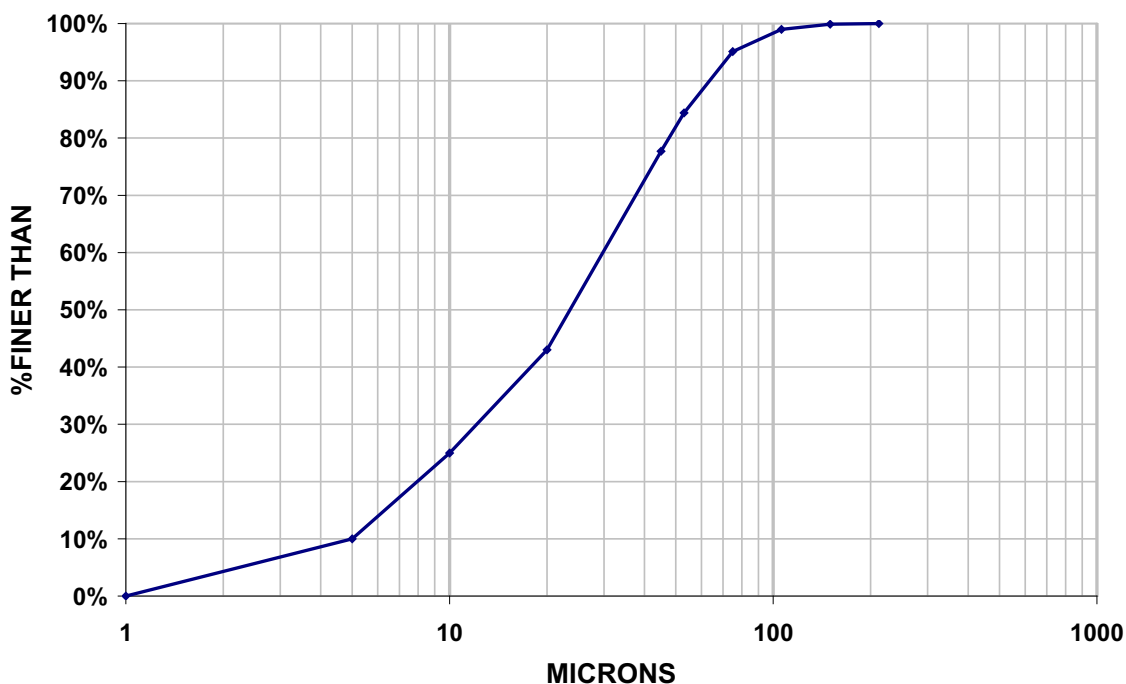


Figure 1: Sil-Co-Sil 106 particle size distribution verified according to ASTM D422 (AASHTO T88)

delivery line freely discharged the synthetic waste stream with a Sil-Co-Sil 106 concentration of 200-300 mg/L into the open top of the Up-Flo™ test tank at a rate of 23 gpm. A steady-state water level in the Up-Flo™ Filter test tank was continuously maintained to confirm the desired filtration rate of 23 gpm per Filter Module. Influent grab samples were taken from the free discharge of the delivery network. Effluent grab samples were taken from the free discharge of the Up-Flo™ Filter outlet pipe, two (2) feet downstream of the Up-Flo™ Filter.

SAMPLE ANALYSIS

Influent and effluent samples were analyzed using an equivalent standard to the TSS Test Method 2 Filtration in ASTM, 1999, D 3977-97 - the Standard Methods 19th Ed 1995 for the Examination of Water and Wastewater prepared and published by the American Public Health Association (APHA), American Water Works Association (AWWA), and Water Environment Federation (WEF) chapter 2-2540 D Total Suspended Solids Dried at 103-

105 °Celsius.

A total of 17 paired influent and effluent samples were analyzed for TSS concentration. All influent samples had TSS concentrations in the 190 – 300 mg/L range, while all effluent concentrations were in the 10 – 42 mg/L range (see **Figure 2**).

DATA ANALYSIS

The percent of Sil-Co-Sil 106 removed was derived from the concentrations of each paired sample. To ascertain the representativeness of the data, the sample sets were subjected to a Dixon Q's test and an ANOVA analysis.

Table 1 shows the percent of Sil-Co-Sil 106 removed during the Filter Sand test trials. The percent of Sil-Co-Sil 106 removed for each sample pair was determined using **Equation 1**:

$$\% \text{ Removal} = 100 \times ([\text{TSS}]_{\text{INF}} - [\text{TSS}]_{\text{EFF}}) / [\text{TSS}]_{\text{INF}}$$

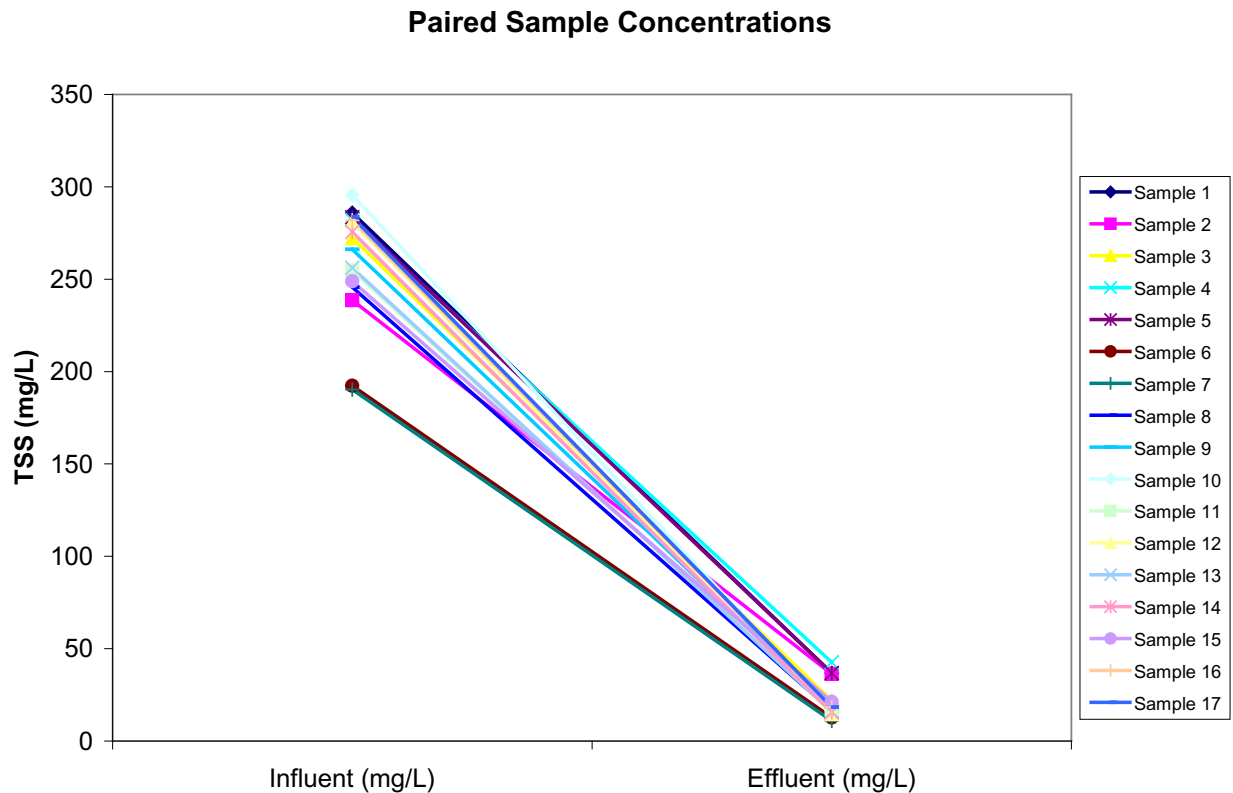


Figure 2: TSS concentrations of paired influent and effluent samples

Paired Samples for Filter Sand Trials

	Sample	Influent (mg/L)	Effluent (mg/L)	% Removed
Sample Set 1	1	285.92	36.81	87.1%
	2	238.60	36.36	84.8%
	3	272.39	21.84	92.0%
Sample Set 2	4	281.94	42.68	84.9%
	5	283.54	36.78	87.0%
	6	192.31	12.75	93.4%
Sample Set 3	7	190.34	10.98	94.2%
	8	245.71	16.26	93.4%
	9	266.18	18.42	93.1%
Sample Set 4	10	295.59	16.44	94.4%
	11	254.69	16.78	93.4%
	12	280.90	14.67	94.8%
Sample Set 5	13	256.21	15.79	93.8%
	14	275.56	15.58	94.3%
	15	248.86	21.18	91.5%
		281.93	18.29	93.5%
		283.70	18.40	93.5%
	AVG	295.62	24.67	91.7%

Table 1: Paired sample TSS concentrations and percent removed

The Average % Removal for each laboratory trial was calculated using Equation 2:

$$\%REM = 100 \times ([TSS]_{AVG\ INF} - [TSS]_{AVG\ EFF}) / [TSS]_{AVG\ INF}$$

By Equation 2, the average Sil-Co-Sil 106 Removal for

all 15 trials is 91.7% at a flow rate of 23 gpm per Filter Module.

To evaluate the sample sets for statistical validity, a Dixon's Q analysis was conducted. Table 2 shows that all samples have a Q < Q₁₇, thus there are no "outliers" within the samples and the data set may be deemed valid

DIXON Q TEST of Filter Sand Trials on Sil-Co-Sil 106

SAMPLE SET			
Influent (mg/L)	Q influent	Effluent (mg/L)	Q effluent
190.34		10.98	
192.31	0.0187	12.75	0.0558
238.60	0.4398	14.67	0.0606
245.71	0.0676	15.58	0.0289
248.86	0.0299	15.79	0.0065
254.69	0.0553	16.26	0.0148
256.21	0.0145	16.44	0.0056
266.18	0.0947	16.78	0.0109
272.39	0.0591	18.29	0.0476
275.56	0.0301	18.40	0.0032
280.90	0.0508	18.42	0.0008
281.93	0.0098	21.18	0.0869
281.94	0.0002	21.84	0.0209
283.54	0.0152	36.36	0.4581
283.70	0.0014	36.78	0.0132
285.92	0.0211	36.81	0.0009
295.59	0.0919	42.68	0.1852

99% confidence Q17=0.495

Table 2: Dixon's Q test for paired influent and effluent sample concentrations

ANOVA: Single Factor - Log Influent and Effluent for Filter Sand Trials

SUMMARY

Groups	Count	Sum	Average	Variance
Log (Influent, mg/L)	17	41.024	2.411	0.003
Log (Effluent, mg/L)	17	22.135	0.382	0.031

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	10.494	1	10.494	621.580	1.56E-22	4.149
Within Groups	0.540	32	0.017			
Total	11.034	33				

Table 3: ANOVA regression analysis for the log values of influent and effluent sample concentrations

with 99% confidence. An ANOVA single factor test was conducted on the influent and effluent sample sets to show that the data sets were significantly different. The log values of the influent and effluent concentrations were used, as most water quality data follow a log normal distribution. **Table 3** shows the results of the ANOVA analysis. The P-value is shown to be 1.56 E-22, which indicates that the influent and effluent sample sets are significantly different with over 99.9% confidence.

CONCLUSIONS

Based on laboratory testing, the Up-Flo™ Filter with Filter Sand media will remove over 91% of Sil-Co-Sil 106 at a filtration rate of 23 gpm per Filter Module.

A detailed lab report is available upon request.