Flood Control District
of Maricopa County

INTEROFFICE MEMORANDUM

Date: October 17, 2013

To: Bob Stevens, Environmental Program Manager
Planning & Project Management Division

From: Carlos Cortez Carriaga, PhD, P.E., CFM, Software Systems Engineer
Engineering Application Development and River Mechanics Branch
Engineering Division

Registered Professional Engineer (Civil) CERTIFICATE NO. 30003 CARLOS C. CARRIAGA Date Signed 10/17/13 ARIZONA, U.S.A.

CC: Bing Zhao, PhD, PE, Branch Manager
Engineering Application Development and River Mechanics
Engineering Division

Subject: Groundwater Protection Level (GPL) and Contaminant Transport Analysis
Property Address: 304 South 67th Avenue, Phoenix, AZ 85043
Durango Regional Conveyance Channel
Site Risk assessment

The Engineering Application Development and River Mechanics (EADRM) Branch of the Engineering Division was requested to assist in the Site Assessment of the above referenced Property (APN# 104-09-045G) by performing contaminant transport analysis on petroleum hydrocarbons detected beneath the project site. The goal of the study was to determine potential impacts to groundwater due to the existing contamination detected beneath the site in addition to defining subsequent impacts as a result of recharge from the current conveyance channel.

Results of the analysis performed on this study indicate that the concentration level of 1,3,5-TMB (i.e., 24 mg/Kg) at the known depth of incorporation will not pose water quality threat to the underlying groundwater resource. This conclusion is based on the evaluated depth-specific GPL of 43.84 mg/Kg which is about 1.8 times more than the detected concentration level at the site. Basically, for the contaminant to pose a threat, the concentration would have to be at least 43.84 mg/Kg, which is much higher than the detected level of 24 mg/Kg.

I. BACKGROUND

1.1 The property in question sits on a portion of the Durango Regional Conveyance Channel (DRCC) project located directly downstream of 67th Avenue (see LOCATION MAP, FIGURE 1.1). Earlier soil boring assessments of the site by Western Technologies, Inc. (WT) indicated concentration of 24 mg/Kg of 1,3,5-TMB at 50-ft below ground surface (bgs). This concentration is in excess of the established residential soil remediation level (SRL) of 21 mg/Kg, but well below the non-residential SRL of 70 mg/Kg established by the Arizona Department of Environmental Quality (ADEQ). These soil remediation levels do not apply to a specific depth but are levels that pose health risk to humans by direct exposure and contact with the contaminant.

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I. BACKGROUND

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1.2 Since no groundwater protection level (GPL) has been established by ADEQ for 1,3,5-TMB, an attempt was made to evaluate this guidance level by utilizing the GPL spreadsheet tool developed by ADEQ. The GPL tool is a screening method to determine soil concentrations protective of groundwater quality.

1.3 Another program called VLEACH, a contaminant fate and transport model developed by EPA, is used as a supplementary tool for the project site assessment to determine potential impacts of the subject contaminant on groundwater quality. VLEACH is used to supplement the contaminant flow analysis results provided by GPL.

1.4 The modeling and analysis efforts using GPL and VLEACH will provide the basis to assess impact of the contaminant on the groundwater resource considering all assumptions generated from the actual field data.

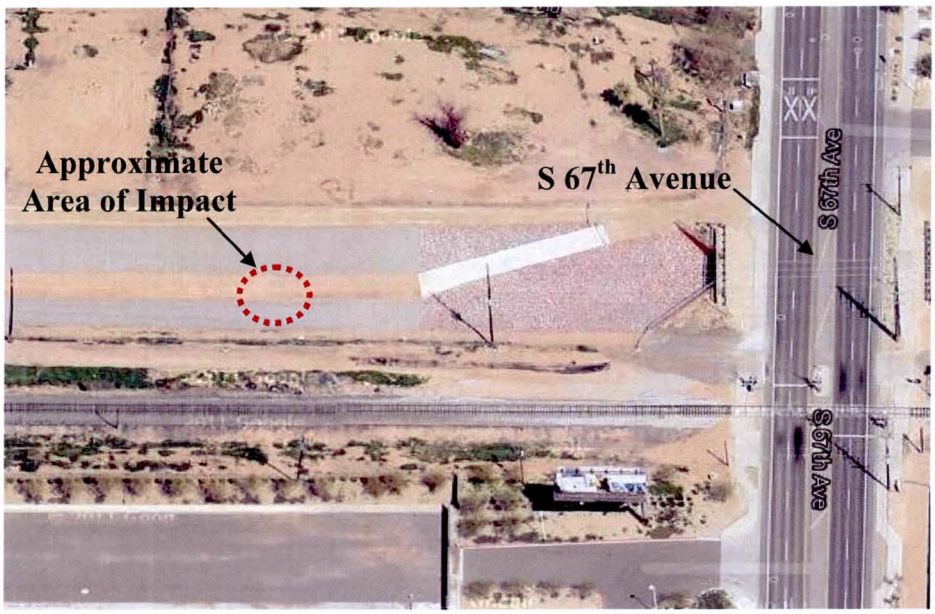

FIGURE 1.1 – LOCATION MAP
(SOURCE: 2013 GOOGLE MAP)

II. ANALYSIS TOOLS AND ASSUMPTIONS

2.1 The GPL (Groundwater Protection Leaching) tool is developed by ADEQ as an upgrade to the 1996 Fortran Program. The GPL model which is implemented in spreadsheet format follows the leaching theory presented in a 1996 publication by ADEQ entitled, "A SCREENING METHOD TO DETERMINE SOIL CONCENTRATIONS PROTECTIVE OF GROUNDWATER QUALITY." The tool is utilized to evaluate the GPL of 1,3,5-TMB which is the targeted contaminant for the site being investigated. In addition to establishing the guidance level protective of groundwater quality, the GPL tool has other capabilities that include:

(a) Evaluation of the Chemical Saturation Concentration for the subject contaminant (i.e., 1,3,5 - TMB), which put a cap on the GPL

(b) Plot of contaminant flow through the vadose zone from the source to the groundwater or depth of interest

(c) Plot of contaminant concentration as a function of time

(d) Sensitivity analysis involving infiltration rates and location of contaminant (i.e., source).

2.2 The assumptions in the use of GPL are provided as follows:

(a) 1,3,5-TMB is assumed non-biodegradable with assumed half-life of 100,000 days.

(b) Water flux and infiltration rate take the same values assuming that the soil materials are homogeneous and exhibit the same properties. The rate use is the water recharge to the groundwater.

(c) The recharge rate used in the GPL analysis is equivalent to 12.3% of the average annual precipitation of 8.2 inches that is observed in the Phoenix area. This recharge rate is equivalent to 0.007cm/day which is the default minimum water flux and infiltration rate values by GPL.

2.3 The VLEACH (Vadose Zone Leaching Model) was developed for the US Environmental Protection Agency (EPA) in 1997. The program evaluates the impact due to the mobilization and migration of a sorbed organic contaminant located in the vadose zone on the underlying groundwater resource. The program was designed specifically for the Phoenix-Goodyear Airport Superfund site where it was successfully used to evaluate groundwater impacts due to volatilization of volatile organic compounds in the wells (see Rosenbloom et al., 1993).

2.4 VLEACH describes the movement of an organic contaminant within and between three different phases: (1) as a solute dissolved in water, (2) as a gas in the vapor phase, and (3) as an absorbed compound in the solid phase. Equilibrium between the phases occurs according to distribution coefficients defined by the user. In particular, VLEACH simulates vertical transport by advection in the liquid phase and by gaseous diffusion in the vapor phase.

These processes are conceptualized as occurring in a number of distinct, user-defined polygons that are vertically divided into a series of user-defined cells. The polygons may differ in soil properties, recharge rate, and depth of water, but, within each polygon, it is assumed that homogeneous conditions prevail, with the exception of contaminant concentration, which can vary between layered cells. During each time step the migration of the contaminant within and between cells is calculated. Consequently, VLEACH can account for lateral heterogeneities but is limited when simulating vertical variation.

2.5 The VLEACH program offers capabilities that are complimentary to the site assessment analysis results provided by GPL. These include:

(a) Evaluation of the mass rate of concentration reaching the groundwater

(b) Predictive plot of groundwater impact as a function of time

(c) Predictive plot of soil concentration versus depth for a user-specified time

(d) Sensitivity analysis involving key variables that have uncertain values and information

2.6 The most important assumption in the use of the VLEACH Model is the steady-state condition in the vadose zone with respect to water movement. More specifically, the moisture content profile within the vadose is constant. However, this assumption rarely occurs in the field and although moisture gradients cannot be simulated, the user can still estimate the impacts of various moisture contents by comparing results from several simulations that cover the common or possible ranges in soil moisture conditions.

III. DATA

3.1 GPL INPUT DATA. The input data for the GPL model are provided in TABLE A.1 (see APPENDIX A).

3.2 VLEACH INPUT DATA. The input data for the VLEACH program are listed in TABLE A.2 (see APPENDIX A).

3.3 RECHARGE RATE DATA. TABLE A.3 (in APPENDIX A) lists several recharge studies that show the relationship between the evaluated recharge and precipitation data.

IV. ANALYSIS RESULTS

4.1 GPL Model Results (see APPENDIX B)

(a) The SOIL SATURATION CONCENTRATION based on the water solubility of 48 mg/L is 43.84 mg/Kg. This saturation level is defined as the level at which free organic phase may form in the soil.

(b) The evaluated GPL based on the input data provided in TABLE 4.1 below is 47.83 mg/Kg. This is based on the field data as follows:

- DEPTH OF INCORPORATION = 40 ft (Depth of contaminant source minus the projected 10-ft deep conveyance channel below current grade)
- DEPTH TO GROUNDWATER = 86.1 ft (Depth at which groundwater was encountered during boring activities, minus the projected 10-ft deep conveyance channel below current grade).

(c) TABLE 4.1 shows the Alternative GPLs for 1,3,5-TMB with the Depth of INCORPORATION and DEPTH TO GROUNDWATER as variables.

(d) TABLE 4.2 below shows the comparison of key important guidance levels for 1,3,5-TMB. The evaluated GPL of 47.83 mg/Kg is twice the site contaminant concentration of 24 mg/Kg. TABLE 4.2 also shows the RESIDENTIAL SRL of 21 mg/Kg and NON-RESIDENTIAL SRL of 70 mg/Kg established by ADEQ. The evaluated SATURATION CONCENTRATION of 43.84 mg/Kg is based on the water solubility of 48 mg/L for 1,3,5-TMB putting a cap on the GPL of the contaminant.

TABLE 4.1 – ALTERNATIVE GPL'S FOR 1,3,5-TMB

			DEPTH OF INCORPORATION					
			10 FT	20 FT	30 FT	40 FT	50 FT	60 FT
DEPTH TO GROUNDWATER	(CM)	(FT)	304.8 CM	609.8 CM	914.4 CM	1219.2 CM	1524 CM	1928.8 CM
	457.2	15	39.95					
	762.0	25	63.59	16.26				
	1066.8	35	124.82	31.27	13.60			
	1371.6	45	208.92	51.71	22.87	12.49		
	1676.4	55	309.16	77.21	34.45	19.11	11.94	
	1981.2	65	432.83	108.13	48.13	26.90	17.02	11.52
	2286.0	75	577.43	144.73	64.20	36.09	22.96	15.72
	2624.3	86.1	764.29	191.44	85.04	47.83	30.51	21.08
	2895.6	95	935.09	233.98	104.02	54.48	37.35	25.81

TABLE 4.2 – GPL VS SRL VS SATURATION CONCENTRATION FOR 1,3,5-TMB

	SITE CONCENTRATION	RESIDENTIAL SRL	NON-RESIDENTIAL SRL	GPL	SATURATION CONCENTRATION
	(MG/KG)	(MG/KG)	(MG/KG)	(MG/KG)	(MG/KG)
DATA SOURCES	WESTERN TECHNOLOGY (2010)	ADEQ	ADEQ	THIS STUDY	THIS STUDY
LEVELS	24	21	70	47.83	43.84
ADJ. LEVELS	-	-	-	43.84	-

(e) FIGURE 4.1 below shows the plot of the alternative GPLs for 1,3,5-Trimethylbenzene as tabulated in TABLE 4.1. The figure shows the point GPL for the site (encircled) and is bounded by the NON-RESIDENTIAL SRL of 70 mg/Kg and the RESIDENTIAL SRL of 21 mg/Kg.

(f) The plots showing the evaluated contaminant concentrations versus time for 1,3,5-TMB are provided in FIGURES B.1, B.2, and B.3 in APPENDIX B. Peak values or maximum concentrations from these plots, which occur at time = 4189 days (called the time to peak), are listed in TABLE 4.3.

(g) The maximum soil contamination concentration in the vadose zone is equivalent to 10.15% (or 2436.9 μg/Kg = 2.44 mg/Kg, see TABLE 4.3) of the initial contaminant concentration of 24,000 μg/Kg.

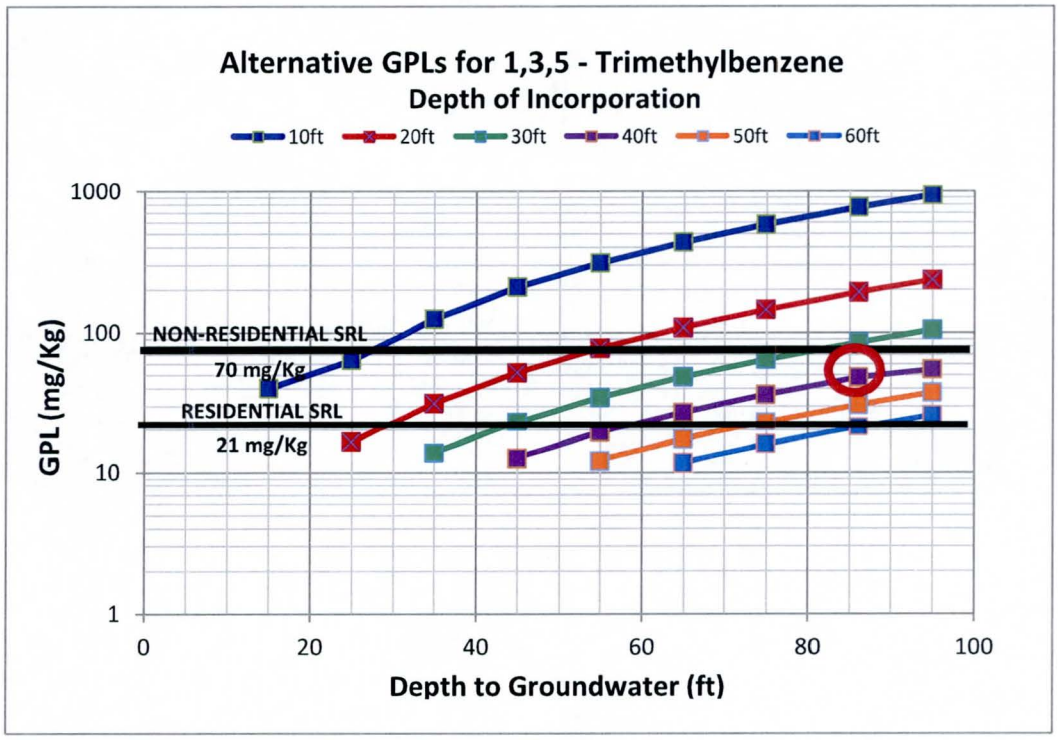

FIGURE 4.1 – ALTERNATIVE GPLS FOR 1,3,5-TRIMETHYLBENZENE

TABLE 4.3 – PEAK CONTAMINANT CONCENTRATIONS AT 86.1 FT (2624.3 CM)

PHASES	CONTAMINANT CONCENTRATIONS		TIME TO PEAK	REFERENCES (APPENDIX B)
	µg/Kg	µg/L	Days	
GAS		853.7	4189	SEE FIGURE B.1
LIQUID		2668.0	4189	SEE FIGURE B.1
SORBED	2185.0		4189	SEE FIGURE B.2
TOTAL	2436.9		4189	SEE FIGURE B.2

(h) The plots showing the contaminant concentration versus depth at time = 4189 days for 1,3,5-TMB are provided in FIGURES B.4, B.5, and B.6 in APPENDIX B. Peak values or maximum concentrations from these plots, which occur at 49.3 ft (or 1502.2 cms) bgs are provided in TABLE 4.4A. TABLE 4.4B shows the concentrations at the depth of 86.1 ft (2624.3 cms) bgs, which is the groundwater depth. Note that the tabulated values provided in TABLE 4.3 are similar to the values in TABLE 4.4B.

TABLE 4.4 – CONTAMINANT CONCENTRATIONS AT TIME = 4189 DAYS

PHASES	CONTAMINANT CONCENTRATIONS		DEPTH IN THE VADOSE ZONE		REFERENCES (APPENDIX B)
	μg/Kg	μg/L	cms	ft	
	A. PEAK CONCENTRATIONS AT DEPTH = 49.3 FT (1502.2 CMS)				
GAS		1343.8	1502.2	49.3	SEE FIGURE B.4
LIQUID		4199.5	1502.2	49.3	SEE FIGURE B.4
SORBED	3439.4		1502.2	49.3	SEE FIGURE B.5
TOTAL	3835.9		1502.2	49.3	SEE FIGURE B.5
	B. CONTAMINATION CONCENTRATIONS AT DEPTH = 86.1 FT (GROUNDWATER)				
GAS		853.6	2624.3	86.1	SEE FIGURE B.4
LIQUID		2668.0	2624.3	86.1	SEE FIGURE B.4
SORBED	2185.1		2624.3	86.1	SEE FIGURE B.5
TOTAL	2436.9		2624.3	86.1	SEE FIGURE B.5

(i) The infiltration rate and water flux values used in the study were 0.007 cm/day (0.084 ft/year), which is the default minimum value recommended for GPL analysis. At the average annual precipitation of 8.2 inches (i.e., 208 mm or 20.8 cm) in Phoenix, Arizona, this rate of 0.084 ft/year corresponds to about 12.3% of the annual rainfall rate.

(j) From several recharge rate studies performed in the Southwest as shown in TABLE A.3 (see APPENDIX A), recharge rate (net infiltration rate) values were found to range from less than 1% to 5.7% of the total rainfall (Heilweil, 2007). Assuming the largest recharge rate of 5.7% (i.e., 0.0032 cm/day) is employed for the Phoenix project site, the GPL tool defaults to the minimum recharge rate of 0.007 cm/day to provide a GPL value of 43.84 mg/Kg, which is the SOIL SATURATION CONCENTRATION established for 1-3-5, TMB.

4.2 VLEACH Model Results (see APPENDIX C)

(a) The two plots generated from VLEACH are (a) the groundwater impact curve as shown in FIGURE C.1; and, (b) the soil-depth contamination profile as shown in FIGURE C.2.

(b) The generated mass flux to the groundwater is shown by the exponential curve in FIGURE 4.2 derived from the VLEACH analysis results provided in FIGURE C.1 in APPENDIX C. The exponential relation derived from the model results is provided in Equation (1) below:

$$M = 42270e^{-0.037T} \quad (1)$$

Where M is the mass flux in mg/year and T is the time in years.

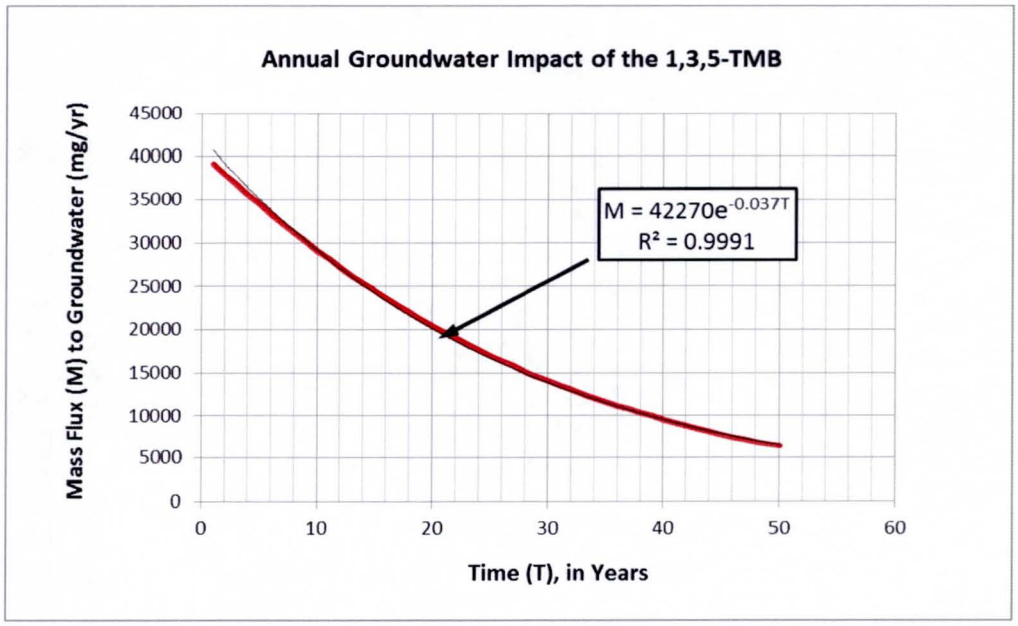

FIGURE 4.2 – ANNUAL GROUNDWATER IMPACT OF 1,3,5-TMB

(c) The projected annual mass flux levels of the 1,3,5-TMB contaminant to the groundwater for selected years are tabulated in TABLE 4.5. The figures provided are from the VLEACH model output and not from equation (1).

TABLE 4.5 – PROJECTED ANNUAL GROUNDWATER IMPACT

NO.	YEAR	MASS FLUX (mg/yr)
1	1	39,159
2	5	34,442
3	10	29,131
4	15	24,476
5	20	20,449
6	30	14,075
7	40	9,546
8	50	6,401

(d) Into the future (for example, 2 years, 5 years, 10 years, 15 years and 20 years), the projected soil concentration profiles for the contaminant would flatten out with significant reduction of peak concentrations as shown in FIGURE 4.3. These projected profiles were generated from the VLEACH model developed for the project site.

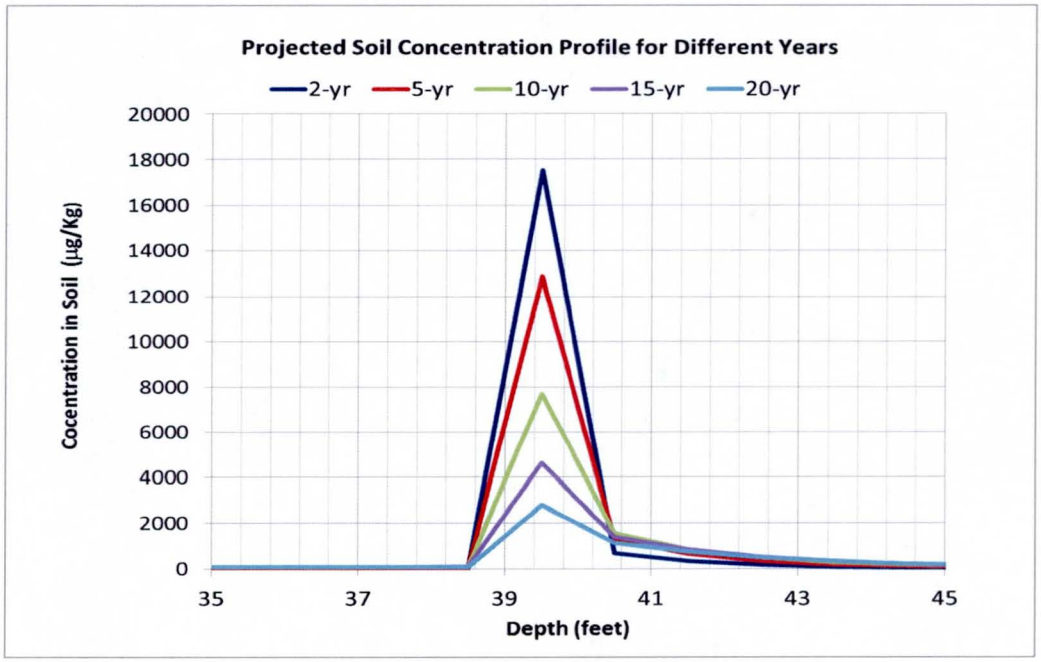

FIGURE 4.3 – PROJECTED SOIL CONTAMINANT CONCENTRATION PROFILES

(e) From the results of VLEACH program, the projected reductions of concentration levels of 1,3,5-TMB in the next 20 years are tabulated in TABLE 4.6. At the end of the first year, the concentration level would reach 19.40 mg/Kg which is observed to be less than the Residential SRL of 21 mg/Kg. This fact indicates that the concentration level of 1,3,5-TMB becomes a non-issue starting 2010.

TABLE 4.6 – MAXIMUM SOIL CONCENTRATIONS

NO.	YEAR (ACTUAL YEAR)	MAX SOIL CONCENTRATIONS (µg/Kg)
1	0 (2009)	24,000
2	1 (2010)	19,400
3	2 (2011)	17,503
4	3 (2012)	15,800
5	4 (2013)	14,200
6	5 (2014)	12,847
7	10 (2019)	7,687
8	15 (2024)	4,614
9	20 (2029)	2,781

(f) If the field site investigation was conducted in 2009 (Western Technologies, Inc., 2010) when the 24 mg/Kg level of concentration of 1,3,5-TMB was initially measured at the site, then the current year (2013) should be the fourth year, which puts the contamination level at 14.20 mg/Kg (see TABLE 4.6).

V. CONCLUSIONS

5.1 The evaluated GPL of 47.83 mg/Kg exceeds the SATURATION CONCENTRATION of 43.84 mg/Kg as shown on TABLE 4.2. Adjustment is made for the GPL to cap at the SATURATION CONCENTRATION of 43.84 mg/Kg.

5.2 The analysis adopted to determine the GPL of 47.83 mg/Kg was based on a conservative assumption that the soil material through the vadose zone is entirely sandy soil. A clay soil resulted in a GPL of 60.26 mg/Kg. Regardless of which soil media is employed for the vadose zone, the GPL would cap at 43.84 mg/Kg, which is the SATURATION CONCENTRATION evaluated for the contaminant.

5.3 The measured concentration level of the contaminant at the site, which is 24 mg/Kg, is below the level (GPL of 43.84 mg/Kg) that could pose risk to contaminating the quality of the underlying groundwater resource.

5.4 Results of the VLEACH analysis indicate that after 2009, the concentration level of 1,3,5-TMB is reduced to 19.40 mg/Kg (see TABLE 4.6) indicating that the contaminant becomes a non-issue since 2010 when the level drops below the Residential SRL of 21.0 mg/Kg.

5.5 Findings from VLEACH modeling results compliment the results derived from the GPL analysis leading to the conclusion that the current (2013) concentration level of 1,3,5-TMB is a non-issue to pose health risk to humans and threaten the quality of the underlying groundwater resource.

VI. RECOMMENDATION

6.1 The District recommends that no further site assessment is required to determine potential impacts of the 1,3,5-TMB to the groundwater. This recommendation is based on the conclusions drawn that the contamination level must be at least 43.83 mg/Kg to impact the quality of the underlying groundwater resource.

VII. REFERENCES

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7.2 Arizona Department of Environmental Quality (ADEQ), (2008), Instructions for Spreadsheet GPL, November 2008. pp. 9

7.3 US Environmental Protection Agency (1997), User's Manual, VLEACH – A One-Dimensional Finite Difference Vadose Zone Leaching Model, Version 2.2, pp. 70

7.4 Western Technologies Inc. (2010), Site-Specific Risk Assessment, DRCC Project, 304 South 67th Avenue, Phoenix, AZ, Job No. 2189JC398, report prepared for Flood Control District of Maricopa County, Phoenix, AZ 85009. February 26, 2010.

7.5 Rosenbloom, J., P. Mock, P. Lawson, J. Brown, and H.J. Turin (1993). Application of VLEACH to Vadose Zone Transport of VOCs at an Arizona Superfund Site, Ground Water Monitoring and Remediation, Vol. 13, No. 3, pp. 159-169.

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APPENDIX A – DATA INPUTS AND RECHARGE RATES

TABLE A.1 – INPUT DATA FOR GPL				
NO.	SYMBOLS	DESCRIPTION	VALUES	UNITS
1	1,3,5 – TMB	1,3,5 – Trimethylbenzene	-	-
2	C_O	Initial Total Soil Contamination	24,000	µg/Kg
3	K_H	Henry's Law Constant	0.32	-
4	S	Water Solubility	48	mg/Kg
5	K_{OC}	Organic Carbon Partition Coefficient	819	µg/Kg
6	$T_{1/2, VZ}$	Half-life of Contaminants in the Vadose Zone	100000	days
7	$T_{1/2, GZ}$	Half-life of Contaminants in the Groundwater Zone	100000	days
8	Sand	Sand Soil	-	-
9	ϕ	Total Porosity	0.375	-
10	P_b	Dry Bulk Density	1.66	g/cm^3
11	$f_{OC, VZ}$	Fraction of Organic Carbon in the Vadose Zone	0.001	-
12	$f_{OC, GZ}$	Fraction of Organic Carbon in the Groundwater Zone	0.001	-
13	D_G^a	Gaseous Diffusion Coefficient	7000	cm^2/d
14	D_L^w	Liquid Diffusion Coefficient	0.7	cm^2/d
15	d	Diffusion Layer Thickness	0.5	cm
16	θ_W	Moisture Content	0.054	-
17	J_W	Water Flux	0.007	Cm/d
18	t	Time Step	91.06	days
19	L	Depth of Incorporation	1219.2	cm
20	z	Depth to Water or Depth of Interest	1371.6	cm
21	T_D	Depth of Profile Time	4189	Days
22	Z	Total Vadose Zone Depth	2590	cm
23	S_C	Distance to Compliance Point	30	m
24	w	Release width	10	m
25	s	Well Screen Interval	8.2	m
26	S_Q	Water Quality Standard (Aquifer Water Quality Standard)	12	µg/L
27	V_{GW}	Groundwater Velocity (Actual Velocity not Darcy Velocity)	10	cm/d
28	A_I	Infiltration Rate Outside of Source Area	0.007	cm/d

TABLE A.2 – INPUT DATA FOR VLEACH PROGRAM				
NO.	DATA	DESCRIPTION	VALUES	UNITS
	A. Simulation Parameters			
1	Title	1,3,5 TMB Contaminant Transport Analysis	-	-
2		Simulation Time	20	Years
3		Time Step	1	Year
4		Output Time Interval	1	Year
5		Profile Time Interval	1	Year
	B. Chemical Parameters			
6	Chemical Name	1,3,5- Trimethylbenzene	-	-
7	K_{OC}	Organic Carbon Distribution Coefficient	819	ml/L
8	K_H	Henry's Law Constant	0.32	-
9	S	Water Solubility	48	mg/LG/l
10	D_G^a	Free Air Diffusion Coefficient	0.7	m^2/day
	C. Polygon #1 Data			
11		Area of Polygon	2025	sq. ft
12		Vertical Cell Dimension	1	ft
13		Number of Cells	86	-
14		Height of Polygon	86	ft
	D. Soil Parameters for Sand			
15	P_b	Dry Bulk Density	1.66	g/cm^3
16	ϕ	Effective Porosity	0.375	-
17	θ_W	Volumetric Water Content	0.054	-
17	f_{OC}	Soil Organic Carbon Content	0.001	-
	E. Boundary Conditions			
18		Recharge Rate	0.084	ft/year
19		Concentration of Recharge Rate	0	mg/L
20		Upper Boundary Vapor Condition	0	mg/L
21		Lower Boundary Vapor Condition	0	mg/L
	F. Initial Contaminant Concentrations			
	From Depth	To Depth		
22	1 ft	40 ft	1	µg/Kg
23	40 ft	41 ft	24000	µg/Kg
24	41 ft	86 ft	1	µg/Kg

TABLE A.3 – RECHARGE RATES (SOURCE: INFILTRATION AND RECHARGE AT SAND HOLLOW, AN UPLAND BEDROCK BASIN IN SOUTHWESTERN UTAH, HEILWEIL ET AL, 2007)					
NO.	STUDY SITE	BASIN NAMES	PRECIPITATION (MM)	GROUND WATER RECHARGE (MM)	RECHARGE TO PRECIPITATION, PERCENT (%)
1	Abo Arroyo	Rio Grande - Albuquerque	195	2.0	1.02
2	Amargosa River	Upper Amargosa	121	0.9	0.74
3	Arroyo Hondo	Rio Grande – Santa Fe	243	1.7	0.70
4	Mojave Tributaries	Mojave	106	1.9	1.79
5	Rillito Creek	Rillito	303	4.4	1.45
6	Sand Hollow	Upper Virgin	303	17.3	5.71
7	San Pedro Tributaries	Upper San Pedro	294	3.9	1.33
8	Trout Creek	Middle Humboldt	246	3.6	1.46

APPENDIX B - GPL MODEL RESULTS

(B.1 CONCENTRATION VS. TIME)

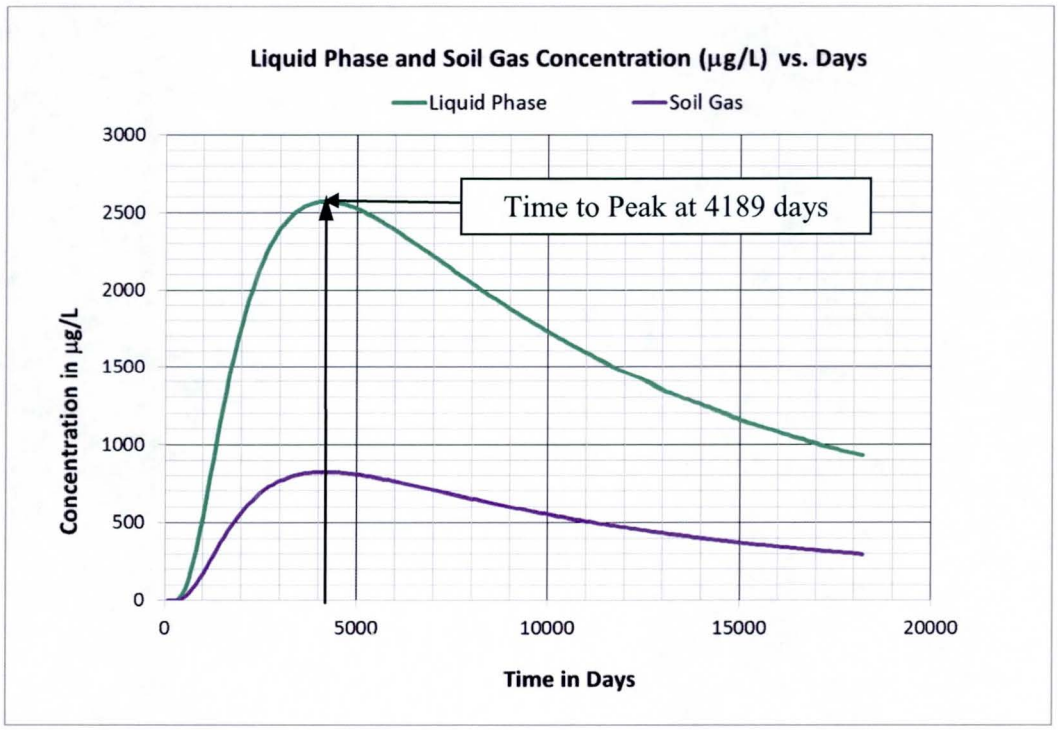

FIGURE B.1 - LIQUID PHASE AND SOIL GAS CONCENTRATION

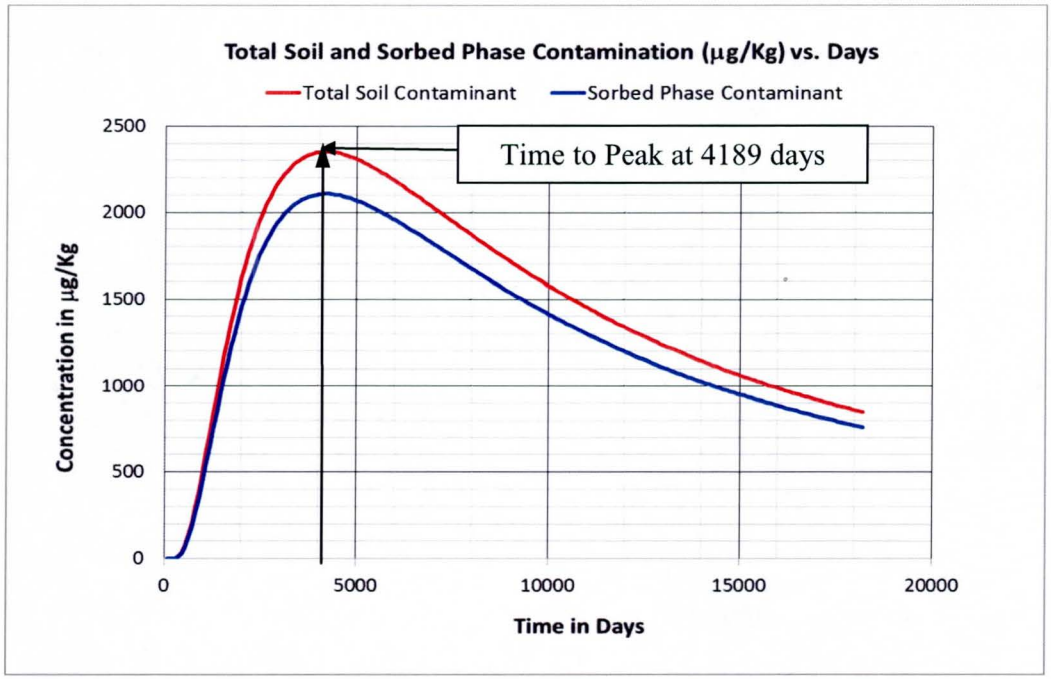

FIGURE B.2 - TOTAL SOIL AND SORBED PHASE CONCENTRATION

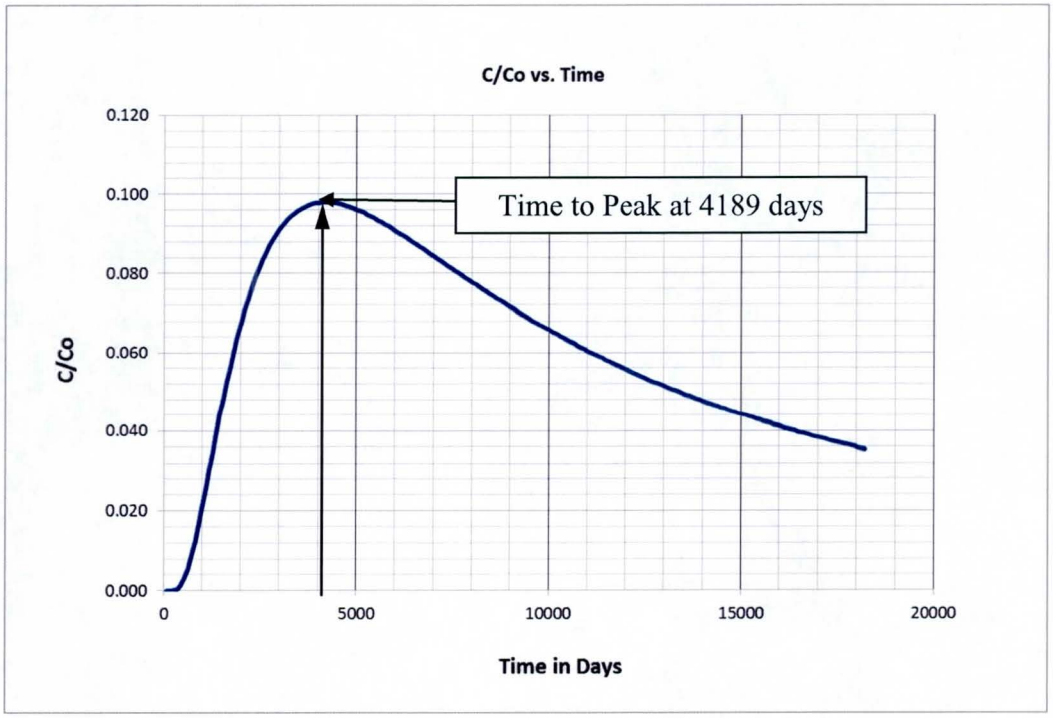

FIGURE B.3 - CONTAMINANT CONCENTRATION RATIO

APPENDIX B – GPL MODEL RESULTS

(B.2 CONCENTRATION VS. DEPTH @ TIME TO PEAK OF 4189 DAYS)

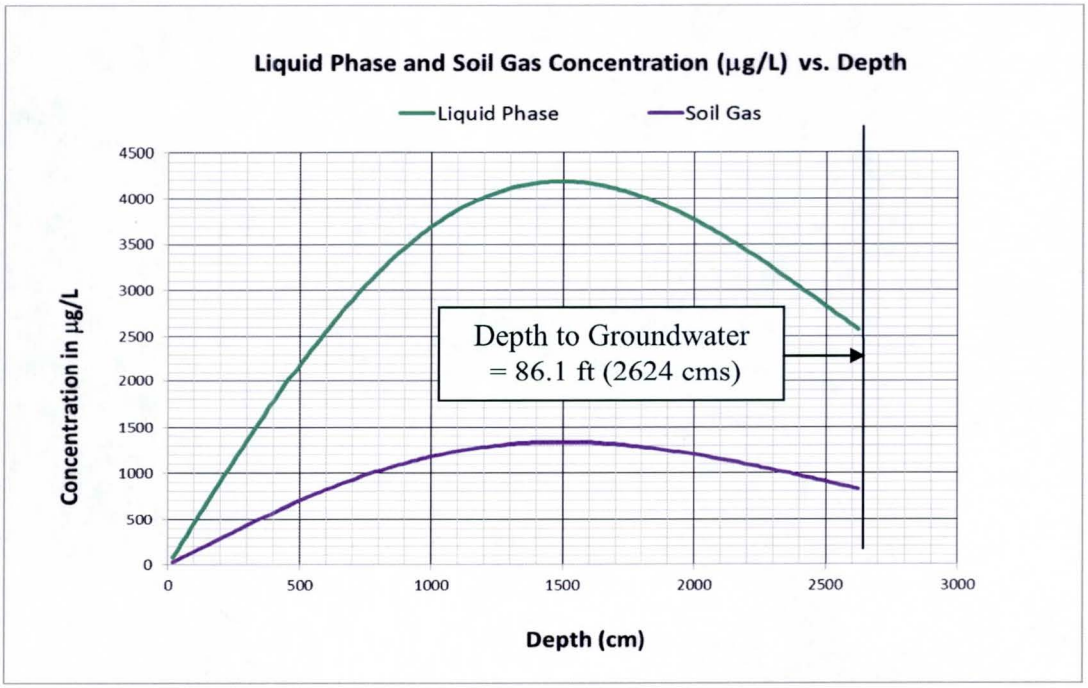

FIGURE B.4 - LIQUID PHASE AND SOIL GAS CONCENTRATION

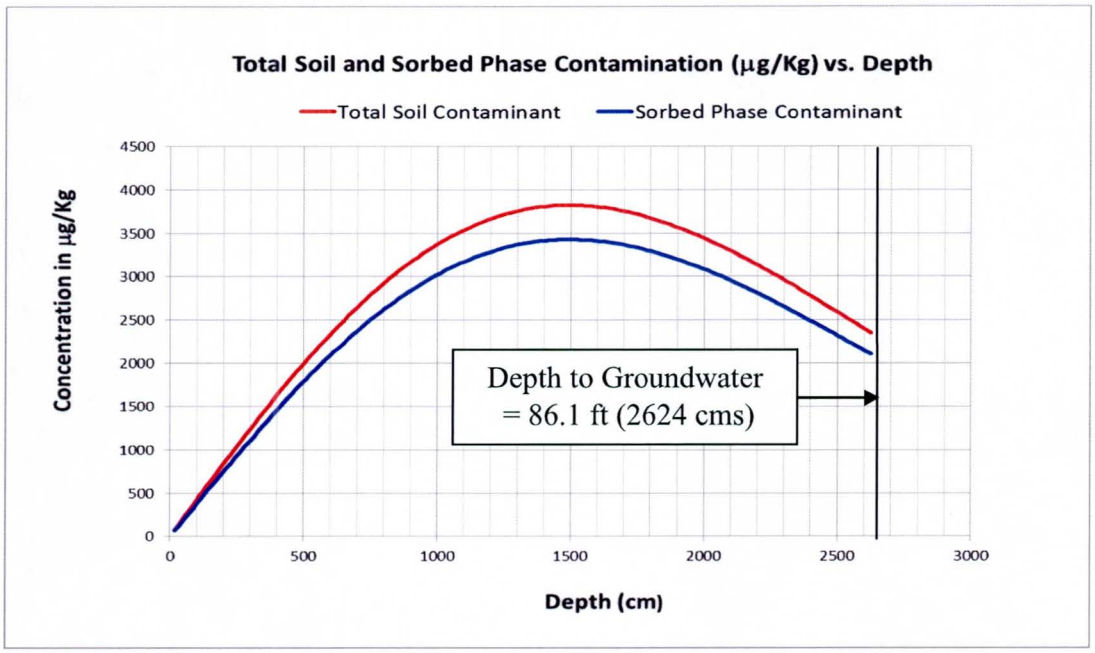

FIGURE B.5 - TOTAL SOIL AND SORBED PHASE CONCENTRATION

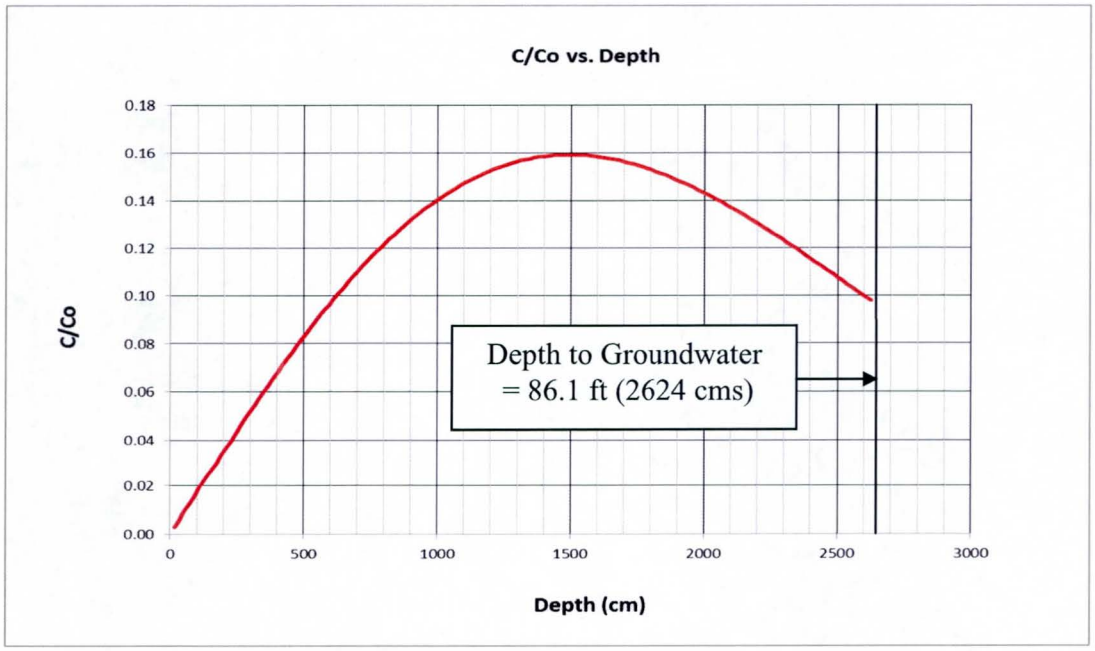

FIGURE B.6 - CONTAMINANT CONCENTRATION RATIO

APPENDIX C – VLEACH MODEL GRAPHICAL RESULTS

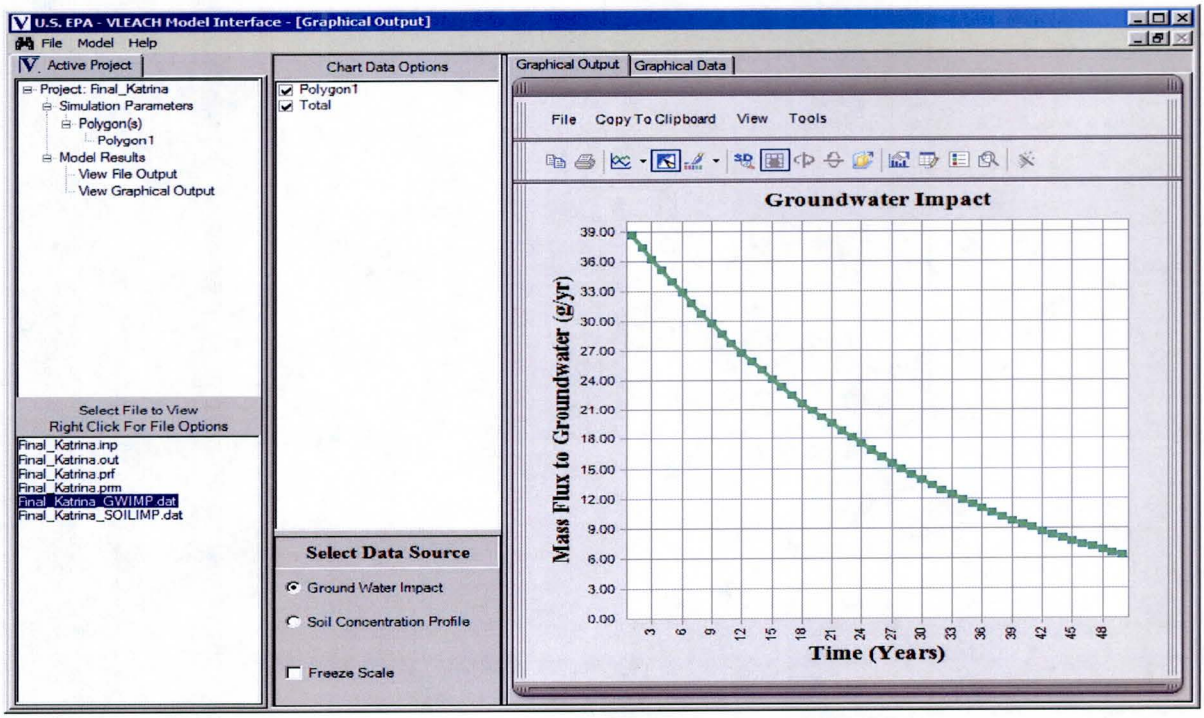

FIGURE C.1 - GROUNDWATER IMPACT CURVE

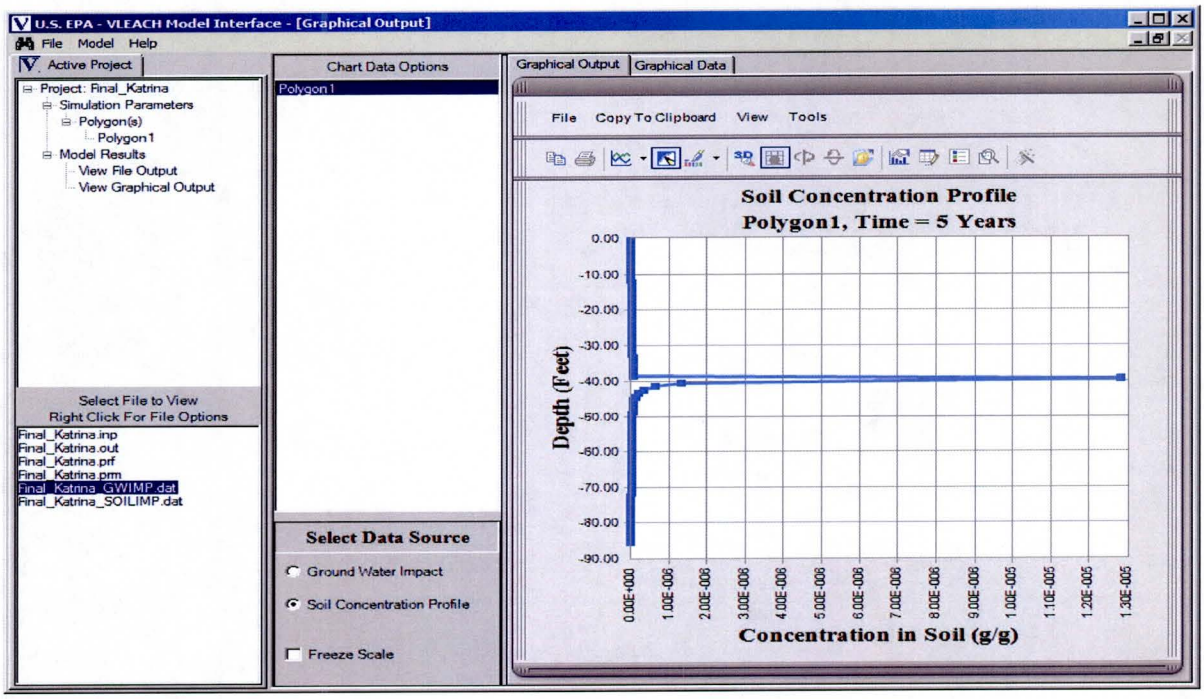

FIGURE C.2 - SOIL-DEPTH CONTAMINATION PROFILE