Chevron

December 22, 1995

Chevron U.S.A. Products Company
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P O. Box 5004
San Ramon, CA 94583-0804

Mark A. Miller
SAR Engineer
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Ms. Juliet Shin
Alameda County Health Care Services
Department of Environmental Health
1131 Harbor Bay Parkway, Suite 250
Alameda, CA 94502-6577

Re: Former Chevron Service Station #9-5630
997 Grant Avenue, San Lorenzo, CA

Dear Ms. Shin:

Enclosed is the Health Risk Evaluation dated December 12, 1995, prepared by Chevron's Research and Technology Company for the above referenced site. This report evaluates the theoretical risk which may be present to future occupants and construction workers at the site due to residual hydrocarbon concentrations in soil and ground water.

The report concludes that residual hydrocarbon concentrations present in soil and ground water do not present a significant threat to human health above currently accepted regulatory thresholds.

If you have any questions or comments, please feel free to contact me at (510) 842-8134.

Sincerely,
CHEVRON U.S.A. PRODUCTS COMPANY

Mark A. Miller
Site Assessment and Remediation Engineer

95 DEC 28 PM 2:28

cc: Ms. B.C. Owen

Mr. Darryl Snow, Geraghty & Miller - Richmond

Mr. Lawrence E. Cogan, Ware & Freidenrich, 400 Hamilton Avenue, Palo Alto, CA 94301

Mr. Michael Meniktas, Meniktas & Associates, 3440 Lakeshore Avenue, Suite 206, Oakland, CA 94610

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MEMORANDUM

Richmond, California
December 12, 1995

Health Risk Evaluation
Former Chevron Station #9-5630
997 Grant Avenue, San Lorenzo CA

Mr. Mark Miller:
San Ramon, California

This memorandum presents the results of a health risk evaluation performed on former Chevron service station #9-5630 to aid in proceeding with the sale and development of the site. Two receptor-specific exposure scenarios were modeled for the site: 1) Residential dermal and inhalation exposure to site soils and the enclosed-space exposure to vapors emanating from the groundwater plume and 2) Construction worker dermal and inhalation exposure to site soils. The health risk evaluation for Residential and Construction Worker exposure to soil vapor inhalation and soil dermal contact was performed using the American Petroleum Institute Decision Support System (APIDSS) exposure and risk evaluation software package. The health risk evaluation for residential exposure to volatilized contaminants from the groundwater plume was performed using the American Society for Testing and Materials Risk-Based Corrective Action (ASTM RBCA) equations for volatilization of contaminants from groundwater into enclosed spaces (VFwesp). The ingestion of groundwater was not considered as an exposure pathway because the water for this area is supplied by a local water company.

Chevron chose to model conservative estimates of exposure and health risk values at this site by using the maximum contaminant concentration in site soils. These values were input into the vadose zone fate and transport model SESOIL in APIDSS to determine residual contaminant concentrations at the site. These residual concentrations were then input into the Chemical Intake module to calculate health risk values. Based on the health risk results generated within APIDSS, exposure to site soils through dermal contact and inhalation of soil vapors would not represent a significant health threat to residents or construction workers at the site. Based on the results generated from the ASTM RBCA volatilization model, the volatilization of contaminants from the groundwater plume into an enclosed space directly above the plume would not represent a significant health threat to future residents.

The APIDSS calculated carcinogenic risk values for residential dermal exposure and inhalation exposure to benzene in site soils were 8.6e-11 and 3.4e-8 (9 in 100 billion and 3 in 100 million), well below an accepted 1e-6 (1 in one million) threshold. The calculated carcinogenic risk values for construction worker dermal and inhalation exposure to benzene in site soils were 6e-12 and 8e-9 (6 in 1 trillion and 8 in 1 billion), well below accepted risk values for these exposures. These risk values do not represent significant threats to human health due to these exposure scenarios at this site.

The APIDSS calculated hazard indices for residential dermal and inhalation exposures to ethylbenzene, toluene and xylenes in site soils were 4e-7 and 3.8e-5 (4 in 10 million and 4 in 100,000), well below the accepted hazard index of 1.0. For a construction worker, the calculated hazard indices for dermal and inhalation exposure to ethylbenzene, toluene and xylene were 1e-6 and 3e-4 (1 in 1 million and 3 in 10,000). These results are well below the 1.0 hazard threshold for human health protection.

The ASTM RBCA calculated carcinogenic risk for exposure to enclosed-space vapors from a groundwater plume ranged from 3e-6 to 1e-7 for groundwater concentrations of 150 ppb benzene (maximum site value 9/91well C-3) and 4.6 ppb (9/14/95 site maximum well C-6). The 150 ppb benzene concentration value was included for conservative estimation purposes only as it represents the highest recorded benzene value for the site. Current benzene concentrations are greatly reduced from past concentrations. These risk values are close to and below accepted health values for this exposure and do not represent significant threats to human health.

Based on the health risk evaluation for this site, it is apparent that the residual contamination present in site soils and the current groundwater contaminant plume do not represent a threat to future site residents or construction workers exposed through dermal contact, inhalation of soil emissions or to enclosed-space vapors.

Background

During December 1990 and February 1991, Chevron removed three UST's, one waste oil tank, product lines and dispensers from the site. Approximately 500 yds^3 of soil was excavated from the original tank pit and an additional 4700 yds^3 of soil was over-excavated, aerated and placed back into the former tankpit. Six wells are available for groundwater monitoring (a seventh well was destroyed during UST excavation), and these wells are currently monitored quarterly at the site. Low level groundwater contamination has been detected in six of the seven wells at the site. Based on groundwater monitoring well data and boring logs, the depth to water for the site is approximately 12 feet with the site divided into 2 lithologic units. The upper unit extends from surface to 4 feet below ground surface (bgs) and consists of a sandy clay. The second layer extends from 4 feet bgs to 12 feet bgs and consists of a sandy silt.

SESOIL Model Input Parameters

Site specific physical and chemical parameters were input into the vadose zone leaching model SESOIL in an effort to determine the receptor point concentration values for both dermal contact exposure and inhalation exposure to hydrocarbon contaminated soils for future residents and construction workers. The SESOIL model was run using the maximum residual contaminant levels seen in the 0-4 foot and 4-12 foot soil layers at the site to provide the most conservative estimate of human health risk due to dermal and inhalation exposures. Receptor concentration values and health risk values were generated for two different receptors by the model: 1) Future Resident at the site (potential chronic exposure), and 2) Future Construction worker for activities associated with site development (potential acute exposure).

The attached APIDSS Data Requirements Section outlines the SESOIL model and Data for Risk Assessment input parameters that were used to model the soils and to generate risk values at this site. The input parameters will be discussed in the order that they are presented on the attached output sheets.

1) Chemicals Modeled

The BTEX constituents were chosen to be modeled because they are the regulated primary chemicals of concern at the site. TPH-gas can not be modeled as a single compound because it is a complex mixture of many chemicals.

2) SESOIL Model Control/Climate Parameters

The model was simulated for 50 years through 2 soil zones (0-4' upper sandy clay zone and 4-12' lower sandy silt zone) at the site. The surface temperature was modeled as 16°C, with 0.001 cm/day evapotranspiration (negligible). Rainfall was modeled at 50 cm/year (20 inches/year) based on actual average rainfall amounts, with 6 storms per year lasting 2 days each over a 5 month period.

3) Soil Column Data

The soil column was modeled with a 25% effective porosity over the entire interval, a conservative estimate based on the sandy clay/sandy silt lithology at the site. The soil bulk density was assumed to be 1.70 g/cm^3, consistent with bulk densities for similar lithologies. The hydrocarbon source area was assumed to be the unexcavated areas beneath the former product lines and portions of associated dispenser islands based on trench sample soil analysis. This area was modeled as measuring 10 m by 10 m.

A) <u>Layer 1</u>

Layer 1 was modeled as a 1.2 meter thick (from 0'-4' depth) sandy clay layer based on site boring logs. The intrinsic permeability was conservatively estimated to be 1e-9 cm^2 (1e-3 cm/sec) based on lithology. The fraction Organic Carbon was conservatively estimated to be 0.05% (500 mg/Kg) for this layer.

The mass of BTEX was determined for this layer by inputting the <u>highest concentrations</u> of these contaminants found in the onsite trench bottom samples C-2-4', CT-6-3.5' and CT-7-3.5'. These contaminant concentrations were assumed to be present throughout the entire layer in the amounts calculated by the following formula:

$$\text{Mass (Kg)} = \frac{\text{Contaminant (mg/Kg)} * \text{Volume soil (m}^3) * \text{Soil Density (Kg/m}^3)}{1e{+}6 \text{ mg/Kg}}$$

where the volume of impacted soil was defined as 10 m by 10 m by 1.2 m for Layer 1, or 120 m^3; and the soil density is defined as 1700 Kg/m^3.

Soil results from trench sample C-2-4' had benzene present at 0.046 mg/Kg; toluene and xylene were present in sample CT-6-3.5' at 0.01 mg/Kg and 0.15 mg/Kg, respectively; ethylbenzene was present in sample CT-7-3.5' at 0.007 mg/Kg. Based on these concentrations, the benzene mass was calculated to be 0.009 Kg; the ethylbenzene mass was calculated to be 0.0014 Kg; the toluene mass was calculated to be 0.002 Kg and the xylene mass was calculated to be 0.031 Kg for Layer 1 in the source area.

B) <u>Layer 2</u>

Layer 2 was modeled as a 2.44 m thick (from 4'-12') sandy silt layer based on lithology logs from the site soil borings. The intrinsic permeability was estimated as 1e-9 cm^2 (1e-3 cm/sec) and the fraction Organic Carbon was conservatively estimated to be 0.05% (500 mg/Kg). The bulk density was estimated to be 1700 Kg/m^3 and the volume of Layer 2 was 10 m by 10 m by 2.44 m, or 244 m^3.

The mass of BTEX present in Layer 2 was based on the <u>maximum contaminant</u> concentrations found in site soils in the 4-12' interval. Benzene was present in boring C-3-5.5' at 1.7mg/Kg; toluene in C-6-10' at 1.9 mg/Kg; ethylbenzene in C-3-10.5' at 1.4 mg/Kg; and xylene in C-2-9' at 1.5 mg/Kg. The calculated mass for the BTEX contaminants in Layer 2 is: Benzene at 0.71 Kg; Toluene at 0.79 Kg; Ethylbenzene at 0.58 Kg; and Xylene at 0.62 Kg.

4) SESOIL Chemical Specific Parameters

The specific physical parameters for the <u>pure phases</u> of benzene, toluene, ethylbenzene and xylene were input into the model. Note that gasoline is made up of a mixture of these pure phases and the chemical specific effective solubilities will be less than the pure phase solubilities. Note that there was <u>no</u> Unsaturated Zone Degradation Rate Constant applied in the SESOIL model. This is a very conservative model assumption. For the Air Dispersion Box Model, the average wind speed was input as 2.5 m/sec through a box 2 m high by 2 m wide placed directly over the modeled surface soil contamination.

Data For Risk Assessment Portion of APIDSS

The Residential and Construction Worker exposure scenarios modeled for the Risk Assessment portion of this assessment varied in the exposure frequency, exposure duration, inhalation rate, time outdoors and adherence factor of the soil. The dermal contact, inhalation, inhalation dose and dermal dose parameters were the same for each exposure scenario. The input parameters for the Risk Assessment portion of APIDSS are presented below.

1) Body Weight and Lifetime

The receptor modeled had an average weight of 70 Kg and an expected lifetime of 70 years in both exposure scenarios. These are values typical of adult exposures.

2) Inhalation of Soil Emissions

The Residential receptor exposure scenario was modeled as 350 days/year for 9 years at an inhalation rate of 0.833 m^3/hour for 3 hours outdoors. The Construction Worker receptor exposure scenario was modeled as 0.25 years (13 weeks of actual onsite worker exposure) at an inhalation rate of 3 m^3/hour for 9 hours outdoors.

The Bioavailability of the BTEX constituents for both scenarios was modeled as 1, meaning that all available BTEX would be taken into the receptor, a conservative assumption. The Inhalation Dose for both scenarios was given as the accepted slope factor for benzene and as the accepted reference dose for toluene, ethylbenzene and xylene.

3) Dermal Contact

The Residential receptor exposure scenario was modeled as 350 days/year for 9 years over a skin surface area of 3120 cm^2 with a soil adherence factor of 0.6 mg/cm^2. The Construction Worker exposure scenario was modeled for 0.25 years over a skin surface area of 3120 cm^2 with a skin adherence factor of 2 mg/cm^2. The dermal absorption factors were modeled as 1 (all available BTEX absorbed - a conservative assumption) with dermal dose slope factors and reference doses the same as for the inhalation exposure scenario.

ASTM RBCA VFwesp Equation Risk Evaluation Data Input

The volatilization factor for inhalation of vapors emanating from a groundwater plume that have migrated through the soil column and into an enclosed space (residence) was calculated for this site.

Using the ASTM RBCA document ES 38-94 (Table X2.1 attached) and Table X2.5 parameters, the VFwesp value is calculated in step 1) below. The VFwesp value is then combined with actual site groundwater concentration values to calculate a vapor concentration (C building) in the enclosed space (step 2). The Chemical Intake value is generated for specific receptor characteristics (step 3) and a Risk value is calculated by multiplying the Cancer Slope Factor for benzene (0.029 mg/Kg-day) times the calculated Chemical Intake value (step 4).

1) Volatilization Factor wesp - (VFwesp) - groundwater to enclosed space vapors:

A) See attached ES 38-94 Table x2.1; note that VFwesp calculation requires the solving of equations for effective diffusion between groundwater and soil and for effective diffusion between soil and foundation crack.

2) Vapor concentration in a building - C (building) = VFwesp * C (groundwater)

3) Intake Value - Intake = $\frac{\text{C (building) * Respiration rate * Days exposed * Years exposed}}{\text{Receptor Weight * Days/years * Lifetime (years)}}$

4) Risk Value - Risk = Intake * Cancer Slope Factor for Benzene (0.029 mg/Kg-day)

For this site, a depth to groundwater of 3.66 meters (12 feet) will be modeled. An effective porosity of 25% will be input into the equation. The solving of equation 2) will be for both the maximum site benzene groundwater concentration (9/91 in well C-3) and for the current site maximum benzene concentration. For equation 3), the modeled receptor will be an adult with a 70 year lifetime, weighing 70 kilograms, exposed for 30 years, at 350 day/year at a breathing rate of 15 m^3/day.

APIDSS SESOIL Model Results

The SESOIL model output results for both the Resident (9-5630R.sav) and Construction Worker (9-5630CW.sav), based on the above referenced data input parameters, indicate that receptor point concentrations for BTEX in Soil, Air and Volatile Emissions (Tables attached) are present at the site in relatively small concentrations. The Chemical Intake Analysis, based upon these receptor point concentrations, for both the Resident and Construction Worker indicate that dermal and inhalation exposures to these contaminant levels will not pose a significant health threat to either receptor.

Carcinogenic risk for exposure to benzene by inhalation of soil emissions was calculated to be between 3.4e-8 to 8.6e-9 (3 in one hundred million to 9 in one billion) for a future resident at the site. Carcinogenic risk for exposure to benzene by dermal contact with the site soils was calculated to be between 7.6e-9 to 5.9e-12 (8 in one billion to 6 in one trillion) for a construction worker at the site. These calculated risk values are all below the 1e-4 to 1e-6 cancer risk threshold and would not represent a threat to human health. Calculated Hazard Indices for both exposure scenarios were all below 2.6e-4, well below the 1.0 threshold accepted to be representative of a human health threat.

ASTM RBCA VFwesp Results

In an effort to conservatively model the potential exposure to volatilized groundwater plume contaminants, Chevron chose to model both the maximum benzene groundwater contaminant concentration seen at the site and the current benzene groundwater concentration at the site.

Solving the equation for determining the Volatilization Factor for groundwater to enclosed spaces for this site (solved equation attached) for a depth to groundwater of 3.66 meters (12 feet) gave a VFwesp value of 7.7e-3 mg/m^3-air/mg/L-water. The vapor concentration of benzene in the enclosed space was calculated to range between 1.16e-3 (150 ppb benzene in well C-3) to 1.54e-5 mg/m3-air (in well). Based on these ranges the Chemical Intake was calculated to range between 1.02e-4 to 1.4e-6 mg/Kg-day. The Risk calculated for this site due to inhalation of vapors emanating from the groundwater plume ranged from 3e-6 (150 ppb benzene 9/91) to 1e-7 (4.6 ppb benzene 9/95). These values are consistent with expected residential inhalation values calculated in APIDSS. Based on current site groundwater concentrations of benzene, these levels would not represent a threat to human health.

this exceeds the 1×10^{-6} risk used for residential

Summary

Fate and Transport modeling of the soil contamination at this site indicates that future residents and construction workers would not be exposed to contaminant concentrations that presented a significant threat to human health. The results of the groundwater contaminant volatilization model indicated that future residents living directly above the current groundwater plume would not be exposed to contaminant levels that would pose a threat to human health. Based on the results of this modeling, it is recommended that this site be presented to Alameda County Health Care Services for soils closure.

Please contact me at 510-242-7086 with questions or comments regarding this review.

Sincerely,

Curtis A. Peck

Curtis A. Peck, R. G.
Lead Hydrogeologist

Attachments:

1) 9/95 Groundwater Monitoring Data
2) Site Soils Data - Compiled
3) ASTM RBCA ES 38-94 Table X2.1
4) ASTM RBCA ES 38-94 Table X2.5
5) APIDSS Input/Output Parameters - Resident - C:\APIDSS\9-5630R.SAV
6) APIDSS Input/Output Parameters - Construction Worker - C:\APIDSS\9-5630CW.SAV

cc: JM Randall
U Kelmser
TE Buscheck
JN Stambolis

#9-5630 ASTM RBCA - Volatilization Factor for Enclosed Spaces

EQUATIONS

1) VFwesp =

$$VFwesp = \frac{(0.22)\,\dfrac{[(3.61e\text{-}4\ cm2/s)\ /\ (366\ cm)]}{[(1.4e\text{-}4\ s\text{-}1) * (200\ cm)]}}{1 + \dfrac{[(3.61e\text{-}4\ cm2/s)\ /\ (366\ cm)]}{[(1.4e\text{-}4\ s\text{-}1) * (200\ cm)]} + \dfrac{[(3.61e\text{-}4\ cm2/s\ /\ (366\ cm)]}{[(1.67e\text{-}2\ cm/s)\ /\ 15\ cm)e0.01]}} * [1e3\ L/m*3]$$

$$VFwesp = \frac{(0.22)\ (3.52e\text{-}5)}{1 + [(3.52e\text{-}5) + (1.1e\text{-}6)]} * 1e3\ L/m*3$$

$$VFwesp = \frac{(7.7e\text{-}6)}{1 + 3.63e\text{-}5} * 1e3\ L/m*3$$

VFwesp = (7.7e-6) * 1e3 L/m*3

VFwesp = 7.7e-3 $\mathbf{\frac{mg/m*3\text{-}air}{mg/L\text{-}water}}$

2a) C building = (VFwesp) * (C water) ; where C water = 150 ppb (0.150 mg/L) from well C-3

C building = 7.7e-3 $\frac{[mg/m*3\text{-}air]}{[mg/L\text{-}water]}$ * (0.150 mg/L)

C building = 1.16e-3 mg/m*3-air at 150 ppb groundwater benzene concentration

2b) C building at 4.6 ppb benzene = 3.54e-5 mg/mg*3 air

3a) Chemical Intake = $\frac{(C\ building) * (Respiration\ Rate) * (Days\ Exposed) * (Years\ Exposed)}{(Receptor\ Weight) * (Days/year) * (Expected\ Lifetime)}$

Intake = $\frac{(1.16e\text{-}3\ mg/m*3) * (15\ m*3/day) * (350\ days) * (30\ years)}{(70\ Kg) * (365\ days) * (70\ years)}$

Intake = 1.02e-4 mg/Kg-day at 150 ppb benzene

3b) Chemical Intake = 3.1e-6 mg/Kg-day at 4.6 ppb benzene

4a) Risk = Chemical Intake * Cancer Potency Factor (benzene); where CPF = 0.029 mg/Kg-day

Risk = (1.02e-4 mg/Kg/day) * (0.029 mg/Kg-day)

Risk = 3e-6 at 150 ppb benzene

4b) Risk = 1e-7 at 4.6 ppb benzene, the current situation at the site.

The following chemicals were selected:
Benzene
Ethylbenzene
Toluene
Xylene

Data for Fate and Transport Models

Sesoil Model - Deterministic

Model Control Parameters

Simulation Time (max=100) [years]	50
Number of soil layers	2
Sublayers in layer 1	1
Sublayers in layer 2	1
Volatile emissions:	Yes

Climate Parameters

Surface Temperature [C]	16
Evapotranspiration [cm/day]	0.001
Precipitation [cm/yr]	50
Storm duration [days]	2
Number of storms [yr^-1]	6
Length of Rainy Season [months]	5

Soil Column Data

Effective porosity [-]	0.25
Dry Wt. Soil Bulk Density [g/cm^3]	1.7
X-dimension of the source [m]	10
Y-dimension of the source [m]	10
Layer 1	
Thickness of Layer [m]	1.2
Intrinsic Permeability [cm^2]	1e-9
Fraction Organic Carbon [-]	0.05
Benzene Load [kg]	0.009
Ethylbenzene Load [kg]	0.002
Toluene Load [kg]	0.002
Xylene Load [kg]	0.031
Layer 2	
Thickness of Layer [m]	2.44
Intrinsic Permeability [cm^2]	1e-9
Fraction Organic Carbon [-]	0.05
Benzene Load [kg]	0.71
Ethylbenzene Load [kg]	0.58
Toluene Load [kg]	0.79
Xylene Load [kg]	0.62

Sesoil Chemical Specific Parameters

Benzene	
Solubility [mg/l]	1750
Diffusion Coeff. in Air [cm^2/s]	0.087
Henrys Constant [Atm/m^3/mol]	2.49E-01
Koc [ug/gOC/ug/ml]	83
Degradation Rate Constant in Unsaturated Zc	0.0E+00s]
Vapor Pressure [mmHg]	95.2
Ethylbenzene	
Solubility [mg/l]	152
Diffusion Coeff. in Air [cm^2/s]	0.066
Henrys Constant [Atm/m^3/mol]	2.87E-01
Koc [ug/gOC/ug/ml]	1100
Degradation Rate Constant in Unsaturated Zc	0.00E+00]
Vapor Pressure [mmHg]	7
Toluene	
Solubility [mg/l]	535

Diffusion Coeff. in Air [cm^2/s]	0.078
Henrys Constant [Atm/m^3/mol]	2.84E-01
Koc [ug/gOC/ug/ml]	300
Degradation Rate Constant in Unsaturated Zc	0.00E+00]
Vapor Pressure [mmHg]	28.1
Xylene	
Solubility [mg/l]	198
Diffusion Coeff. in Air [cm^2/s]	0.072
Henrys Constant [Atm/m^3/mol]	3.15E-01
Koc [ug/gOC/ug/ml]	240
Degradation Rate Constant in Unsaturated Zc	0.00E+00]
Vapor Pressure [mmHg]	10

Sesoil Model - Deterministic

Model Control Parameters

Simulation Time (max=100) [years]	50
Number of soil layers	2
Sublayers in layer 1	1
Sublayers in layer 2	1
Volatile emissions:	Yes

Climate Parameters

Surface Temperature [C]	16
Evapotranspiration [cm/day]	0.001
Precipitation [cm/yr]	50
Storm duration [days]	2
Number of storms [yr^-1]	6
Length of Rainy Season [months]	5

Soil Column Data

Effective porosity [-]	0.25
Dry Wt. Soil Bulk Density [g/cm^3]	1.7
X-dimension of the source [m]	10
Y-dimension of the source [m]	10
Layer 1	
Thickness of Layer [m]	1.2
Intrinsic Permeability [cm^2]	1e-9
Fraction Organic Carbon [-]	0.05
Benzene Load [kg]	0.009
Ethylbenzene Load [kg]	0.002
Toluene Load [kg]	0.002
Xylene Load [kg]	0.031
Layer 2	
Thickness of Layer [m]	2.44
Intrinsic Permeability [cm^2]	1e-9
Fraction Organic Carbon [-]	0.05
Benzene Load [kg]	0.71
Ethylbenzene Load [kg]	0.58
Toluene Load [kg]	0.79
Xylene Load [kg]	0.62

Sesoil Chemical Specific Parameters

Benzene	
Solubility [mg/l]	1750
Diffusion Coeff. in Air [cm^2/s]	0.087
Henrys Constant [Atm/m^3/mol]	2.49E-01
Koc [ug/gOC/ug/ml]	83
Degradation Rate Constant in Unsaturated Zc	0.0E+00s]
Vapor Pressure [mmHg]	95.2
Ethylbenzene	
Solubility [mg/l]	152
Diffusion Coeff. in Air [cm^2/s]	0.066
Henrys Constant [Atm/m^3/mol]	2.87E-01
Koc [ug/gOC/ug/ml]	1100
Degradation Rate Constant in Unsaturated Zc	0.00E+00]

Vapor Pressure [mmHg]	7
Toluene	
Solubility [mg/l]	535
Diffusion Coeff. in Air [cm^2/s]	0.078
Henrys Constant [Atm/m^3/mol]	2.84E-01
Koc [ug/gOC/ug/ml]	300
Degradation Rate Constant in Unsaturated Zc	0.00E+00]
Vapor Pressure [mmHg]	28.1
Xylene	
Solubility [mg/l]	198
Diffusion Coeff. in Air [cm^2/s]	0.072
Henrys Constant [Atm/m^3/mol]	3.15E-01
Koc [ug/gOC/ug/ml]	240
Degradation Rate Constant in Unsaturated Zc	0.00E+00]
Vapor Pressure [mmHg]	10

Box Dispersion Model - Deterministic

Wind Speed [m/s]	2.5
Height of Box [m]	2
Width of Box [m]	2

Data for Risk Assessment

Body Weight and Lifetime - Deterministic

Average Weight (kg)	70
Lifetime (yrs)	70

Inhalation of Soil Emissions

Exposure Frequency [days/yr]	260
Exposure Duration [years]	0.25
Inhalation Rate [m^3/hr]	3
Time Outdoors [hours/day]	9

Inhalation of Soil Emissions Chemical Specific Parameters

Benzene	
Bioavailability [fraction]	1
Ethylbenzene	
Bioavailability [fraction]	1
Toluene	
Bioavailability [fraction]	1
Xylene	
Bioavailability [fraction]	1

Dermal Contact with Soil

Exposure Frequency [days/yr]	260
Exposure Duration [years]	0.25
Skin Surface Area [cm^2]	3120.
Adherence Factor [mg/cm^2]	2

Dermal Contact Chemical Specific Parameters

Benzene	
Dermal Absorption Factors [fraction]	1
Ethylbenzene	
Dermal Absorption Factors [fraction]	1
Toluene	
Dermal Absorption Factors [fraction]	1
Xylene	
Dermal Absorption Factors [fraction]	1

Dermal Dose

Benzene	
Slope Factor [1/(mg/kg-day)]	0.029
Reference Dose [mg/kg-day]	ND
Ethylbenzene	

Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	0.1
Toluene	
Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	0.2
Xylene	
Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	2

Inhalation Dose

Benzene	
Slope Factor [1/(mg/kg-day)]	0.029
Reference Dose [mg/kg-day]	ND
Ethylbenzene	
Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	2.86E-1
Toluene	
Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	1.14E-1
Xylene	
Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	0.2

Analysis for #5630 SESOIL Model - Upper Exposed Surface Model Concentrations
Receptor Point Concentration In Soil

Averaging Time* [Years]	Benzene [mg/kg]	Ethylbenzene [mg/kg]	Toluene [mg/kg]	Xylene [mg/kg]
5	8.99E-04	9.62E-04	1.27E-03	1.56E-04
10	6.46E-04	9.56E-04	1.17E-03	8.51E-05
15	4.80E-04	9.47E-04	1.06E-03	5.72E-05
20	3.74E-04	9.35E-04	9.58E-04	4.29E-05
25	3.03E-04	9.21E-04	8.63E-04	3.43E-05
30	2.54E-04	9.05E-04	7.83E-04	2.86E-05
35	2.18E-04	8.88E-04	7.12E-04	2.45E-05
40	1.91E-04	8.69E-04	6.50E-04	2.15E-05
45	1.70E-04	8.50E-04	5.96E-04	1.91E-05
50	1.53E-04	8.02E-04	5.49E-04	1.72E-05
55	1.53E-04	8.02E-04	5.49E-04	1.72E-05
60	1.53E-04	8.02E-04	5.49E-04	1.72E-05
65	1.53E-04	8.02E-04	5.49E-04	1.72E-05
70	1.53E-04	8.02E-04	5.49E-04	1.72E-05
75	1.53E-04	8.02E-04	5.49E-04	1.72E-05

*The maximum RUNNING average concentration is shown for these averaging times.
For example, the maximum 5-year average concentration may not occur in the first five years.
To find out when the maximum RUNNING concentrations occured, view the charts.
Simulation Time = 50 Years
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Analysis for #9-5630 - Receptor Air Exposure Model Concentrations
Receptor Point Concentration In Air

Averaging Time* [Years]	Benzene [mg/m^3]	Ethylbenzene [mg/m^3]	Toluene [mg/m^3]	Xylene [mg/m^3]
5	2.67E-04	1.93E-05	1.08E-04	1.73E-05
10	1.92E-04	1.92E-05	1.00E-04	9.43E-06
15	1.43E-04	1.90E-05	9.11E-05	6.34E-06
20	1.11E-04	1.88E-05	8.21E-05	4.76E-06
25	9.02E-05	1.85E-05	7.40E-05	3.81E-06
30	7.55E-05	1.82E-05	6.71E-05	3.17E-06
35	6.49E-05	1.78E-05	6.10E-05	2.72E-06
40	5.68E-05	1.75E-05	5.58E-05	2.38E-06
45	5.05E-05	1.71E-05	5.11E-05	2.11E-06
50	4.54E-05	1.61E-05	4.70E-05	1.90E-06
55	4.54E-05	1.61E-05	4.70E-05	1.90E-06
60	4.54E-05	1.61E-05	4.70E-05	1.90E-06
65	4.54E-05	1.61E-05	4.70E-05	1.90E-06
70	4.54E-05	1.61E-05	4.70E-05	1.90E-06
75	4.54E-05	1.61E-05	4.70E-05	1.90E-06

*The maximum RUNNING average concentration is shown for these averaging times.
For example, the maximum 5-year average concentration may not occur in the first five years.
To find out when the maximum RUNNING concentrations occured, view the charts.
Simulation Time = 75 Years
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Analysis for #9-5630 - Volatile Emissions From Surface Soil Contamination
Volatile Emissions

Averaging Time* [Years]	Benzene [kg/year]	Ethylbenzene [kg/year]	Toluene [kg/year]	Xylene [kg/year]
5	8.41E-02	6.10E-03	3.42E-02	5.46E-03
10	6.06E-02	6.06E-03	3.16E-02	2.98E-03
15	4.50E-02	6.01E-03	2.87E-02	2.00E-03
20	3.51E-02	5.93E-03	2.59E-02	1.50E-03
25	2.84E-02	5.84E-03	2.33E-02	1.20E-03
30	2.38E-02	5.74E-03	2.12E-02	1.00E-03
35	2.05E-02	5.63E-03	1.93E-02	8.57E-04
40	1.79E-02	5.51E-03	1.76E-02	7.50E-04
45	1.59E-02	5.39E-03	1.61E-02	6.67E-04
50	1.43E-02	5.08E-03	1.48E-02	6.00E-04
55	1.43E-02	5.08E-03	1.48E-02	6.00E-04
60	1.43E-02	5.08E-03	1.48E-02	6.00E-04
65	1.43E-02	5.08E-03	1.48E-02	6.00E-04
70	1.43E-02	5.08E-03	1.48E-02	6.00E-04
75	1.43E-02	5.08E-03	1.48E-02	6.00E-04

*The maximum RUNNING average concentration is shown for these averaging times.
For example, the maximum 5-year average concentration may not occur in the first five years.
To find out when the maximum RUNNING concentrations occured, view the charts.
Simulation Time = 50 Years
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Chemical Intake Analysis For Construction Worker - #9-5630

Carcinogenic Risk by Chemical for Each Route of Concern

Chemical	Inhalation of Soil Emissions	Dermal Contact With Soil	Total
Benzene	7.59E-09	5.91E-12	7.60E-09
Ethylbenzene	ND	ND	0.00E+00
Toluene	ND	ND	0.00E+00
Xylene	ND	ND	0.00E+00
Total	7.59E-09	5.91E-12	7.60E-09

Hazard Index by Chemical for Each Route of Concern

Chemical	Inhalation of Soil Emissions	Dermal Contact With Soil	Total
Benzene	ND	ND	0.00E+00
Ethylbenzene	1.86E-05	6.11E-07	1.92E-05
Toluene	2.61E-04	4.02E-07	2.61E-04
Xylene	2.38E-05	4.96E-09	2.38E-05
Total	3.03E-04	1.02E-06	3.04E-04

Deterministic Run
ND = Not Determined because RfD or Slope Factor not entered
NA = Not Applicable
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Diffusion Coeff. in Air [cm^2/s]	0.078
Henrys Constant [Atm/m^3/mol]	2.84E-01
Koc [ug/gOC/ug/ml]	300
Degradation Rate Constant in Unsaturated Zc	0.00E+00]
Vapor Pressure [mmHg]	28.1
Xylene	
Solubility [mg/l]	198
Diffusion Coeff. in Air [cm^2/s]	0.072
Henrys Constant [Atm/m^3/mol]	3.15E-01
Koc [ug/gOC/ug/ml]	240
Degradation Rate Constant in Unsaturated Zc	0.00E+00]
Vapor Pressure [mmHg]	10

Sesoil Model - Deterministic

Model Control Parameters

Simulation Time (max=100) [years]	50
Number of soil layers	2
Sublayers in layer 1	1
Sublayers in layer 2	1
Volatile emissions:	Yes

Climate Parameters

Surface Temperature [C]	16
Evapotranspiration [cm/day]	0.001
Precipitation [cm/yr]	50
Storm duration [days]	2
Number of storms [yr^-1]	6
Length of Rainy Season [months]	5

Soil Column Data

Effective porosity [-]	0.25
Dry Wt. Soil Bulk Density [g/cm^3]	1.7
X-dimension of the source [m]	10
Y-dimension of the source [m]	10
Layer 1	
Thickness of Layer [m]	1.2
Intrinsic Permeability [cm^2]	1e-9
Fraction Organic Carbon [-]	0.05
Benzene Load [kg]	0.009
Ethylbenzene Load [kg]	0.002
Toluene Load [kg]	0.002
Xylene Load [kg]	0.031
Layer 2	
Thickness of Layer [m]	2.44
Intrinsic Permeability [cm^2]	1e-9
Fraction Organic Carbon [-]	0.05
Benzene Load [kg]	0.71
Ethylbenzene Load [kg]	0.58
Toluene Load [kg]	0.79
Xylene Load [kg]	0.62

Sesoil Chemical Specific Parameters

Benzene	
Solubility [mg/l]	1750
Diffusion Coeff. in Air [cm^2/s]	0.087
Henrys Constant [Atm/m^3/mol]	2.49E-01
Koc [ug/gOC/ug/ml]	83
Degradation Rate Constant in Unsaturated Zc	0.0E+00s]
Vapor Pressure [mmHg]	95.2
Ethylbenzene	
Solubility [mg/l]	152
Diffusion Coeff. in Air [cm^2/s]	0.066
Henrys Constant [Atm/m^3/mol]	2.87E-01
Koc [ug/gOC/ug/ml]	1100
Degradation Rate Constant in Unsaturated Zc	0.00E+00]

Vapor Pressure [mmHg]	7
·Toluene	
Solubility [mg/l]	535
Diffusion Coeff. in Air [cm^2/s]	0.078
Henrys Constant [Atm/m^3/mol]	2.84E-01
Koc [ug/gOC/ug/ml]	300
Degradation Rate Constant in Unsaturated Zc	0.00E+00]
Vapor Pressure [mmHg]	28.1
Xylene	
Solubility [mg/l]	198
Diffusion Coeff. in Air [cm^2/s]	0.072
Henrys Constant [Atm/m^3/mol]	3.15E-01
Koc [ug/gOC/ug/ml]	240
Degradation Rate Constant in Unsaturated Zc	0.00E+00]
Vapor Pressure [mmHg]	10

Box Dispersion Model - Deterministic

Wind Speed [m/s]	2.5
Height of Box [m]	2
Width of Box [m]	2

Data for Risk Assessment

Body Weight and Lifetime - Deterministic

Average Weight (kg)	70
Lifetime (yrs)	70

Inhalation of Soil Emissions

Exposure Frequency [days/yr]	350
Exposure Duration [years]	9
Inhalation Rate [m^3/hr]	0.833
Time Outdoors [hours/day]	3

Inhalation of Soil Emissions Chemical Specific Parameters

Benzene	
Bioavailability [fraction]	1
Ethylbenzene	
Bioavailability [fraction]	1
Toluene	
Bioavailability [fraction]	1
Xylene	
Bioavailability [fraction]	1

Dermal Contact with Soil

Exposure Frequency [days/yr]	350
Exposure Duration [years]	9
Skin Surface Area [cm^2]	3120.
Adherence Factor [mg/cm^2]	0.6

Dermal Contact Chemical Specific Parameters

Benzene	
Dermal Absorption Factors [fraction]	1
Ethylbenzene	
Dermal Absorption Factors [fraction]	1
Toluene	
Dermal Absorption Factors [fraction]	1
Xylene	
Dermal Absorption Factors [fraction]	1

Dermal Dose

Benzene	
Slope Factor [1/(mg/kg-day)]	0.029
Reference Dose [mg/kg-day]	ND
Ethylbenzene	

Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	0.1
Toluene	
Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	0.2
Xylene	
Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	2

Inhalation Dose

Benzene	
Slope Factor [1/(mg/kg-day)]	0.029
Reference Dose [mg/kg-day]	ND
Ethylbenzene	
Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	2.86E-1
Toluene	
Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	1.14E-1
Xylene	
Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	0.2

Analysis for #9-5630 Residential Receptor Concentration in Air
Receptor Point Concentration in Air

Averaging Time* [Years]	Benzene [mg/m^3]	Ethylbenzene [mg/m^3]	Toluene [mg/m^3]	Xylene [mg/m^3]
5	2.67E-04	1.93E-05	1.08E-04	1.73E-05
10	1.92E-04	1.92E-05	1.00E-04	9.43E-06
15	1.43E-04	1.90E-05	9.11E-05	6.34E-06
20	1.11E-04	1.88E-05	8.21E-05	4.76E-06
25	9.02E-05	1.85E-05	7.40E-05	3.81E-06
30	7.55E-05	1.82E-05	6.71E-05	3.17E-06
35	6.49E-05	1.78E-05	6.10E-05	2.72E-06
40	5.68E-05	1.75E-05	5.58E-05	2.38E-06
45	5.05E-05	1.71E-05	5.11E-05	2.11E-06
50	4.54E-05	1.61E-05	4.70E-05	1.90E-06
55	4.54E-05	1.61E-05	4.70E-05	1.90E-06
60	4.54E-05	1.61E-05	4.70E-05	1.90E-06
65	4.54E-05	1.61E-05	4.70E-05	1.90E-06
70	4.54E-05	1.61E-05	4.70E-05	1.90E-06
75	4.54E-05	1.61E-05	4.70E-05	1.90E-06

*The maximum RUNNING average concentration is shown for these averaging times.
For example, the maximum 5-year average concentration may not occur in the first five years.
To find out when the maximum RUNNING concentrations occured, view the charts.
Simulation Time = 75 Years
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Analysis for #9-5630 Residential Receptor Point Soil Concentration
Receptor Point Concentration in Soil

Averaging Time* [Years]	Benzene [mg/kg]	Ethylbenzene [mg/kg]	Toluene [mg/kg]	Xylene [mg/kg]
5	8.99E-04	9.62E-04	1.27E-03	1.56E-04
10	6.46E-04	9.56E-04	1.17E-03	8.51E-05
15	4.80E-04	9.47E-04	1.06E-03	5.72E-05
20	3.74E-04	9.35E-04	9.58E-04	4.29E-05
25	3.03E-04	9.21E-04	8.63E-04	3.43E-05
30	2.54E-04	9.05E-04	7.83E-04	2.86E-05
35	2.18E-04	8.88E-04	7.12E-04	2.45E-05
40	1.91E-04	8.69E-04	6.50E-04	2.15E-05
45	1.70E-04	8.50E-04	5.96E-04	1.91E-05
50	1.53E-04	8.02E-04	5.49E-04	1.72E-05
55	1.53E-04	8.02E-04	5.49E-04	1.72E-05
60	1.53E-04	8.02E-04	5.49E-04	1.72E-05
65	1.53E-04	8.02E-04	5.49E-04	1.72E-05
70	1.53E-04	8.02E-04	5.49E-04	1.72E-05
75	1.53E-04	8.02E-04	5.49E-04	1.72E-05

*The maximum RUNNING average concentration is shown for these averaging times.
For example, the maximum 5-year average concentration may not occur in the first five years.
To find out when the maximum RUNNING concentrations occured, view the charts.
Simulation Time = 50 Years
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Analysis for #9-5630 Residential Receptor Point Volatile Emissions From Site Contaminated Soils
Volatile Emissions

Averaging Time* [Years]	Benzene [kg/year]	Ethylbenzene [kg/year]	Toluene [kg/year]	Xylene [kg/year]
5	8.41E-02	6.10E-03	3.42E-02	5.46E-03
10	6.06E-02	6.06E-03	3.16E-02	2.98E-03
15	4.50E-02	6.01E-03	2.87E-02	2.00E-03
20	3.51E-02	5.93E-03	2.59E-02	1.50E-03
25	2.84E-02	5.84E-03	2.33E-02	1.20E-03
30	2.38E-02	5.74E-03	2.12E-02	1.00E-03
35	2.05E-02	5.63E-03	1.93E-02	8.57E-04
40	1.79E-02	5.51E-03	1.76E-02	7.50E-04
45	1.59E-02	5.39E-03	1.61E-02	6.67E-04
50	1.43E-02	5.08E-03	1.48E-02	6.00E-04
55	1.43E-02	5.08E-03	1.48E-02	6.00E-04
60	1.43E-02	5.08E-03	1.48E-02	6.00E-04
65	1.43E-02	5.08E-03	1.48E-02	6.00E-04
70	1.43E-02	5.08E-03	1.48E-02	6.00E-04
75	1.43E-02	5.08E-03	1.48E-02	6.00E-04

*The maximum RUNNING average concentration is shown for these averaging times.
For example, the maximum 5-year average concentration may not occur in the first five years.
To find out when the maximum RUNNING concentrations occured, view the charts.
Simulation Time = 50 Years
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Analysis for Residential Risk at #9-5630

Carcinogenic Risk by Chemical for Each Route of Concern

Chemical	Inhalation of Soil Emissions	Dermal Contact With Soil	Total
Benzene	3.40E-08	8.59E-11	3.41E-08
Ethylbenzene	ND	ND	0.00E+00
Toluene	ND	ND	0.00E+00
Xylene	ND	ND	0.00E+00
Total	3.40E-08	8.59E-11	3.41E-08

Hazard Index by Chemical for Each Route of Concern

Chemical	Inhalation of Soil Emissions	Dermal Contact With Soil	Total
Benzene	ND	ND	0.00E+00
Ethylbenzene	2.31E-06	2.47E-07	2.56E-06
Toluene	3.26E-05	1.62E-07	3.28E-05
Xylene	2.96E-06	2.00E-09	2.96E-06
Total	3.79E-05	4.11E-07	3.83E-05

Deterministic Run
ND = Not Determined because RfD or Slope Factor not entered
NA = Not Applicable
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