Assessing Variability in Petroleum Vapor Intrusion with PVIScreen

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(US EPA, retired)

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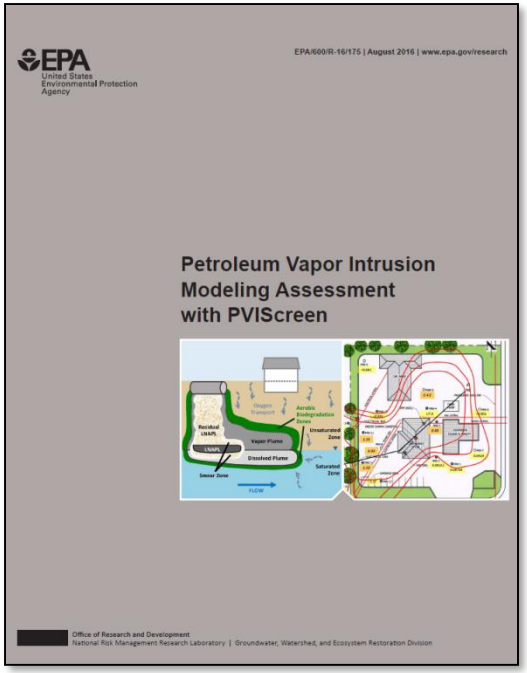
Louisville, KY
Sept 13, 2018

Outline

- Characteristics of Environmental Models
- Vapor Intrusion and Petroleum Vapor Intrusion
- PVIScreen model
- Excerpts from examples
  - PVI indicated versus not indicated
- Secrets of PVIScreen
- Summary
- Availability

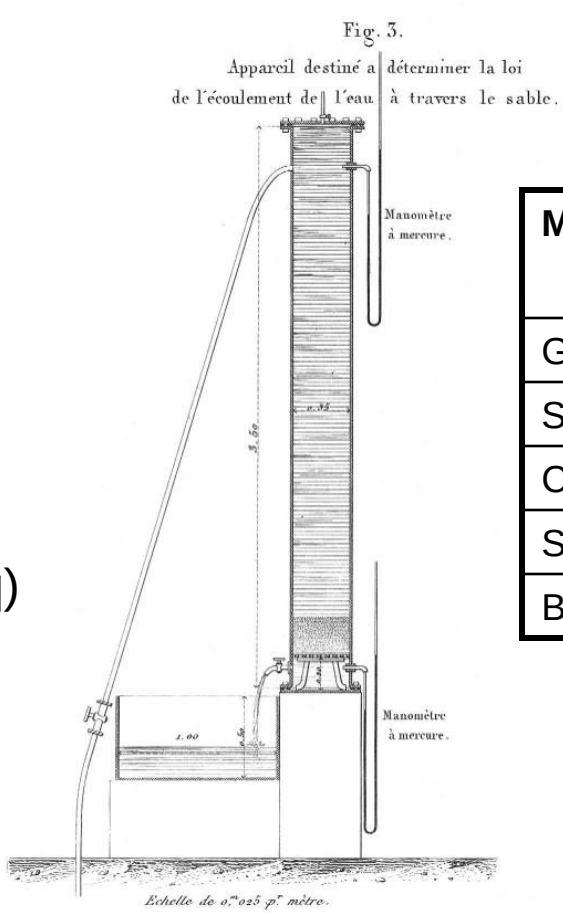


Vapor Intrusion and Models

- Series of articles in the Denver Post in 2000
  - The vapor intrusion model (Johnson-Ettinger) over-predicted indoor air concentrations sometimes and under-predicted indoor air concentrations sometimes
  - Model used with “defaults” and very few site specific values

Limits to Predictibility: Darcy's Law

- Darcy flux q = -K dh/dl
  - Relationship from Darcy's sand tank experiments
  - Empirical coefficient, the hydraulic conductivity (K), from experiment: measuring the flow (q)



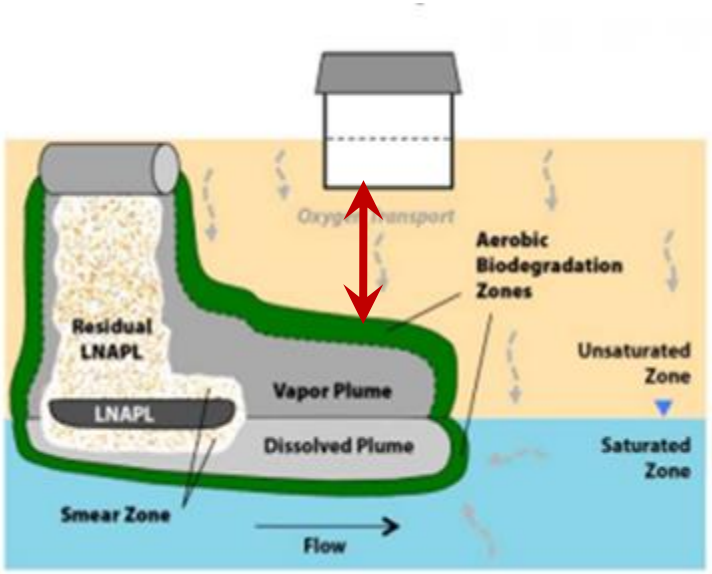
Material	Value (m/d)
Gravel	10^{2} to 10^{4}
Sand	10^{-1} to 10^{3}
Clay	10^{-8} to 10^{-3}
Sandstone	10^{-5} to 10
Basalt	10^{-6} to 10^{-2}

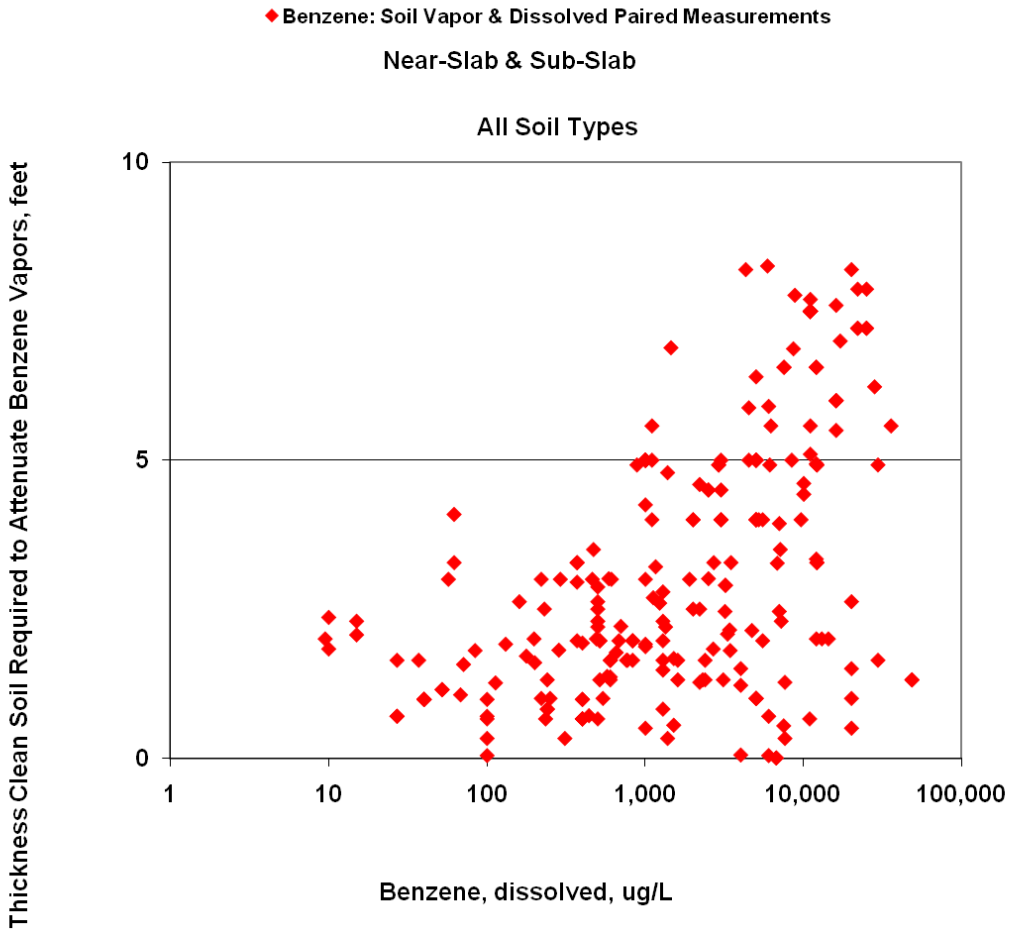
Limits to Predictability

- Note the work of N. Oreskes on ideal applications for models:
  - Weather forecasting
    - Forecast *given* and *received* with uncertainties

- Oreskes, Naomi, 2003, The role of quantitative models in science, in Models in Ecosystem Science, C.D. Canham and W.K. Lauenroth, eds. Princeton University Press, 13-31

PVIScreen rests on a foundation of field data:





Robin V. Davis, 2009, Update on Recent Studies and Proposed Screening Criteria for the Vapor-Intrusion Pathway, LUSTLine Bulletin 61, pp 11-14.

Petroleum Vapor Intrusion and biodegradation:

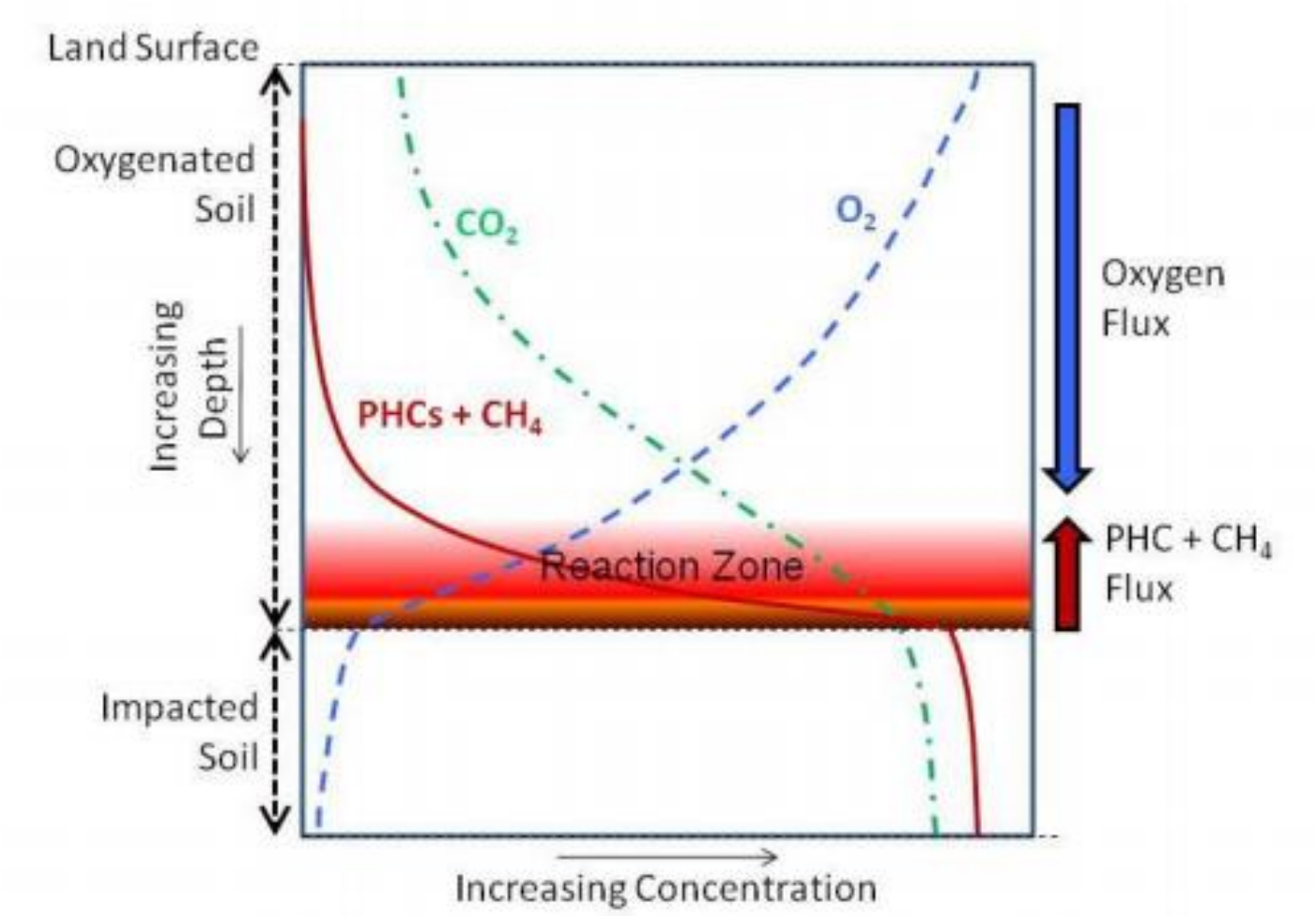
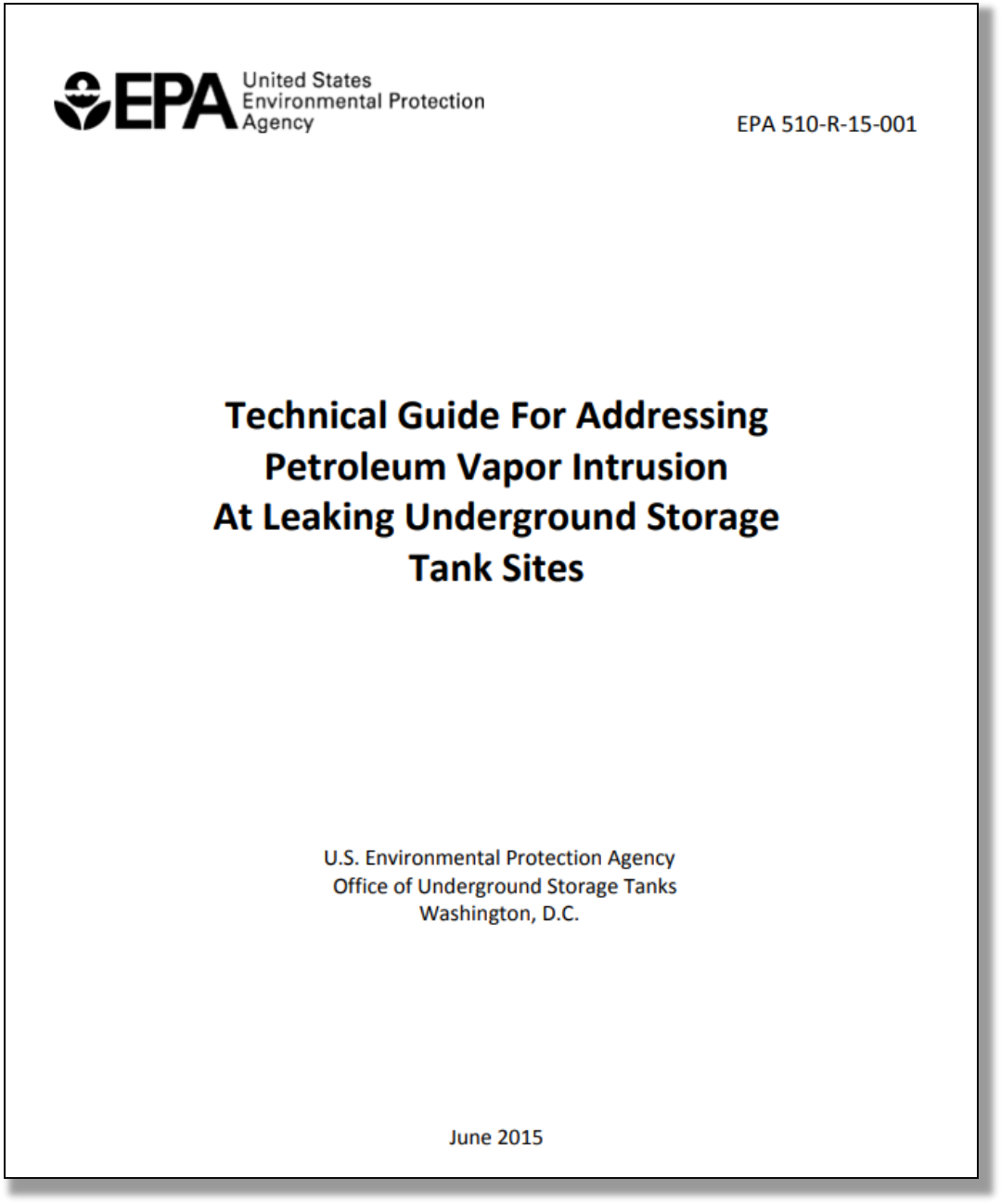


Table 3. Recommended Vertical Separation Distance Between Contamination And Building Basement Floor, Foundation, Or Crawlspace Surface.

Media	Benzene	TPH	Vertical Separation Distance (feet)*
Soil (mg/Kg)	≤10	≤ 100 (unweathered gasoline), or ≤ 250 (weathered gasoline, diesel)	6
	>10 (LNAPL)	> 100 (unweathered gasoline) >250 (weathered gasoline, diesel)	15
Groundwater (mg/L)	≤5	≤30	6
	>5 (LNAPL)	>30 (LNAPL)	15

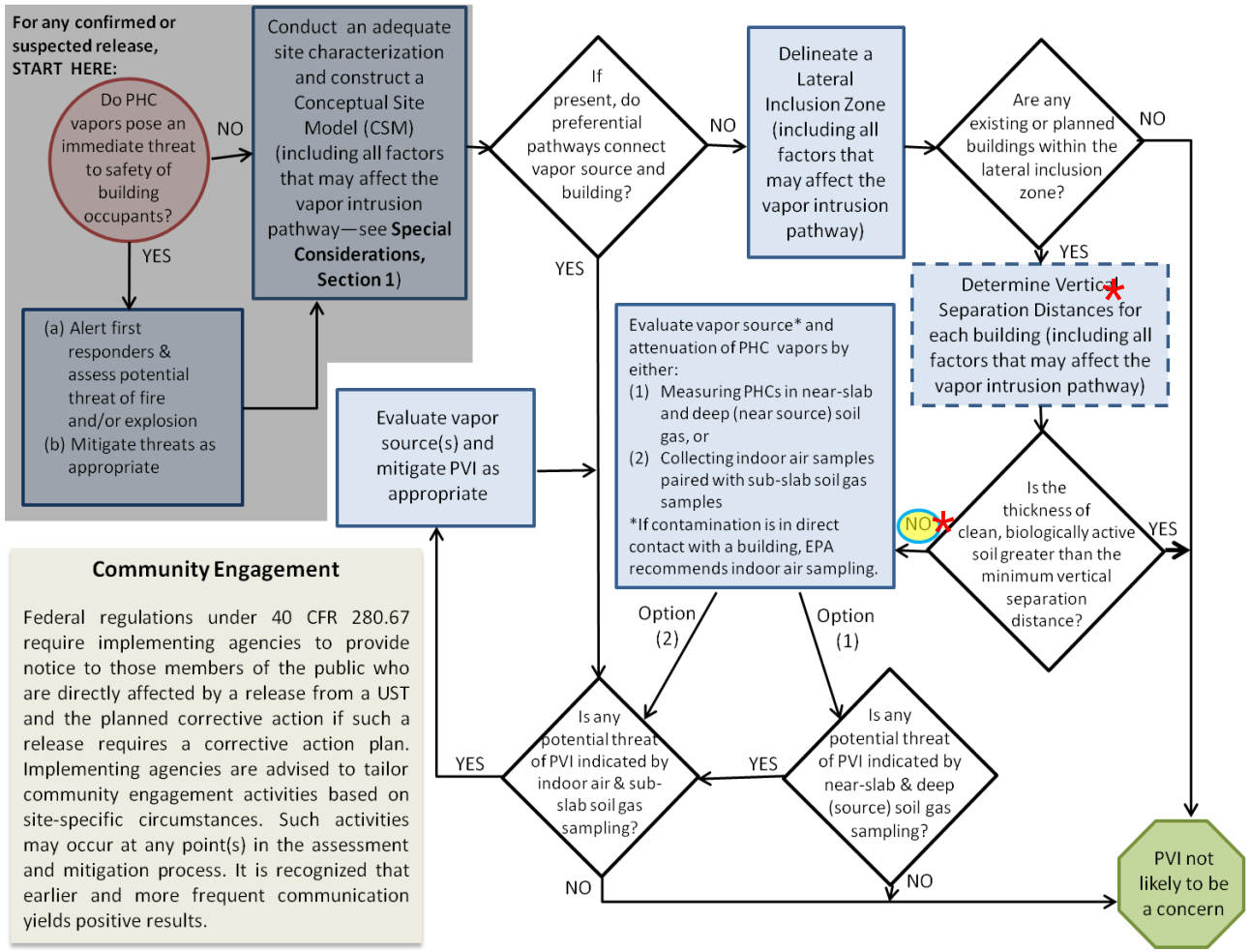
Consider PVIScreen usage in marginal cases as a second line of evidence


EPA United States Environmental Protection Agency
EPA 510-R-15-001
Technical Guide For Addressing Petroleum Vapor Intrusion At Leaking Underground Storage Tank Sites
U.S. Environmental Protection Agency
Office of Underground Storage Tanks
Washington, D.C.
June 2015

Site assessment flow chart from OUST guide on PVI

Model Use:

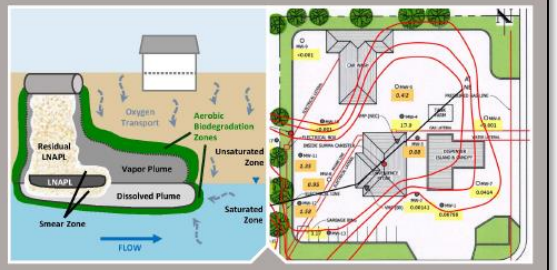
- NOT without mitigating immediate threats
- NOT without site characterization
- As a line of evidence for related to determination of vertical separation distance*



EPA
United States
Environmental Protection
Agency

EPA/600/R-16/175 | August 2016 | www.epa.gov/research

Petroleum Vapor Intrusion Modeling Assessment with PVIScreen



Office of Research and Development
National Risk Management Research Laboratory | Groundwater, Watershed, and Ecosystem Restoration Division

EPA/600/R-16/175
August 2016

Petroleum Vapor Intrusion Modeling Assessment with PVIScreen

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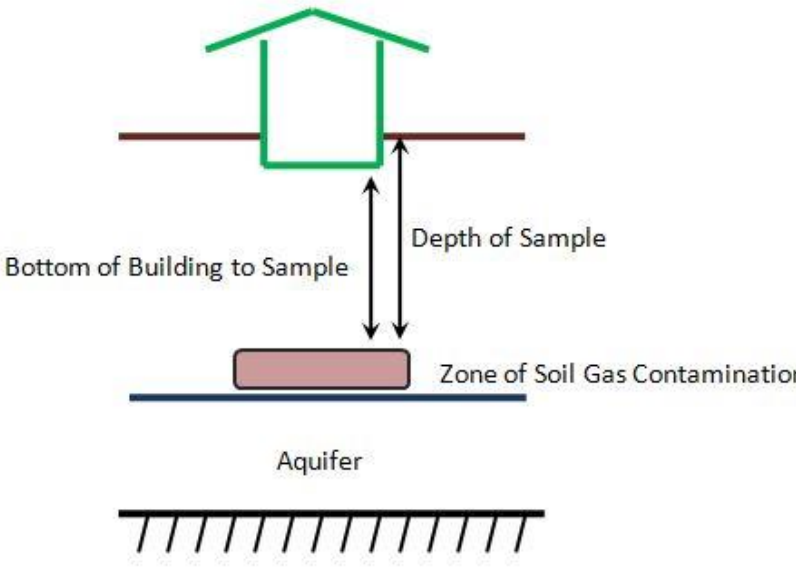
National Risk Management Research Laboratory | Groundwater, Watershed, and Ecosystem Restoration Division

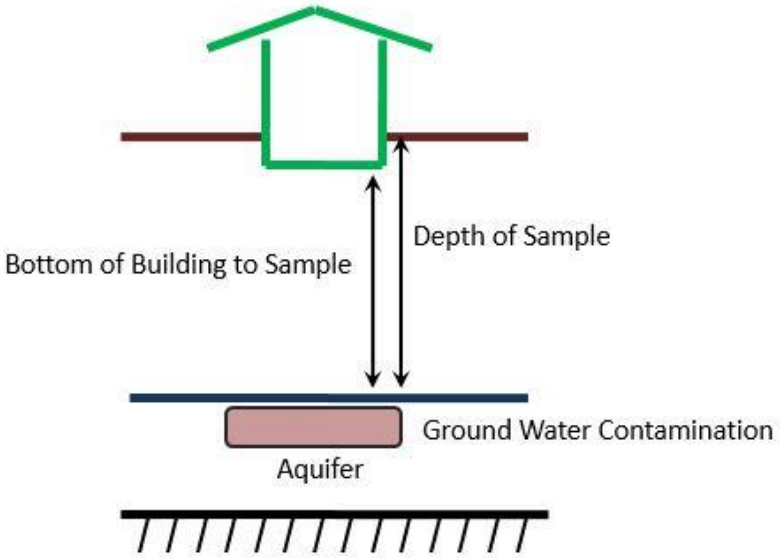
http://www.epa.gov/land-research/pviscreen

PVIScreen

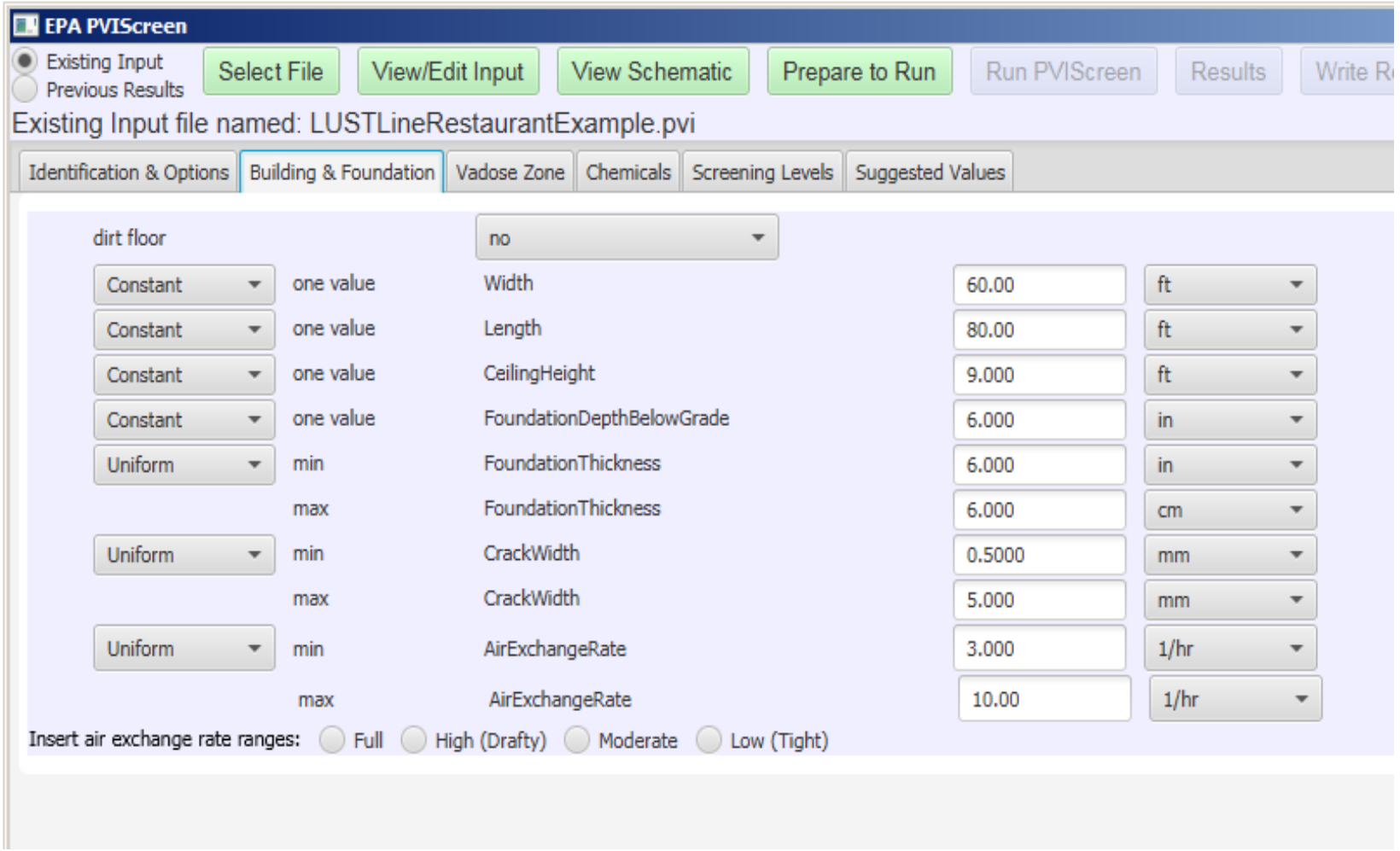
- PVIScreen includes:
  - BioVapor equations, recoded in Java for speed
  - Automated Monte Carlo uncertainty analysis
    - the native way the code is used
  - Soil gas or ground water source
  - Comparison to screening levels
  - Flexible and customizable unit choices
  - Automated Report
- Primary focus:
  - To add line of evidence for site assessment and closure decisions
  - To make uncertainty analysis practical by giving a prediction and estimate of its uncertainty

PVIScreen Sources: Soil Gas or GW Data



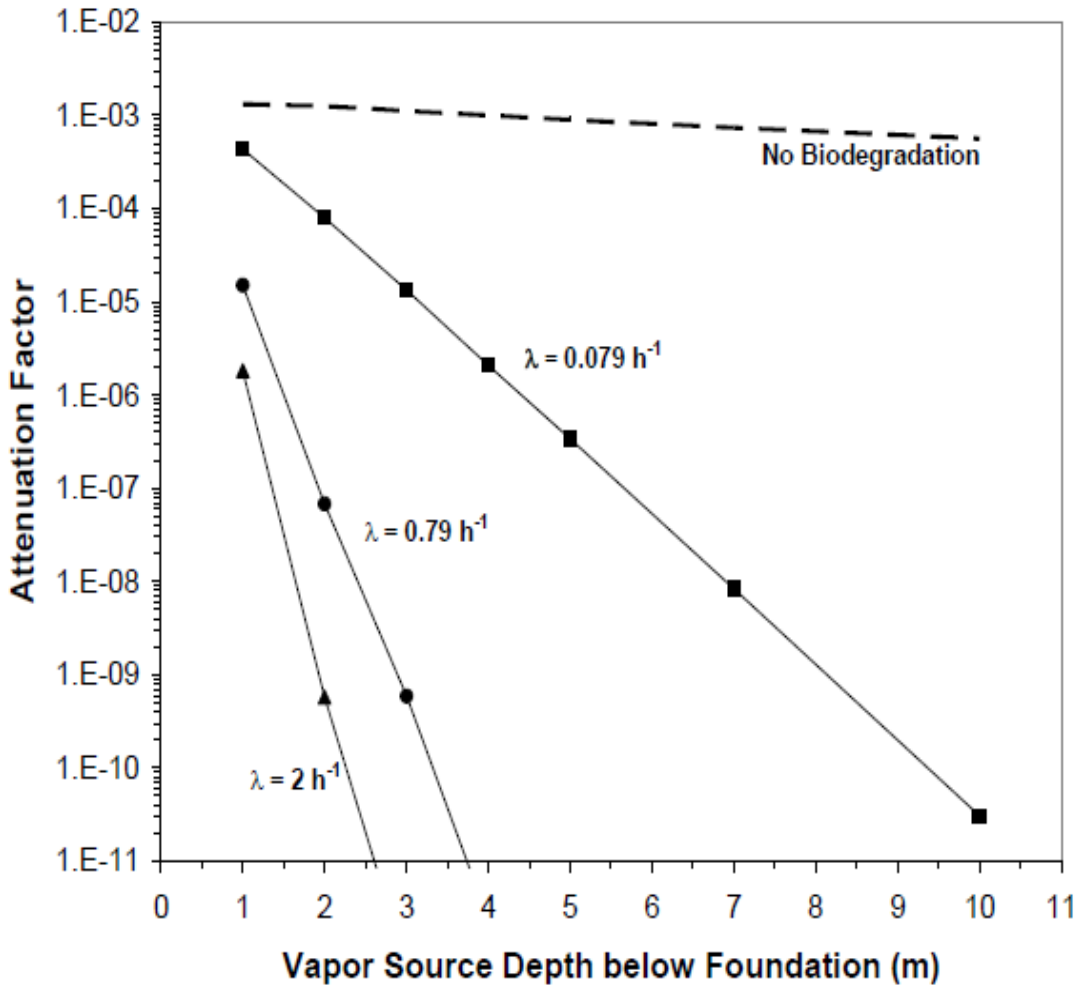


Example inputs: constants or ranges



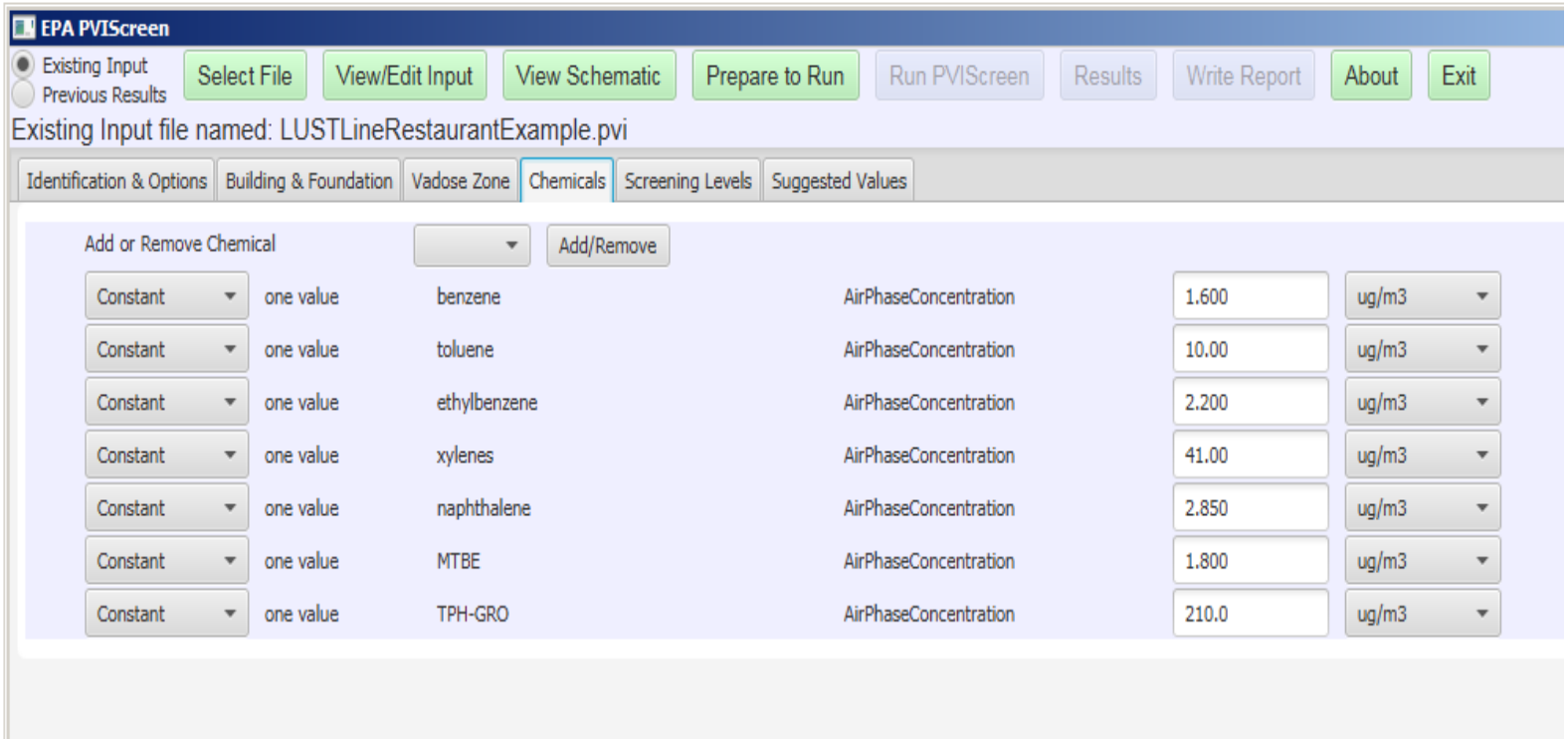
Factors controlling biodegradation are uncertain, variable

- Hydrocarbon degradation rates vary by factor of 100
- How does this impact PVI?

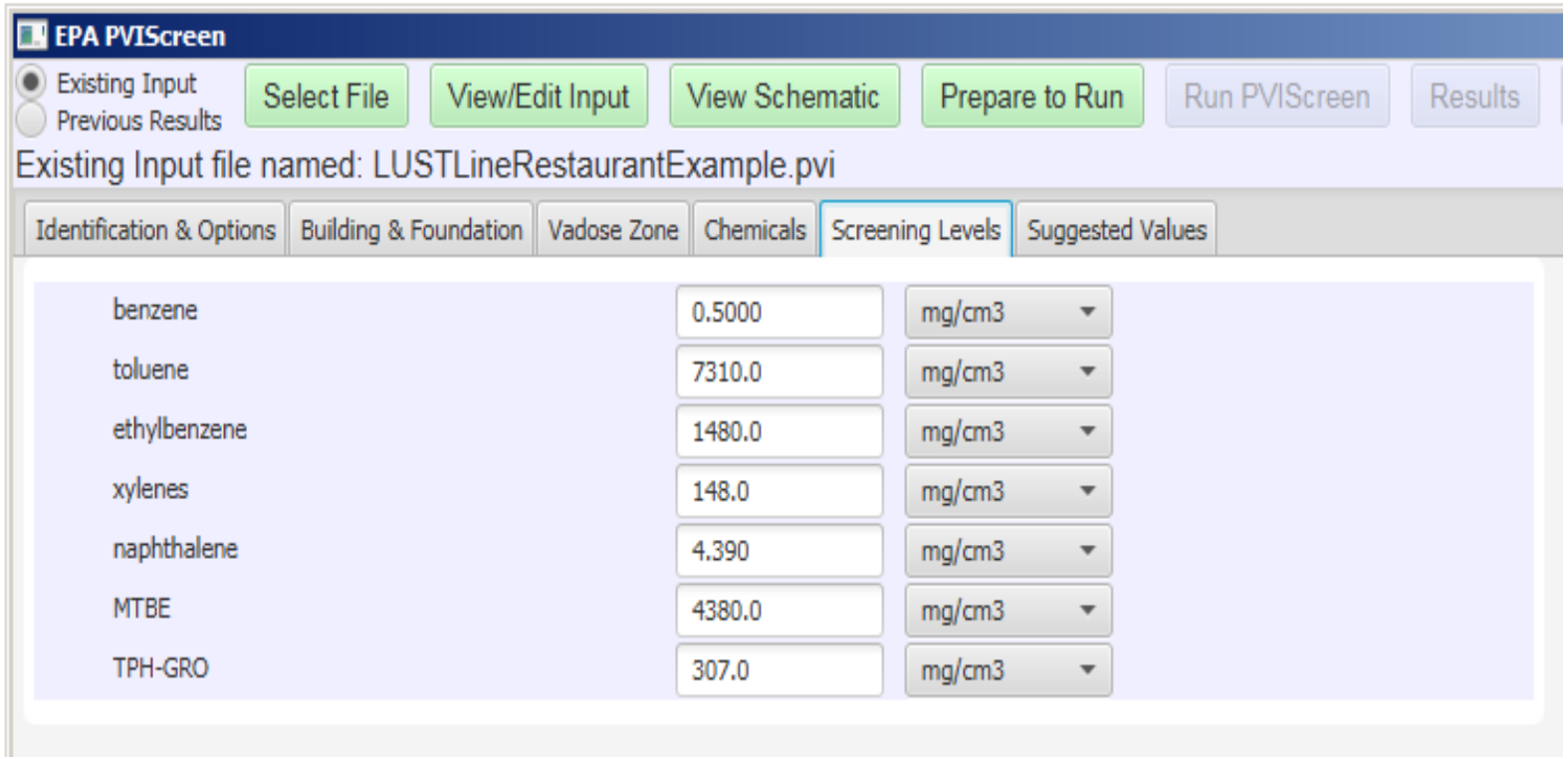


Inputs of multiple constituents

- all oxygen should NOT go to degrade only benzene,
- Include TPH or petroleum fractions



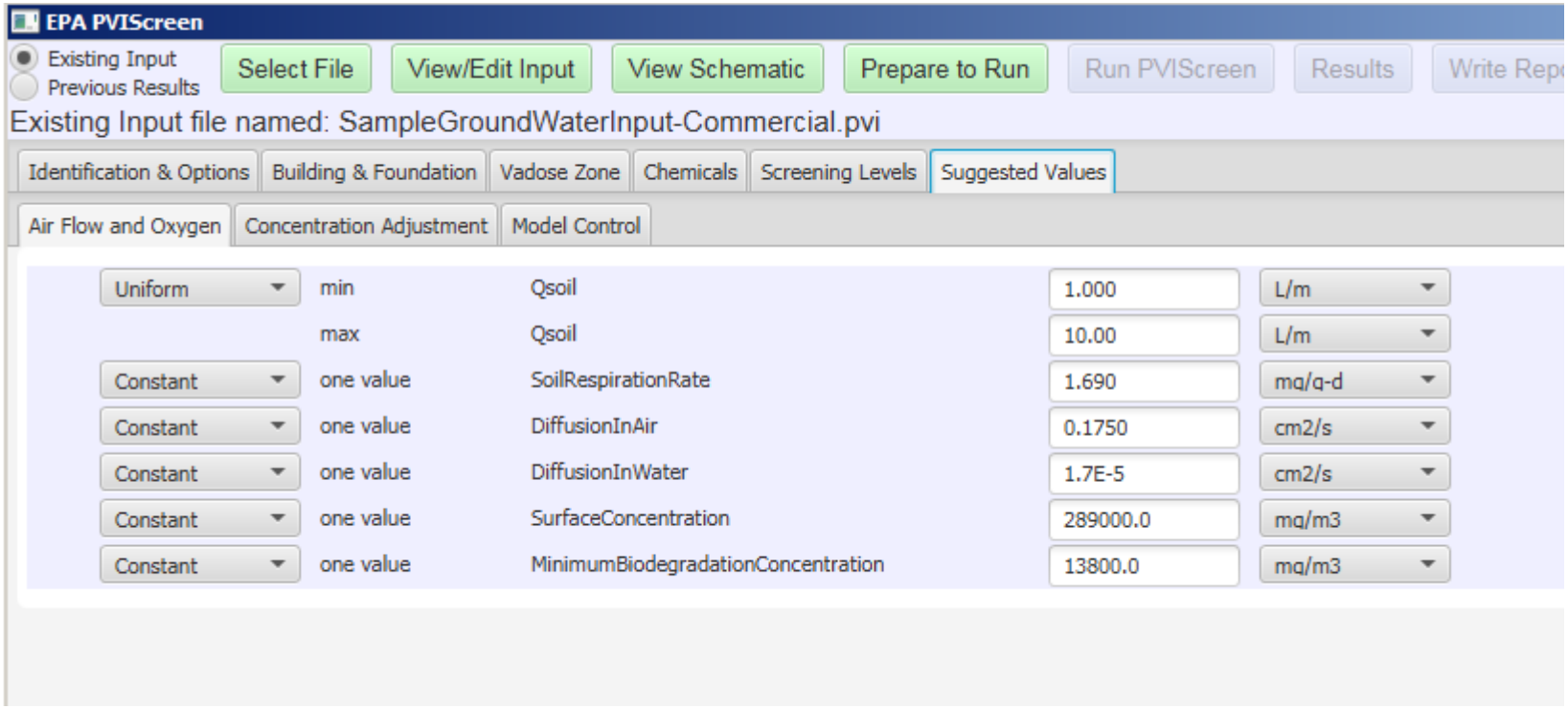
Input of Screening Levels:

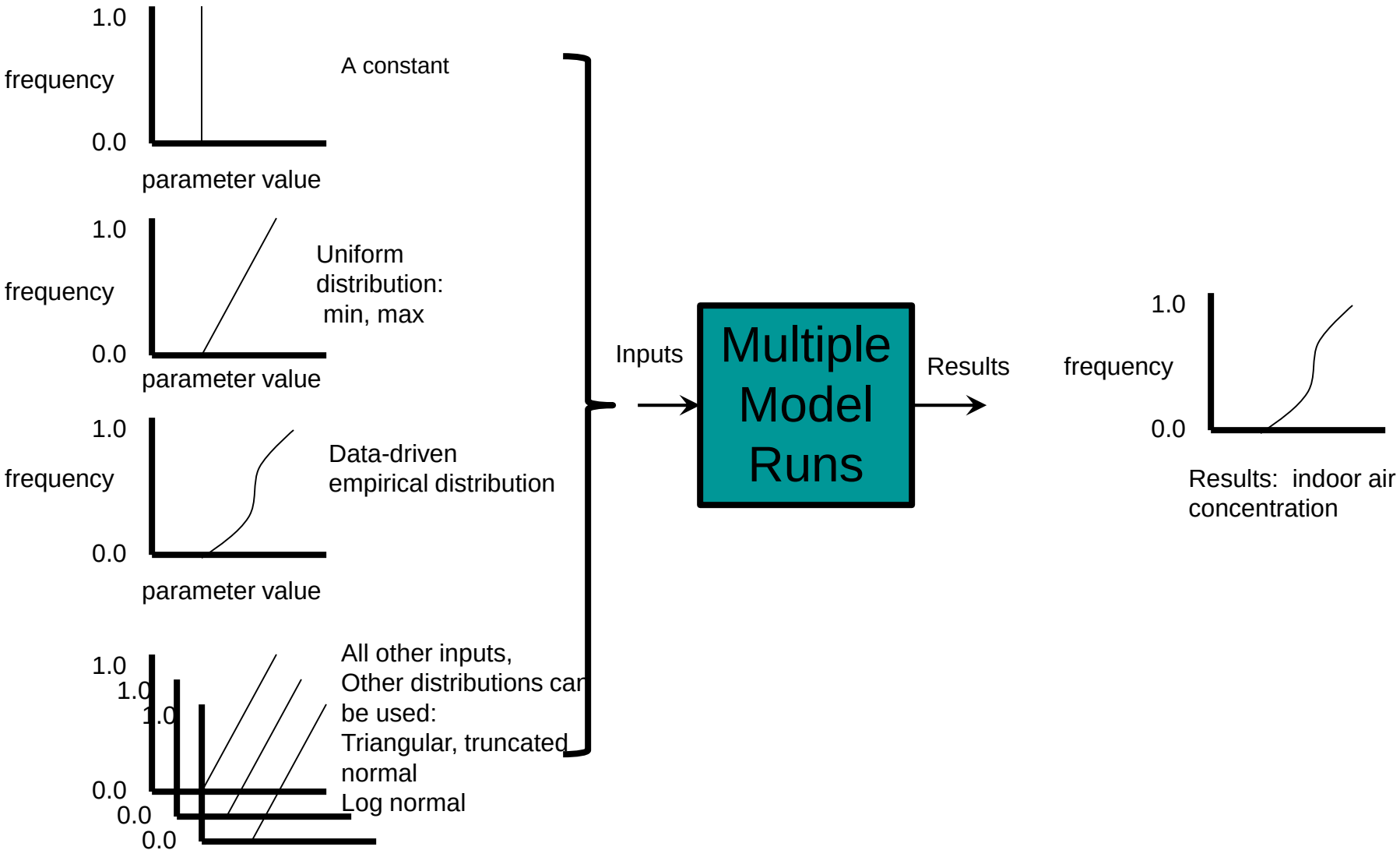


State-specific or EPA RSL

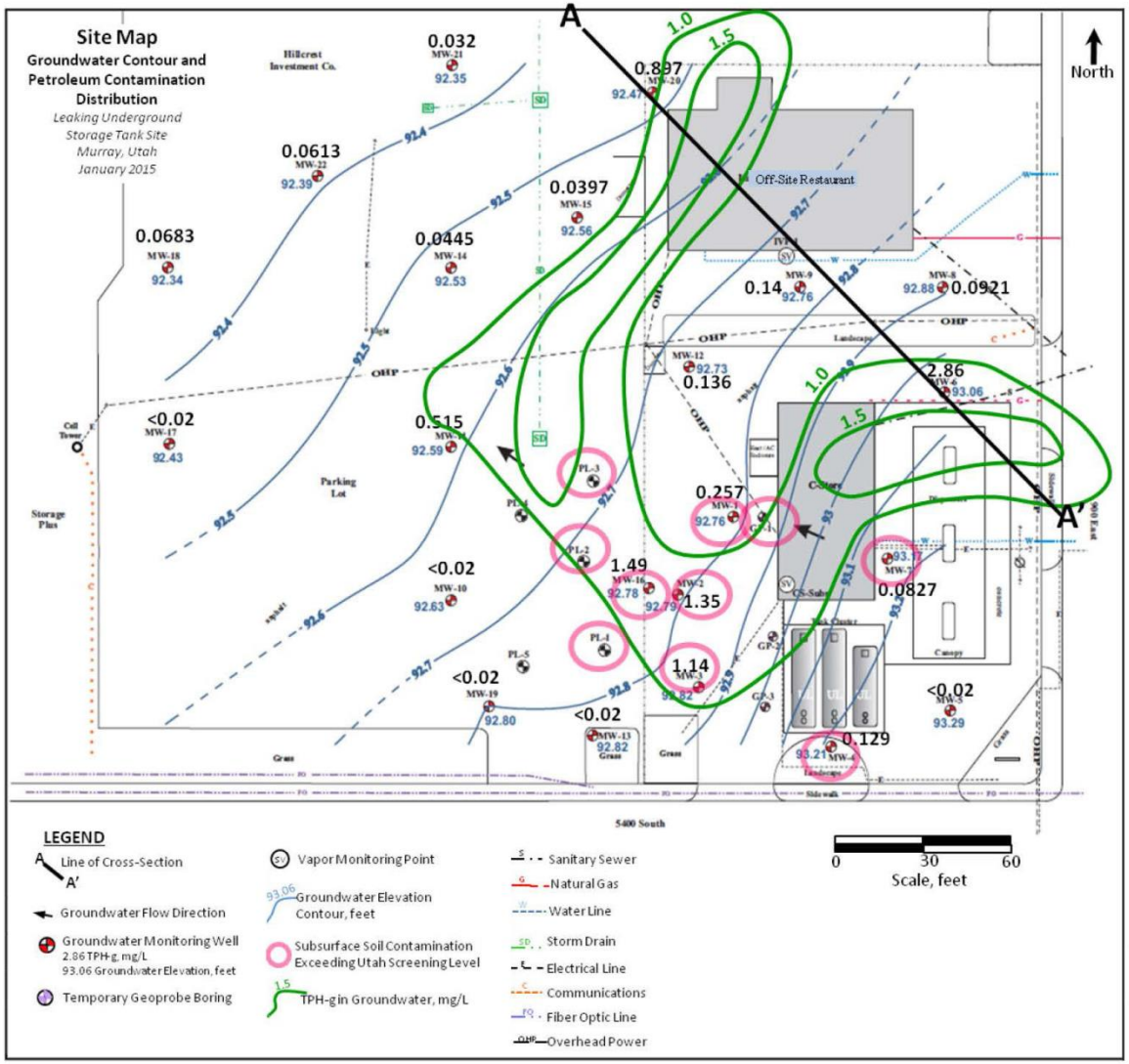
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

Suggested Values

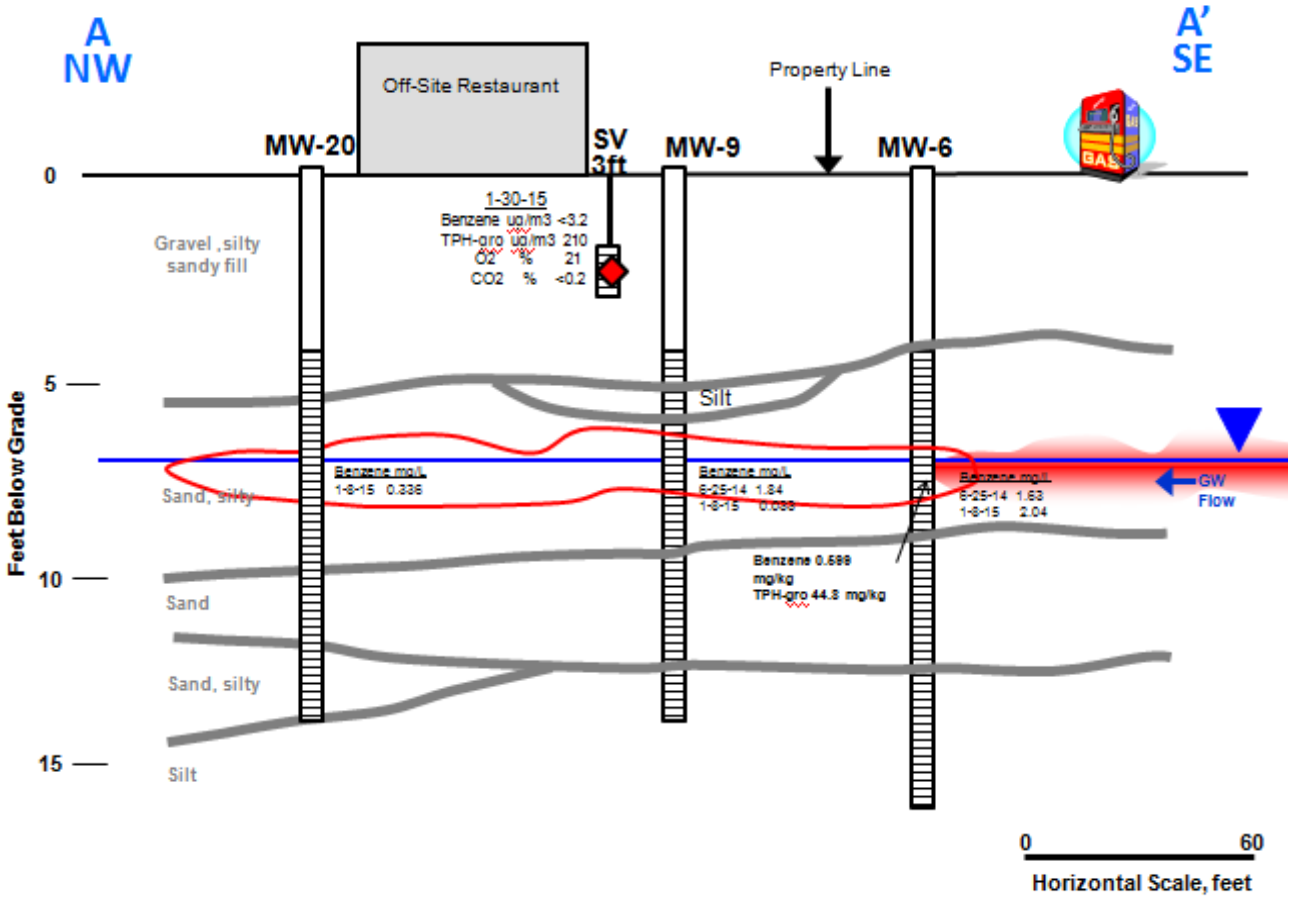


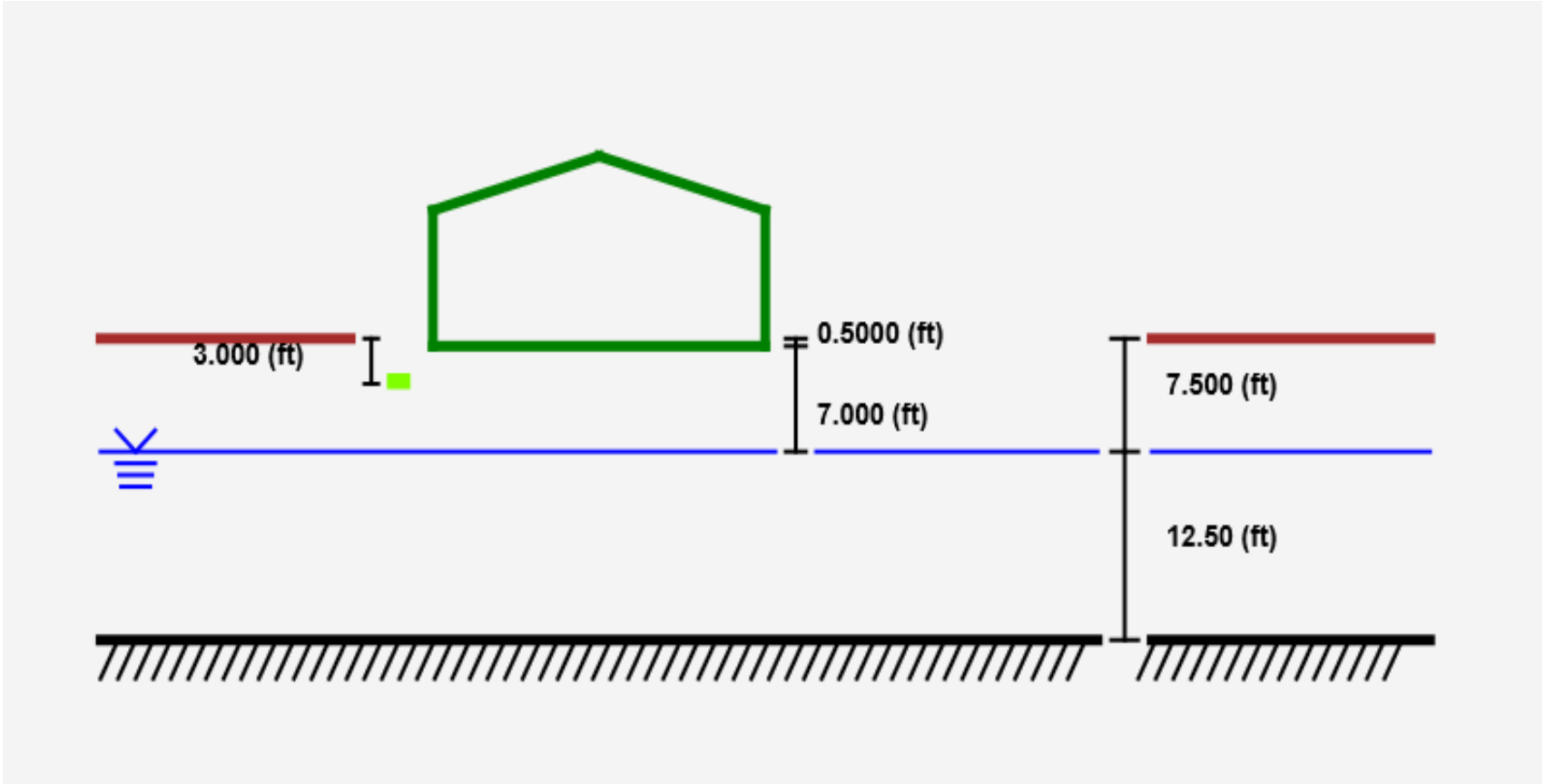

1.0
frequency
0.0
parameter value
A constant
1.0
frequency
0.0
parameter value
Uniform distribution: min, max
1.0
frequency
0.0
parameter value
Data-driven empirical distribution
1.0
1.0
1.0
0.0
0.0
0.0
All other inputs, Other distributions can be used: Triangular, truncated normal Log normal
Inputs
Multiple Model Runs
Results
1.0
frequency
0.0
Results: indoor air concentration

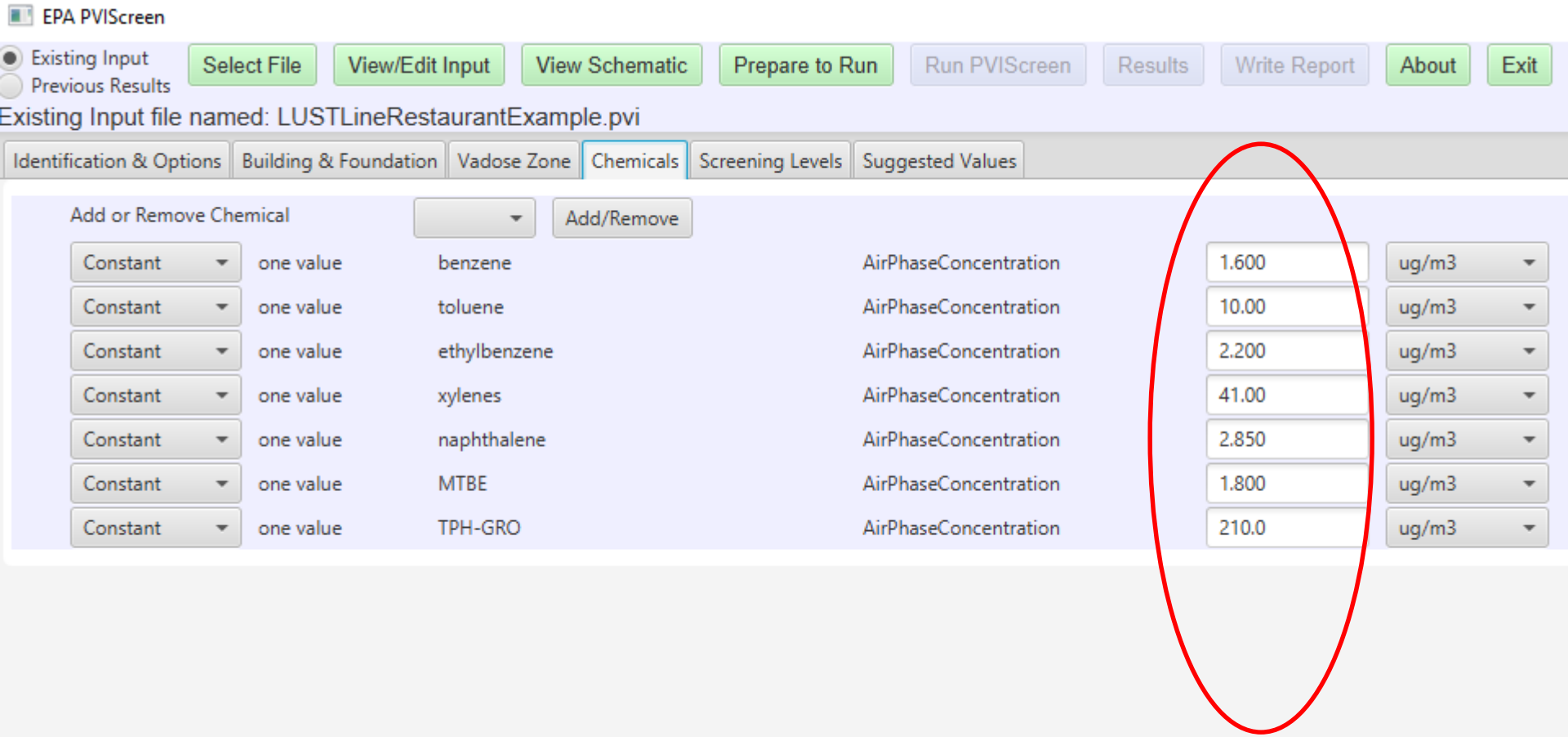
Soil gas input data example from a site in Utah:



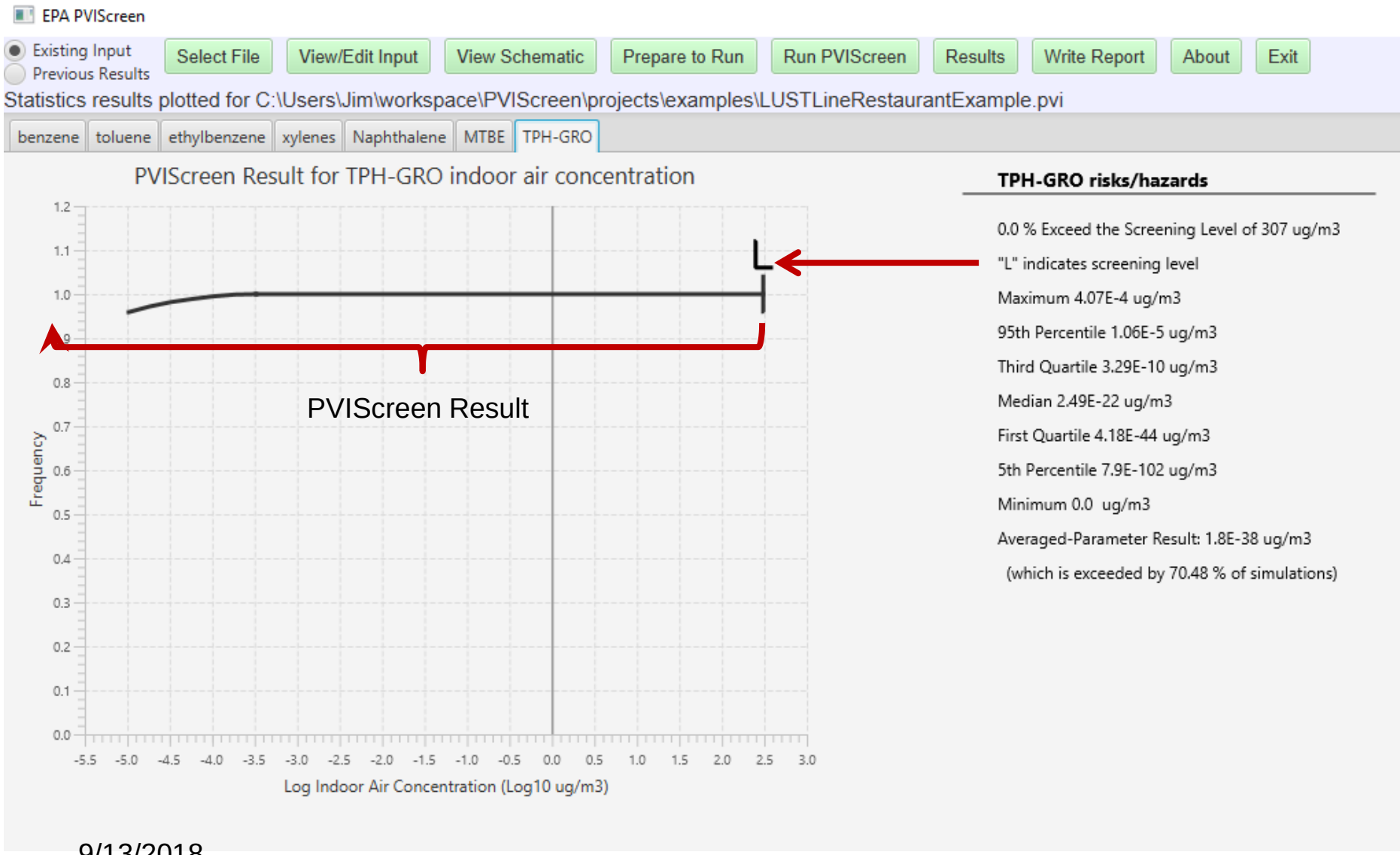
Impacts to Off-Site Restaurant? PVIScreen 'driven' by soil gas data at 3' below the surface



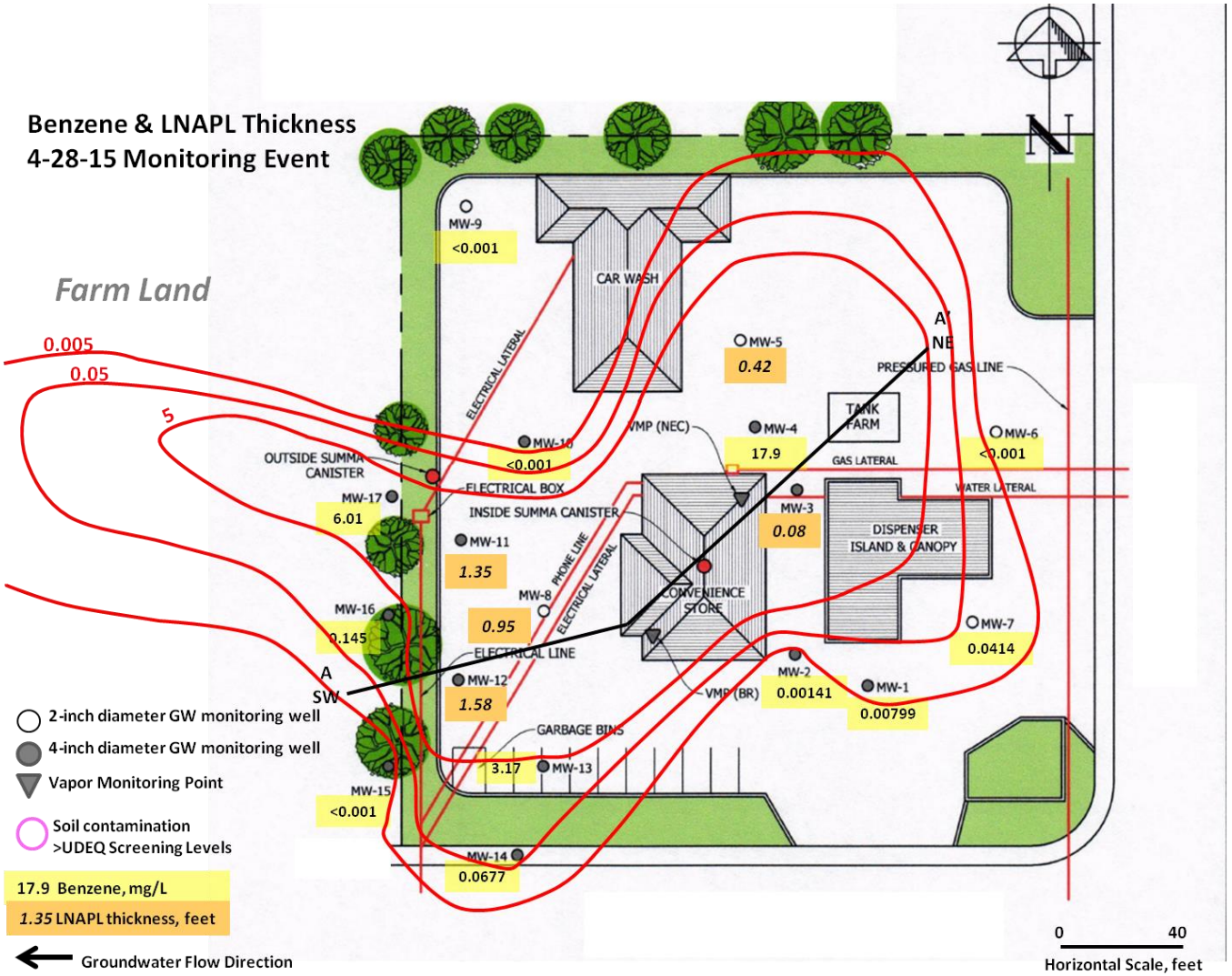

3.000 (ft)
0.5000 (ft)
7.000 (ft)
7.500 (ft)
12.50 (ft)

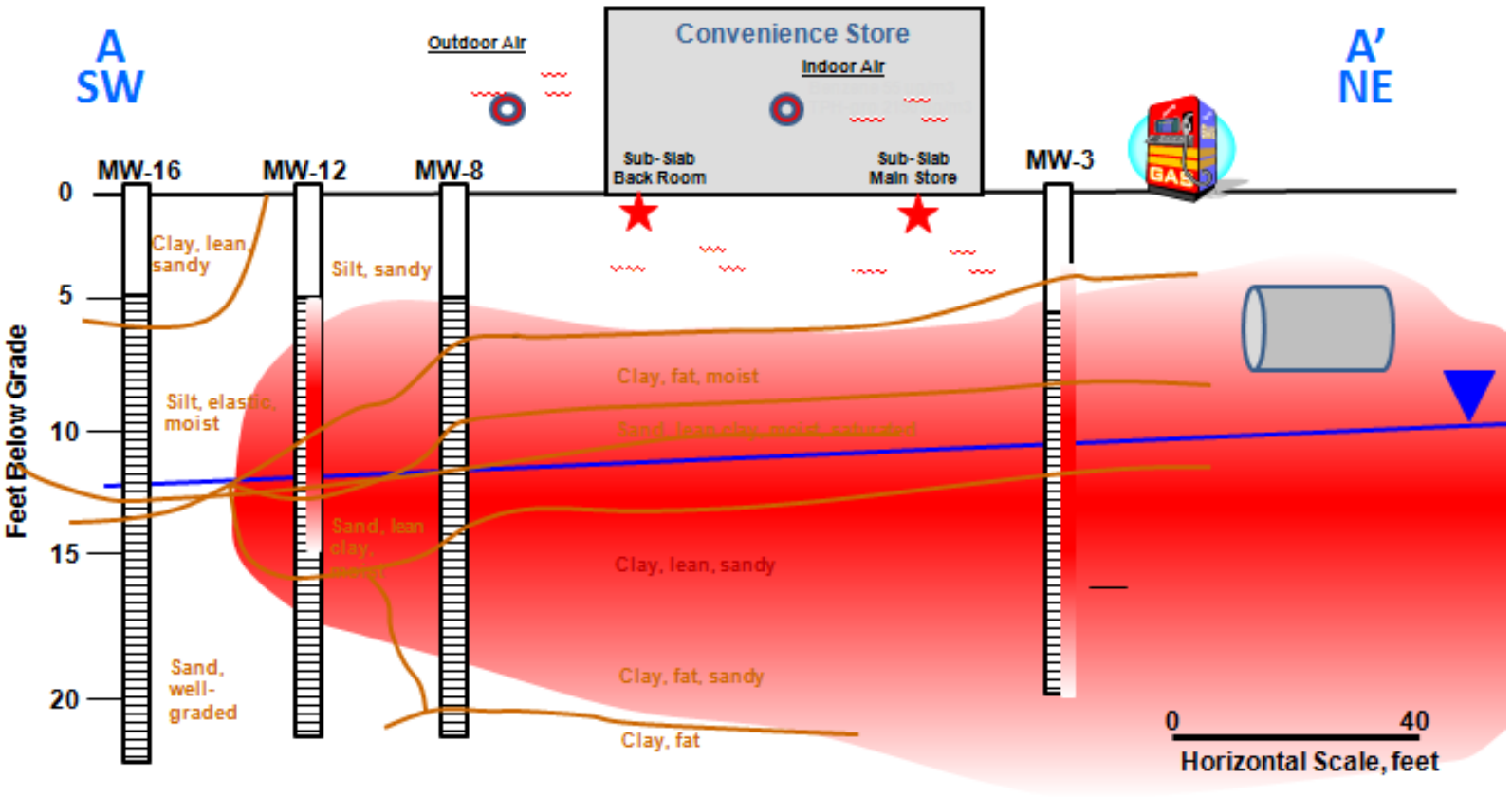

EPA PVIScreen
Existing Input
Previous Results
Select File
View/Edit Input
View Schematic
Prepare to Run
Run PVIScreen
Results
Write Report
About
Exit
Existing Input file named: LUSTLineRestaurantExample.pvi
Identification & Options
Building & Foundation
Vadose Zone
Chemicals
Screening Levels
Suggested Values
Add or Remove Chemical
Add/Remove
Constant one value benzene AirPhaseConcentration 1.600 ug/m3
Constant one value toluene AirPhaseConcentration 10.00 ug/m3
Constant one value ethylbenzene AirPhaseConcentration 2.200 ug/m3
Constant one value xylenes AirPhaseConcentration 41.00 ug/m3
Constant one value naphthalene AirPhaseConcentration 2.850 ug/m3
Constant one value MTBE AirPhaseConcentration 1.800 ug/m3
Constant one value TPH-GRO AirPhaseConcentration 210.0 ug/m3

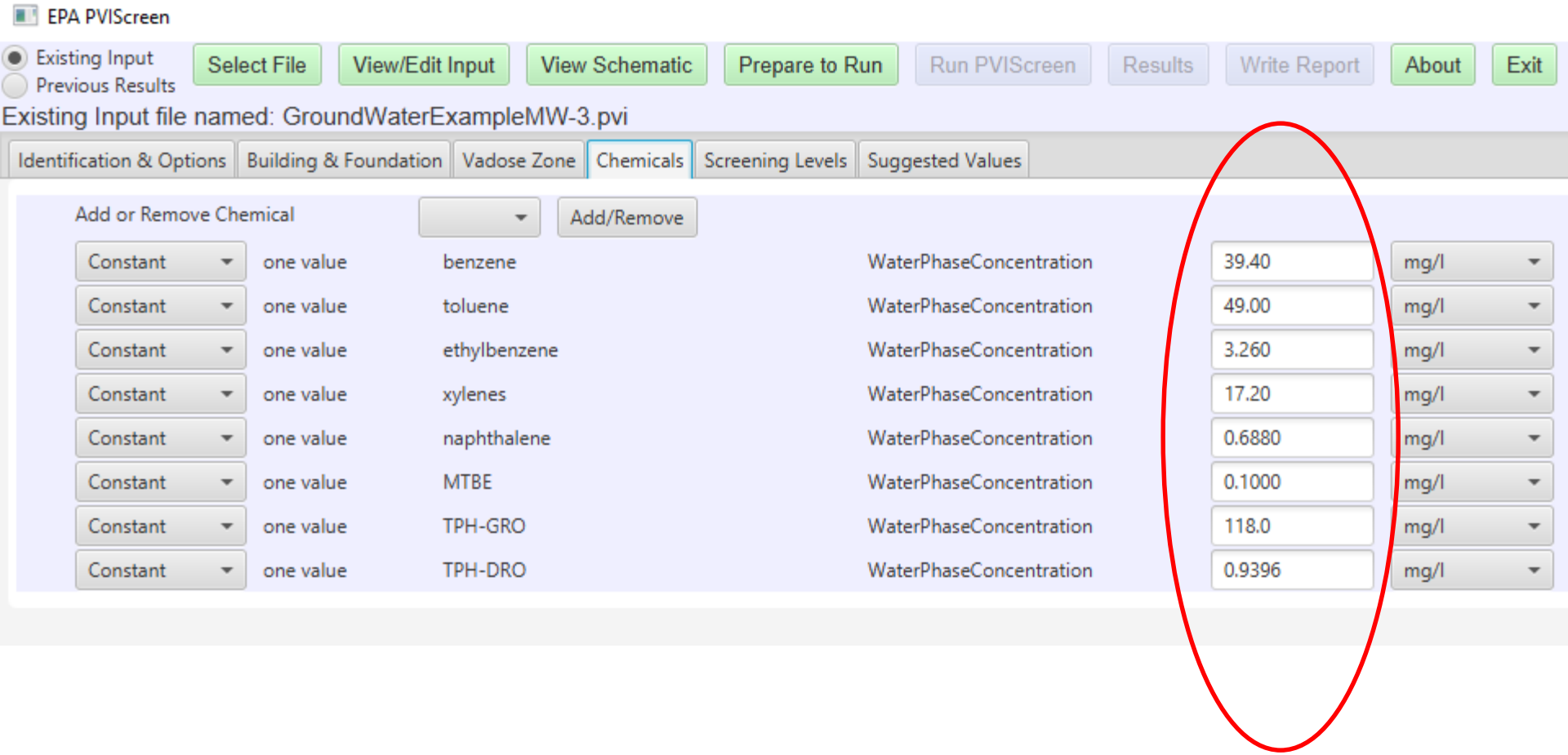
Results: PVIScreen model runs indicate no impact



Example with impact indicated:




A
SW
A'
NE
Outdoor Air
Convenience Store
Indoor Air
Sub-Slab
Back Room
Sub-Slab
Main Store
MW-16
MW-12
MW-8
MW-3
GAS
0
5
10
15
20
Feet Below Grade
Clay, lean, sandy
Silt, sandy
Silt, elastic, moist
Clay, fat, moist
Sand, lean clay, moist, saturated
Sand, lean clay,
Clay, lean, sandy
Sand, well-graded
Clay, fat, sandy
Clay, fat
0
40
Horizontal Scale, feet


EPA PVIScreen
Existing Input
Previous Results
Select File
View/Edit Input
View Schematic
Prepare to Run
Run PVIScreen
Results
Write Report
About
Exit
Existing Input file named: GroundWaterExampleMW-3.pvi
Identification & Options
Building & Foundation
Vadose Zone
Chemicals
Screening Levels
Suggested Values
Add or Remove Chemical
Add/Remove
Constant one value benzene WaterPhaseConcentration 39.40 mg/l
Constant one value toluene WaterPhaseConcentration 49.00 mg/l
Constant one value ethylbenzene WaterPhaseConcentration 3.260 mg/l
Constant one value xylenes WaterPhaseConcentration 17.20 mg/l
Constant one value naphthalene WaterPhaseConcentration 0.6880 mg/l
Constant one value MTBE WaterPhaseConcentration 0.1000 mg/l
Constant one value TPH-GRO WaterPhaseConcentration 118.0 mg/l
Constant one value TPH-DRO WaterPhaseConcentration 0.9396 mg/l

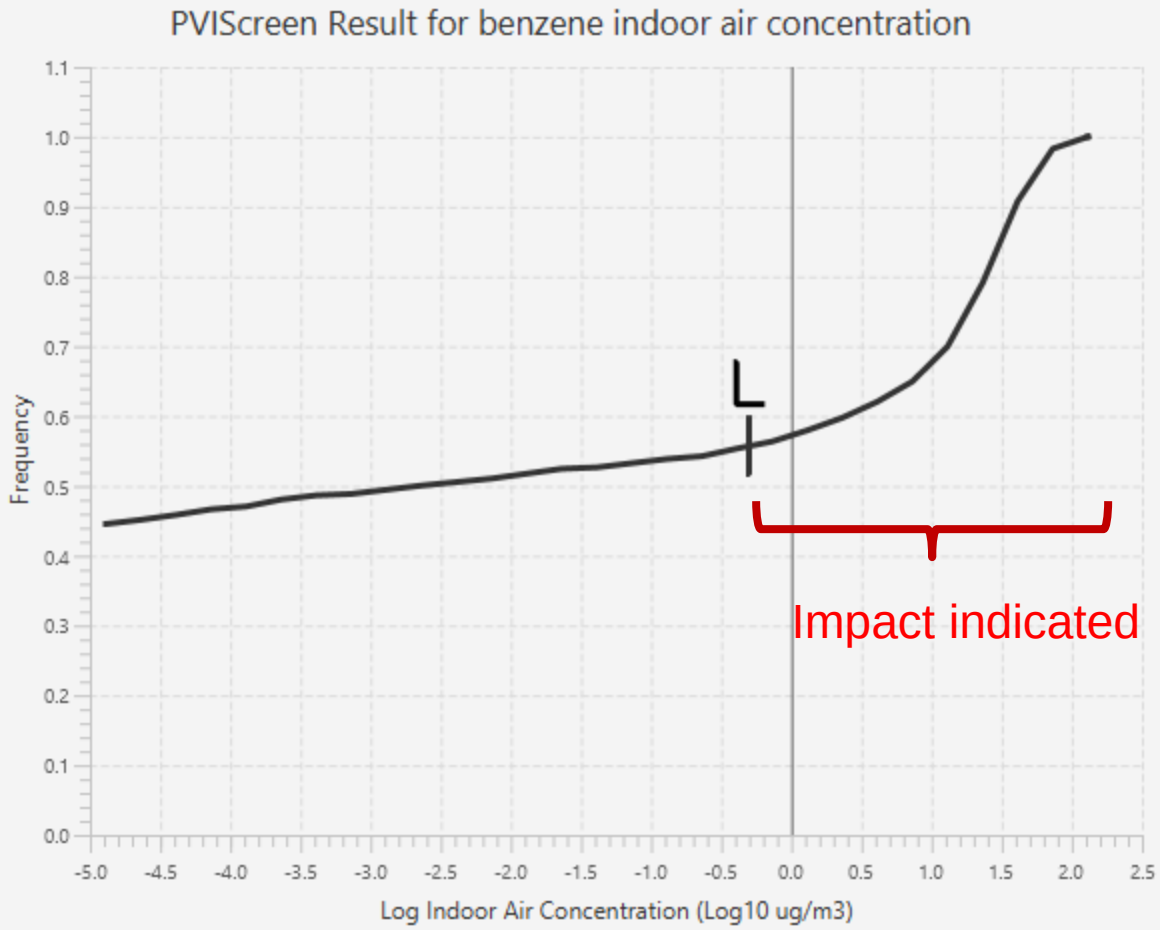
EPA PVIScreen

Existing Input
Previous Results

Select File | View/Edit Input | View Schematic | Prepare to Run | Run PVIScreen | Results | Write Report | About | Exit

Statistics results plotted for C:\Users\Jim\workspace\PVIScreen\projects\examples\GroundWaterExampleMW-3.pvi

benzene | toluene | ethylbenzene | xylenes | Naphthalene | MTBE | TPH-GRO | TPH-DRO



benzene risks/hazards

44.3% Exceed the Screening Level of 0.5 ug/m

"L" indicates screening level

Maximum 163.32 ug/m3

95th Percentile 68.57 ug/m3

Third Quartile 25.11 ug/m3

Median 2.77E-3 ug/m3

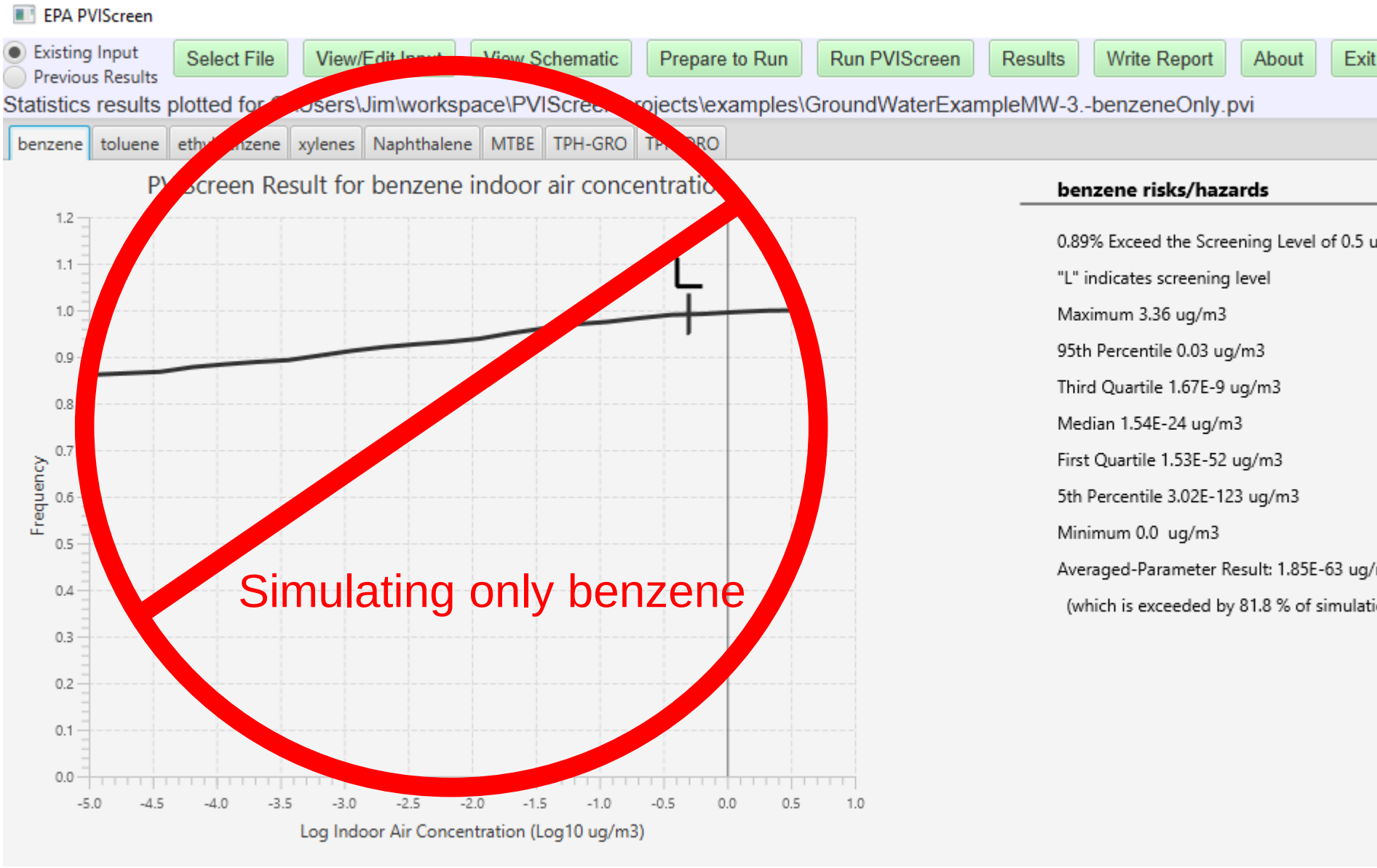
First Quartile 3.25E-20 ug/m3

5th Percentile 4.95E-89 ug/m3

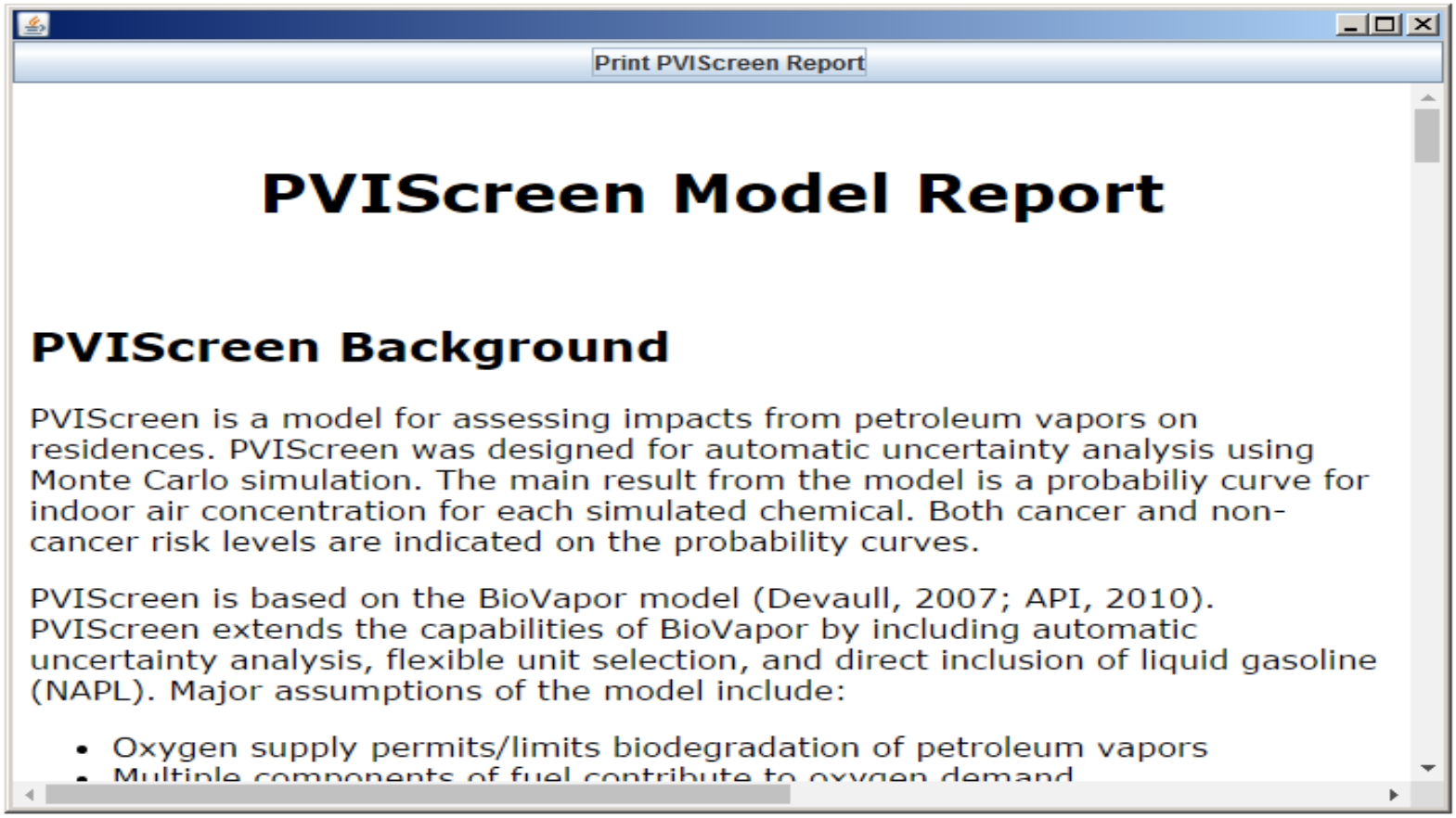
Minimum 0.0 ug/m3

Averaged-Parameter Result: 1.15E-10 ug/m3

(which is exceeded by 64.93 % of simulation


EPA PVIScreen
Existing Input
Previous Results
Select File
View/Edit Input
View Schematic
Prepare to Run
Run PVIScreen
Results
Write Report
About
Exit
Statistics results plotted for C:\Users\Jim\workspace\PVIScreen Projects\examples\GroundWaterExampleMW-3.-benzeneOnly.pvi
benzene
toluene
ethylbenzene
xylenes
Naphthalene
MTBE
TPH-GRO
TPH-DRO
PVIScreen Result for benzene indoor air concentration
Frequency
Log Indoor Air Concentration (Log10 ug/m3)
Simulating only benzene
benzene risks/hazards
0.89% Exceed the Screening Level of 0.5 u
"L" indicates screening level
Maximum 3.36 ug/m3
95th Percentile 0.03 ug/m3
Third Quartile 1.67E-9 ug/m3
Median 1.54E-24 ug/m3
First Quartile 1.53E-52 ug/m3
5th Percentile 3.02E-123 ug/m3
Minimum 0.0 ug/m3
Averaged-Parameter Result: 1.85E-63 ug/
(which is exceeded by 81.8 % of simulati

Automated Report:



+ Full results in spreadsheet files

…Secrets of PVIScreen…

- Use the correct template to begin.
- Concentrations needed to drive model.
- Biodegradation is always treated as being uncertain.
- When an impact is shown…
  - ~~Because of randomness, % will very with each simulation~~
  - If result has marginal exceedances (say <5%) consider refining ranges of parameters.
- DON'T only simulate benzene or BTEX.
  - you will probably not see an impact, because the whole hydrocarbon loading (TPH) needs to be included.

Summary

- Immediate threats must be handled first.
- Site characterization and development of a Conceptual Site Model next.
- Model use (including PVIScreen) should be embedded with site assessment.
- PVIScreen incorporates parameter. uncertainty into PVI modeling.
- Results can add a line of evidence to an assessment.

Available at http://www.epa.gov/land-research/pviscreen

(look for updated copy from Sept 2018)

Recorded webinar from Monday on NEIWPCC Tanks Conference web site

- EPA Contact: kremer.fran@epa.gov
- *The views expressed in this presentation are those of the author and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency*