APPENDIX A

CALCULATION OF AIR CONCENTRATIONS FOR CHEMICALS RELEASED FROM SOIL

This appendix describes the calculation of volatile chemical concentrations in ambient air resulting from volatilization from on-site soils. The calculated air concentrations were used to estimate inhalation exposures for commercial/industrial workers and construction workers. The discussion is organized as follows:

- Calculation of on-site air concentrations for chemicals volatilized from soil.
- Calculation of the volatilization factors (VFs) and chemical flux estimates used in estimating air concentrations in the preceding calculations.

<u>Calculation of Air Concentrations</u>
On-site air concentrations of the chemicals of concern were calculated by dividing the soil concentration of the chemical (in mg/kg) by the appropriate volatilization factor (VF). The resultant concentrations were then used to assess exposure and risk for on-site receptors (i.e., on-site worker, trespasser, and the construction worker).

On-site air concentration (mg/m^3) for volatile chemicals = $\dfrac{\text{Soil concentration (mg / kg)}}{\text{VF }(m^3/\text{kg})}$

<u>Calculation of Volatilization Factors (VFs)</u>
VOCs having a Henry's Law Constant greater than 10^{-5} ($atm\text{-}m^3/mol$) and a molecular weight less than 200. In addition, TPH as gasoline was also considered to be a VOC.

Several of the terms used in the calculation of the VF are chemical-specific; they were derived from physical and chemical information obtained from the SFRWQCB guidance (SFRWQCB, 2003) and USEPA's <u>Soil Screening Guidance: Technical Background Document</u> (USEPA, 1996). In those cases where air diffusivities (Di) and Henry's Law Constants were not provided in the SFRWQCB or USEPA reference, Di's and Henry's Law Constants were derived based on analogy to structurally similar chemicals.

The equation presented below was used to calculate VFs for the volatile chemicals of concern:

$$VF\ (m^3/kg) = (Q/C) \times [(3.14 \times D_A \times T)^{0.5}/(2 \times d_b \times D_A)] \times 10^{-4}\ (m^2/cm^2)$$

where

$$DA = [(ø_a^{10/3}\ D_iH' + ø_w^{10/3}D_W)/n^2]/(d_bK_d + ø_W + ø_aH')$$

and

D_A = Apparent diffusivity, cm^2/s

Q/C = Inverse of the mean concentration of the Hookston Station site (g/m^2-sec per kg/m^3) [A 30-acre source area with a Q/C value of 46.06 for the San Francisco area; USEPA, 1996]

T = Exposure interval, seconds [equal to the exposure duration expressed in second; commercial industrial worker, 7.88E+08 sec; construction worker, 2.21E+08 sec]

d_b = Dry soil bulk density, g/cm^3 [1.5 g/cm^3, USEPA, 1996]

$ø_a$ = Air filled porosity, L_{air}/L_{soil} [0.19; site-specific]

n = Total soil porosity, L_{pore}/L_{soil} [0.28; site-specific]

$ø_w$ = Water filled soil porosity, L_{water}/L_{soil} [0.0.09; site-specific]

d_s = Soil particle density, g/cm^3 [2.65 g/cm^3; USEPA, 1996]

D_i = Diffusivity in air, cm^2/sec [chemical-specific]

H = Henry's Law Constant, atm-m^3/mol [chemical-specific]

H' = Henry's Law Constant, dimensionless [chemical-specific]

D_w = Diffusivity in water, cm^2/sec [chemical-specific]

K_d = Soil water partition coefficient, cm^3/g [chemical-specific; $K_d = K_{oc} \times f_{oc}$]

K_{oc} = Soil organic carbon-water partition coefficient, cm^3/g [chemical-specific]

f_{oc} = Fraction organic carbon in soil, g/g [0.006; USEPA, 1996]

Chemical-specific inputs and calculated VFs and air concentrations are presented in the attached tables.

Model Inputs for Volatile Chemicals

Volatile Chemicals	Koc (cm^3/g)	Diffusivity in air (cm^2/sec)	Diffusivity in water (cm^2/sec)	Henrys Law ($atm\text{-}m^3/mol$)	Calculated Apparent Diffusivity (cm^2/sec)
Acetone	5.75E-01	0.124	1.14E-05	1.59E-03	9.95E-05
Benzene	5.90E+01	0.088	9.80E-06	2.28E-01	2.10E-03
2-Butanone	4.50E+00	0.0895	9.80E-06	1.12E-03	4.15E-05
Carbon disulfide	4.57E+01	0.104	1.00E-05	1.24E+00	1.11E-02
Chloroform	3.98E+01	0.104	1.00E-05	1.50E-01	2.21E-03
cis-1,2-DCE	3.55E+01	0.0736	1.13E-05	1.67E-01	1.86E-03
trans-1,2-DCE	5.25E+01	0.0707	1.19E-05	3.85E-01	2.91E-03
Ethylbenzene	3.63E+02	0.075	7.80E-06	3.23E-01	5.39E-04
Freon 113	1.60E+02	0.029	8.10E-06	2.10E+01	6.36E-03
2-Methylnaphthalene	7.20E+02	0.059	7.50E-06	1.19E-02	8.27E-06
Naphthalene	1.19E+03	0.059	7.50E-06	1.98E-02	8.39E-06
Tetrachloroethylene	1.55E+02	0.072	8.20E-06	7.54E-01	2.41E-03
Toluene	1.82E+02	0.087	8.60E-06	2.72E-01	9.90E-04
1,1,1-Trichloroethane	1.10E+02	0.078	8.80E-06	7.05E-01	3.21E-03
1,1,2-Trichloroethane	5.01E+01	0.078	8.80E-06	3.74E-02	3.72E-04
Trichloroethylene	1.66E+02	0.079	9.10E-06	4.22E-01	1.48E-03
Vinyl chloride	1.86E+01	0.106	1.23E-06	1.11E+00	1.46E-02
m-Xylene	4.07E+02	0.07	7.80E-06	3.01E-01	4.22E-04
o-Xylene	4.07E+02	0.07	7.80E-06	3.01E-01	4.22E-04
Acenaphthylene	2.50E+03	0.0421	7.69E-06	1.45E-03	2.14E-07
Anthracene	2.35E+04	0.0324	7.74E-06	6.50E-05	1.13E-09
Fluorene	1.38E+04	0.0363	7.88E-06	7.70E-05	2.37E-09
Phenanthrene	1.40E+04	0.0608	7.88E-06	3.93E-05	2.09E-09
Gasoline	5.00E+03	0.088	7.50E-06	7.20E-04	1.11E-07

Calculated VFs and Air Concentrations for Volatile Chemicals

Volatile Chemicals	Soil conc (mg/kg)	Commercial/ Industrial Worker VF (m^3/kg)	VOC air conc C/I worker (mg/m^3)	Construction Worker VF (m^3/kg)	VOC air conc Const worker (mg/m^3)
Acetone	0.0629	7.66E+03	8.21E-06	4.05E+03	1.55E-05
Benzene	0.001	1.67E+03	5.90E-07	8.82E+02	1.11E-06
2-Butanone	0.0316	1.19E+04	2.66E-06	6.28E+03	5.03E-06
Carbon disulfide	0.0029	7.26E+02	3.93E-06	3.84E+02	7.42E-06
Chloroform	0.0027	1.62E+03	1.66E-06	8.60E+02	3.14E-06
cis-1,2-DCE	0.082	1.77E+03	4.63E-05	9.38E+02	8.74E-05
trans-1,2-DCE	0.119	1.42E+03	8.40E-05	7.50E+02	1.59E-04
Ethylbenzene	0.0038	3.29E+03	1.15E-06	1.74E+03	2.16E-06
Freon 113	0.015	9.58E+02	1.57E-05	5.07E+02	2.96E-05
2-Methylnaphthalene	0.128	2.66E+04	4.82E-06	1.41E+04	9.10E-06
Naphthalene	0.162	2.64E+04	6.14E-06	1.40E+04	1.16E-05
Tetrachloroethylene	0.009	1.56E+03	5.79E-06	8.23E+02	1.09E-05
Toluene	0.011	2.43E+03	4.53E-06	1.29E+03	8.56E-06
1,1,1-Trichloroethane	0.009	1.35E+03	6.67E-06	7.14E+02	1.26E-05
1,1,2-Trichloroethane	0.001	3.96E+03	2.53E-07	2.10E+03	4.77E-07
Trichloroethylene	0.433	1.99E+03	2.18E-04	1.05E+03	4.12E-04
Vinyl chloride	0.0087	6.32E+02	1.38E-05	3.34E+02	2.60E-05
m-Xylene	0.0087	3.72E+03	2.34E-06	1.97E+03	4.42E-06
o-Xylene	0.0161	3.72E+03	4.33E-06	1.97E+03	8.18E-06
Acenaphthylene	0.337	1.65E+05	2.04E-06	8.75E+04	3.85E-06
Anthracene	0.213	2.27E+06	9.39E-08	1.20E+06	1.77E-07
Fluorene	0.0519	1.57E+06	3.31E-08	8.30E+05	6.25E-08
Phenanthrene	0.357	1.67E+06	2.14E-07	8.85E+05	4.03E-07
Gasoline	2.27	2.29E+05	9.90E-06	1.21E+05	1.87E-05

APPENDIX B

CALCULATION OF EXPOSURES TO CHEMICALS OF POTENTIAL CONCERN IN GROUND WATER USED FOR IRRIGATION AND FILLING SWIMMING POOLS

Irrigation Exposure Scenario

Shallow ground water is assumed to be used to irrigate a yard. In the irrigation scenario, residents are assumed to water a residential lawn during the warmest weeks of the year (18 weeks). Volatile organic compounds are assumed to completely volatilize over an 8 hour period starting with the onset of irrigation. Residents are assumed to be exposed over the entire 8 hour volatilization period by inhaling the volatilizing VOCs. Such a scenario is likely to occur over nighttime hours when residents are at home and evaporation of the irrigation water is efficiently minimized.

Chemicals of potential concern (COPCs) for the irrigation scenario were selected as those chemicals that were detected in ground water from 8 private wells located in the Hookston Station area.

The following assumptions were used to estimate VOC emissions from ground water used for irrigation.

Assumptions

Amount of ground water for irrigation

Conservatively, 7.62 cm (3 inches) of water per week are assumed to be needed for lawn irrigation weekly. According to Maddaus and Mayer ("Splash or Sprinkle? Comparing the Water Use of Swimming Pools and Irrigated Landscapes", undated), annual irrigation water use in arid climates (Boulder, Denver, San Diego, Phoenix, Tempe, Scottsdale, Walnut Valley, Las Virgenes, and Lompoc) ranged from 20.8 to 45.4 inches per year. Given the assumptions below (18 weeks of irrigation at 3 inches per week), annual irrigation with ground water is assumed to be 54 inches per year. This is a reasonably conservative estimate of the amount of ground water used to irrigate lawns in the Hookston Station area.

Number of weeks of lawn irrigation
Lawn irrigation is assumed to occur over 18 weeks (May 15 through September 15).

Number of irrigation events during the irrigation season
Lawns are assumed to be irrigated every other day for 18 weeks for 63 irrigation events per season or 3.5 events per week.

Area irrigated

The USEPA default residential exposure unit of 0.5 acre (20,235,000 cm^2) is assumed.

Total amount of water used per irrigation event
= (7.62 cm per week/3.5 irrigation events per week) x 20,235,000 cm^2 x 0.001 cm^3/L = 44,100 L

Rate of volatile emissions from ground water

VOCs are assumed to entirely volatilize within 8 hours.

Emission Calculations

The rate of volatilization of the VOCs from ground water used for irrigation is calculated according to the formula below:

VOC concentration in water (ug/L) x 1E-6 g/ug x 44,100 L/8 hours x (8 hours/28,800 seconds) x (1/20,250,000 cm^2) = Average rate of VOC flux (g/cm^2/sec)

Calculation of Air Concentrations
The residential VOC air concentrations of resulting from emission from using ground water/surface water for irrigation is calculated according to the formula:

$$C_{air} = \frac{Rate\,of\;VOC\;flux\;\;x\;10^4\;cm^2\;/\;m^2}{Q\,/\,C\;\;x\;10^{-6}\;kg\,/\,mg}$$

where:

CA= Concentration in air; ug/m^3

Rate of VOC flux = calculated value, g/cm^2/sec
If it is assumed that the VOC concentration in ground water is 1 ug/L, the calculated average rate of flux of VOCs during one irrigation event is calculated as

1 ug/L x 1E-6 g/ug x 44,100 L/8 hours x (8 hours/28,800 seconds) x (1/20,250,000 cm^2) = 7.56 x 10^{-14} g/cm^2-s

Q/C = inverse concentration factor for air dispersion for a 0.5 acre property in San Francisco (89.53 g/m^2-s per kg/m^3; USEPA, 1996)

Using the above equation and the assumptions discussed, the average air concentration after an irrigation event (assumed to be 8 hours) is 0.00846 ug/m^3. From this information, an irrigation specific volatilization factor can be calculated. This volatilization factor (VF_{irr}) is 0.00844 ug/m^3 per 1 ug/L or 0.00846 L/m^3. This value is used in calculating inhalation exposures to the chemicals of potential concern in ground water used for irrigation.

Calculated air concentrations by Hookston Station area location are presented in the table below.

Modeled Air Concentrations of VOCs from Irrigation Activity

Volatile Chemical	(a) Bermuda		(b) Bermuda		(c) Stimel		(d) Stimel	
	GW conc	Modeled air conc	GW conc	Modeled air conc	GW conc	Modeled air conc	GW conc	Modeled air conc
Acetone	26.0	0.2200	2.2	0.0186	12.0	0.1010	ND	NC
Chloromethane	ND	NC	0.8	0.0069	ND	NC	ND	NC
1,1-Dichloroethane	ND	NC	0.2	0.0014	ND	NC	ND	NC
1,2-Dichloroethane	ND	NC	ND	NC	ND	NC	ND	NC
1,1-Dichloroethene	11.0	0.0930	1.4	0.0118	5.0	0.0423	4.9	0.0414
cis-1,2-Dichloroethene	24.0	0.2030	0.3	0.0022	17.0	0.1440	37.0	0.3130
trans-1,2-Dichloroethene	ND	NC	ND	NC	2.4	0.0203	ND	NC
Tetrachloroethene	ND	NC	ND	NC	ND	NC	ND	NC
Trichloroethene	670.0	5.6600	29.0	0.2450	130.0	1.1000	210.0	1.7700
Vinyl chloride	ND	NC	ND	NC	1.0	0.0085	ND	NC

Volatile Chemical	(e) Stimel		(f) Gragg Lane		(g) Thames Dr		(h) Waterloo	
	GW conc	Modeled air conc	GW conc	Modeled air conc	GW conc	Modeled air conc	GW conc	Modeled air conc
Acetone	ND	NC	3.0	0.0254	ND	NC	12.0	0.1010
Chloromethane	ND	NC	0.9	0.0076	ND	NC	ND	NC
1,1-Dichloroethane	0.3	0.0025	ND	NC	1.8	0.0152	ND	NC
1,2-Dichloroethane	0.3	0.0024	ND	NC	ND	NC	ND	NC
1,1-Dichloroethene	1.7	0.0144	ND	NC	9.2	0.0777	4.4	0.0372
cis-1,2-Dichloroethene	12.0	0.1010	ND	NC	13.0	0.1100	6.5	0.0549
trans-1,2-Dichloroethene	0.5	0.0041	ND	NC	ND	NC	ND	NC
Tetrachloroethene	ND	NC	ND	NC	ND	NC	ND	NC
Trichloroethene	8.0	0.0676	ND	NC	500.0	4.2300	380.0	3.2100
Vinyl chloride	1.5	0.0127	ND	NC	ND	NC	ND	NC

GW conc = ground water concentration in ug/L

Modeled air conc = modeled air concentration from irrigation activities in ug/m^3

ND = not detected

NC = not calculated, chemical not detected in ground water

Swimming Exposure Scenario

In the swimming exposure scenario, a resident is assumed to fill a backyard pool with ground water containing the chemicals of potential concern. Chemicals of potential concern (COPCs) for the swimming exposure scenario were selected as those chemicals that were detected in ground water samples from 8 private wells in the Hookston Station area.

Exposure to the chemicals of potential concern in swimming pool water was assumed to occur via skin uptake during swimming, inhalation of volatilizing COPCs, and ingestion of pool water.

Pool filling was assumed to occur once per season. Ground water was also assumed to be used to make up for losses resulting from evaporation and splashing.

The swimming season is assumed to last 18 weeks (approximately May 15 through September 15) or 126 days. During this time, a child is assumed to swim 6 days per week for 1 hour per day.

Concentration of the COPCs in Swimming Pool Water
Due to their volatile nature, losses of the COPCs via volatilization are accounted for by assuming an average rate of volatilization in which 50% of the chemical in the pool water will volatilize with 3.5 days. A typical backyard swimming pool is 30 feet long x 15 feet wide x 5 feet deep and would contain approximately 2250 cubic feet or 64,000 liters of water. Based on estimates for the Sacramento area prepared by the California Spa and Pool Industry Energy, Codes and Legislative Council (SPEC, 2002), a pool this size would require approximately 1000 L per day of water to replenish the pool (from water losses caused by evaporation, splashing, etc.).

Assuming that 1000 L per day of ground water are needed to replenish the pool, the seasonal average COPC concentration the pool over 126 days is calculated below.

Assume 3.5 day half life (volatilization rate constant of 0.198 days^{-1})
Assume ground water concentration is 1 ug/L
Assume pool contains 64,000 L of ground water
The first day after filling, the concentration of COPC in pool after 24 hours of original filling = 1 mg/L x $e^{(-0.198 \times 1)}$ = 0.82 mg/L at a volume of 63,000L

Add to this 1000 L containing 1 ug/L- what is the adjusted COPC concentration in pool water?

(Concentration in pool x 63,000 L) + (1 ug/L x 1000 L) divided by 64,000 L

= 0.823 ug/L x $e^{(-0.198 \times 1)}$ = 0.675 ug/L at a volume of 63,000L

Add to this 1000 L containing 1 ug/L and the adjusted Day 2 COPC concentration in pool water is calculated as (0.675 ug/L x 63,000 L) + (1 ug/L x 1000 L) divided by 64,000 L = 0.68 ug/L. This calculation was repeated for 30 days. It was determined that the concentration declines to 0.083 mg/L after about 30 days and remains fairly constant from Day 30 through Day 126. The average COPC concentration in water over the 126 day swimming season is 0.122 ug/L. Based on these calculations, a swimming pool loss factor of 0.122 (0.122 ug/L divided by 1 ug/L) was calculated.

The equation used to calculate the dermally absorbed dose of the chemicals of concern in swimming pool water requires the calculation of a chemical-specific dermally absorbed dose through the skin. This value is called the DA_{event}.

For tetrachloroethylene and trichloroethylene, the DA_{event} was calculated using the following formula:

$$2\ x\ K_p\ x\ CW\ x\ 0.001 mg/ug\ x\ swimming\ pool\ loss\ factor\ x\ \frac{0.001 mg}{microgram}\ x\ \frac{L}{1000 cm^3}\ x\ \sqrt{\frac{6\ x\ tau\ x\ t_{event}}{pi}}$$

For all other VOCs of potential concern, DA_{event} was calculated using the formula presented below:

$$K_p\ x\ CW\ x\ 0.001 mg/ug\ x\ swimmimig\ pool\ loss\ factor\ x\ \left[\frac{t_{event}}{1+B}\right] + 2tau\ x\ \left[\frac{1+3B}{1+B}\right]$$

where:
DA_{event} =dermal dose absorbed through the skin per exposure event (mg/cm^2)
K_p = dermal permeability coefficient from Exhibit B-3 of USEPA, 2001 (cm/hr)
CW = concentration in water (ug /L)
tau = Chemical-specific; from Exhibit B-3 of USEPA, 2001 (hours)
t_{event} = hours of exposure to water per event (1 hour)
pi = 3.14

The values of K_p, tau, and the calculated DA_{event} by Hookston Station location are presented in the tables below.

Values for K_p and tau for the Chemicals of Potential Concern

Chemical	K_p	tau
Acetone	0.0006	0.27
Chloromethane	0.0033	0.2
1,1-Dichloroethane	0.0067	0.38
1,2-Dichloroethane	0.0042	0.38
1,1-Dichloroethene	0.012	0.37
cis-1,2-Dichloroethene	0.0077	0.37
trans-1,2-Dichloroethene	0.0077	0.37
Tetrachloroethene	0.033	0.91
Trichloroethene	0.012	0.58
Vinyl chloride	0.0056	0.24

Modeled DA_{event} by Hookston Station Site Location

Volatile Chemical	(a) Bermuda		(b) Bermuda		(c) Stimel		(d) Stimel	
	GW conc	DA_{event}	GW conc	DA_{event}	GW conc	DA_{event}	GW conc	DA_{event}
Acetone	26.0	2.78E-09	2.2	2.35E-10	12.0	1.28E-09	ND	NC
Chloromethane	ND	NC	0.8	4.62E-10	ND	NC	ND	NC
1,1-Dichloroethane	ND	NC	0.2	2.45E-10	ND	NC	ND	NC
1,2-Dichloroethane	ND	NC	ND	NC	ND	NC	ND	NC
1,1-Dichloroethene	11.0	2.80E-08	1.4	3.57E-09	5.0	1.27E-08	4.9	1.25E-08
cis-1,2-Dichloroethene	24.0	3.92E-08	0.3	4.25E-10	17.0	2.78E-08	37.0	6.05E-08
trans-1,2-Dichloroethene	ND	NC	ND	NC	2.4	3.92E-09	ND	NC
Tetrachloroethene	ND	NC	ND	NC	ND	NC	ND	NC
Trichloroethene	670.0	2.07E-06	29.0	8.94E-08	130.0	4.01E-07	210.0	6.47E-07
Vinyl chloride	ND	NC	ND	NC	1.0	1.01E-09	ND	NC

Volatile Chemical	(e) Stimel		(f) Gragg Lane		(g) Thames Dr		(h) Waterloo	
	GW conc	DA_{event}	GW conc	DA_{event}	GW conc	DA_{event}	GW conc	DA_{event}
Acetone	ND	NC	3.0	3.21E-10	ND	NC	12.0	1.28E-09
Chloromethane	ND	NC	0.9	5.07E-10	ND	NC	ND	NC
1,1-Dichloroethane	0.3	4.17E-10	ND	NC	1.8	2.59E-09	ND	NC
1,2-Dichloroethane	0.3	2.53E-10	ND	NC	ND	NC	ND	NC
1,1-Dichloroethene	1.7	4.33E-09	ND	NC	9.2	2.34E-08	4.4	1.12E-08
cis-1,2-Dichloroethene	12.0	1.96E-08	ND	NC	13.0	2.13E-08	6.5	1.06E-08
trans-1,2-Dichloroethene	0.5	8.01E-10	ND	NC	ND	NC	ND	NC
Tetrachloroethene	ND	NC	ND	NC	ND	NC	ND	NC
Trichloroethene	8.0	2.47E-08	ND	NC	500.0	1.54E-06	380.0	1.17E-06
Vinyl chloride	1.5	1.52E-09	ND	NC	ND	NC	ND	NC

GW conc = ground water concentration in ug/L
DA_{event} = dermal absorption per swim in mg/cm^2
ND = not detected
NC = not calculated, chemical not detected in ground water

Concentration of COPCs in Air Above Swimming Pool

The air concentration of COPCs above the pool was calculated to evaluate swimmer inhalation of VOCs over the swimming season. Given the assumed half-life of 3.5 days for VOC volatilization from pool water, the average emission rate of VOCs from a swimming pool containing 1 mg/L of VOC is calculated as

$$\frac{1 ug / L \ x \ 64{,}000 L \ x \ 0.5}{86{,}400 \sec onds / day \ x \ 3.5 days} = 0.106 ug / s$$

To calculate a seasonal average emission rate, the emission rate is multiplied by swimming pool loss factor of 0.122 (calculated above) to give a seasonally adjusted emission rate of 0.0127 ug/s (0.106 ug/s x 0.12).

The box model was used to calculate air concentrations above the swimming pool at receptor height. The seasonally adjusted air concentration is 0.000977 ug/m^3 where

Seasonally adjusted emission rate = 0.0129 ug/s
Receptor height above water = 0.5 m
Side of pool perpendicular to the wind = 6.5 m (square root of pool area)
Wind speed = 4 m/s (http://ggweather.com/ca_climate/wind.htm)

$$\frac{0.0127 \text{ ug/s}}{0.5 \text{ m x } 6.5 \text{ m x } 4 \text{ m/s}} = 0.000977 \text{ ug/m}^3$$

A seasonally adjusted swimming pool volatilization factor (VF_{pool}) can be calculated as 0.000977 ug/m^3 per 1 ug/L or 0.000977 L/m^3. This value is used in calculating risk-based concentrations for the chemicals of potential concern in ground water used for swimming pools.

Calculated air concentrations of the VOCs of potential concern over a swimming pool filled with ground water are presented in the table below.

Modeled Air Concentrations of VOCs Over a Swimming Pool

Volatile Chemical	(a) Bermuda		(b) Bermuda		(c) Stimel		(d) Stimel	
	GW conc	Modeled air conc	GW conc	Modeled air conc	GW conc	Modeled air conc	GW conc	Modeled air conc
Acetone	26.0	2.59E-02	2.2	2.19E-03	12.0	1.19E-02	ND	NC
Chloromethane	ND	NC	0.8	8.16E-04	ND	NC	ND	NC
1,1-Dichloroethane	ND	NC	0.2	1.69E-04	ND	NC	ND	NC
1,2-Dichloroethane	ND	NC	ND	NC	ND	NC	ND	NC
1,1-Dichloroethene	11.0	1.09E-02	1.4	1.39E-03	5.0	4.97E-03	4.9	4.87E-03
cis-1,2-Dichloroethene	24.0	2.39E-02	0.3	2.59E-04	17.0	1.69E-02	37.0	3.68E-02
trans-1,2-Dichloroethene	ND	NC	ND	NC	2.4	2.39E-03	ND	NC
Tetrachloroethene	ND	NC	ND	NC	ND	NC	ND	NC
Trichloroethene	670.0	6.67E-01	29.0	2.89E-02	130.0	1.29E-01	210.0	2.09E-01
Vinyl chloride	ND	NC	ND	NC	1.0	9.95E-04	ND	NC

Volatile Chemical	(e) Stimel		(f) Gragg Lane		(g) Thames Dr		(h) Waterloo	
	GW conc	Modeled air conc	GW conc	Modeled air conc	GW conc	Modeled air conc	GW conc	Modeled air conc
Acetone	ND	NC	3.0	2.98E-03	ND	NC	12.0	1.19E-02
Chloromethane	ND	NC	0.9	8.95E-04	ND	NC	ND	NC
1,1-Dichloroethane	0.3	2.89E-04	ND	NC	1.8	1.79E-03	ND	NC
1,2-Dichloroethane	0.3	2.79E-04	ND	NC	ND	NC	ND	NC
1,1-Dichloroethene	1.7	1.69E-03	ND	NC	9.2	9.15E-03	4.4	4.38E-03
cis-1,2-Dichloroethene	12.0	1.19E-02	ND	NC	13.0	1.29E-02	6.5	6.47E-03
trans-1,2-Dichloroethene	0.5	4.87E-04	ND	NC	ND	NC	ND	NC
Tetrachloroethene	ND	NC	ND	NC	ND	NC	ND	NC
Trichloroethene	8.0	7.96E-03	ND	NC	500.0	4.97E-01	380.0	3.78E-01
Vinyl chloride	1.5	1.49E-03	ND	NC	ND	NC	ND	NC

GW conc = ground water concentration in ug/L
Modeled air conc = modeled air concentration from irrigation activities in ug/m^3
ND = not detected
NC = not calculated, chemical not detected in ground water

References

USEPA 2001. Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment Interim) Review Draft for Public Comment. September 2001. EPA/540/R/99/005 PB99-963312

APPENDIX C

CALCULATION OF AIR CONCENTRATIONS FOR CHEMICALS VOLATILIZING FROM WALNUT CREEK SURFACE WATER

This appendix describes the calculation of volatile chemical concentrations in ambient air released from Walnut Creek surface water. The method used is from Thomas, 1990. cis-1,2-Dichloroethylene (cis-1,2-DCE), tetrachloroethylene (PCE), and trichloroethylene (TCE) were detected in Walnut Creek surface water in samples collected in 2002 (ERM, 2004).

According to Thomas (1990), emissions from surface water from a stream or river may be calculated by determining the mass transfer coefficient (K_L), estimating the emission rate in milligrams of chemical release per second, and calculating a modeled air concentration in milligrams of chemical per cubic meter of air.

<u>Calculation of Mass Transfer Coefficient</u>

According to methods described by Thomas (1990), the mass transfer coefficients may be calculated by calculating the gas (k_g) and liquid phase (k_l) coefficients and using these values to calculate the overall mass transfer coefficient (K_L).

k_g (in cm/hr) is calculated as:

$$k_g = 1137.5 \; x \left(V_{wind} + V_{curr}\right) x \sqrt{\frac{18}{M}}$$

and

k_l (in cm/hr) is calculated as:

$$k_l = 23.51 \; x \left(\frac{V_{curr}^{0.969}}{Z^{0.673}}\right) x \sqrt{\frac{32}{M}} \; x \, e^{0.526 \, x \, (V_{wind} - 1.9)}$$

and

K_L (in cm/hr) is calculated as:

$$K_L = \frac{H' \, x \, k_g \; x \, k_l}{\left(H' \, x \, k_g\right) + k_l}$$

Where:

V_{wind} = windspeed in m/s; a value of 4 m/s was assumed for the Walnut Creek area

V_{curr} = stream flow velocity in m/s; a value of 1 m/s was assumed for Walnut Creek

M = molecular weight of the chemical of interest

Z = depth of the stream in meters; the depth of Walnut Creek was assumed to be 0.61 m

H' = Henry's Law constant, unitless; values for cis-1,2-DCE, PCE, and TCE are 0.167, 0.754, 0.422, respectively.

Emissions of VOCs from Walnut Creek surface water may be calculated by the equation

$$E = K_L \text{ x hr/3600s x CW x1 L/1000 cm}^3 \text{ x A}$$

Where:

E = emission rate in ug/s

K_L = the calculated chemical-specific mass transfer coefficient in cm/hr

CW = concentration of VOC in surface water in ug/L

A = area in cm^2; the area of the stream assumed to continuously emit VOCs is assumed to be 30 feet wide (914 cm) by the length of a 0.5 acre lot (about 148 feet or 4500 cm) = 4.11×10^6 cm^2

Air concentrations of the VOCs near the stream (CA) were calculated using a simple box model as

$$CA = \frac{E}{LS\ x\ \mathrm{V}\ x\ MH}$$

Where:

CA = concentration of VOC in air in ug/m^3

E = emission rate in ug/s

LS = length of the side perpendicular to the wind; this value is assumed to be the length of a side of a 0.5 acre lot (45 meters)

MH = mixing height; assumed to be 2 m

Calculated k_g, k_l, K_L, E, and CA values are presented in the attached table.

Reference

Thomas, R.G. 1990. Chapter 15. Volatilization from Water. In: *Handbook of Chemical Property Estimation Methods.* Ed: W. J. Lyman, W. F. Reehl, and D. H. Rosenblatt. American Chemical Society. Washington, D.C.

Calculation of VOC Concentrations in Air Emitted from Surface Water
Inputs and Calculated Constants and Concentrations

Volatile Chemicals	Surface Water Concentration	Gas phase Transfer Coefficient (k_g)	Liquid phase transfer coefficient (k_l)	Overall Mass Transfer Coefficient (K_L)	Emission rate (E)	Calculated Air Concentration (CA)
	ug/L	cm/hr	cm/hr	cm/hr	ug/s	ug/m^3
cis-1,2-Dichloroethylene	1.4	2450	56.84	49.91	79.82	0.222
Tetrachloroethylene	2.6	1873	43.45	42.15	125.2	0.348
Trichloroethylene	3.3	2108	48.91	46.36	174.8	0.486

APPENDIX D

ESTIMATION OF LEAD EXPOSURE

Unlike other chemicals for which human exposure is calculated in terms of chemical intake (intake in milligrams of chemical per kilogram of body weight per day, mg/kg/day), exposure and risks associated with exposure to lead are based on an estimated blood lead concentration. Due to the existence of a growing database relating blood lead concentration (typically expressed in terms of micrograms of lead per deciliter of blood, µg/dL) and human toxicity, blood lead concentration is the most direct means by which the toxic effects of lead in humans can be assessed.

The State of California DTSC, United States Environmental Protection Agency (EPA), and others have developed lead exposure models for evaluating blood lead concentrations associated with intake of lead from food, water, air, and soil. An updated version of California DTSC lead exposure model (Leadspread 7) was used in this HRA to predict blood lead increases for the future on-site resident and construction worker. The model also includes lead exposure from background sources including air, food, and water.

The DTSC uses a 10 µg/dL blood lead concentration as its "concentration of concern" in both children and adults. This level is consistent with USEPA's guidance regarding lead exposure in children. However, this level is lower than California Occupational and Health Administration's (Cal OSHA) guidance with regard to construction workers. CCR (California Code of Regulations) Title 8 § 1532.1 requires that a construction worker be removed for medical reasons if any blood lead test on the worker yields a blood lead concentration that is at or above 50 µg/dL. A blood lead concentration of 40 µg/dL to 49 µg/dL triggers several employee notification requirements. Appendix A to §1532.1 indicates that maintaining a blood lead concentration below 30 µg/dL is a "health protection goal".

Thus, while the regulation does not establish a medical removal for a blood lead concentration level less than 40 µg/dL, it does recommend that worker blood lead levels be lower than 30 µg/dL. Thus, Cal OSHA regulations allow for higher levels of worker exposure than the current DTSC point of departure of 10 µg/dL.

The site-specific exposure inputs used in the DTSC lead exposure model are presented in table below. All other exposure inputs used in the DTSC lead exposure model were DTSC default residential or occupational values.

Calculated blood lead concentrations for the future on-site resident, future on-site worker, and future construction worker are presented in the attached tables. Tables 1 and 2 present blood lead calculation results for the on-site commercial/industrial worker and construction worker exposed to lead in soil in the 0 to 10 feet bgs depth range. The calculated blood lead concentrations were below 10 µg/dL for both workers even at the 99^{th} percentile of calculated blood lead concentrations.

*Site-Specific Exposure Parameters for Lead Exposure Model

Parameter	Input	Source/Comment
Lead in Soil/Dust	0-10' bgs soils = 104 ug/g	Calculated 95% upper confidence limit on the arithmetic mean concentrations of soil lead
Lead in water	1 µg/L	The 90^{th} percentile at the tap drinking water lead concentrations was "ND" Annual Water Quality Report 2003 Contra Costa County Water District. The 1 ug/L value is one-half the State of California Public Health Goal for drinking water.
Respirable dust	Construction worker 700 $\mu g/m^3$	Construction worker RWQCB default
Soil Ingestion	Construction worker 165 mg	Soil ingestion was assumed to be one-half of default upper bound soil ingestion rate for construction workers (330 mg/day) in keeping with the use of central tendency estimates of soil exposure. For the purpose of blood lead exposure calculations, the DTSC sets soil ingestion rates for the child and adult resident at one-half of the USEPA default upper bound value.

*Unless specified in this table, default Leadspread exposure parameter used

Table 1
On-Site Commercial/Industrial Worker Soil Exposure-0 to 10 feet bgs Soil

LEAD RISK ASSESSMENT SPREADSHEET

CALIFORNIA DEPARTMENT OF TOXIC SUBSTANCES CONTROL

USER'S GUIDE to version 7

INPUT	
MEDIUM	LEVEL
Lead in Air (ug/m^3)	0.028
Lead in Soil/Dust (ug/g)	104.0
Lead in Water (ug/l)	1
% Home-grown Produce	7%
(ug/m^3)	1.5

OUTPUT							
	Percentile Estimate of Blood Pb (ug/dl)					PRG-99	PRG-95
	50th	90th	95th	98th	99th	(ug/g)	(ug/g)
BLOOD Pb, OCCUPATIONAL	0.4	0.7	0.8	1.0	1.2	4692	6681

EXPOSURE PARAMETERS			
	units	adults	children
Days per week	days/wk	7	
Days per week, occupational		5	
Geometric Standard Deviation		1.6	
Blood lead level of concern (ug/dl)		10	
Skin area, residential	cm^2	5700	2900
Skin area occupational	cm^2	2900	
Soil adherence	ug/cm^2	70	200
Dermal uptake constant	(ug/dl)/(ug/d	0.0001	
Soil ingestion	mg/day	50	100
Soil ingestion, pica	mg/day		200
Ingestion constant	(ug/dl)/(ug/d	0.04	0.16
Bioavailability	unitless	0.44	
Breathing rate	m^3/day	20	6.8
Inhalation constant	(ug/dl)/(ug/d	0.08	0.19
Water ingestion	l/day	1.4	0.4
Food ingestion	kg/day	1.9	1.1
Lead in market basket	ug/kg	3.1	
Lead in home-grown produce	ug/kg	46.8	

Click here for REFERENCES

PATHWAYS						
ADULTS	Residential			Occupational		
	Pathway contribution			Pathway contribution		
Pathway	PEF	ug/dl	percent	PEF	ug/dl	percent
Soil Contact	3.8E-5	0.00	#DIV/0!	1.4E-5	0.00	0%
Soil Ingestion	8.8E-4	0.09	#DIV/0!	6.3E-4	0.07	17%
Inhalation, bkgrnd		0.05	#DIV/0!		0.03	8%
Inhalation	2.5E-6	0.00	#DIV/0!	1.8E-6	0.00	0%
Water Ingestion		0.06	#DIV/0!		0.06	14%
Food Ingestion, bkgrnd		0.22	#DIV/0!		0.23	60%
Food Ingestion	2.4E-3	0.25	#DIV/0!			0%

CHILDREN	typical			with pica		
	Pathway contribution			Pathway contribution		
Pathway	PEF	ug/dl	percent	PEF	ug/dl	percent
Soil Contact	5.6E-5	0.01	#DIV/0!		0.01	#DIV/0!
Soil Ingestion	7.0E-3	0.73	#DIV/0!	1.4E-2	1.46	#DIV/0!
Inhalation	2.0E-6	0.00	#DIV/0!		0.00	#DIV/0!
Inhalation, bkgrnd		0.04	#DIV/0!		0.04	#DIV/0!
Water Ingestion		0.06	#DIV/0!		0.06	#DIV/0!
Food Ingestion, bkgrnd		0.50	#DIV/0!		0.50	#DIV/0!
Food Ingestion	5.5E-3	0.58	#DIV/0!		0.58	#DIV/0!

Table 2

On-Site Construction Worker Soil Exposure-0 to 10 feet bgs Soil

LEAD RISK ASSESSMENT SPREADSHEET

CALIFORNIA DEPARTMENT OF TOXIC SUBSTANCES CONTROL

USER'S GUIDE to version 7

INPUT	
MEDIUM	LEVEL
Lead in Air (ug/m^3)	0.028
Lead in Soil/Dust (ug/g)	104.0
Lead in Water (ug/l)	1
% Home-grown Produce	7%
(ug/m^3)	700

OUTPUT							
	Percentile Estimate of Blood Pb (ug/dl)					PRG-99	PRG-95
	50th	90th	95th	98th	99th	(ug/g)	(ug/g)
BLOOD Pb, OCCUPATION/	0.6	1.1	1.4	1.6	1.9	1039	1480

EXPOSURE PARAMETERS			
	units	adults	children
Days per week	days/wk	7	
Days per week, occupational		5	
Geometric Standard Deviation		1.6	
Blood lead level of concern (ug/dl)		10	
Skin area, residential	cm^2	5700	2900
Skin area occupational	cm^2	2900	
Soil adherence	ug/cm^2	70	200
Dermal uptake constant	(ug/dl)/(ug/d	0.0001	
Soil ingestion	mg/day	165	100
Soil ingestion, pica	mg/day		200
Ingestion constant	(ug/dl)/(ug/d	0.04	0.16
Bioavailability	unitless	0.44	
Breathing rate	m^3/day	20	6.8
Inhalation constant	(ug/dl)/(ug/d	0.08	0.19
Water ingestion	l/day	1.4	0.4
Food ingestion	kg/day	1.9	1.1
Lead in market basket	ug/kg	3.1	
Lead in home-grown produce	ug/kg	46.8	

Click here for REFERENCES

PATHWAYS						
ADULTS	Residential			Occupational		
	Pathway contribution			Pathway contribution		
Pathway	PEF	ug/dl	percent	PEF	ug/dl	percent
Soil Contact	3.8E-5	0.00	#DIV/0!	1.4E-5	0.00	0%
Soil Ingestion	2.9E-3	0.30	#DIV/0!	2.1E-3	0.22	35%
Inhalation, bkgrnd		0.05	#DIV/0!		0.03	5%
Inhalation	1.1E-3	0.12	#DIV/0!	8.2E-4	0.09	14%
Water Ingestion		0.06	#DIV/0!		0.06	9%
Food Ingestion, bkgrnd		0.22	#DIV/0!		0.23	37%
Food Ingestion	2.4E-3	0.25	#DIV/0!			0%

CHILDREN	typical			with pica		
	Pathway contribution			Pathway contribution		
Pathway	PEF	ug/dl	percent	PEF	ug/dl	percent
Soil Contact	5.6E-5	0.01	#DIV/0!		0.01	#DIV/0!
Soil Ingestion	7.0E-3	0.73	#DIV/0!	1.4E-2	1.46	#DIV/0!
Inhalation	9.1E-4	0.10	#DIV/0!		0.10	#DIV/0!
Inhalation, bkgrnd		0.04	#DIV/0!		0.04	#DIV/0!
Water Ingestion		0.06	#DIV/0!		0.06	#DIV/0!
Food Ingestion, bkgrnd		0.50	#DIV/0!		0.50	#DIV/0!
Food Ingestion	5.5E-3	0.58	#DIV/0!		0.58	#DIV/0!