Large/Old Industrial Buildings – Will the Real Attenuation Factor Please Stand Up?

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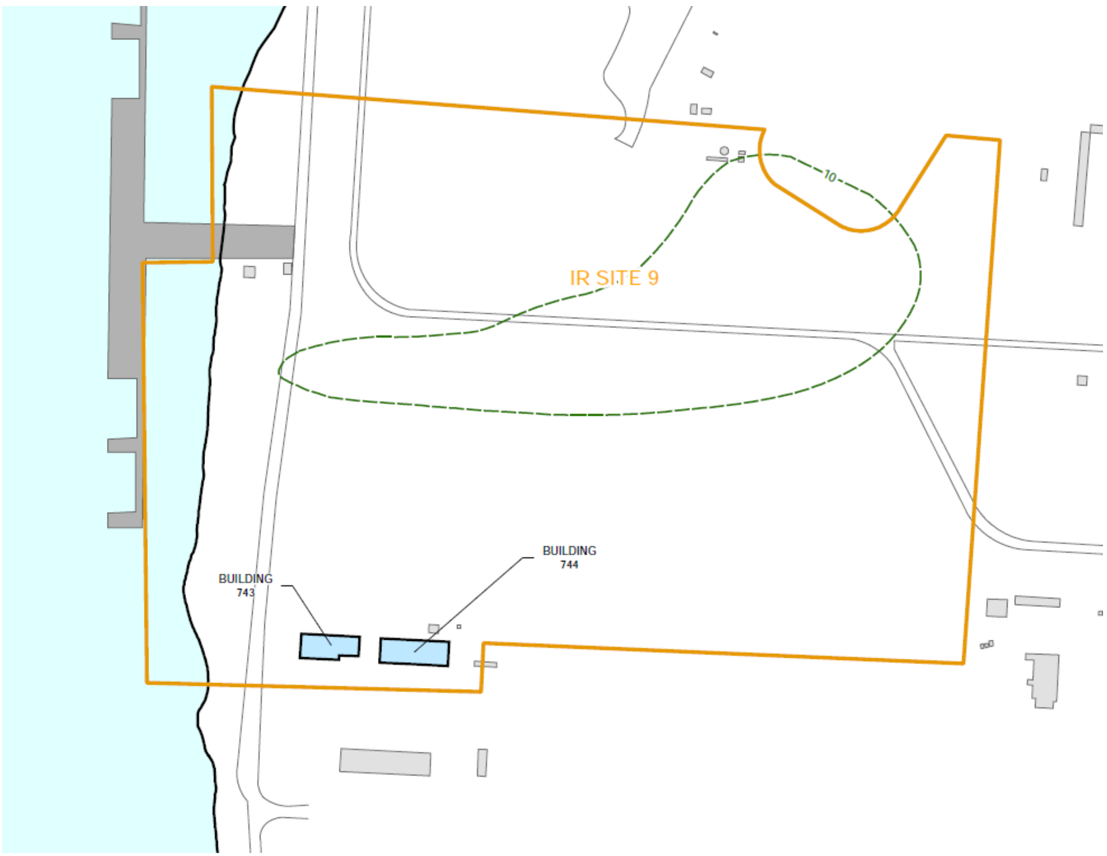
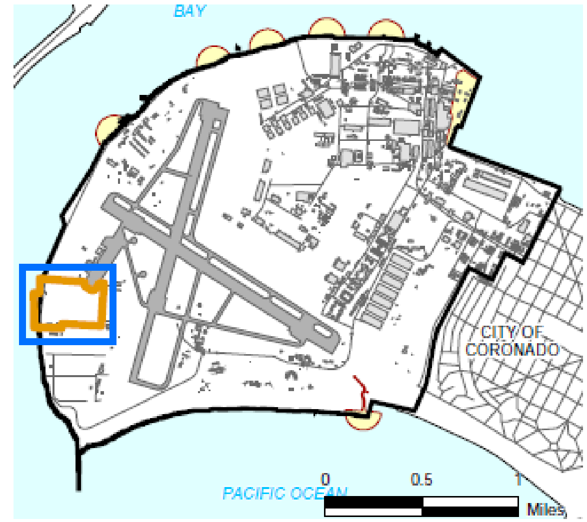
Presentation Overview

1. Introduction
2. Objectives
3. Approach
4. Results
5. Conclusions

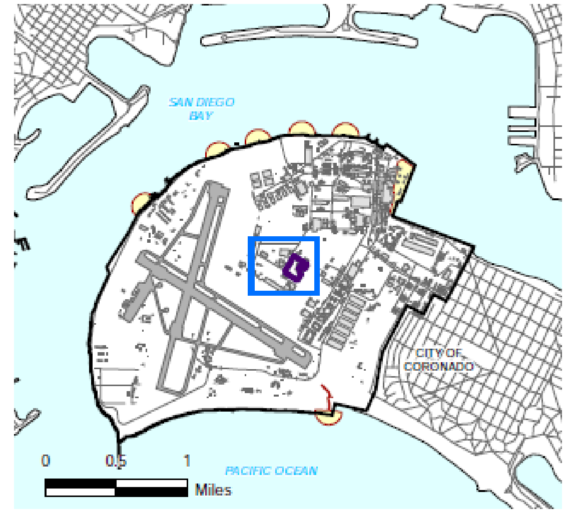
1. Introduction: NAS North Island IR Site 9





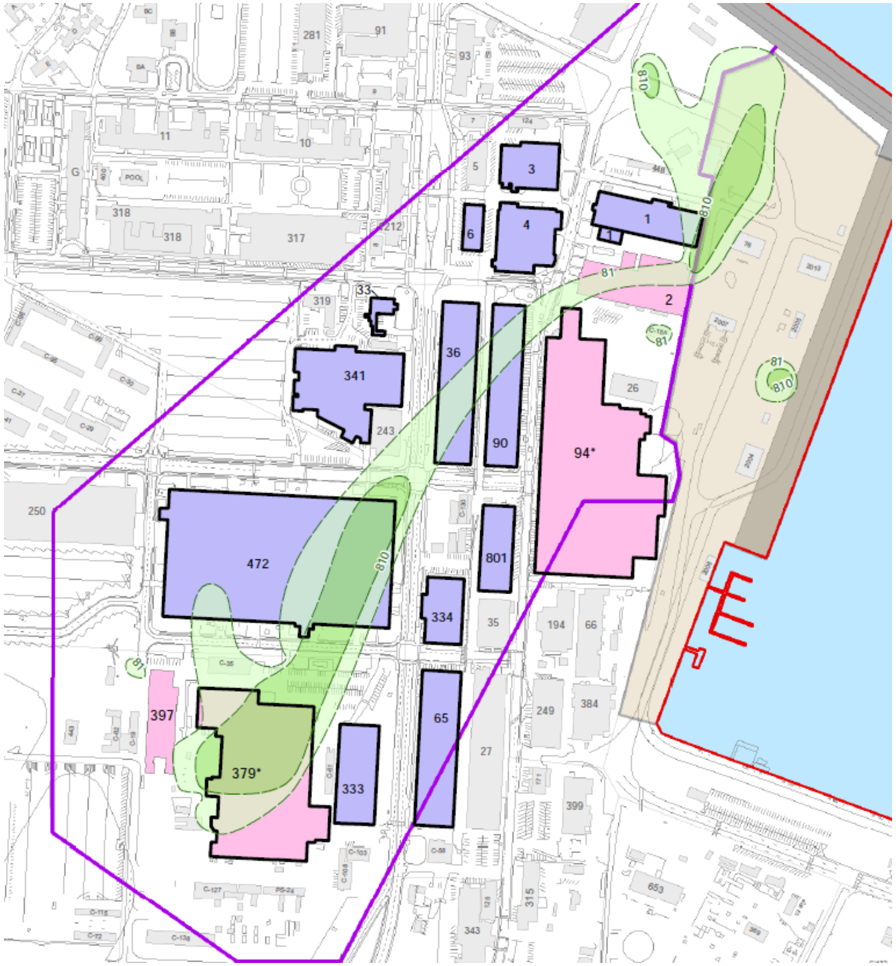
Evaluated 2 Buildings

1. Introduction: NAS North Island Operable Unit 11



Evaluated 3 Buildings

1. Introduction: NAS North Operable Unit 20

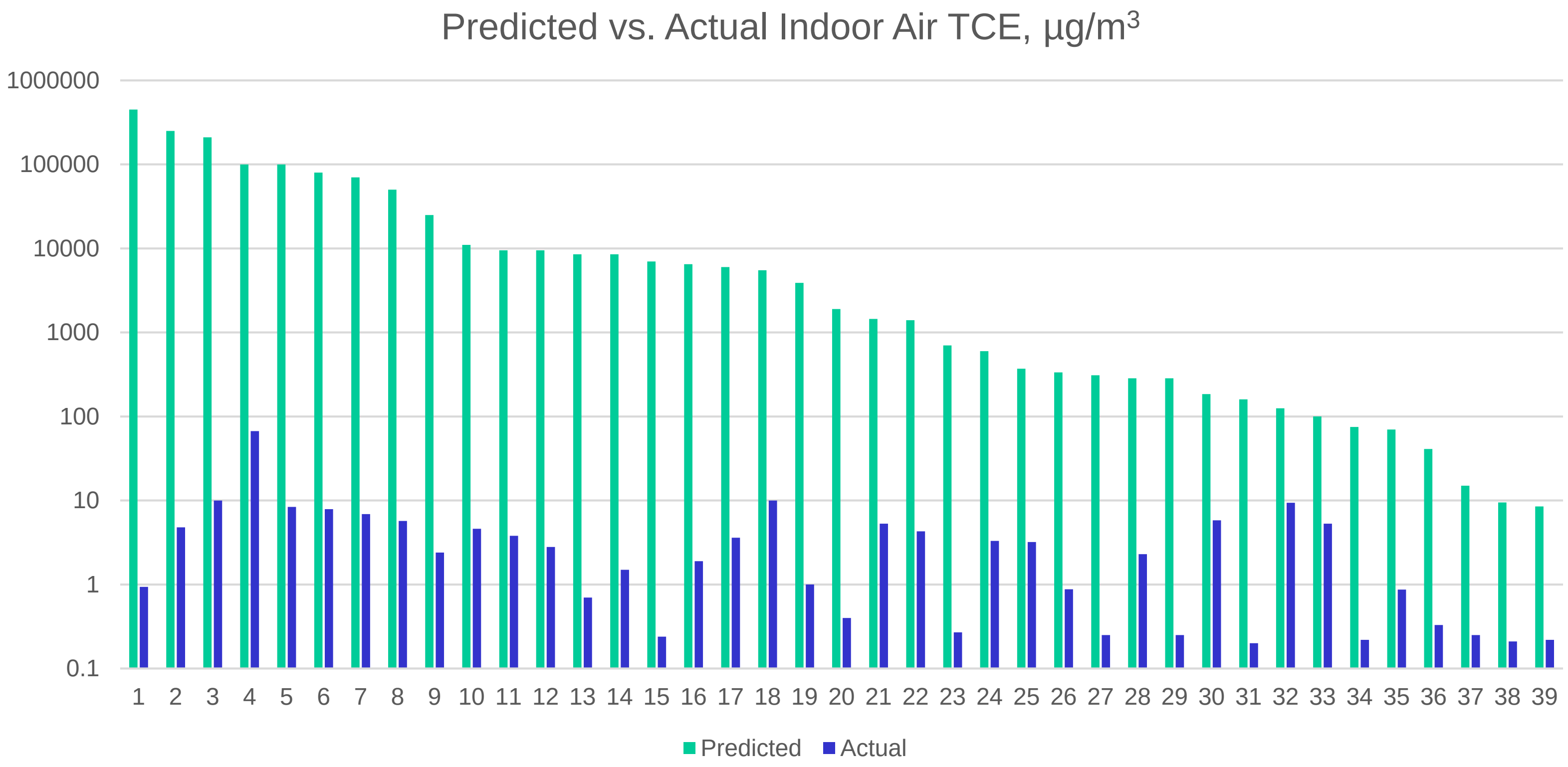


Evaluated 17 Buildings

1. Introduction: Project Background

- Concentrations of cVOCs in shallow groundwater prompted VI investigation
- Since 2014, subslab soil gas (SSG) and indoor air (IA) have been sampled at 22 Buildings
- Sampling has been conducted during winter and summer seasons: 2 to 5 events
- TCE is the primary VOC detected in SSG and IA samples

1. Introduction: Predicted (based on DTSC AF) vs. Actual TCE in Indoor Air



Predicted Indoor Air based on DTSC AF of 0.05

Predicted > Actual by at least one order of magnitude, and as high as 6 orders of magnitude

US EPA/DTSC TCE Accelerated Action Level 8 ug/m^3, Urgent Action Level 24 ug/m^3

1. Introduction: Current Regulatory Guidance (DTSC)

- In Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air (October 2011), DTSC states that :

  "to use subslab soil gas concentrations to evaluate vapor intrusion, contaminant attenuation over the foundation slab must be known to determine the associated indoor air concentrations. If the attenuation factor associated with the building slab is unknown or cannot be determined, an attenuation factor of 0.05 should be used (see Appendix B)."

  In Appendix B, DTSC states that:

  "The national empirical vapor intrusion database (USEPA, 2008) was used to select a default subslab attenuation factor……..The resulting data set consisted of 311 paired subslab-indoor air samples representing 13 sites. An attenuation factor of 0.05, representing approximately the 90th percentile of the data, was selected as an appropriate subslab attenuation factor for screening purposes for residential structures. The national database lacks sufficient information concerning commercial buildings to conclusively infer a subslab attenuation factor for this building scenario. Hence, the residential subslab attenuation factor of 0.05 should also be used for commercial buildings."

1. Introduction: Current Regulatory Guidance (EPA)

- USEPA proposes an AF of 0.03

This is based on data from more than 1,000 buildings. The range and frequency of estimated attenuation factors are presented in the following figure:

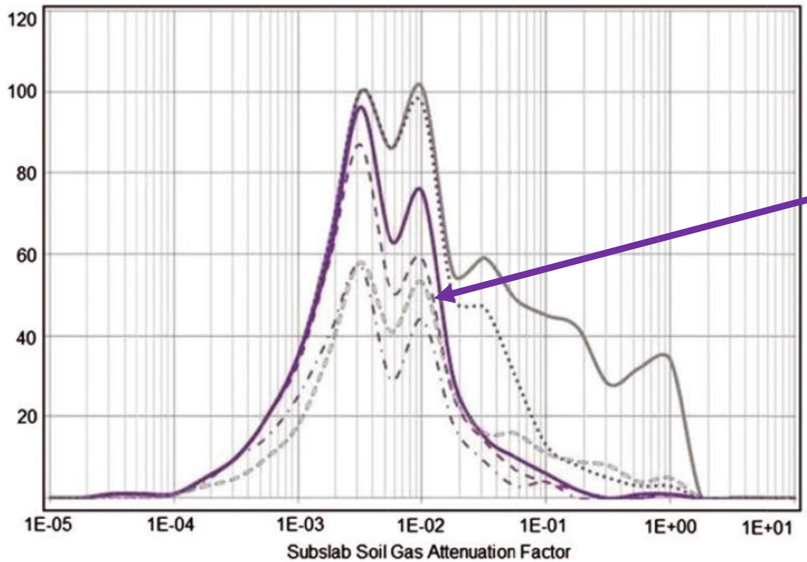


Figure 2. Range and frequency of ratios of indoor air to subslab soil gas data for individual buildings included in the USEPA database, assumed to represent SSAFs for the structures (from USEPA 2012b).

- Different plots on the graph reflect different filters applied to the database,
- Purple plot representing data sets where VOCs in subslab soil gas samples were 50 times greater than the anticipated indoor air background
- Statistical analysis of this particular set of data is used to generate generic AFs for general screening purposes, resulting in a median value of 0.003 and a 95th percentile value of 0.03.

1. Introduction: Issues with USEPA Database

- Concentrations of VOCs in indoor air were within the assumed background levels for most of the samples in the database

- Of the original 1,231 sets of paired subslab and indoor air data sets, 464 were filtered out in order to address:
  - Known or suspected indoor sources
  - Concentrations of VOCs in the subslab soil gas sample that were less than that reported for indoor air
  - Other potentially complicating factors

1. Introduction: Issues with USEPA Database (contd.)

- All but 320 sets of paired data were eliminated after screening out indoor air data that fell within the assumed background range of a VOC.
- Most of the AFs are from a small number of sites that represent a relatively narrow set of soil and building characteristics;
- Sites with very low AFs and sites where vapor intrusion was not occurring were excluded from further consideration
- Therefore, the median, mean, and 95th percentile AFs presented in the USEPA 2012 report are biased toward cases with less attenuation and do not reflect the database population as a whole
- These findings indicate that the updated database may not be sufficiently robust to obviate site-specific screening.

Neither USEPA nor DTSC differentiate between residential and industrial structures

1. Introduction: Attenuation Factors For Industrial Buildings

- Industrial buildings in general and old buildings, such as the ones at NAS North Island, in particular, behave very differently from residential buildings when it comes to VI:
  - Air exchanges are different because:
    - Door/window openings are quite substantial
    - Some buildings are “permanently” open to outside air
  - The square footage and height of the buildings are substantially different than the typical residential or industrial buildings
  - Floors are much thicker (sometimes > 8 inches thick concrete)

1. Introduction: Attenuation Factors For Industrial Buildings

- Considering the issues with the over prediction of indoor air concentration using the generic AFs (DTSC or USEPA) and the low action TCE levels, it is prudent to establish a site-specific AF for NASNI buildings

- Currently, there are site-specific data from 22 Buildings at NASNI

- In addition, Navy has published data from 12 installations, 13 sites, and 49 buildings (excluding NASNI) that can be used to support site-specific AF values for NASNI Buildings (VI Framework, 2015)

2. Objectives

- Establish a robust data set of Attenuation Factors for multiple industrial buildings

- Develop a site specific Attenuation Factor for use in Risk Management

  - Particularly if IA levels are below action levels, but SSG levels are significantly higher

3. Approach

- SSG/IA samples at 22 Buildings (3 plumes)
- Every SSG location had a co-located Summa
- Attenuation Factors:
  - BSAF for each building is the average of AFs calculated for that building
  - We also calculated an "inverse" BSAF for ease of interpretation (so that it is > 1)
  - A larger inverse BSAF means there is more attenuation, a smaller BSAF means that there is more attenuation
  - We excluded locations where:
    - The indoor air levels were below DLs
    - Subslab soil gas was below 176 µg/m^3 (calculated based on IASL of 8.8 µg/m^3 and DTSC default AF of 0.05).
  - A total of 6 buildings remained

3. Approach: OU 20 Sampling Locations

LEGEND

- VAPOR PIN - GROUP II
- SUB-SLAB PROBE - GROUP I
- SUMMA CANISTER SAMPLING LOCATION

4. Results: Statistics for TCE in IA/SSG samples

OU/IR	Building	Highest TCE (µg/m³) Subslab[A]	Average TCE (µg/m³) Subslab[A]	Highest TCE (µg/m³) Indoor Air[A]	Average TCE (µg/m³) Indoor Air[A]	No. of Subslab Events	No. of Indoor Air Events
Group I							
9	743	350	154	<0.084	<0.084	3	1
	744	240	103	<0.11	<0.11	3	1
11	1454	2,000	1,140	0.20	0.095	3	2
	1472	1,200	224	0.12	0.086	4	2
	1482	2,600	238	0.12	0.089	4	2
20	2	1,000	197	0.55	0.190	3	2
	94	9,000,000	447,735	6.1	0.217	5	4
	379[B]	6,000,000	1,594,014	67[C]	8.89	4	3
	397	350	153	0.57	0.280	3	2
Group II							
20	1	17,000	3,926	0.20	0.20	2	2
	3	150	88	<0.049	<0.049	2	2
	4	120	64	<0.042	<0.042	2	2
	6	20	10	<0.049	<0.049	2	2
	33	110	42	<0.051	<0.051	2	2
	36	38,000	7,300	0.88	0.15	2	2
	65	74	20	<0.041	<0.041	2	2
	90	52,000	11,452	0.42 J	0.42	2	2
	333	25,000	7,118	<0.047	<0.047	2	2
	334	680	248	<0.044	<0.044	2	2
	341[D]	19,000	12,750	0.25	0.16	1	1
	472	19,000	2,351	1.4 J	0.28	2	2
	801	47,000	14,311	0.16 J	0.16	2	2

(A) Highest and average TCE concentrations are taken from all events at all sample locations.
(B) Data for Building 379 for Summer 2016 (and beyond) are not included here, since a TCRA has been implemented at this building.
(C) Based on the detection of elevated TCE in indoor air, a Time Critical Removal Action (TCRA) was implemented for Building 379, which has resulted in acceptable indoor air levels since May 2016.
(D) Building 341 was not sampled in Winter 2017 due to ongoing asbestos abatement and building demolition.

4. Results: Building Specific Attenuation Factors (BSAFs) at NASNI

Building	Event	Vapor Pin Location	Vapor Pin TCE, µg/m³	Summa TCE, µg/m³	Sub-Slab TCE Below 176?	IA Samples Non-Detect?	Location-specific Inverse AF	Location-specific AF	Building Average Inverse BSAF	Building Average BSAF
94	W15	OU20-B5	31	0.21 U	Yes	Yes	NC	NC	NC	NC
		OU20-B6	36	0.21 U	Yes	Yes	NC	NC		
		OU20-B7	830	0.21 U	No	Yes	NC	NC		
		OU20-B8	11,000	0.26 U	No	Yes	NC	NC		
		OU20-B9	330	0.21 U	No	Yes	NC	NC		
		OU20-B11	910	0.21 U	No	Yes	NC	NC		
		OU20-B12	60	0.23 U	Yes	Yes	NC	NC		
	S15	OU20-B5	40	0.18 U	Yes	Yes	NC	NC	22,961	0.000163
		OU20-B6	43	0.056 J	Yes	No	NC	NC		
		OU20-B7	1,600	0.11 J	No	No	14,545	0.000069		
		OU20-B8	14,000	0.27	No	No	51,852	0.000019		
		OU20-B9	820	0.33	No	No	2,485	0.000402		
		OU20-B11	1,100	0.18 U	No	Yes	NC	NC		
		OU20-B12	100	0.18 U	Yes	Yes	NC	NC		
	S16	VP01	29	0.044 J	Yes	No	NC	NC	1,663,290	0.000027
		VP02	1,100	0.086 J	No	No	12,791	0.00008		
		VP04	5,700	0.16 J	No	No	35,625	0.00003		
		VP05	9,900	0.11 J	No	No	90,000	0.00001		
		VP06	3,600	0.15 J	No	No	24,000	0.00004		
		VP07	3.1	0.050 J	Yes	No	NC	NC		
		VP08	2.5	0.064 J	Yes	No	NC	NC		
		VP09	9,000,000	0.94	No	No	9,574,468	0.00000		
		VP10	170,000	0.70	No	No	242,857	0.00000		
379	W15	OU20-B13	1,400,000	6.9	No	No	202,899	0.000005	247,695	0.000664
		OU20-B15	2,500	9.4	No	No	266	0.003760		
		OU20-B16	5,000,000	4.8	No	No	1,041,667	0.000001		
		OU20-B18	1,600,000	7.9	No	No	202,532	0.000005		
		OU20-B19	120,000	3.6	No	No	33,333	0.000030		
		OU20-B20	29,000	5.3	No	No	5,472	0.000183		
	S15	OU20-B13	1,000,000	5.7	No	No	175,439	0.000006	130,529	0.000040
		OU20-B14	2,000,000	67	No	No	29,851	0.000034		
		OU20-B15	28,000	4.3	No	No	6,512	0.000154		
		OU20-B16	4,200,000	10	No	No	420,000	0.000002		
		OU20-B17	110,000	10	No	No	11,000	0.000091		
		OU20-B18	2,000,000	8.4	No	No	238,095	0.000004		
		OU20-B19	190,000	3.8	No	No	50,000	0.000020		
		OU20-B20	170,000	1.5	No	No	113,333	0.000009		
	S16	VP01	140,000	0.24	No	No	583,333	0.00000	96,656	0.000491
		VP04	220,000	4.6	No	No	47,826	0.00002		
		VP05	190,000	2.8	No	No	67,857	0.00001		
		VP13	3,700	5.8	No	No	638	0.00157		
		VP14	12,000	3.3	No	No	3,636	0.00028		
		VP15	2,000	5.3	No	No	377	0.00265		
		VP16	7,400	3.2	No	No	2,313	0.00043	96,656	0.000491
		VP17	5,700	2.3	No	No	2,478	0.00040		
		VP18	500,000	2.4	No	No	208,333	0.00000		
		VP19	130,000	1.9	No	No	68,421	0.00001		
		VP20	78,000	1.0	No	No	78,000	0.00001		
36	S16	VP01	170	0.22	Yes	No	NC	NC	26,180	0.000520
		VP02	190	0.21	No	No	905	0.00111		
		VP03	300	0.25	No	No	1,200	0.00083		
		VP04	38,000	0.40	No	No	95,000	0.00001		
		VP05	6,700	0.88	No	No	7,614	0.00013		
90	S16	VP01	1,500	0.22	No	No	6,818	0.00015	90,146	0.000071
		VP02	3,200	0.20	No	No	16,000	0.00006		
		VP03	52,000	0.42 J	No	No	247,619	0.00000		
		VP04	6,600	0.13 U	No	Yes	NC	NC		
		VP05	1,200	0.081 U	No	Yes	NC	NC		
341	S16	VP01	6,200	0.25	No	No	24,800	0.00004	71,775	0.000024
		VP02	19,000	0.16 J	No	No	118,750	0.00001		
472	S16	VP01	12	0.078 J	Yes	No	NC	NC	36,333	0.000388
		VP02	4.1	0.17 U	Yes	Yes	NC	NC		
		VP03	2,400	0.17 U	No	Yes	28,235	0.00004		
		VP04	1,400	0.87	No	No	1,609	0.00062		
		VP05	4,400	0.093 J	No	No	47,312	0.00002		
		VP06	1,400	0.14 J	No	No	10,000	0.00010		
		VP07	19,000	0.081 J	No	No	234,568	0.00000		
		VP08	1,300	0.15 J	No	No	8,667	0.00012		
		VP09	5,700	0.25	No	No	22,800	0.00004		
		VP10	48	0.023 J	Yes	No	NC	NC		
		VP11	29	0.062 U	Yes	Yes	NC	NC		
		VP12	180	0.024 J	No	No	7,500	0.00013		
		VP13	7.2	0.053 U	Yes	Yes	NC	NC		
		VP14	14	0.033 J	Yes	No	424	0.00236		
		VP15	3,100	1.4 J	No	No	2,214	0.00045		
		VP16	100	0.023 J	Yes	No	NC	NC		
		VP17	140	0.039 J	Yes	No	NC	NC		

Average	248,222	0.000288
Maximum	1,663,290	0.000664
Minimum	22,961	0.000024
DTSC Default	20	0.05
Updated DTSC Default	100	0.01
Proposed	**1000**	**0.001**

Proposed BSAF is ~23 times more conservative than the Minimum BSAF observed at NASNI

4. Results: Building Specific Attenuation Factors (BSAFs) at NASNI

Building	Building Average	
	Inverse BSAF	BSAF
94	843,125	9.54E-05
379	142,884	4.21E-04
36	26,180	5.20E-04
90	90,146	7.11E-05
341	71,775	2.44E-05
472	36,333	3.88E-04

- Buildings 94 and 379, which had the highest levels of TCE in subslab soil gas, showed the most attenuation (i.e., least conservative BSAFs)
- This suggests that if SSGs at any of the others buildings were to increase, there would likely not be a commensurate increase in IA levels

4. Results: Effect of Default AF vs. Proposed AF on Risk Management

Building No.	Highest TCE in SSG (µg/m³)	Building Area (ft²)
94	9,000,000	227,233
379	6,000,000	161,480
90	52,000	50,329
801	47,000	26,540
36	38,000	56,423
333	25,000	38,069
341	19,000	72,170
472	19,000	281,107
1	17,000	38,069
1482	2,600	72,000
1454	2,000	30,000
1472	1,200	34,000
2	1,000	45,800
334	680	24,325
743	350	6,600
397	350	20,000
744	240	8,300
3	150	25,205
4	120	36,900
33	110	5,339
65	74	58,260
6	20	8,647

- Default Inverse AF of 20 requires potential future action for sub-slab soil gas TCE of 176 µg/m^3
- Number of Buildings (out of 22) requiring potential future action with default AF = **17** (77% of study group)
- Proposed Inverse AF of 1,000 requires potential future action for sub-slab soil gas TCE of 8,800 µg/m^3
- Number of Buildings (out of 22) requiring potential future action with proposed AF = **9** (41% of study group)

4. Results: Comparison to Navy VI Framework (2015)

- Database includes 12 installations, 13 sites, and 49 buildings (the database did not include NASNI)
- Commercial/industrial buildings exhibit markedly different VI behavior than residential structures included in the USEPA residential database
- **The PCE and TCE data plots suggested the use of an attenuation factor of 0.001 for large military nonresidential buildings in the absence of atypical preferential pathways**

5. Conclusions

An inverse BSAF of 1000 (or a BSAF of 0.001) is justifiable for NASNI:

- BSAFs were evaluated for the six buildings where indoor air TCE levels were above detection limits; and where subslab soil gas concentrations were above 176 µg/m³ (conservative limit based on DTSC default inverse AF of 20 and IASL of 8.8 µg/m³). The BSAFs were found to be significantly less conservative than DTSC's default AF of 0.05

- The average inverse BSAF for the 6 buildings was 248,222 while the minimum was 22,961 – our proposed BSAF has a Factor of Safety of almost 23 vs. the minimum

- Consistent with AF proposed in Navy's 2015 VI Framework