APPENDIX N

Calculation of SVC Roll Using Post Volume Exchange and Post Gas Volume

www.usace.army.mil/inet/usace-docs/eng-manuals/em.htm

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	Engineering and Design SOIL VAPOR EXTRACTION AND BIOVENTING	
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(7) Because single well systems generally involve the lowest installation cost, these systems form the first tier of the well configuration loop (Figure 5-13). For sites with impermeable surface covers, the required flow rate for a single well system can be calculated via:

$$Q_v^* = \frac{\pi r^2 b n_a}{t_{xc}} \qquad (5\text{-}6)$$

where

Q_v^* = volumetric flow rate at amospheric pressure [L^3/T]

r = radius of the treatment zone [L]

b = vadose zone thickness [L]

n_a = air-filled porosity of the soil [L^3/L^3]

t_{xc} = the time required for one pore volume exchange [T]

Equation 5-6 is based on the assumption of incompressible flow, which is valid for applied vacuums less than about 0.2 atmospheres, gauge. For vacuums exceeding this level, the extraction rate should be multiplied by a factor of safety proportional to the applied vacuum.

(8) For sites without impermeable surface covers, flow rate calculations require determination of the travel time from the limits of contamination to the extraction well. If the maximum extent of contamination occurs near the ground surface, dimensionless travel times provided by Shan, Falta, and Javendal (1992) can be used to determine the required flow rate. Using the definition of dimensionless travel time provided by them, the required flow rate for a single well system is:

$$Q_v^* = \frac{2\pi b^2 n_a A (L-l)\tau}{t_{ex}} \qquad (5\text{-}7)$$

where

Q_v^* = volumetric flow rate at atmospheric pressure [L^3/T]

A = ratio of horizontal to vertical permeability

l = depth to the top of the well screen [L]

L = depth to the bottom of the well screen [L]

τ = dimensionless travel time from Shan et al. (1992)

This analysis is based on the travel time from the ground surface to the extraction well, as provided by Shan, Falta, and Javendal. If the maximum extent of contamination occurs near the water table, then dimensionless travel times obtained from Figure 5-14 may be used in Equation 5-7. It should be noted, however, that the dimensionless travel times shown in Figure 5-14 assume that there is no reduction in flow velocity due to increased water saturations near the water table.

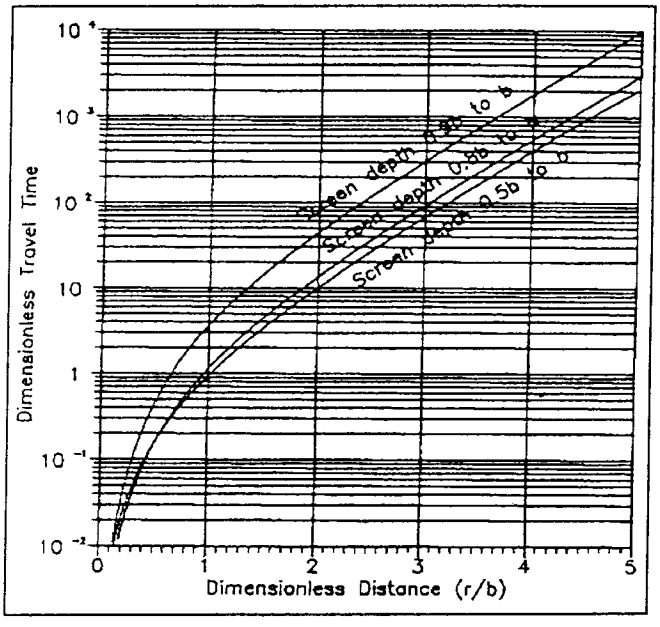


Figure 5-14. Dimensionless travel times at the water table for wells screened within the lower half, fifth, and tenth of the vadose zone (Brailey 1995, unpublished data)

(9) To evaluate the adequacy of a single well system, the flow rate obtained from Equation 5-6 or 5-7 should be compared against the acceptance criteria shown in Figure 5-13. Since the vacuum necessary to develop the design flow rate may exceed blower horsepower or water table upwelling limitations, vacuum requirements should be measured or calculated using the appropriate flow equations. Well inefficiencies and friction losses through piping and equipment must also be considered. Alternatively, pilot test data can be used to estimate vacuum requirements.

To Matthew Ko 852-2891-0305

Symmes, Frederick R.

From: Symmes, Frederick R.
Sent: Wednesday, February 03, 1999 9:14 PM
To: 'Matthew KO'
Cc: 'Eric LAI'; 'Brian Kam'; 'Matthew Ko at home'
Subject: Additional Responses to OCTF Comments

Matthew,

1. Concerning the ROI calculated using pore volume exchange, Table 3 in XDD's report indicates ROI's of 3.1 to 5.0m for VT1, VT2,and VT4. Using and air-filled porosity of 0.3, I calculate ROI's of approximately 11.5m at a flow of 20 cfm (3 pore volumes/day). It appears that the permeabilities used by XDD are unreasonably low and have skewed their estimates of ROI and cleanup time.

2. Therefore, at 20 cfm, there would be approximately 1,086 pore volume exchanges per year (3 per day) in 2.2m treatment zone that is 11.5 m in diameter.

3. A minimum average pore velocity of 0.01 cm/s results in a ROI of 23m. For the design basis 11.5m ROI, the minimum average pore velocity is approximately 0.08 cm/sec, substantially greater than the recommended minimum 0.01cm/sec. Again, it appears that they are skewing their data by using unreasonably low permeability measurements.

4. While the flows may not be strictly radial, the concrete surface seal and shallow depth to water will promote flow that is substantially radial. It is true that moisture will reduce the ROI in the vicinity of the water table but, the test results indicate good aeration of the zone immediately above the water table (refer to soil gas data from Long-Term SVE Retests.

5. Based on the face that the soil samples were disturbed during the air-rotary drilling process, the porosity measurement of 0.4 is probably high, and 0.3 to 0.35 is probably more realistic.

I'll send additional comments later tonight. I'm working at my office (603-656-5412) this evening if you want to call with questions.

Regards

Fred

MEMCL					
Rec'd on	2-2-99				
File No.					
	Act	Info	Init	Date	Remarks
HF					
TC					
PO					

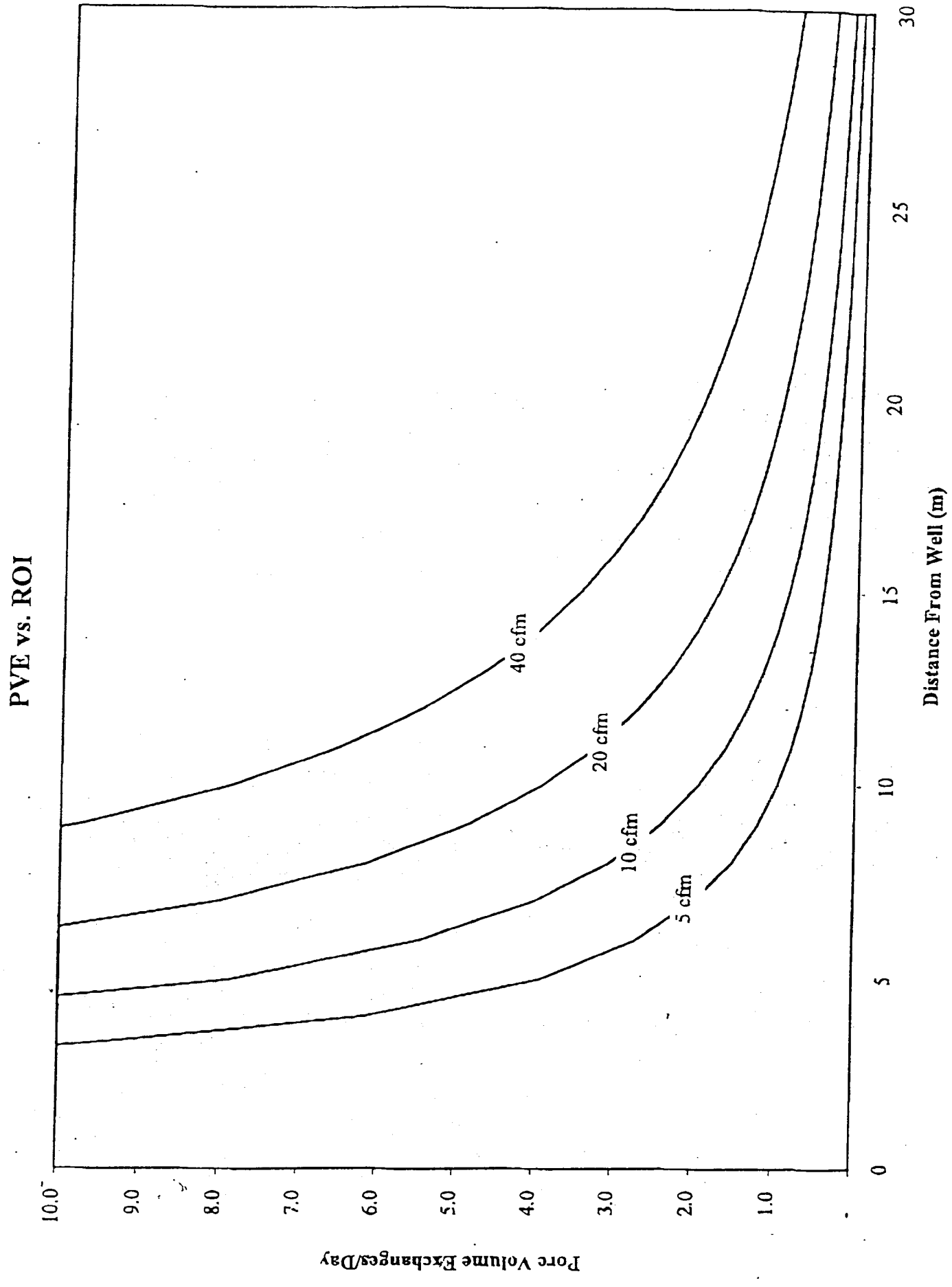
20 cfm

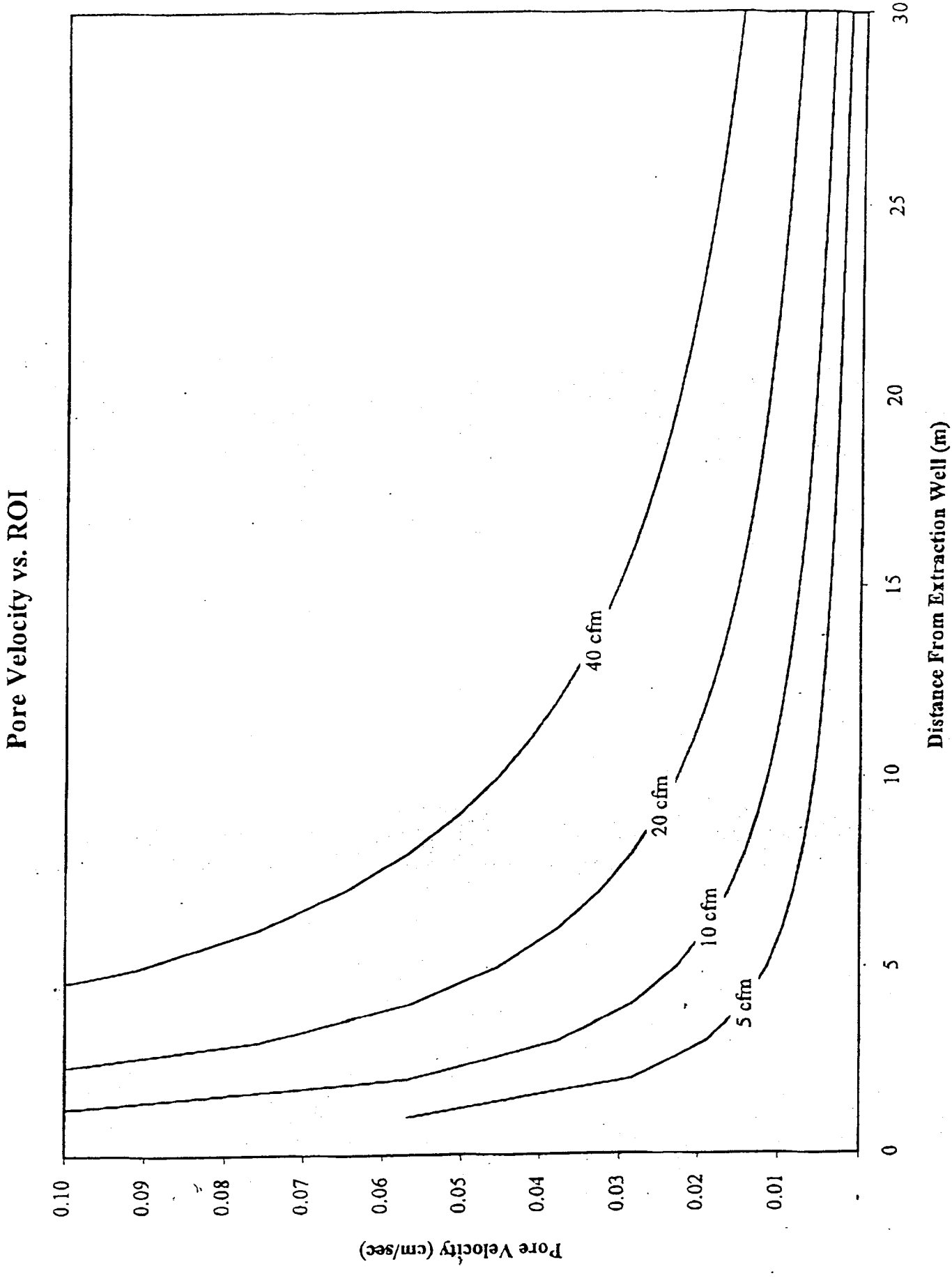
Radius of Influence Based on Pore Volume Exchange (PVE):

Design Basis PVE	3.0	/day	Given
Pore Volumes per Year	1,095	/year	(3.0PVE/day)*(365days/yr)
Flow	20	cfm	Given
Flow	0.57	m^3/min	(20cfm)/(35.315ft^3/m^3)
Flow	816	m^3/day	(0.57m^3/min)*(1440min/day)
Porosity	0.30		Given
Total Soil Pore Volume Treated by 3 PVEs	272	m^3	(816m^3/day)/(3PVE/day)
Total Soil Volume Treated	906	m^3	272m^3/0.3
Thickness of Treatment Zone	2.20	m	Measured
Surface Area of Treatment Zone	412	m^2	906m^3/2.20m
Radius of Treatment Zone	11.45	m	(412m^2/pi)^0.5

Radius of Influence Based on Pore Gas Velocity:

Pore Gas Velocity	0.01	cm/sec	Given
Pore Gas Velocity	0.0001	m/sec	(0.01cm/sec)/(100 cm/m)
Pore Gas Velocity	0.006	m/min	(0.0001 m/sec)*(60 sec/min)
Flow	20	cfm	Given
Flow	0.57	m^3/min	(20cfm)/(35.315ft^3/m^3)
Pore Area on Outside Perimeter of Treatment Zone (assume zone is a cylinder)	94	m^2	(0.57m^3/min)/(0.006m/min)
Porosity	0.30		Given
Total Area on Outside of Cylinder	315	m^2	(94m^2)/0.3
Thickness	2.2	m	Given
Circumference of Cylinder	143	m	(315m^2/2.2m)
Radius	23	m	143m/(pi*2)


PVE vs. ROI
40 cfm
20 cfm
10 cfm
5 cfm
Distance From Well (m)
0
5
10
15
20
25
30
Pore Volume Exchanges/Day
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0


Pore Velocity vs. ROI
Pore Velocity (cm/sec)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
5
10
15
20
25
30
Distance From Extraction Well (m)
40 cfm
20 cfm
10 cfm
5 cfm