Pressure Field Extension Testing

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OBAR SYSTEMS, INC.

INDOOR Environments 2023™
Radon and Vapor Intrusion Symposium
Nashville

Topics

- Why Diagnostics?
- Designing Systems
- Pressure Field Extension Testing Equipment
- Pressure Field Extension Testing Process
- Examples

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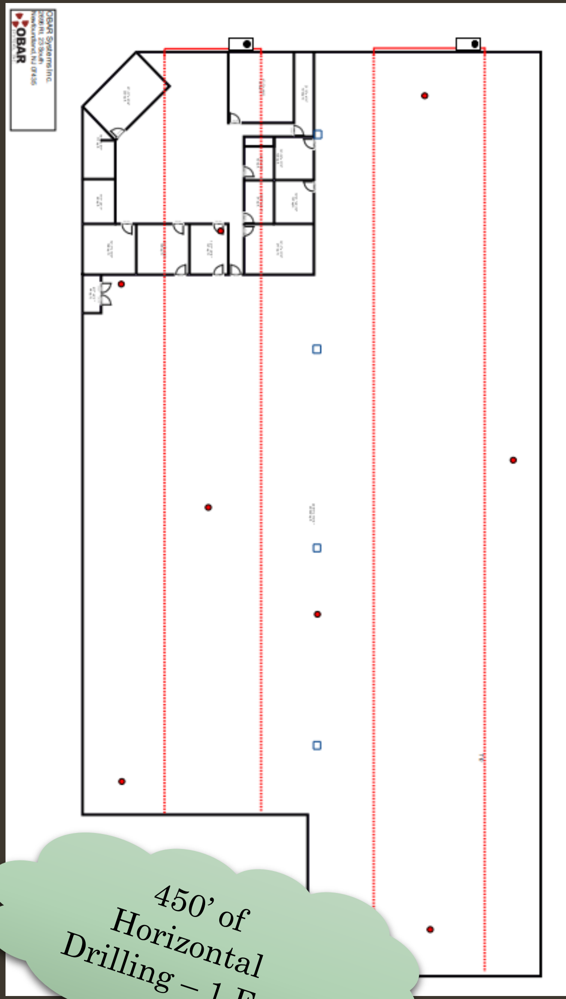
Why Diagnostics? – Side by Side Buildings (Michigan)



450' of Horizontal Drilling – 1 Fan

	Distance (ft.)	Series 1
Airflow Yield (cfm)		5
Applied Vacuum ("w.c.)		30
SSP 1 (1' from applied)		12
T-1	10	0.1340
T-2	20	0.0020
T-3	30	BG
T-4	40	BG
T-5	10	0.0210
T-6	20	BG
T-7	30	BG
T-8	10	0.9270
T-9	20	0.0060
T-10	30	BG
T-11	10	0.3740
T-12	20	0.0020
T-13	30	BG

12' ROI
30" w.c. applied

	Distance (ft.)	Series 1	Series 2
Airflow Yield (cfm)		7	<5
Applied Vacuum ("w.c.)		30	20
SSP 1 (1' from applied)		10	7.5
T-1	5	1.1000	0.7510
T-2	10	0.7010	0.5210
T-3	15	0.5100	0.7310
T-4	25	0.1010	0.1830
T-5	35	0.0640	0.1210
T-6	45	0.0160	0.0760
T-7	40	0.1020	0.0900
T-8	30	0.1080	0.1010
T-9	55	0.0190	0.0130

55' ROI
8" w.c. applied

5 Suction Pits
1 Fan

Mitigation Using Sub Slab Depressurization Systems (SSD)

- Designed to:
  - Meet a minimum sub slab vacuum
  - Apply vacuum to the soil below the slab through pits
  - Discharge soil gas outside the building
  - Run continually
  - Mitigate not remediate

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Designing SSDS – Required Information – A.R.E.

- Applied Vacuum
  - Expressed in inches of water column or pascals
- Resulting Airflow Yield
  - Expressed in Cubic Feet Per Minute
- Effected Area
  - Expressed as radius of influence (ROI)

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Obtaining design data through Pressure Field Extension Testing (PFE)

- Pressure Field Extension Testing
  - Apply vacuum through diagnostic suction pits
  - 2-3 inch holes
  - Record applied vacuum
  - Record airflow yield
- Record vacuum at diagnostic test holes
  - ~ 3/8 inch holes
  - Various distances from suction pit
- Run test at multiple fan speeds
- Detailed building drawing

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PFE Testing Equipment

1. Head
2. Inline HEPA Filter
3. Custom Diagnostic Fan
4. Carbon on Exhaust

PFE General Process

- Select diagnostic suction pits locations that can be used as permanent suction pit locations
- Test near interior and exterior walls and columns
- Determine test speeds based on initial readings
- Test for sub slab communication across footings, grade beams, and tenant spaces
- Look for sub slab anomalies
- Don't stop collecting data until you are confident with the results

Anomalies

- Soil types
- Grade Beams
- Utility Trenches
- Elevation Changes
- Drainages Systems
- Settling in high traffic areas

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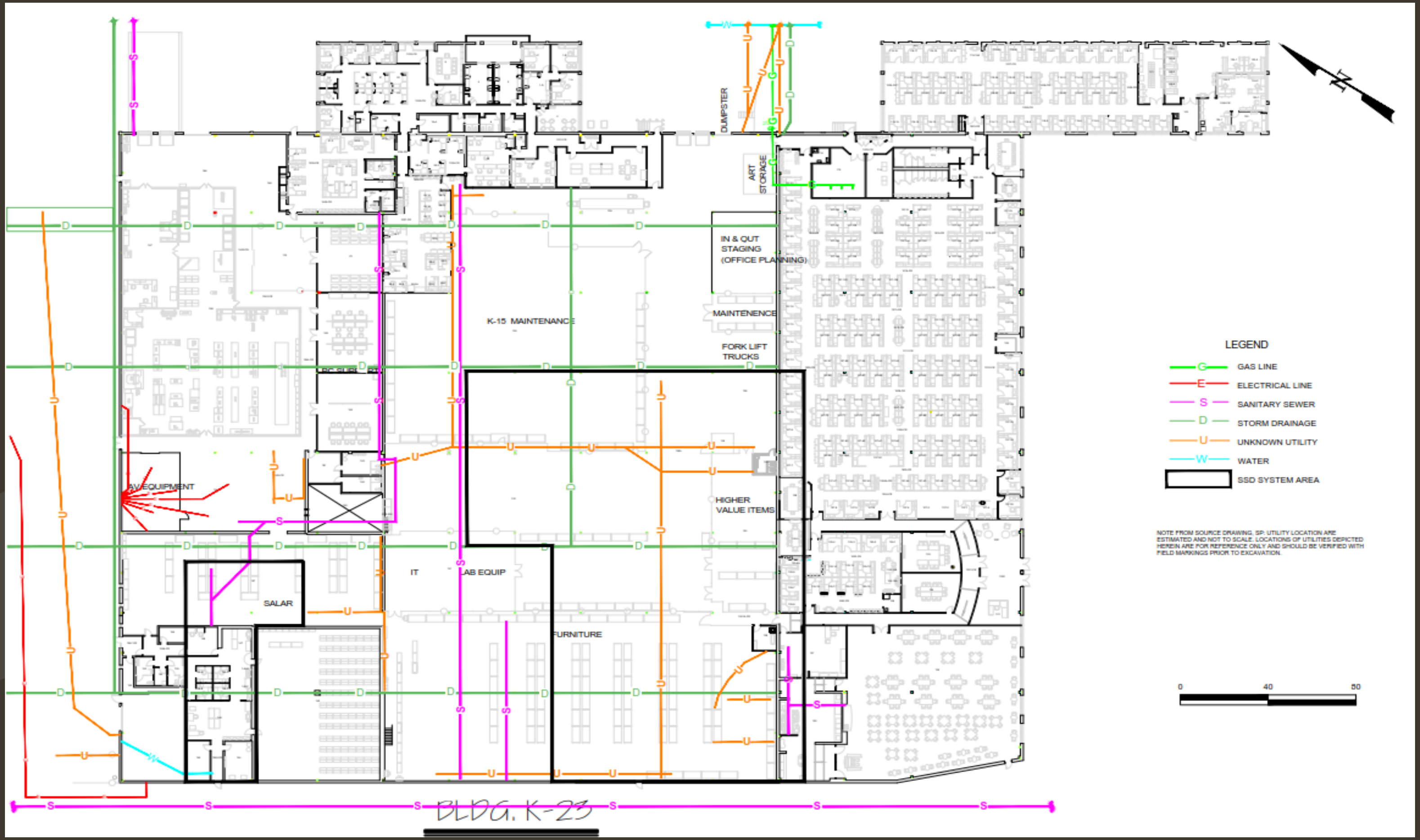
Safety Concerns



Case Study

- NYC Suburb
- Warehouse
- 25,000 square Feet
- Two tenants

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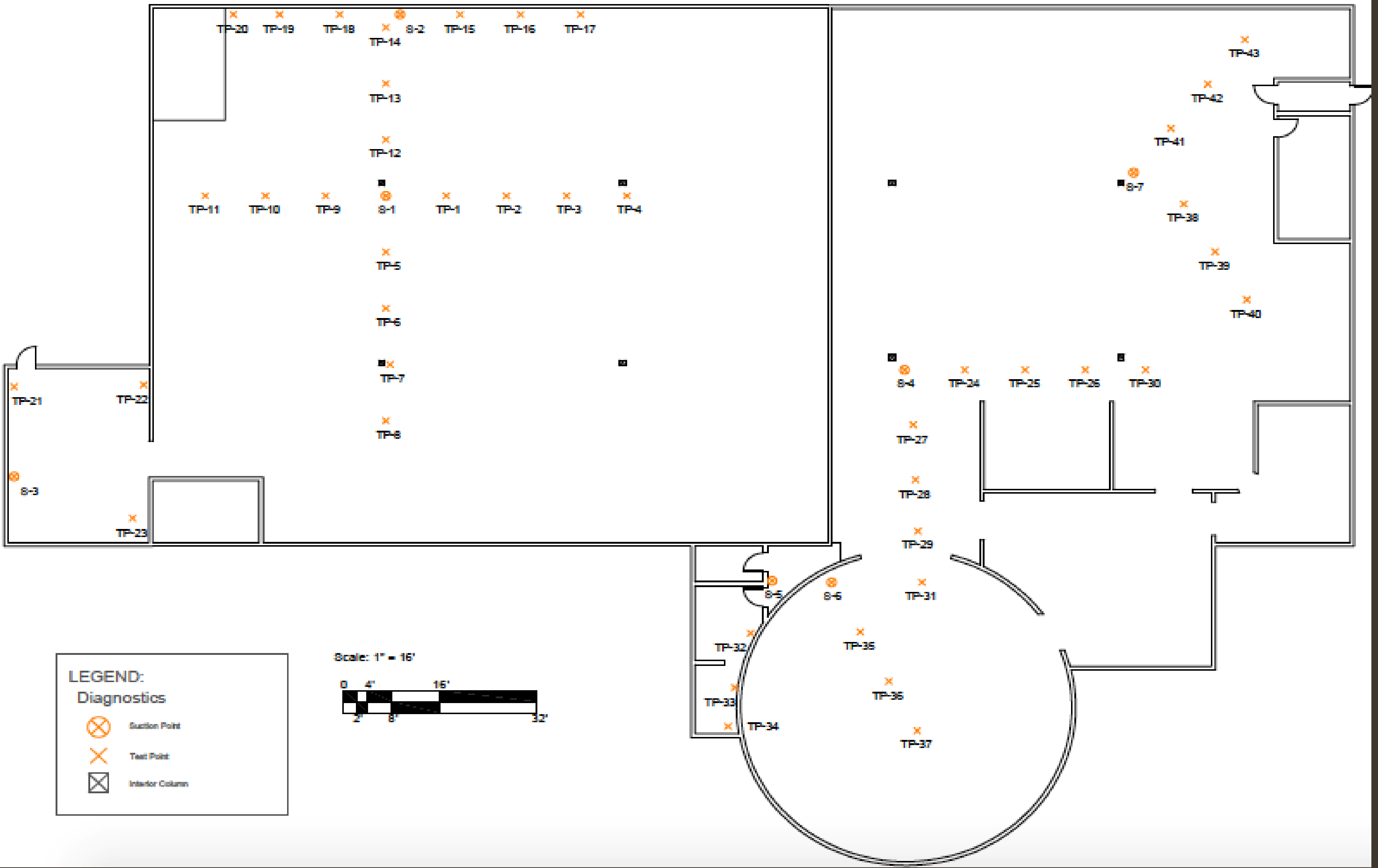

- 4 People – 1 Day
- 7 Diagnostics Suction Pits
- 43 Test Holes
- 90 Data Points

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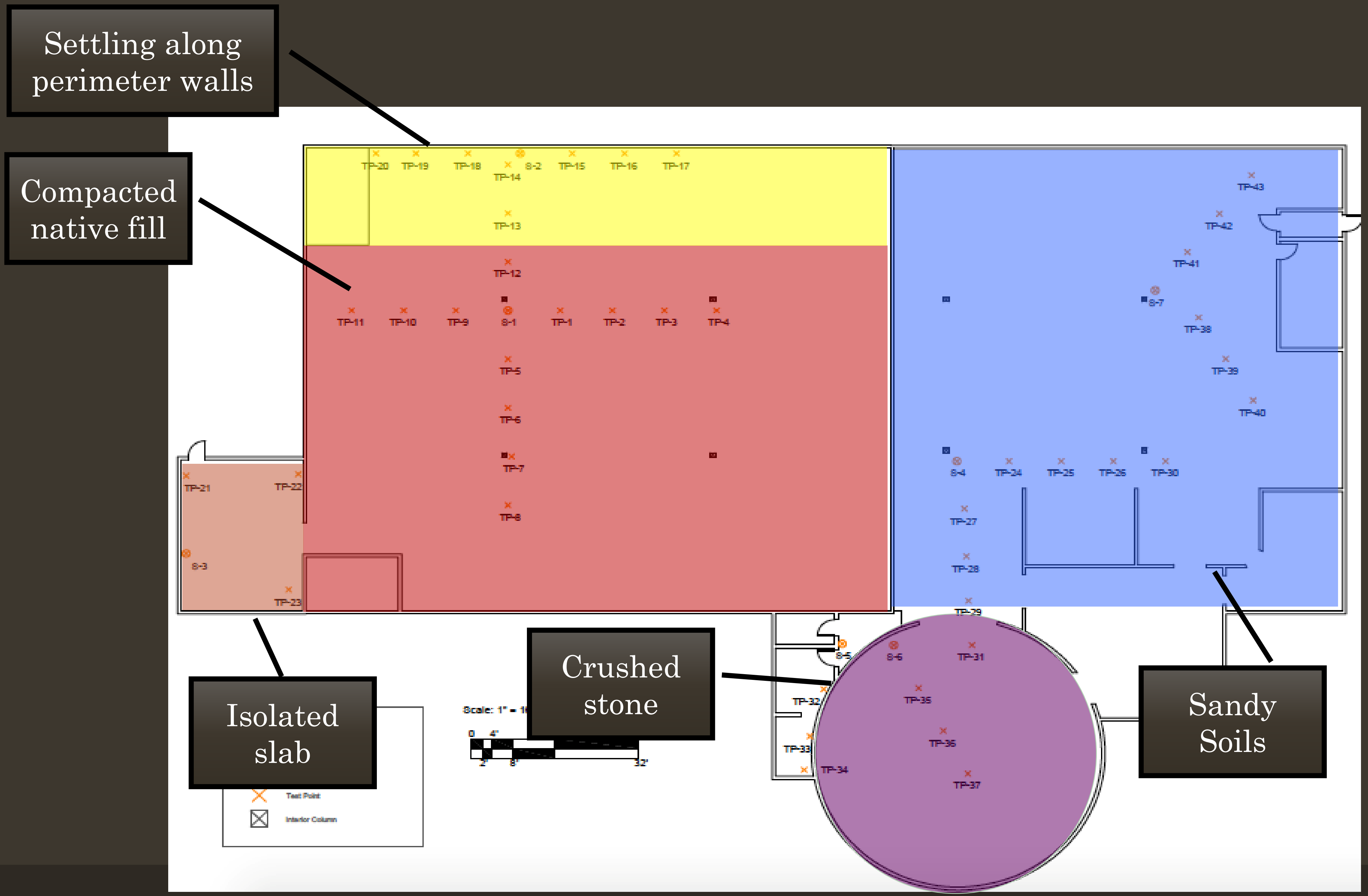

Settling along perimeter walls
Compacted native fill
Isolated slab
Crushed stone
Sandy Soils
TP-20 TP-19 TP-18 S-2 TP-15 TP-16 TP-17
TP-14
TP-13
TP-12
TP-11 TP-10 TP-9 S-1 TP-1 TP-2 TP-3 TP-4
TP-5
TP-6
TP-7
TP-8
TP-21 TP-22
S-3
TP-23
TP-43
TP-42
TP-41
S-7
TP-38
TP-39
TP-40
S-4 TP-24 TP-25 TP-26 TP-30
TP-27
TP-28
TP-29
S-5 S-6 TP-31
TP-32
TP-35
TP-36
TP-33
TP-34
TP-37
Test Point
Interior Column

Gathering Data

Various distances and directions from applied vacuum

Resulting airflow yields (cfm)

2 different applied vacuum levels (“w.c.)

	Distance (ft.)	Series 1	Series 2
Airflow Yield (cfm)		45	30
Applied Vacuum ("w.c.)		20	12
T-1	10	0.104	0.071
T-2	20	0.012	0.005
T-3	30	0.005	BG
T-4	40	BG	BG
T-5	10	0.701	0.495
T-6	20	0.150	0.111
T-7	30	0.003	0.002
T-8	40	0.003	BG
T-9	10	0.129	0.091
T-10	20	0.018	0.011
T-11	30	0.002	0.002
T-12	10	0.205	0.155
T-13	20	0.050	0.040
T-14	30	0.002	0.002

20’ ROI
12” w.c. applied
30 cfm airflow yield

Gathering Data

	Distance (ft.)	Series 1	Series 2
Airflow Yield (cfm)		15	10
Applied Vacuum (''w.c.)		20	12
T-38	10	0.239	0.143
T-39	20	0.011	0.027
T-40	30	0.009	0.004
T-41	10	0.247	0.137
T-42	20	0.036	0.051
T-43	30	0.021	0.180

Resulting airflow yields (cfm)

2 different applied vacuum levels (“w.c.)

30’ ROI
12” w.c. applied
10 cfm airflow yield

Gathering Data

	Distance (ft.)	Series 1
Airflow Yield (cfm)		40
Applied Vacuum ("w.c.)		1.8
SSP 1 (1' from applied)		1.4
T-31	10	1.30
T-35	15	1.230
T-36	20	1.330
T-37	38	1.270

ROI in excess of room size
1.8" w.c. applied
40 cfm airflow yield

- It's rare
  - But it happens
- Justifies extensive diagnostics

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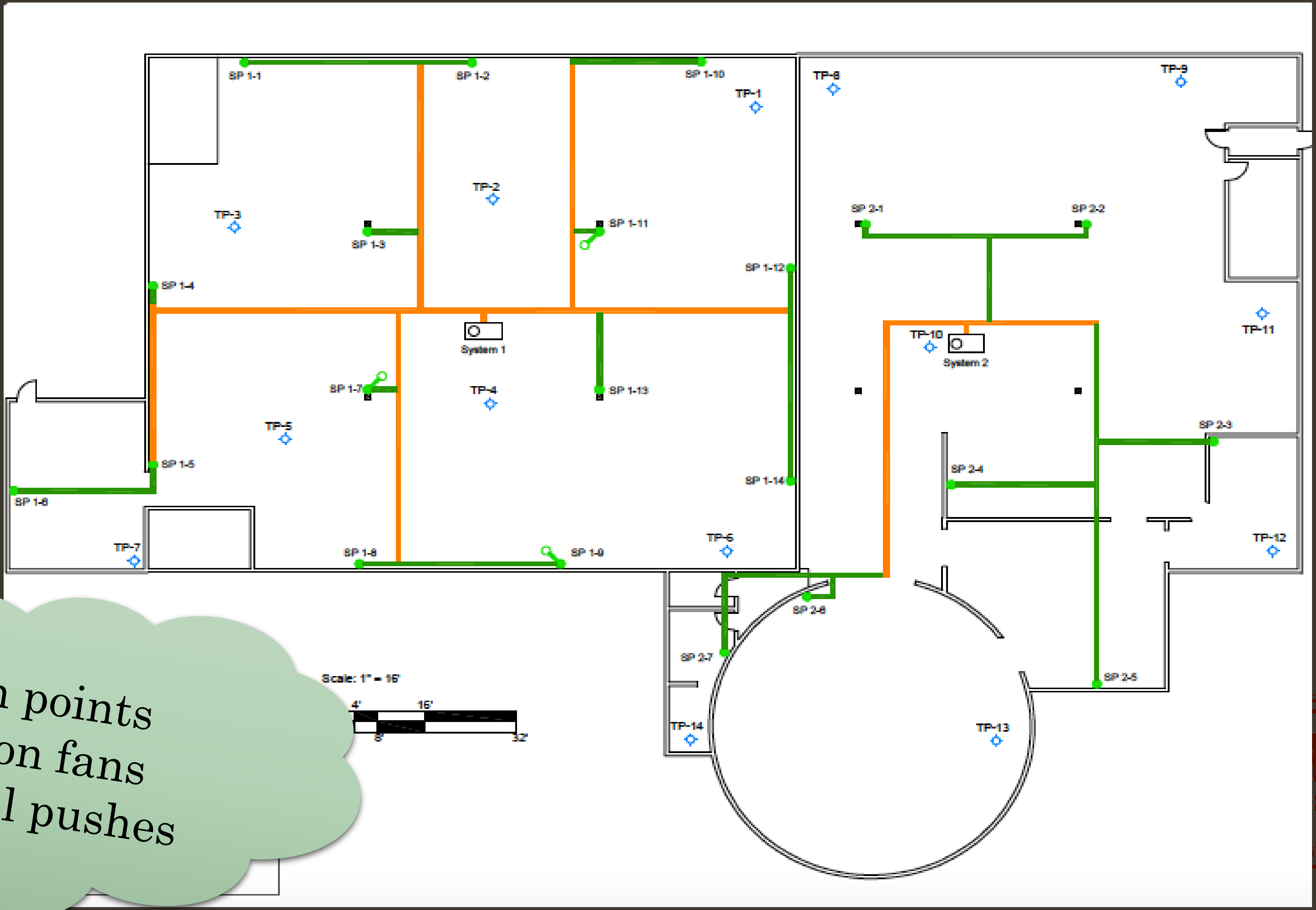
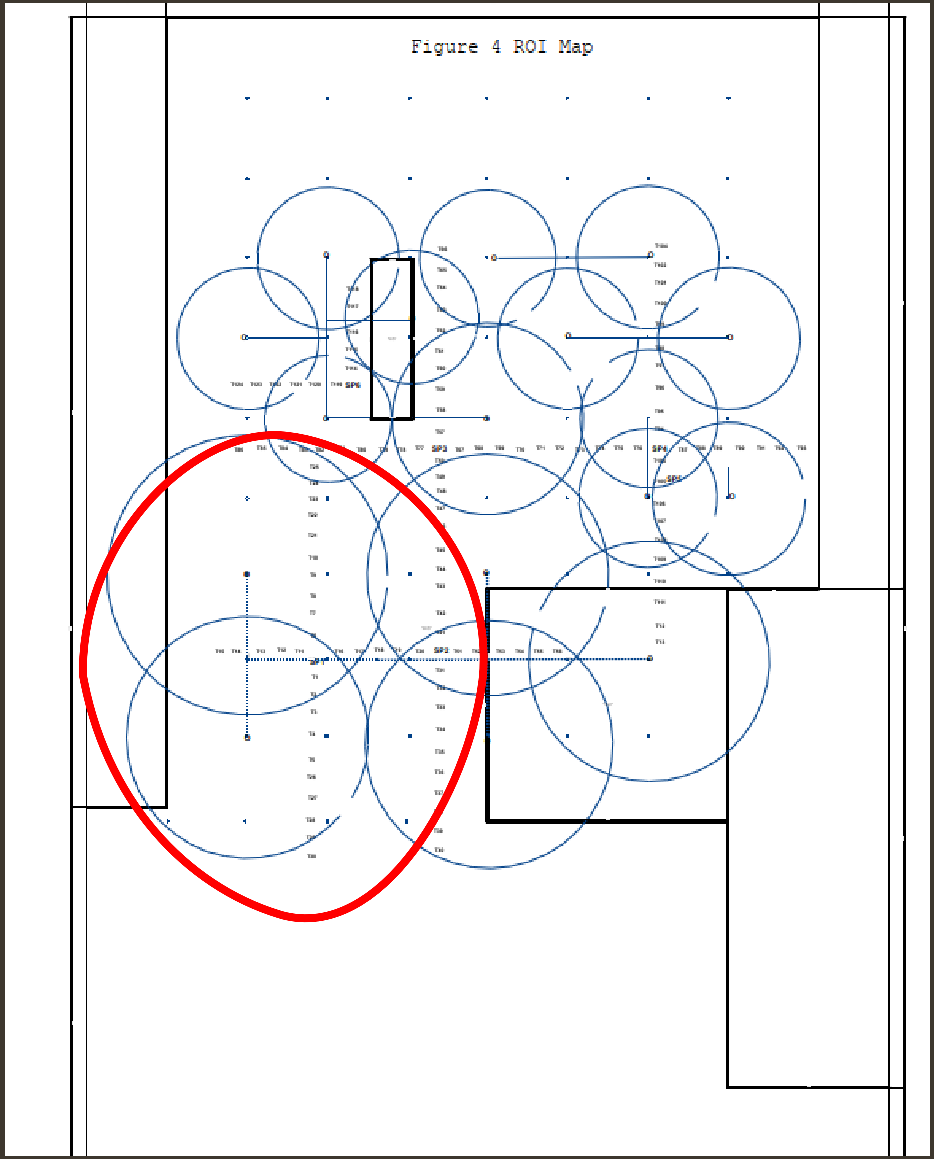
Final Design



21 suction points
2 mitigation fans
3 mechanical pushes

Another look at ROIs

	D	SUCTION POINT 1				MAX	BG	DATE	T	W
		V1	V2	V3			0.001	01/06/15	25	snw
CFM		52	37	23		67				
SSP 1		4.9	2.8	1.57		71				
SSP 2										
PORT		20	10	5						
T1	10	1.5400	0.9500	0.5600						
T2	20	0.8200	0.5000	0.3100						
T3	30	0.4800	0.2900	0.1700						
T4	40	0.3700	0.2200	0.1300						
T5	50	0.2700	0.1500	0.0780						
T6	10	1.4000	0.8700	0.5300						
T7	20	0.9500	0.6300	0.3700						
T8	30	0.6600	0.4200	0.2600						
T9	40	0.5000	0.3200	0.2000						
T10	50	0.3400	0.2200	0.1400						
T11	10	1.2800	0.8050	0.4620						
T12	10	0.6500	0.4190	0.2410						
T13	30	0.5670	0.3590	0.2100						
T14	40	0.4100	0.2610	0.1690						
T15	50	0.1970	0.1250	0.0790						
T16	10	1.3200	0.0890	0.4910						
T17	20	0.9370	0.5890	0.3590						
T18	30	0.4950	0.3080	0.1890						
T19	40	0.1680	0.1070	0.0610						
T20	50	0.1380	0.0790	0.0500						
T21	60	0.0490	0.0530	0.0390						
T22	70	0.0520	0.0320	0.0210						
T23	80	0.0220	0.0130	0.0100						
T24	90	0.0130	0.0070	0.0060						
T25	100	0.0060	0.0040	0.0030						
T26	60	0.1200	0.0770	0.0420						
T27	70	0.0500	0.0280	0.0150						
T28	80	0.0600	0.0330	0.0200						
T29	90	0.0300	0.0150	0.0090						
T30	100	0.0200	0.0110	0.0080						
		All values negative unless proceeded by a P								
		BG= Background								

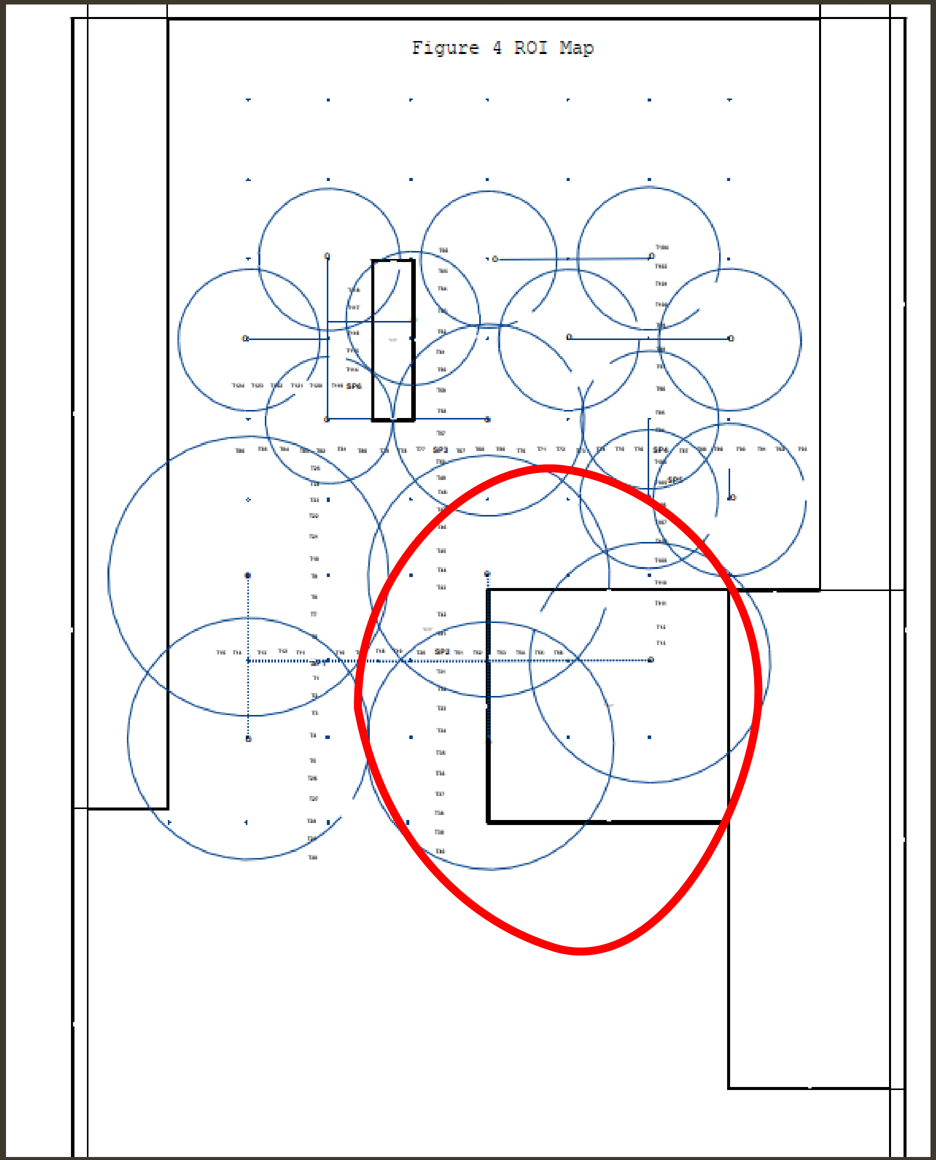


Another look at ROIs

	D	SUCTION POINT 2					MAX	BG	DATE	T	W
		V1	V2	V3			85		01/06/15	25	snw
CFM		78	48								
SSP 1		3.9	2.2				4.3				
SSP 2											
PORT		20	10								
T20	10	1.6600	0.9610					p.001			
T19	20	1.0600	0.6160								
T18	30	0.6010	0.3440								
T17	40	0.2330	0.1310								
T16	50	0.1210	0.0640								
T6	60	0.0830	0.0430								
T11	70	0.0560	0.0330								
T12	80	0.0380	0.0210								
T13	90	0.0350	0.0200								
T14	100	0.0270	0.0150								
T15	110	0.0170	0.0120								
T31	10	1.6800	0.9380								
T32	20	1.0700	0.6180								
T33	30	0.4900	0.2690								
T34	40	0.2700	0.1380								
T35	50	0.1700	0.0780								
T36	60	0.1000	0.0390								
T37	70	0.0800	0.0270								
T38	80	0.0400	0.0270								
T39	90	0.0280	BG								
T40	100	0.0200	BG								
T41	10	0.0060	0.0040								
T42	20	0.0070	0.0040								
T43	30	0.0080	0.0040								
T44	40	0.1000	0.0050								
T45	50	0.0130	0.0070								
T46	60	0.0100	0.0050								
T47	70	0.0050	0.0020								
T48	80	BG	BG								
T49	90	BG	0.0010								
T50	100	BG	BG								
T51	10	1.5900	0.9140								
T52	20	0.7510	0.4300								
T53	30	0.5790	0.3310								
T54	40	BG	BG								
T55	50	0.2810	0.1570								
T56	60	0.0210	0.0110								

BG= Background

all values are negative unless proceeded by a P

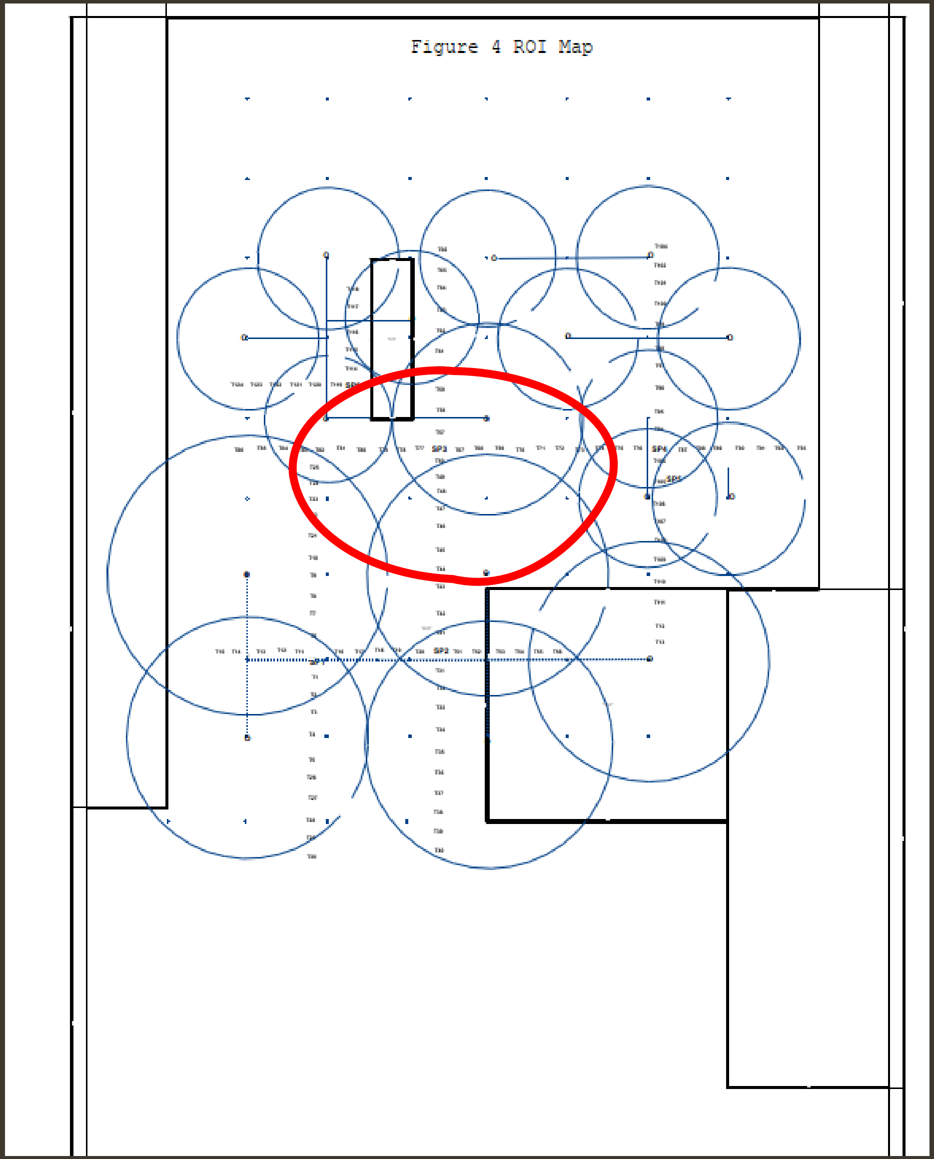


Another look at ROIs

	D	SUCTION POINT 3				MAX	BG	DATE	T	W
		V1	V2	V3						
CFM		100	75	50		105	0.0000	11/06/14	15	SNW
SSP 1		4.3	2.9	1.7						
SSP 2										
PORT		16	10	5.4						
T50	10	1.1300	0.8820	0.5040						
T49	20	0.3920	0.2770	0.1760						
T48	30	NA	NA	NA						
T47	40	0.0690	0.0480	0.0300						
T46	50	0.0340	0.0210	0.0130						
T45	60	0.0350	0.0240	0.0150						
T44	70	NA	NA	NA						
T43	80	0.0040	0.0010	BG						
T42	90	BG	BG	BG						
T41	100	BG	BG	BG						
T40	110	BG	BG	BG						
T57	10	1.3270	0.9340	0.5760						
T58	20	0.7730	0.5520	0.3420						
T59	30	0.3600	0.2650	0.1590						
T60	40	0.1460	0.1060	0.0650						
T61	50	0.0880	0.0650	0.0400						
T62	60	0.0200	0.0150	0.0110						
T63	70	0.0070	0.0060	0.0050						
T44	80	0.0050	0.0040	0.0030						
T65	90	0.0020	0.0030	0.0020						
T66	100	BG	BG	BG						
T67	10	0.8750	0.5960	0.3690						
T68	20	0.3480	0.2740	0.1370						
T69	30	0.1500	0.1310	0.0870						
T70	40	0.0820	0.0580	0.0360						
T71	50	0.0460	0.0580	0.0360						
T72	60	0.0110	0.0070	0.0040						
T73	70	0.0020	BG	BG						
T74	80	BG	BG	BG						
T75	90	BG	BG	BG						
T76	100	BG	BG	BG						
T77	10	0.9370	0.7280	0.4440						
T78	20	0.2720	0.2010	0.1310						
T78	30	0.1030	0.0770	0.0510						
T80	40	0.0570	0.0440	0.0290						
T81	50	0.0360	0.0270	0.0180						
T82	60	0.0240	0.0190	0.0130						
T83	70	0.0180	0.0150	0.0100						
T84	80	0.0090	0.0080	0.0060						
T85	90	0.0060	0.0070	0.0040						
T86	100	BG	BG	BG						

All values negative unless proceeded by a P

BG= Background

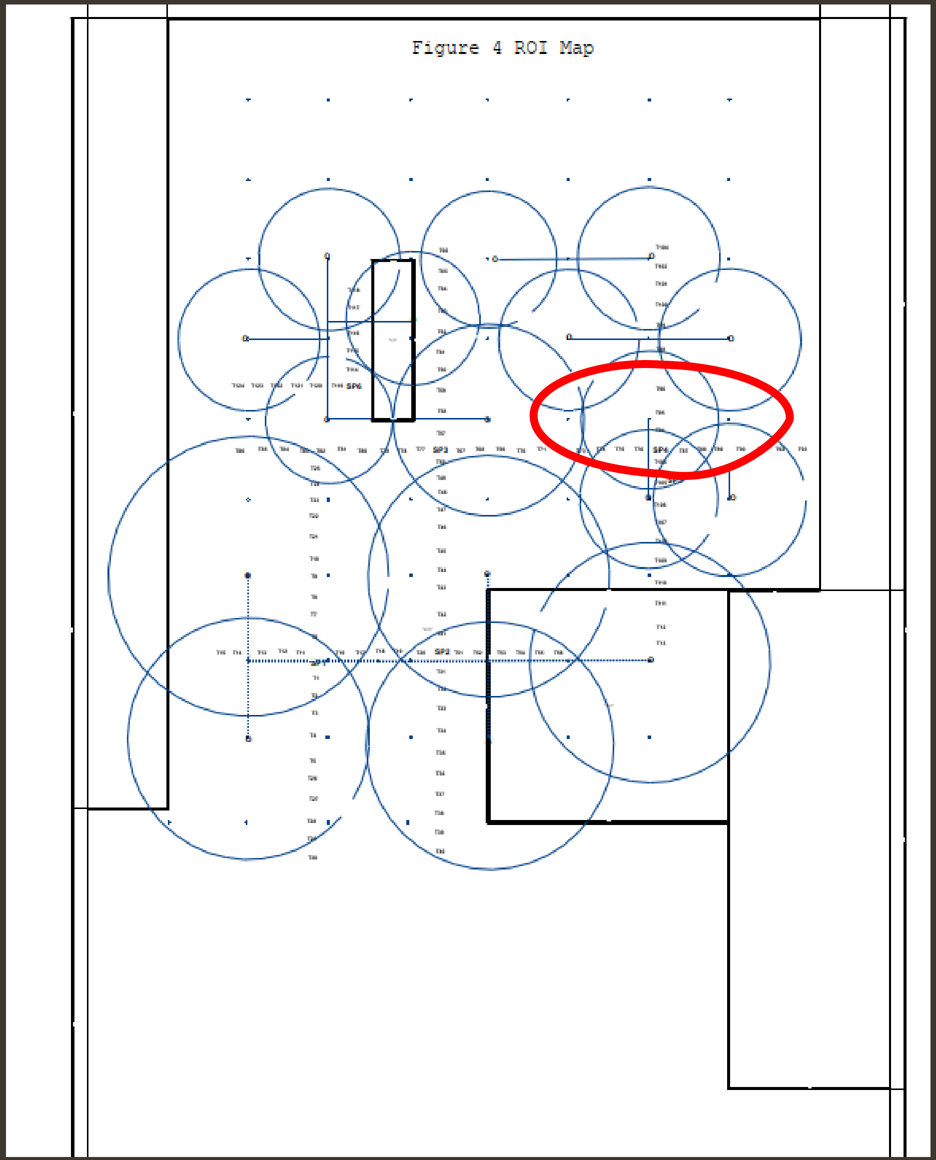


Another look at ROIs

	D	SUCTION POINT 4				MAX	BG	DATE	T	W
		V1	V2	V3			0.001	11/07/14	15	CL
CFM		27				45				
SSP 1		0.9				1.7				
SSP 2										
PORT		20				43				
T76	10	0.0610								
T75	20	0.0230								
T74	30	0.0040								
T73	40	0.0020								
T72	50	0.0010								
T71	60	0.0010								
T70	70	BG								
T69	80	BG								
T68	90	BG								
T67	100	BG								
T87	10	0.0920								
T88	20	0.0590								
T89	30	0.0070								
T90	40	0.0030								
T91	50	BG								
T92	60	BG								
T93	70	BG								
T94	10	0.0620								
T95	20	0.0300								
T96	30	0.0060								
T97	40	0.0030								
T98	50	BG								
T99	60	BG								
T100	70	BG								
T101	80	BG								
T102	90	BG								
T103	100	BG								
T104	10	0.1930								
T105	20	0.0430								
T106	30	0.0060								
T107	40	0.0040								
T108	50	BG								
T109	60	BG								
T110	70	BG								
T111	80	BG								
T112	90	BG								
T113	100	BG								

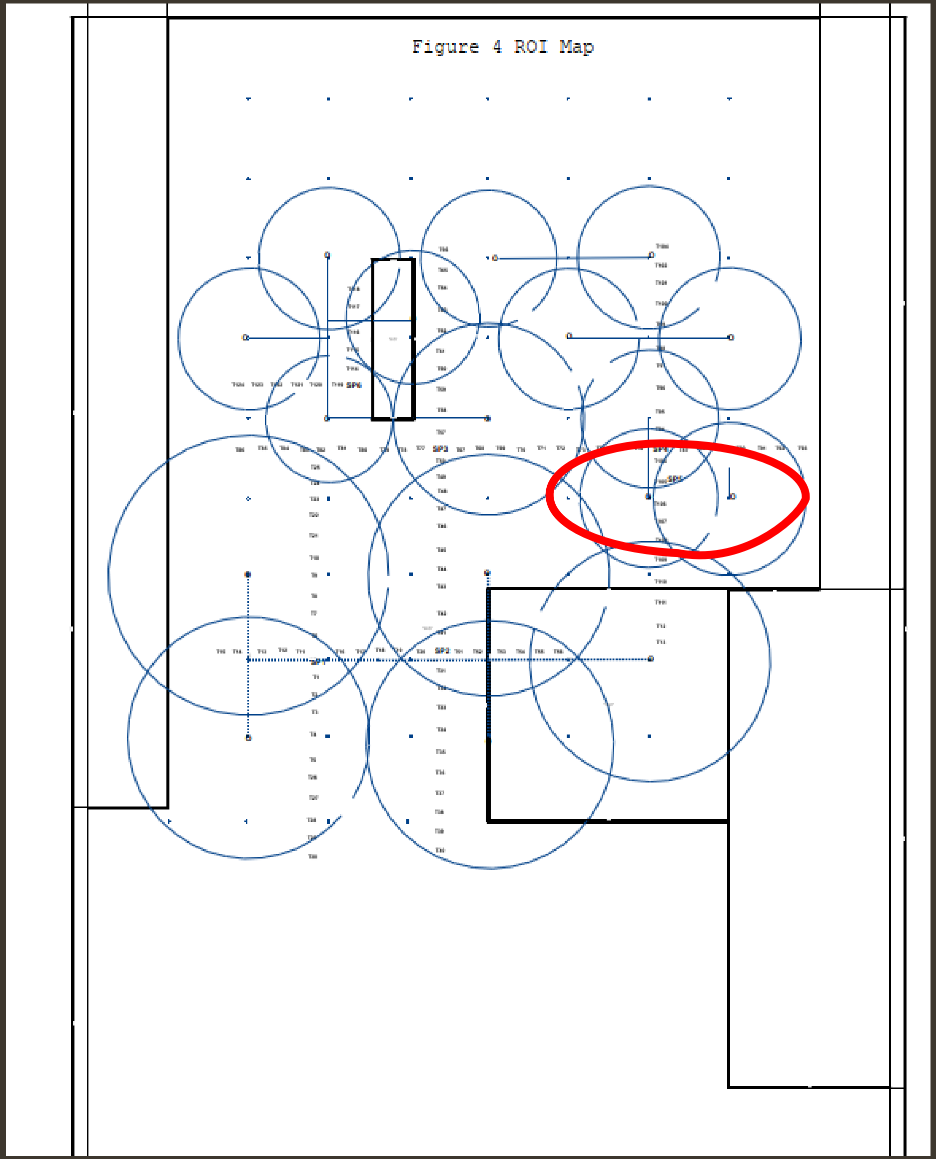
All values negative unless proceeded by a P

BG= Background



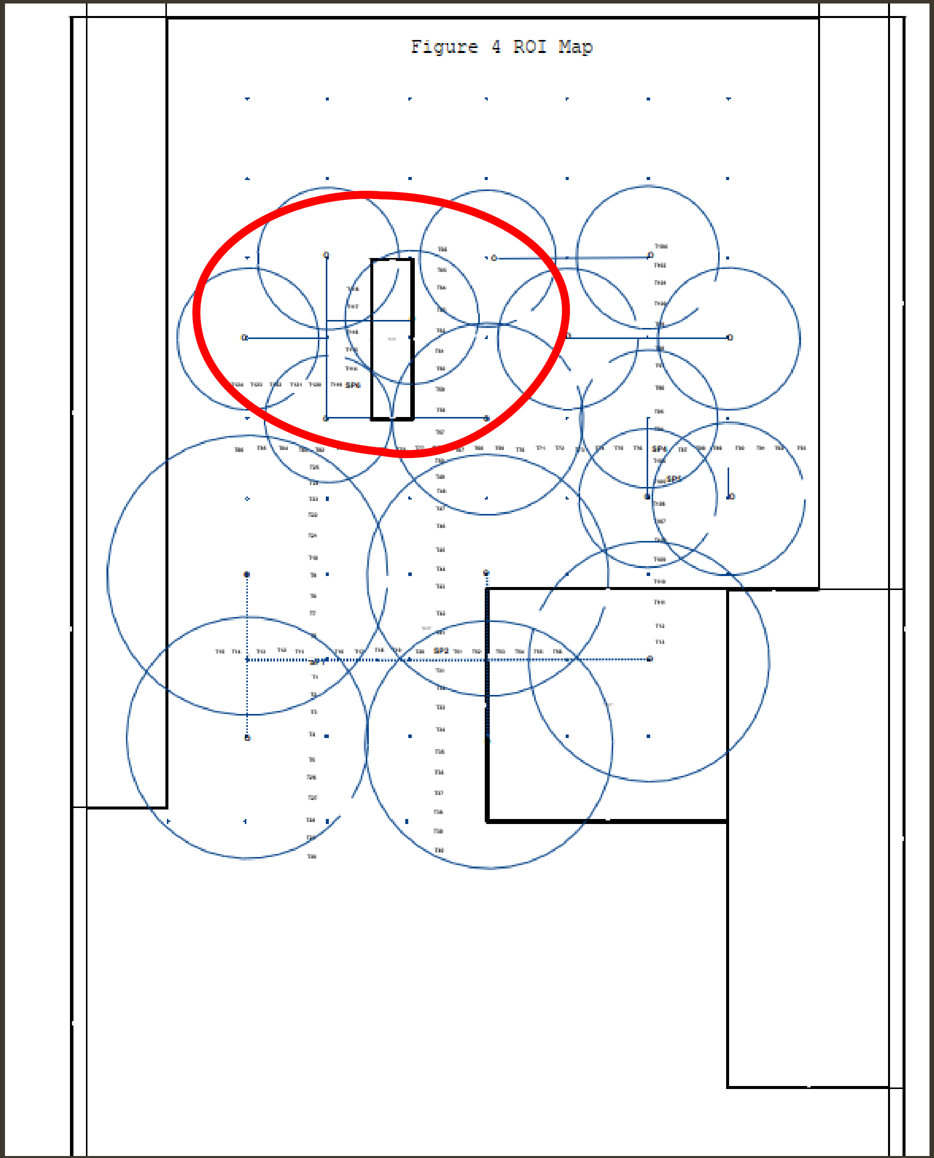
Another look at ROIs

	D	SUCTION POINT 5					MAX	BG	DATE	T	W
		V1	V2	V3					01/07/15	25	clr
CFM		47	27				67				
SSP 1		6.2	3.6				9.9				
SSP 2											
PORT		20	10								
76	20	0.0370	0.0200					0.001			
75	25	0.0360	0.0210								
74	35	0.0140	0.0070								
73	45	0.0050	0.0020								
72	55	na	na								
71	65										
70	75										
69	85										
68	95										
67	105										
87	10	0.0490	0.0280					P.002			
88	20	0.0550	0.0320								
89	30	0.0060	0.0030								
90	40	0.0010	BG								
91	50	na									
92	60	na									
93	70	na									
94	30	0.0160	0.0100								
95	40	0.0100	0.0060								
96	50	0.0020	0.0020								
97	60	0.0010	0.0010								
98	70		0.0010								
99	80										
100	90										
101											
102	100										
103	110										
104	10	0.6200	0.3550								
105	0										
106	10	0.2290	0.1400								
107	20	0.0780	0.0450								
108	30	0.0200	0.0130								
109	40	0.0100	0.0080								
110	50	0.0030	0.0030								
111		0.0020	BG								
112	60	0.0010	BG								
113	70										
		BG= Background									
		All Values are negative unless proceeded by a P									



Another look at ROIs

	D	SUCTION POINT 6					MAX	BG	DATE	T	W
		V1	V2	V3			24	0	01/07/15	15	CL
CFM		12	9	7							
SSP 1		0.6	0.366	0.238			1.1				
SSP 2											
PORT		20	10	5							
T114	10	0.0970	0.0590	0.0380							
T115	20	0.0280	0.0170	0.0120							
T116	30	0.0080	0.0060	0.0040							
T117	40	0.0060	0.0040	0.0030							
T118	50	0.0040	0.0020	0.0020							
T119	10	0.1070	0.0630	0.0410							
T120	20	0.0670	0.0390	0.0260							
T121	30	0.0380	0.0220	0.0140							
T122	40	0.0600	0.0110	0.0070							
T123	50	0.0110	0.0100	0.0070							
82		0.0700	0.0420	0.0290							
81		0.0220	0.0140	0.0090							
124	37	0.0090	0.0050	0.0040							
57	58	0.0010	BG	BG							
79		0.0130	0.0070	0.0050							
80		0.0220	0.0140	0.0090							
83		0.0700	0.0420	0.0290							
		All values negative unless proceeded by a P									
		BG= Background									
T											



Don’t Forget

- Vapor Intrusion is Pressure Differential Driven
- Sub Slab Depressurization is our best tool for mitigation
- Design using A.R.E. (Applied, Resulting, Effected)
- Proper Pressure Field Extension Technique is key
  - Safety
  - Thorough
  - Don’t stop collecting data until you are confident in results

Thanks for listening!!

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