Sampling Rate & Capacity Studies in Optimizing Diffusive Sampler Designs

by

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Poster 256, Session 402

Diffusive Sampler Design …

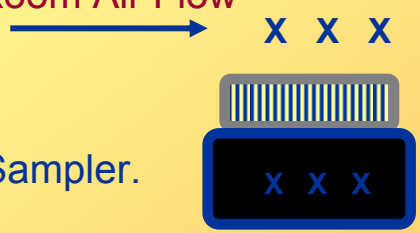
Issue #1:

DETECTION at Low Levels

Action:

Maximize Sampling Rate to maximize quantity of Sample collected

Room Air Flow



Higher Sampling Rate means getting more X's into the Sampler.

Diffusive Sampler

Diffusive Sampler Design …

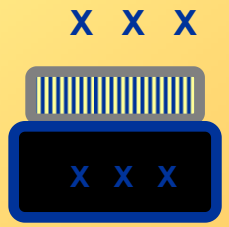
Issue #2

avoiding STARVATION effects

- **Sampling Rate must be balanced by room air velocity at the face of the sampler**

- **for typical industrial Face Velocity of 30 ft/min maximum** Sampling Rate = 5 ml/min-cm2
  (15 mL/min for Sampler w/ Area = 3 cm2)

"Starvation" means that the Sampler is sucking in molecules (X) faster than room ventilation blows fresh molecules to the Sampler's face



Diffusive Sampler

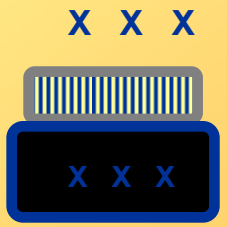
Diffusive Sampler Design …

Issue #3

adequate Sample CAPACITY ...

- **carbon samplers have a specific capacity for each chemical**
- **when that capacity is exceeded,sample can be lost**
- **Sample Capacity can be extended by increasing the carbon mass in the Sampler or decreasing the Sampling Rate**

When Sample Capacity is exceeded, some of the sample can “leak out” of the sampler like excess water expressed from a saturated sponge.



Diffusive Sampler

Reconciling Sampling Rate with Sample Capacity

Issues…

if …

Sampling Rate Too Low

SAMPLE Not Detectable by Lab

SAMPLE *Can't Be Analyzed*

if…

Sampling Rate Too High

SAMPLE Overloads Media … leading to Reverse Diffusion

RESULTS *Under-Estimated*

OPTIMIZE →

if … Sampling Rate …

Optimal

Sample Detectable by Lab, but does not overload Sampler

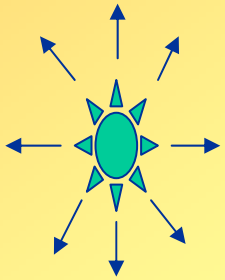
ACCURATE Sample *Analysis*

Samplers in the Study

Sampler	AT546	AT541	AT566	AT561
Sampling Rate (ml/min) ...	1.5	6.0	10	18
Carbon Loading (mg)	150	150	150	150
Ratio Mass/S.R.	100	25	15	8

Experimental Conditions

Concentration Generator



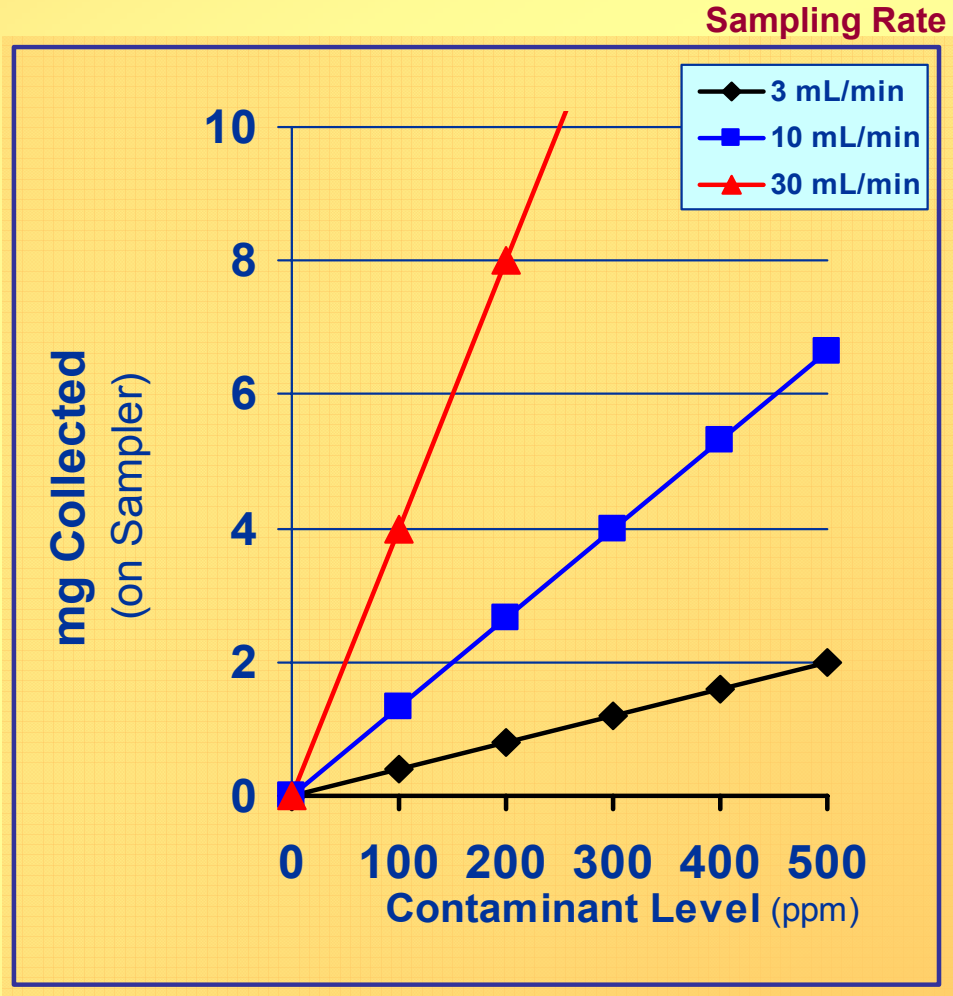
MNR Generator

Organic Solvents were metered into a 1-pass Exposure Chamber via liquid syringe pump utilizing a heated injection needle. Dilution air was generated by a Miller-Nelson HCS-401 atmosphere Generator at 200 L/min generating a linear flow of 33 cm/sec through the chamber. Active Samples were taken using Charcoal Tubes and Carbon Felt Samplers in conjunction with a critical orifice sampling pump.

Sample Capacity

(Effects of Concentration and Time)

It's easy to exceed Sample Capacity at High Contaminant Levels (> 10 ppm) or at Long Sampling Times (> 4 hour).



Comparison of Samplers

Sampling Rates (mL/min)

Analyte Sampled	Sampler 561	Sampler 566	Sampler 541	Sampler 546
Acetone	18.3	10.6	6.40	1.60
Acetonitrile	21.8	11.4	6.55	1.64
Methylene Chloride	15.0	7.82	6.43	1.60
Cyclohexane	14.6	7.23	4.04	1.01
Tetrahydrofuran	16.6	8.86	4.84	1.21
Carbon Tetrachloride	11.2	6.05	4.37	1.09

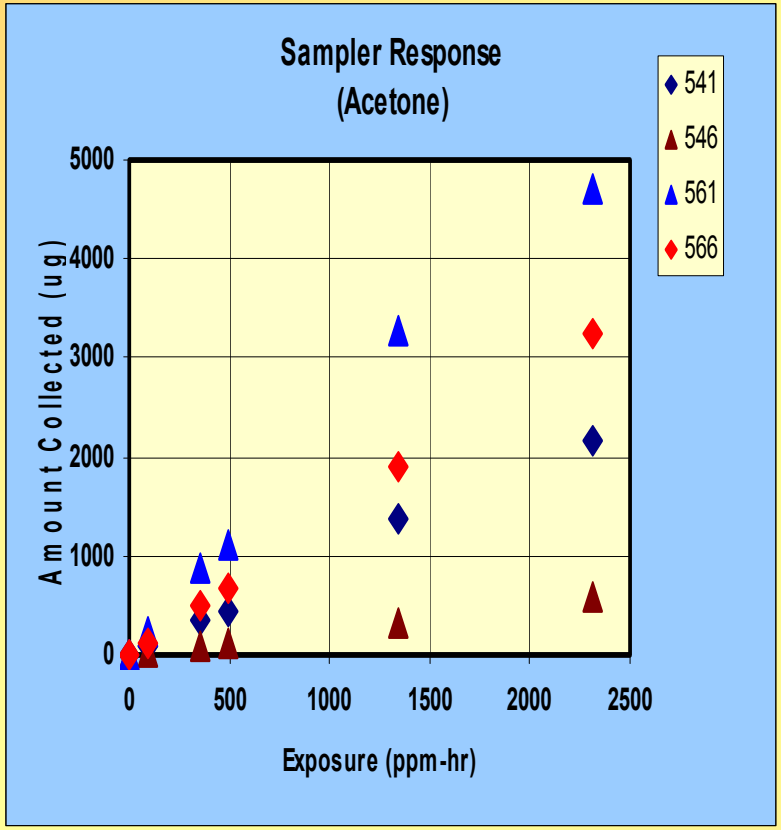
Capacity Comparison of Samplers

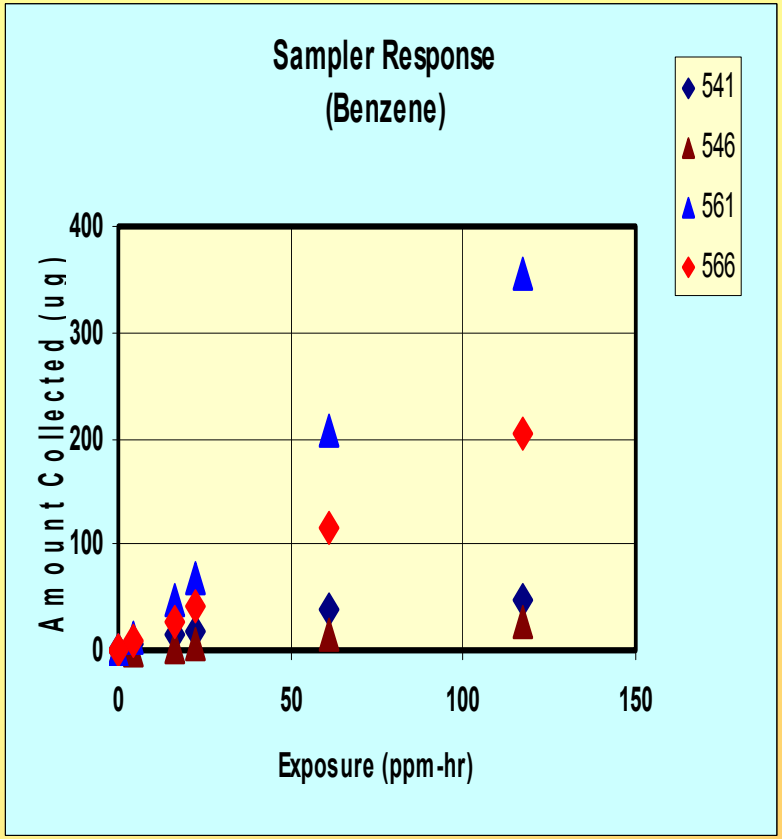
% of Capacity collected in 8-hr Sampling at the PEL

Analyte	Sampler 561	Sampler 566	Sampler 541	Sampler 546
Acetone	527%	305%	184%	46%
Acetonitrile	355%	185%	107%	27%
Methylene Chloride	126%	66%	54%	13%
Cyclohexane	122%	60%	34%	8%
Tetrahydrofuran	40%	21%	12%	3%
Carbon Tetrachloride	11%	6%	4%	1%

Comparison of 4 Samplers

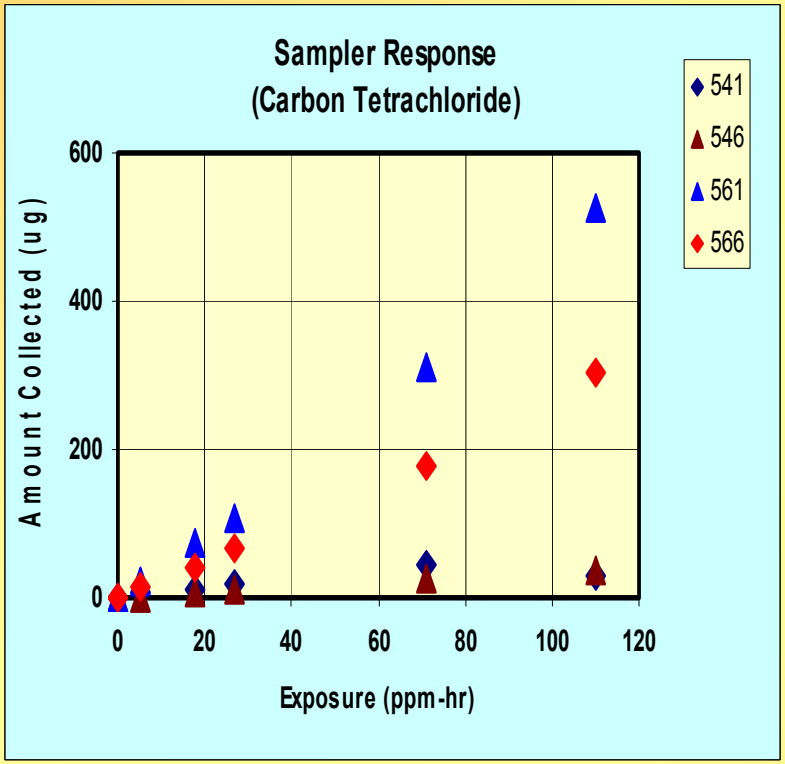
(Acetone and Benzene)

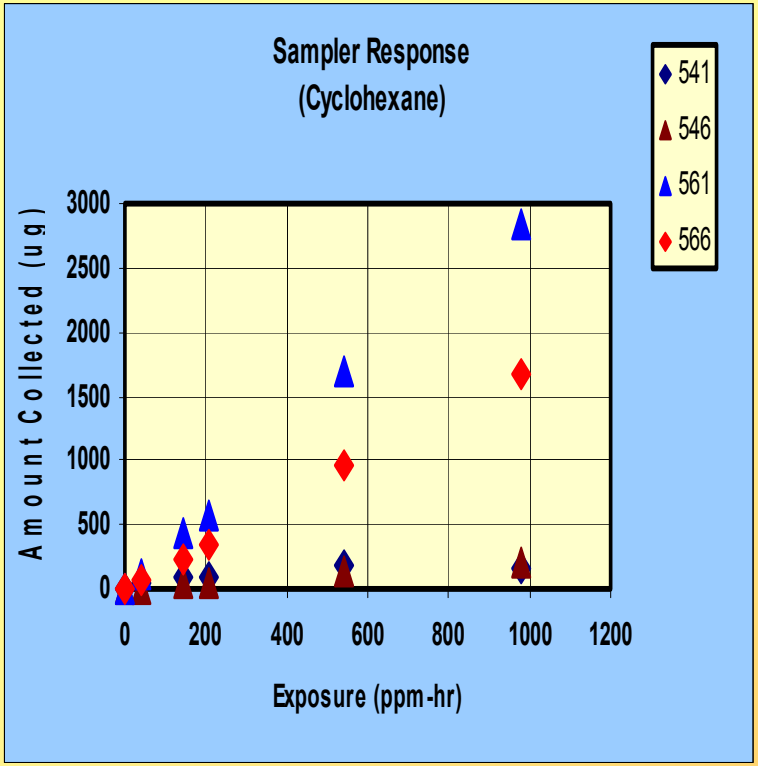




Comparison of 4 Samplers

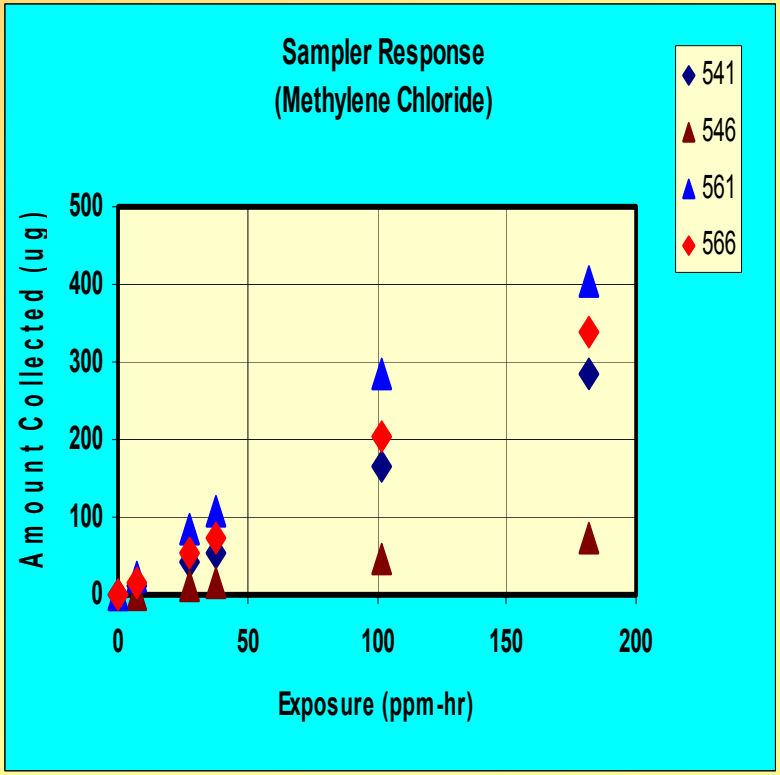
(Carbon Tetrachloride and Cyclohexane)

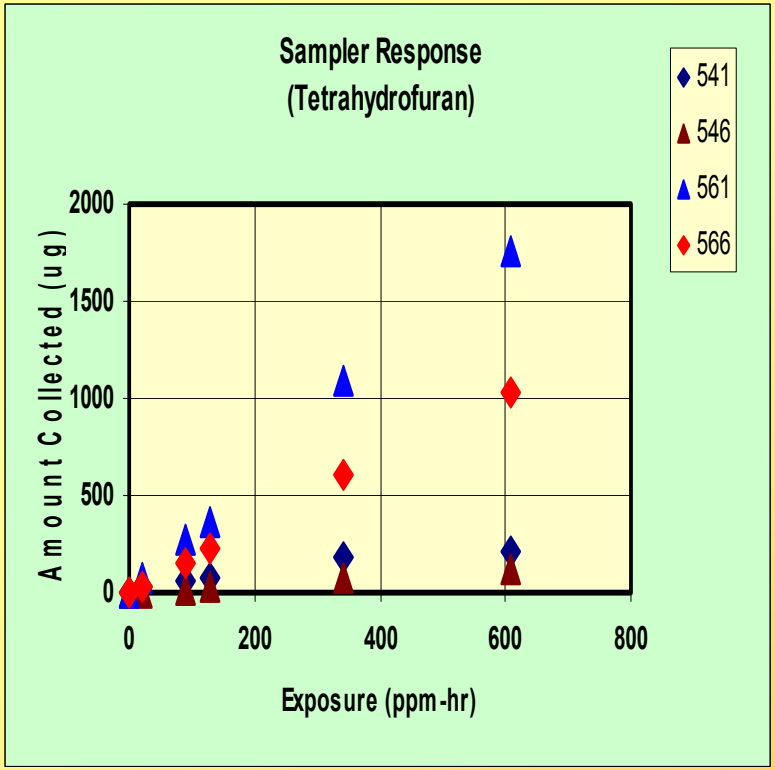




Comparison of 4 Samplers

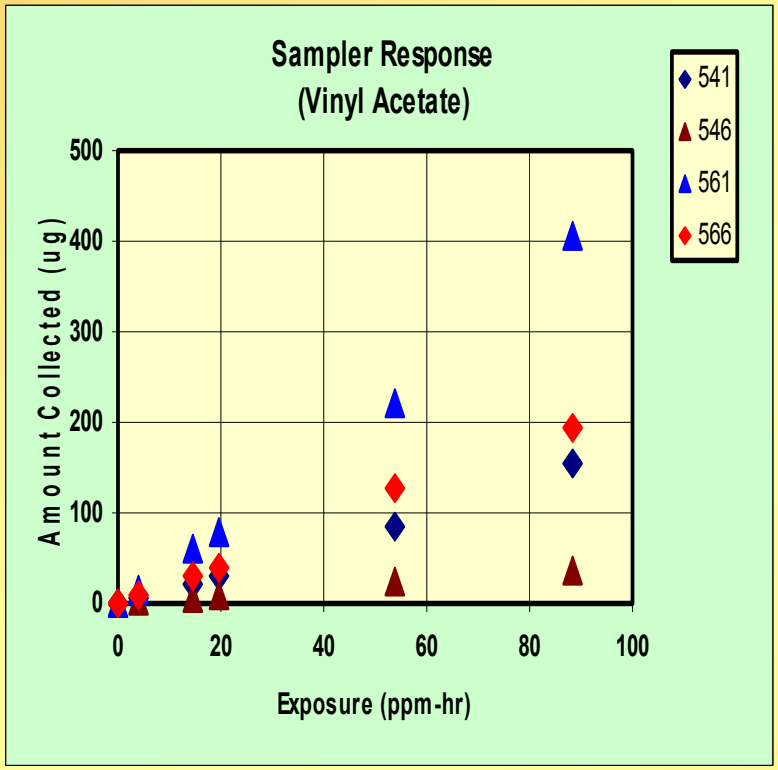
(Methylene Chloride and Tetrahydrofuran)

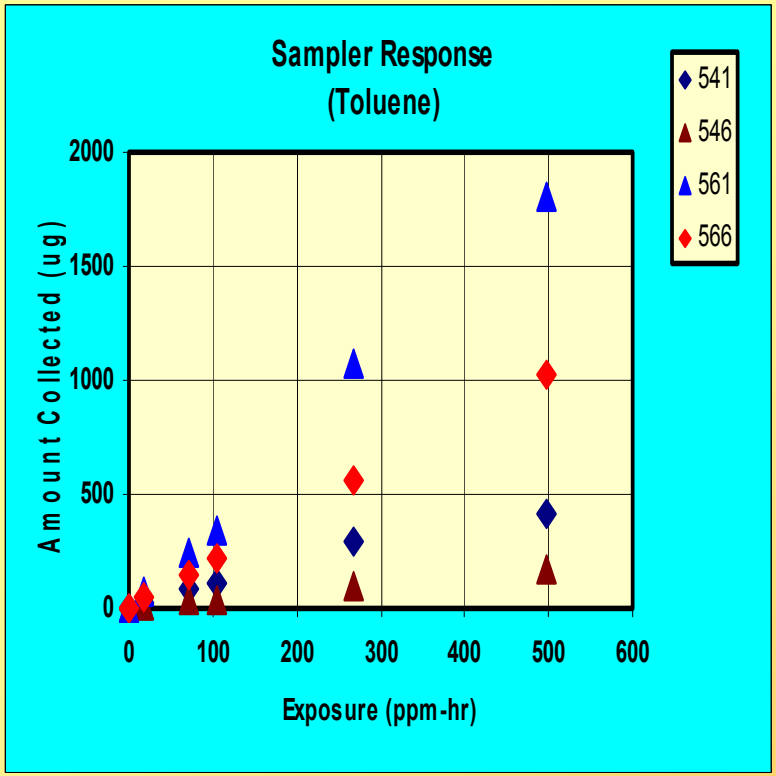




Comparison of 4 Samplers

(Vinyl Acetate and Toluene)





Sampling Rates for 50 Analytes

on 4 Samplers (mL/min)

CAS No.		Analyte	561	566	541	546
64-19-7		Acetic acid	18.0	9.72	5.91	1.48
67-64-1		Acetone	18.3	10.6	6.40	1.60
75-05-8		Acetonitrile	21.8	11.35	6.55	1.64
107-13-1		Acrylonitrile	19.1	10.6	5.68	1.42
628-63-7		Amyl acetate	12.2	6.58	3.20	0.80
71-43-2		Benzene	14.7	8.46	3.85	0.96
106-99-0	1,3-	Butadiene	19.0	10.5	6.42	1.61
71-36-3	n-	Butanol	16.2	8.74	4.43	1.11
111-76-2	2-	Butoxyethanol	12.8	6.91	3.38	0.85
123-86-4	n-	Butyl acetate	13.3	6.51	3.48	0.87
1634-04-4	t-	Butyl methyl ether	14.8	8.01	3.92	0.98
56-23-5		Carbon tetrachloride	11.2	6.05	4.37	1.09
67-66-3		Chloroform	12.7	6.88	4.97	1.24
98-82-8		Cumene	12.7	6.85	3.31	0.83
110-82-7		Cyclohexane	14.6	7.23	4.04	1.01
57041-67-5		Desflurane	10.7	5.79	4.00	1.00
123-42-2		Diacetone alcohol	12.9	6.97	3.49	0.87
107-06-2	1,2-	Dichloroethane	14.0	7.56	5.01	1.25
68-12-2	N,N-	Dimethylformamide	16.3	8.80	4.82	1.21
123-91-1	1,4-	Dioxane	14.8	8.01	4.50	1.13
110-80-5	2-	Ethoxyethanol	14.7	7.92	4.14	1.04
141-78-6		Ethyl acetate	15.3	7.36	4.32	1.08
64-17-5		Ethyl alcohol	20.6	11.1	6.16	1.54
60-29-7		Ethyl ether	16.2	9.23	4.44	1.11
100-41-4		Ethylbenzene	13.5	7.30	3.63	0.91

CAS No.		Analyte	561	566	541	546
142-82-5	n-	Heptane	13.3	7.00	3.41	0.85
	2-	Heptanone	13.0	7.0	3.36	0.84
110-54-3	n-	Hexane	15.0	8.10	3.74	0.94
591-78-6	2-	Hexanone	13.9	7.5	3.69	0.92
26675-46-7		Isoflurane	10.2	5.52	3.78	0.95
109-86-4	2-	Methoxyethanol	16.0	8.63	4.71	1.18
78-93-3		Methyl Ethyl Ketone	16.6	9.2	4.60	1.15
108-10-1		Methyl isobutyl ketone	13.9	7.51	3.68	0.92
80-62-6		Methyl methacrylate	13.9	7.51	3.99	1.00
75-09-2		Methylene chloride	15.0	7.82	6.43	1.61
91-20-3		Naphthalene	12.3	6.64	3.43	0.86
109-66-0		Pentane	16.4	8.86	4.36	1.09
107-87-9	2-	Pentanone	15.0	8.11	4.12	1.03
127-18-4		Perchloroethylene	10.8	5.83	4.06	1.02
67-63-0	iso-	Propyl alcohol	18.0	9.71	5.12	1.28
28523-86-6		Sevoflurane	9.8	5.30	3.51	0.88
100-42-5		Styrene	13.6	7.55	3.75	0.94
79-34-5	1,1,2,2-	Tetrachloroethane	10.7	5.79	3.89	0.97
109-99-6		Tetrahydrofuran	16.4	8.86	4.84	1.21
108-88-3		Toluene	14.1	8.25	3.80	0.95
71-55-6	1,1,1-	Trichloroethane	12.0	6.50	4.32	1.08
79-01-6		Trichloroethylene	12.2	7.05	4.35	1.09
108-05-4		Vinyl acetate	15.0	8.1	4.48	1.12
75-01-4		Vinyl chloride	17.6	9.52	8.32	2.08
1330-20-7		Xylenes	13.5	7.91	3.70	0.93

Conclusions:

- *Low Level Detection.* In sampling low contaminant levels (<10 ppm) at short sampling times (<4 hr), optimal design for a Diffusive Sampler will employ the highest Sampling Rate consistent with avoiding sampler starvation at 30 ft/min. (up to 15 mL/min for each cm2 of area of the Sampler face)

- *High Capacity.* In sampling high contaminant levels (>10 ppm) and/or long sampling times (> 4 hr), optimal design of a Diffusive Sampler will employ a lowered Sampling Rate such that the projected contaminant loading does not exceed Sample Capacity.