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Evaluation of SASS[®] Filters

BG Fritz

September 2011



Pacific Northwest
NATIONAL LABORATORY

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Richland, Washington 99352

Overview

This experiment was conducted to evaluate the collection efficiency of two proprietary filter media. This was done by measuring particle concentrations in front of and behind the filters; the percent difference in these concentrations is the collection efficiency of the filter. The two types of filters tested were electrostatic polymer material. One was an open matrix filter designed for biological sampling; this filter allows substantially higher air flow rates at a given pressure drop than the second filter. The second filter tested was a denser material intended for radiological air sampling, with expected collection efficiency comparable to a standard glass fiber filter.

The purpose in conducting these tests was to characterize the collection efficiency of both filter types. The hypothesis was that the biological filter might be capable of collecting more aerosol mass as the higher flow rate would offset the lower collection efficiency. This was indeed the case; however, the collection efficiency of the biological filter varied with aerosol size fraction and mass loading on the filter. For this reason, use of the biological filter for collection of radiological material would only be recommended for qualitative sampling (i.e. screening or emergency response type sampling). The change in collection efficiency over time for the biological filter would result in a temporal bias, and the varying collection efficiency at different size ranges could also bias results if the contaminant material was not uniformly distributed across all size ranges. Also note that all results discussed here are only applicable to the tests conducted, and may not be indicative of filter performance under other conditions.

Methods

Sample collection was done using a slightly modified SASS[®] 3100 air sampler (Research International, Monroe WA). The sampler had piping added in-between the pump and the filter holder to allow for collection of an iso-kinetic sample behind the air filter. A short collar was also added above the filter, and the inlet aerosol concentration was measured at the front of the collar (Figure 1). Aerosol measurements were made with a pair of Met-One 3400 particle counters (Hach, Loveland CO). The instruments measured eight size ranges (0.5-1, 1-2, 2-4, 4-7, 7-11, 11-25 and >25 μm). Counts were made over ten minute intervals, with flow rates set to 1 cfm. Filters were also weighed before and after sampling to determine the total aerosol mass concentration. Initial testing was conducted in ambient air near an industrial complex; this location provided some variation in ambient aerosol concentrations as truck traffic in and out on dirt roads varied throughout the day. A second phase of testing was conducted inside of a ventilated building where an aerosol generation system was used to vary the aerosol concentration (Figure 2). This system used local dirt as the dust source. For both sets of testing, the majority of the aerosol composition was considered to be inorganic. During the second phase of testing the biological filter, initial measurements were conducted for several hours, then stopped while sample collection on the filter continued. Measurements were then restarted the following morning. This provided a measure of the filter collection efficiency after significant particle loading on the filter had occurred.



Figure 1- Sampler and particle counter set-up (ambient test).

Results

Radiological Air Filter

The radiological air filter had very high collection efficiency (as expected) at all size ranges (Table 1). There was no evidence of any decrease in collection efficiency at higher aerosol concentrations or particle loading on filter. The combined average collection efficiency across all size ranges was 99.94%. Total aerosol mass concentration during this test was $140 \mu\text{g}/\text{m}^3$.

Size Range	0.5-1 μm	1-2 μm	2-4 μm	4-7 μm	7-9 μm	9-11 μm	11-25 μm	>25 μm
Average Collection Efficiency	0.9995	0.9999	0.9999	0.9999	0.9995	0.9995	0.9991	0.9978

Table 1- Collection Efficiency for the radiological air filter.

Biological Air Filter

The biological air filter appeared to have very high collection efficiencies at all size ranges tested for the first 50 m³ of sample volume (Figure 2A&B). For both phases of testing, the collection efficiency was close to or greater than 90% for all 8 size ranges over the first three hours of use (~54 m³). However, after three hours, it appeared that the collection efficiency began to decrease (Figure 2A). This most likely occurs as electrostatic sites become occupied. Over the first three hours of the both tests, the total aerosol concentration averaged about 280 µg/m³. This means that the collection efficiency began to decrease after approximately 15 mg of aerosol had been collected on the filter. The total aerosol mass concentration for the two phases of testing was 200 and 140 µg/m³, respectively. The collection efficiency of larger particles decreased more dramatically than smaller particles; even after 22 hours of collection more than 80% of the particles smaller than 7 micrometers were still captured by the filter (Figure 1B&C). On the other hand, the collection efficiency for all particles large than 7 micrometers was less than 80% after about 20 hours.

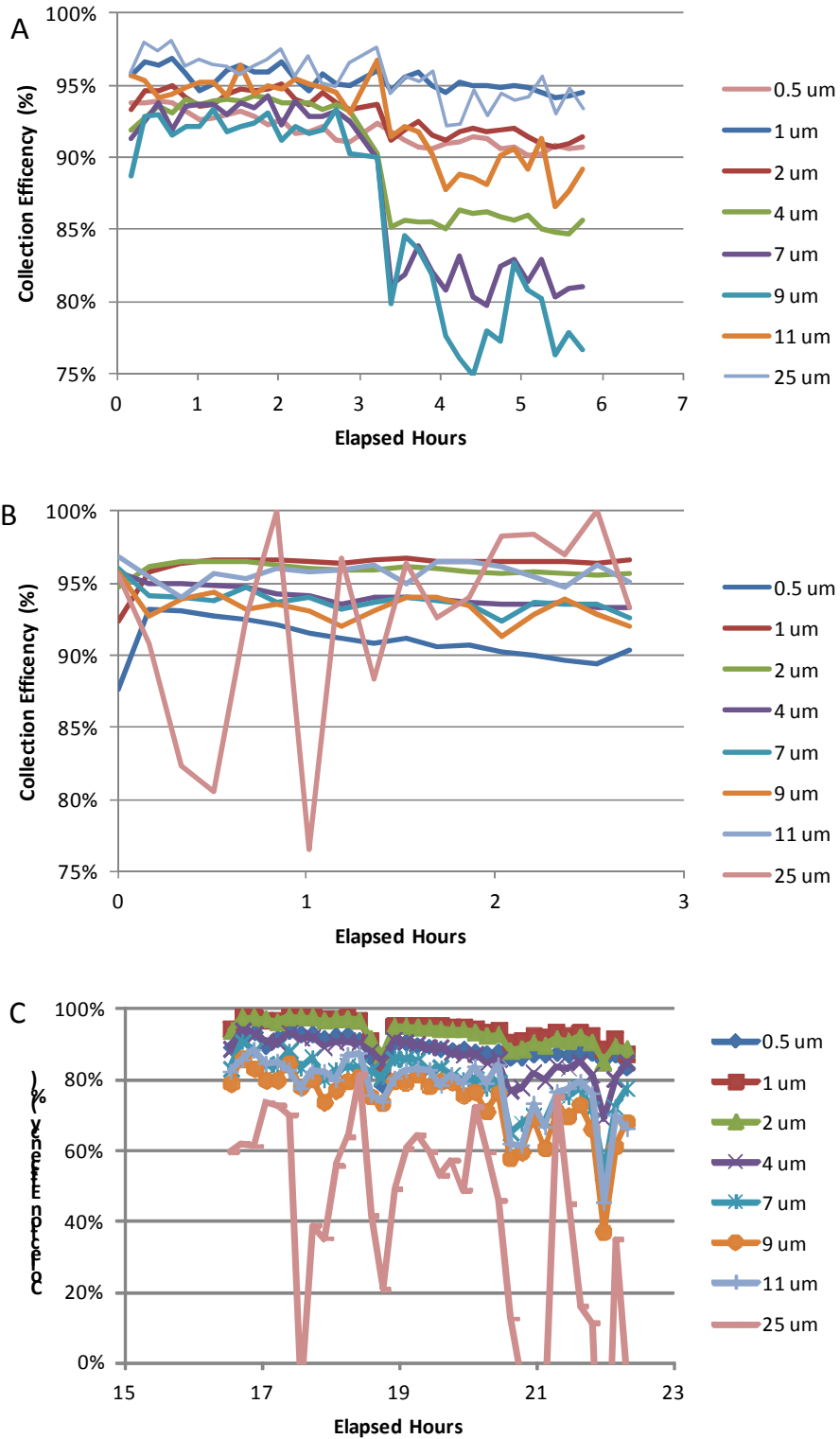


Figure 2- Collection efficiency of the biological air filter over time. A is the initial test in ambient air. B and C are the second test, with particle count measurements not made between hours 3 and 16.

Error Assessment

The accuracy of the laser particle counters was evaluated by operating the system with no filter in place. The speed of the pump was adjusted so that the total flow was 300 L/min, and the inlet for the second instrument was iso-kinetic. If the samplers were perfectly calibrated, they would give identical results when operated in this configuration as there would be zero particulate loss between the two measurement points. The particle counters and sampler were operated in this configuration for 1 hour. Overall, the difference between the two instrument measurements of total particle count was about 10%. The average difference in each size range was less than 30% for all size ranges, and the largest single difference at any one size range for a 10 minute sampling interval was 63% (Table 2). These errors are not significant enough to change the assessment of the results provided above. For example, the 7-9 μm size range results are shown with 30% increase and decrease in particle count applied to the post filter particle count data (Figure 3). While the absolute collection efficiency changes some when this maximum error is assumed, the overall trend remains the same.

Time (min)	0.5-1 μm	1-2 μm	2-4 μm	4-7 μm	7-9 μm	9-11 μm	11-25 μm	>25 μm	Total Particles
10	11%	18%	19%	25%	20%	4%	32%	-3%	15%
20	10%	19%	21%	23%	23%	2%	46%	4%	14%
30	11%	19%	15%	7%	-6%	-35%	11%	-30%	12%
40	11%	16%	8%	4%	-12%	-28%	-8%	-63%	10%
50	9%	10%	0%	-6%	-18%	-24%	-1%	-54%	6%
60	9%	9%	1%	-6%	-13%	-22%	8%	-19%	6%
Avg	10%	15%	11%	8%	-1%	-17%	15%	-28%	11%

Table 2- Percent difference between laser particle counter results when system operated with no filter in place.

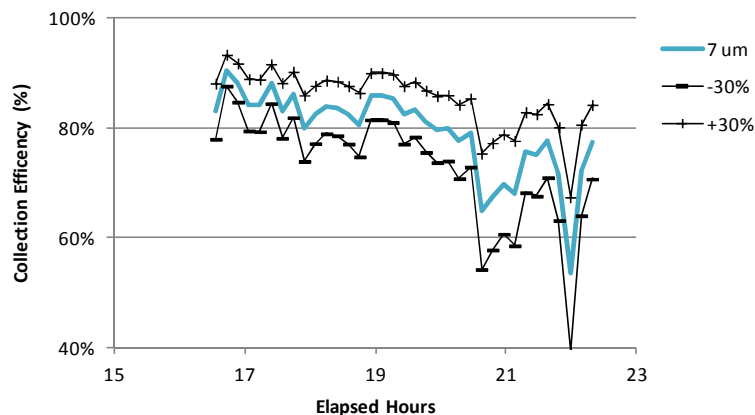


Figure 3- Results of initial collection efficiency test for the 7-9 μm size range, with a + and - 30% error term added to the second particle counter results.

Conclusions

The filter intended for radiological air sample collection has a very high collection efficiency, comparable to standard glass fiber filters commonly used in radiological air sample collection. The filter intended for biological aerosol collection has a lower collection efficiency than the radiological filter. However, the lower pressure drop through this filter does allow for a significantly higher flow rate by the SASS[®] 3100 air sampler. This may make it a more desirable filter for some applications requiring maximum particle collection. For example, a 24 hour sample collected in an atmosphere with a total suspended particle concentration of 150 $\mu\text{g}/\text{m}^3$ using the radiological filter, with a collection flow rate of 80 L/min, would collect approximately 17 mg of aerosol. Under the same conditions, a sample collected on a biological filter operating at 300 L/min would collect approximately 45 mg of aerosol (assuming 70% collection efficiency). This calculation however requires an estimate of the particle size distribution of the aerosol and the collection efficiency at each size fraction. For this reason, the biological filter would not be recommended for use in any type of regulatory or characterization sampling effort where a quantitative result is necessary. The disadvantages of having to account of uncertainties associated with the variable collection efficiency would not be offset by the additional mass collected. However, for a qualitative sampling approach (screening or emergency response type sampling application), the additional mass/filter/time collected by the biological sampling filter could be a valuable asset, making the use of the biological filter advantageous. For example, in an emergency, the time sampling personnel needed to remain at one spot to collect a detectable sample would be reduced by a factor of 3; this would allow more samples to be collected per hour, and would reduce the immersion time of sampling personnel when collecting samples within the plume.

Appendix

Raw Data

Table A1- Initial Test, biological filter, sampler inlet particle count

Date Time	Volume	0.5 um	1 um	2 um	4 um	7 um	9 um	11 um	25 um
8/31/2011 8:55	9.93	342937	102149	76847	19806	3144	955	701	266
8/31/2011 9:05	9.932	341004	93375	63432	14435	2227	637	450	193
8/31/2011 9:15	9.933	340782	97549	73250	18500	2845	735	480	150
8/31/2011 9:25	9.932	337774	92834	63570	13245	1795	528	316	103
8/31/2011 9:36	9.932	361015	108933	93951	31198	6358	2260	1618	509
8/31/2011 9:46	9.933	369462	122946	127438	47921	10019	3362	2521	949
8/31/2011 9:56	9.935	368925	119279	125080	51749	12052	4433	3540	1892
8/31/2011 10:06	9.935	331366	92259	74796	22949	4660	1570	1087	407
8/31/2011 10:16	9.935	307899	84535	65224	17592	2991	923	680	373
8/31/2011 10:26	9.936	308253	88657	74117	21715	3757	1145	797	457
8/31/2011 10:37	9.936	326080	94349	83103	27015	5309	1744	1255	558
8/31/2011 10:47	9.935	303369	79864	61630	17024	2951	936	650	195
8/31/2011 10:57	9.935	315246	93393	87842	31167	6278	2059	1527	552
8/31/2011 11:07	9.936	323940	106445	114103	42700	8548	2870	2113	818
8/31/2011 11:17	9.936	303377	88764	79626	25241	4766	1551	1149	452
8/31/2011 11:27	9.936	298078	87033	76305	23576	4170	1309	885	416
8/31/2011 11:38	9.936	292570	86071	79270	24948	4315	1314	1032	635
8/31/2011 11:58	9.928	324963	98318	72095	18203	3971	1608	2168	1290
8/31/2011 12:08	9.928	366782	119798	90084	19231	3012	969	1092	685
8/31/2011 12:18	9.929	295551	75261	46431	9220	1462	519	548	345
8/31/2011 12:28	9.928	280927	66008	38167	7018	1123	359	379	190
8/31/2011 12:39	9.928	308676	86220	59324	12279	1930	697	675	440
8/31/2011 12:49	9.929	333526	104605	78658	17350	2926	910	1056	758
8/31/2011 12:59	9.928	314908	93296	67234	14020	2252	733	733	520
8/31/2011 13:09	9.928	347077	109700	82684	17738	2757	933	938	603
8/31/2011 13:19	9.929	333540	105738	79653	17401	2673	880	914	675
8/31/2011 13:29	9.929	321199	92426	67446	14692	2434	787	777	524
8/31/2011 13:40	9.928	313106	89962	64859	14323	2269	771	708	448
8/31/2011 13:50	9.929	297242	80295	56092	12119	1916	597	597	347
8/31/2011 14:00	9.929	329970	98452	74002	16062	2654	815	852	588
8/31/2011 14:10	9.93	395263	142653	122930	30069	4921	1540	1552	967
8/31/2011 14:20	9.93	377820	130231	110387	26626	4382	1409	1375	922
8/31/2011 14:30	9.929	403399	138785	117251	29258	5017	1695	1768	1169

Table A2- Initial Test, biological filter, post filter particle count

Date Time	Volume	0.5 um	1 um	2 um	4 um	7 um	9 um	11 um	25 um
8/31/2011	9.979	21326	4475	5163	1611	273	108	30	11
8/31/2011	9.98	21095	3193	3456	1056	168	46	21	4
8/31/2011	9.98	20852	3569	3979	1200	177	52	28	4
8/31/2011	9.979	20930	2970	3210	918	146	45	18	2
8/31/2011	9.981	24676	4575	5503	1877	411	177	83	19
8/31/2011	9.981	27551	6627	8290	3063	632	264	121	31
8/31/2011	9.981	26958	5924	7928	3184	767	298	169	67
8/31/2011	9.981	23420	3704	4229	1378	327	129	63	15
8/31/2011	9.98	21083	3043	3433	1075	185	73	25	16
8/31/2011	9.979	21967	3684	3994	1247	246	88	45	17
8/31/2011	9.98	25280	3857	4356	1582	307	120	64	18
8/31/2011	9.98	22486	2742	3056	1059	230	83	34	5
8/31/2011	9.981	26238	4298	5283	1950	381	162	69	24
8/31/2011	9.98	26730	5738	7226	2648	611	239	104	24
8/31/2011	9.981	23955	3759	4386	1697	344	126	60	22
8/31/2011	9.98	26275	4252	4743	1485	283	88	49	21
8/31/2011	9.981	26287	4358	5341	1714	326	128	71	22
8/31/2011	9.98	24946	3883	4553	1777	403	161	72	31
8/31/2011	9.98	30399	6439	7952	2865	568	195	94	38
8/31/2011	9.98	25971	3331	3762	1331	265	80	43	15
8/31/2011	9.98	26279	2695	2881	1020	182	59	31	9
8/31/2011	9.981	29239	4322	5040	1775	345	127	66	18
8/31/2011	9.981	30165	5713	6977	2598	563	204	129	59
8/31/2011	9.98	28156	4455	5518	1922	381	176	82	40
8/31/2011	9.979	29990	5590	6606	2464	544	234	107	32
8/31/2011	9.98	29171	5376	6534	2405	541	194	109	48
8/31/2011	9.979	30412	4823	5457	2071	428	179	77	29
8/31/2011	9.979	29255	4512	5225	2054	389	134	67	27
8/31/2011	9.979	29324	4167	4805	1698	356	115	65	20
8/31/2011	9.98	32170	5408	6699	2404	454	162	74	26
8/31/2011	9.981	36431	8460	11471	4575	969	366	208	68
8/31/2011	9.98	35468	7528	10065	4083	837	312	170	48
8/31/2011	9.98	37672	7579	10102	4211	950	396	192	78

Table A3- Radiological filter, inlet particle count

Date Time	0.5 um	1 um	2 um	4 um	7um	9um	11um	25um
9/2/2011 7:34	385355	242564	379257	210440	53836	19874	21629	6528
9/2/2011 7:44	168460	37711	26761	9773	2014	722	737	303
9/2/2011 7:54	160395	35436	24220	7173	1316	440	531	224
9/2/2011 8:05	148442	30718	19900	5537	1026	335	375	163
9/2/2011 8:15	152351	37231	28447	7901	1477	532	674	336
9/2/2011 8:25	136894	35148	28561	8430	1576	526	661	300
9/2/2011 8:35	126139	26266	17842	4717	789	284	262	133
9/2/2011 8:45	126806	28731	19922	5203	809	279	312	136
9/2/2011 8:55	121576	27732	20413	5207	841	284	285	104
9/2/2011 9:06	122341	29360	21643	5499	845	265	288	81
9/2/2011 9:16	126909	29516	21052	5054	829	271	264	93
9/2/2011 9:26	150645	39089	31551	8055	1256	369	304	121
9/2/2011 9:36	132415	33466	26859	7097	1022	316	277	95
9/2/2011 9:46	116498	27595	20879	5516	913	271	311	143
9/2/2011 9:56	115879	30542	24884	6984	1300	437	588	324
9/2/2011 10:07	107008	27359	21010	5686	976	357	380	213
9/2/2011 10:17	107602	27962	21347	5530	959	313	382	191
9/2/2011 10:27	115505	33273	26343	6319	997	300	363	124
9/2/2011 10:37	123815	34985	27102	6199	845	261	243	97
9/2/2011 10:47	115938	32059	25552	5828	910	259	218	66
9/2/2011 10:57	119523	32794	25492	6084	928	275	282	98
9/2/2011 11:08	118286	33183	27260	6520	981	325	264	82
9/2/2011 11:18	124826	38990	35152	8892	1297	322	254	78
9/2/2011 11:28	120179	36792	33845	9061	1420	398	263	71
9/2/2011 11:38	127991	37689	31877	8077	1214	397	390	136
9/2/2011 11:48	127529	36835	31406	8270	1356	411	365	110
9/2/2011 11:58	117523	33106	27724	7203	1111	404	325	113
9/2/2011 12:09	769408	551542	863690	442670	107399	40222	50170	19798
9/2/2011 12:20	522179	353506	517975	239943	58033	23165	32899	15624
9/2/2011 12:30	139295	44099	43401	14611	2740	952	830	276
9/2/2011 12:40	143335	45774	45504	14273	2737	893	889	311
9/2/2011 12:50	159566	51516	50422	15208	2722	900	1030	463
9/2/2011 13:01	175539	58210	58949	17309	3138	1056	872	307
9/2/2011 13:11	164957	50855	47270	13294	2294	738	729	251
9/7/2011 13:48	3511999	2661056	3775509	1341365	234583	63485	27898	1164
9/7/2011 13:58	3219171	2292323	2923132	740553	89700	21862	11439	846
9/7/2011 14:08	1217692	506925	434524	78670	9011	2259	1097	32
9/7/2011 14:18	974682	327474	266485	50442	6323	1673	822	56
9/7/2011 14:29	952475	276484	221369	43782	5580	1489	839	46
9/7/2011 14:39	948366	239984	189089	38198	5085	1288	761	39
9/7/2011 14:49	977407	229823	179508	37015	4980	1317	720	35
9/7/2011 14:59	1052980	227918	177190	37147	5158	1392	759	36
9/7/2011 15:09	1075569	220392	173046	37667	5280	1407	819	38
9/7/2011 15:19	1060869	209469	162001	36202	5139	1442	867	50
9/7/2011 15:30	1112924	202838	152070	33488	4732	1329	699	33

Table A4- Radiological filter, post filter particle count

Date Time	0.5 um	1 um	2 um	4 um	7um	9um	11um	25um
9/2/2011 7:34	95	5	19	12	7	7	7	3
9/2/2011 7:44	89	2	4	2	1	1	4	0
9/2/2011 7:54	77	3	3	0	2	3	1	0
9/2/2011 8:05	64	3	0	3	0	0	1	0
9/2/2011 8:15	56	1	2	0	0	0	0	0
9/2/2011 8:25	65	1	0	0	3	2	0	1
9/2/2011 8:35	56	1	2	0	1	0	1	0
9/2/2011 8:45	50	1	0	0	1	0	0	0
9/2/2011 8:55	61	2	3	0	3	1	2	2
9/2/2011 9:06	53	1	3	1	0	0	0	0
9/2/2011 9:16	55	2	2	1	1	0	1	0
9/2/2011 9:26	56	2	7	3	1	0	1	0
9/2/2011 9:36	55	1	0	0	0	1	0	0
9/2/2011 9:46	59	2	0	0	0	0	0	0
9/2/2011 9:56	46	1	1	0	0	0	0	0
9/2/2011 10:07	47	2	1	0	0	1	1	0
9/2/2011 10:17	63	1	1	0	0	0	0	0
9/2/2011 10:27	54	4	1	1	0	0	1	0
9/2/2011 10:37	67	1	12	11	9	0	2	1
9/2/2011 10:47	69	2	0	0	0	0	0	0
9/2/2011 10:57	71	2	0	1	0	0	0	0
9/2/2011 11:08	63	4	1	0	0	0	0	0
9/2/2011 11:18	74	3	0	0	0	0	0	0
9/2/2011 11:28	49	3	1	0	0	0	0	0
9/2/2011 11:38	72	2	1	0	0	0	0	0
9/2/2011 11:48	58	2	0	0	0	0	0	1
9/2/2011 11:58	78	2	0	0	0	0	0	0
9/2/2011 12:09	110	21	13	1	0	0	0	0
9/2/2011 12:20	72	13	9	1	0	0	0	0
9/2/2011 12:30	76	2	3	0	0	0	0	0
9/2/2011 12:40	72	4	1	1	0	0	0	0
9/2/2011 12:50	87	2	1	0	0	0	0	0
9/2/2011 13:01	89	0	0	0	0	0	0	0
9/2/2011 13:11	124	7	1	0	0	0	0	0
9/7/2011 13:48	2742	444	139	26	5	4	7	8
9/7/2011 13:58	1725	244	75	7	2	3	0	0
9/7/2011 14:08	1046	98	12	1	0	0	0	0
9/7/2011 14:18	1036	61	11	0	0	0	0	0
9/7/2011 14:29	796	31	6	4	1	1	0	1
9/7/2011 14:39	708	24	6	0	0	0	0	0
9/7/2011 14:49	689	26	6	0	0	0	0	0
9/7/2011 14:59	738	23	6	0	1	1	0	1
9/7/2011 15:09	741	18	4	1	1	0	0	0
9/7/2011 15:19	735	15	4	2	0	0	0	0
9/7/2011 15:30	774	29	5	1	2	0	0	0

Table A5- Second Test, biological filter, inlet particle count

Date Time	0.5 um	1 um	2 um	4 um	7um	9um	11um	25um
9/7/2011 15:44	3442165	2588201	3775643	1171101	165007	44769	28705	3017
9/7/2011 15:54	1725357	1012052	1032227	202073	24506	6233	3454	153
9/7/2011 16:04	1184269	548897	490403	90493	11146	2892	1501	51
9/7/2011 16:14	1005147	429331	361523	63675	8083	2171	1066	36
9/7/2011 16:24	899386	340272	276629	48016	6181	1625	831	27
9/7/2011 16:34	855907	311355	249129	43374	5554	1480	830	28
9/7/2011 16:45	806913	271593	213750	37481	4843	1291	711	17
9/7/2011 16:55	785544	255030	197856	34504	4599	1217	760	31
9/7/2011 17:05	740029	231720	180210	33068	4386	1162	720	43
9/7/2011 17:15	752453	221099	173666	33163	4524	1293	812	56
9/7/2011 17:25	714072	201497	156021	29595	4066	1142	758	68
9/7/2011 17:35	761530	196365	147530	27761	3829	1134	720	67
9/7/2011 17:46	777540	206527	155715	28119	3795	1020	698	58
9/7/2011 17:56	799333	202616	150485	27271	3642	1001	594	61
9/7/2011 18:06	785772	192805	145815	26552	3586	1005	585	33
9/7/2011 18:16	739959	186209	145853	26634	3588	998	567	36
9/7/2011 18:26	792351	197284	150477	26562	3578	895	567	30
9/8/2011 8:17	1487384	789875	642537	112575	14530	4044	2600	359
9/8/2011 8:27	3299896	1725199	1195352	150386	17765	4768	3025	259
9/8/2011 8:37	3708994	1645168	962346	103285	11768	3100	1762	165
9/8/2011 8:48	5096247	2266475	1291395	114120	10524	2552	1209	49
9/8/2011 8:58	3472395	1450177	890583	111419	13269	3655	2752	522
9/8/2011 9:08	4805157	1978983	1140191	128735	14913	4061	2485	280
9/8/2011 9:18	5152669	2051929	1127062	110678	11521	2984	1400	44
9/8/2011 9:28	4422915	1667844	906660	90856	9528	2367	1224	49
9/8/2011 9:38	4292724	1469512	747274	75042	7863	1978	983	37
9/8/2011 9:49	4419087	1465320	741459	73788	7385	1927	897	27
9/8/2011 9:59	4582594	1485554	745664	72923	7465	1894	1015	58
9/8/2011 10:09	3467237	1079892	561289	61257	6492	1627	846	43
9/8/2011 10:19	3027948	1540342	1622243	420607	60199	16660	11403	1676
9/8/2011 10:29	2224235	1692870	2413825	843934	148659	45944	30938	3406
9/8/2011 10:39	1132563	608946	598690	113091	14207	3933	2590	232
9/8/2011 10:50	920389	438739	396548	71428	9338	2609	1973	215
9/8/2011 11:00	743587	307011	266458	49497	6764	1916	1415	170
9/8/2011 11:10	811677	340452	289184	49664	6278	1724	1205	134
9/8/2011 11:20	748455	280384	233307	40570	5223	1466	862	68
9/8/2011 11:30	781758	291513	234134	38505	4865	1347	826	56
9/8/2011 11:40	895998	350478	272386	41135	4991	1302	740	39
9/8/2011 11:51	662641	222159	175298	31062	4051	1114	799	72
9/8/2011 12:01	629309	214697	171858	30751	3860	1107	744	59
9/8/2011 12:11	664494	221014	175455	31034	4021	1127	703	59
9/8/2011 12:21	562472	182503	146949	27526	3612	990	639	48
9/8/2011 12:31	576144	184328	147518	27264	3549	992	591	34
9/8/2011 12:41	580544	188994	153863	29115	3730	1076	602	30
9/8/2011 12:52	612682	195014	153682	27323	3498	998	587	29
9/8/2011 13:02	612682	202322	161727	30014	3952	1156	691	40
9/8/2011 13:12	688593	229573	192824	39296	5627	1615	980	49
9/8/2011 13:22	678911	228325	191443	38237	5168	1500	895	25
9/8/2011 13:32	710402	236564	191001	36444	4970	1406	785	27
9/8/2011 13:42	699685	235523	191097	36537	4937	1407	749	32
9/8/2011 13:53	780819	291637	251956	53005	7574	2172	1388	149

Table A6- Second Test, biological filter, post filter particle count

Date Time	0.5 um	1 um	2 um	4 um	7um	9um	11um	25um
9/7/2011 15:44	425243	196591	197728	48729	6556	1892	912	135
9/7/2011 15:54	116941	42380	39915	10141	1431	452	156	14
9/7/2011 16:04	82520	19885	17341	4569	665	175	90	9
9/7/2011 16:14	73091	14728	12692	3298	506	123	46	7
9/7/2011 16:24	68227	11397	9846	2549	328	110	39	2
9/7/2011 16:34	67907	10637	9254	2518	351	95	33	0
9/7/2011 16:45	68141	9402	8494	2222	288	89	30	4
9/7/2011 16:55	69650	9104	8049	2215	315	98	31	1
9/7/2011 17:05	67819	7914	7294	1987	277	81	27	5
9/7/2011 17:15	66203	7217	6700	1992	272	77	41	2
9/7/2011 17:25	67071	7027	6257	1803	255	69	27	5
9/7/2011 17:35	71264	6870	6191	1755	249	74	25	4
9/7/2011 17:46	75857	7200	6749	1816	290	89	27	1
9/7/2011 17:56	80143	7153	6373	1758	229	72	27	1
9/7/2011 18:06	81268	6815	6280	1695	232	61	31	1
9/7/2011 18:16	78345	6701	6460	1780	233	72	21	0
9/7/2011 18:26	76751	6693	6461	1778	264	72	28	2
9/8/2011 8:17	161975	46311	40861	12714	2459	855	463	145
9/8/2011 8:27	222314	44039	29453	9119	1684	678	436	99
9/8/2011 8:37	250243	40523	24190	7319	1382	525	209	64
9/8/2011 8:48	531441	77110	38798	10486	1660	518	186	13
9/8/2011 8:58	299906	50030	33183	10790	2108	741	418	143
9/8/2011 9:08	298836	43580	27055	8819	1781	628	427	84
9/8/2011 9:18	367831	48593	28104	9294	1936	662	313	48
9/8/2011 9:28	316282	40167	22486	7264	1325	472	215	30
9/8/2011 9:38	356102	44323	25437	8192	1576	522	176	24
9/8/2011 9:49	344336	40103	22149	6926	1296	444	182	12
9/8/2011 9:59	339970	37858	20347	6688	1207	387	133	21
9/8/2011 10:09	314474	34514	18586	5887	1068	315	106	8
9/8/2011 10:19	416156	139912	136247	50913	10607	4116	2776	980
9/8/2011 10:29	479517	275128	320980	127354	28867	12219	8129	2693
9/8/2011 10:39	105266	30202	30027	9964	2021	806	505	118
9/8/2011 10:50	87297	20413	19636	6692	1327	543	341	85
9/8/2011 11:00	76728	14630	14132	4970	987	359	238	61
9/8/2011 11:10	86692	16429	15748	5504	1106	377	208	54
9/8/2011 11:20	85909	13998	13327	4474	869	301	186	32
9/8/2011 11:30	91027	15055	13914	4780	914	280	155	24
9/8/2011 11:40	101841	18388	16182	5384	1009	320	157	20
9/8/2011 11:51	81894	12284	11640	3968	810	262	131	20
9/8/2011 12:01	80557	13916	13256	4753	867	322	156	24
9/8/2011 12:11	81052	13706	12955	4391	838	268	113	32
9/8/2011 12:21	78055	17376	17357	6398	1271	418	244	42
9/8/2011 12:31	78583	16427	16747	6085	1152	402	228	36
9/8/2011 12:41	75223	14635	14880	5285	1128	335	160	32
9/8/2011 12:52	79780	15789	15920	5558	1115	393	196	32
9/8/2011 13:02	77338	13490	13635	4894	965	337	162	10
9/8/2011 13:12	90020	17569	17761	6615	1402	491	223	27
9/8/2011 13:22	84360	15372	15518	5782	1154	407	184	21
9/8/2011 13:32	88770	17493	18059	6810	1408	478	189	24
9/8/2011 13:42	102453	26982	28970	11361	2298	886	411	54
9/8/2011 13:53	101003	24372	26950	10497	2095	847	417	97

Table A7- QA Test, No filter in place

Inlet Particle Counter								
Date Time	0.5 um	1 um	2 um	4 um	7um	9um	11um	25um
9/2/2011 13:57	145211	46408	47266	15604	2825	839	694	172
9/2/2011 14:08	139932	40864	37378	11690	2139	664	641	160
9/2/2011 14:18	140820	42650	39513	11495	1951	606	570	176
9/2/2011 14:28	150259	47938	46687	13658	2202	695	644	214
9/2/2011 14:38	156680	54772	57425	16169	2610	828	577	161
9/2/2011 14:48	154279	53709	57083	16186	2704	850	637	194
9/2/2011 13:57	130012	38788	39209	12114	2310	807	501	178
"post filter" Particle Counter								
Date Time	0.5 um	1 um	2 um	4 um	7um	9um	11um	25um
9/2/2011 13:57	130012	38788	39209	12114	2310	807	501	178
9/2/2011 14:08	127071	33678	30283	9276	1706	654	400	153
9/2/2011 14:18	126706	35299	33833	10737	2079	861	511	239
9/2/2011 14:28	134799	40746	43048	13140	2488	920	695	411
9/2/2011 14:38	143794	49500	57315	17114	3141	1056	583	281
9/2/2011 14:48	141346	48975	56407	17145	3092	1061	590	235



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