PACIFIC
ENVIRONMENTAL
GROUP, INC.

Phil Briggs (510) 930-3560

FACSIMILE TRANSMITTAL

DATE: July 29, 1997 PROJECT #: 240-001.2G

TO: Ms. Jennifer Eberle FAX: 510-337-9335

ACHCS

FROM: Michelle Gracia

IF YOU HAVE ANY PROBLEMS RECEIVING THIS FACSIMILE, PLEASE CALL (408) 441-7500

SHEETS TO FOLLOW COVER PAGE

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COMMENTS:

Dear Ms. Eberle: I am faxing you a revised copy of the Results of the Soil Vapor Investigation. I discovered that the Averaging Time used for the children's risk from benzene was too low. With the new value, the risk drops to 10E-6. Overall the report has not changed much, just that the benzene risk level for children has improved. Please call me if you have any questions regarding this change.

Sincerely,

Michelle Gracia

PACIFIC
ENVIRONMENTAL
GROUP, INC.

DRAFT
July 28, 1997
Project 320-162.1C

Mr. Phil Briggs
Chevron Products Company
P.O. Box 5004
San Ramon, California 94583

Re: Results of the Soil Vapor Investigation
Former Signal Service Station 0800
800 Center Street at Eighth Street
Oakland, California

Dear Mr. Briggs:

This letter, prepared by Pacific Environmental Group, Inc. (PACIFIC), on behalf of Chevron Products Company (Chevron), presents the results from the soil and soil vapor investigation at the site referenced above (Figure 1). This investigation was performed according to the *Work Plan* prepared by PACIFIC (April 30, 1997), which was approved by Ms. Jennifer Eberle of the Alameda County Health Care Services Agency (ACHCSA), with minor changes, in her letter to Chevron dated May 6, 1997. The changes included collecting soil analytical data as well as soil vapor data, moving Boring SV-1 to the location of former P-3, and adding two additional boring locations (SV-4 and SV-5). These changes were implemented.

SITE BACKGROUND

The site is located at the northeast corner of the intersection of Eighth Street and Center Street in Oakland, California. The former station building and the former pump islands remain at the site, however the site is currently unoccupied. Land use near the site is commercial and residential.

The site was utilized as a retail service station from 1932 to the early 1970s. Station facilities included four 1,000-gallon fuel underground storage tanks (USTs), a waste oil tank, a product island, and associated piping. The USTs were reportedly removed from

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the site during 1973. A complete description of the site background is presented in the *Work Plan*.

SOIL VAPOR INVESTIGATION

Soil Borings

As specified in the *Work Plan*, it has been proposed that the site be redeveloped, along with two adjacent properties, into residential housing. In order to determine if the remaining concentrations of petroleum hydrocarbons in the soil and groundwater at the former Signal service station would pose a risk to human health and safety, soil and soil vapor samples were collected from the site using Geoprobe borings. The locations of the five borings, SV-1 through SV-5, are presented on Figure 2.

Soil and Soil Vapor Analyses

The soil vapor samples were analyzed by EPA Method TO-3 (aromatic volatile organics in air) for concentrations of benzene, toluene, ethylbenzene, and xylenes (BTEX compounds), and total petroleum hydrocarbons (TPH). Along with the vapor analyses, the soil was analyzed for site-specific physical parameters, such as porosity, pH, and moisture content, by EPA Method 584 and ASTM Method D-2974. For the soil BTEX and TPH calculated as gasoline (TPH-g) concentrations, the soil samples were analyzed by EPA Method 8015/8020. The certified analytical results and the chain-of-custody documentation are presented in Attachment A. The soil vapor and physical data were then used to calculate the risk posed by the remaining petroleum hydrocarbon vapors at the site to indoor air inhalation for a residential population of adults and children (1 to 16 years).

Possible Exposure Routes

As stated in the *Work Plan*, the exposure routes deemed possible at the site are:

1. inhalation from groundwater and soil volatilization to indoor and outdoor air

2. dermal contact from any exposed surficial soils that may be impacted.

These exposure routes may affect both the residents who will live on the property and the construction workers who will build the residential housing complex.

For the inhalation exposure pathway, the risk posed by indoor air inhalation is considered the limiting factor. Since the risk from indoor air inhalation is greater, the risk posed from outdoor air inhalation was not calculated in this risk assessment.

INHALATION RISK MODELING

The soil vapor and physical soil data were entered into several equations from the American Society for Testing and Materials' (ASTM) *Standard Guide for Risk-Based corrective Action Applied at Petroleum Release Sites (E 1739-95)* (RBCA). These ASTM equations were compiled by Tom Fojut, Pleas McNeel, and Tim Utterback of Weiss Associates and by Ravi Arulanantham and Stephen Morse of the Regional Water Quality Control Board, San Francisco Bay Region (RWQCB) in order to more accurately model the risk posed to indoor air from the actual soil vapor concentrations in the surficial soil. This model was developed due to the overly conservative outcomes derived from ASTM's original models of risk posed by impacted soil and groundwater volatilizing into indoor air. These overly conservative outcomes were discussed in the *Work Plan*. Due to the extremely unrealistic cleanup-goals derived by these models during the Tier 1 and Tier 2 RBCAs previously performed for the site (*RBCA Analysis*, PACIFIC, April 1, 1997), the soil vapor samples described were collected to evaluate the actual risk posed by the remaining petroleum hydrocarbons at the site instead of relying upon a conservative model. The soil vapor measurements include both the volatilization from petroleum hydrocarbons remaining in soil and groundwater.

The new model developed by Weiss Associates and the RWQCB (presented as Attachment B) utilizes several equations already presented in ASTM's RBCA guidelines, however it removes some of the uncertainties associated with the former indoor air inhalation models. The new vapor model removes the idea of estimating a crack factor for the building's foundation; in the new model it is assumed that there is no foundation, only a dirt floor with direct flux from the soil. Therefore, the model incorporates actual physical and analytical data for more accurate outcomes, plus it is as conservative as the previous ASTM models.

The model allows the calculation of the actual risk posed by soil vapor samples from the site. Weiss Associates and the RWQCB also have back-calculated the highest acceptable levels of BTEX compounds (cleanup goals) for residential and commercial receptors based on ASTM's Tier 1 default parameters (also presented in Attachment B). The recommended maximum allowable concentrations or risk based screening levels (RBSL) of BTEX compounds in soil vapor at 3 feet bgs (no building slab assumed) for children aged 1 to 16 years are as follows:

- Benzene: 0.038 micrograms per liter (µg/L)

- Toluene: 103 µg/L
- Ethylbenzene: 304 µg/L
- Xylenes: 2,230 µg/L

The RBSLs presented above are for children in a residential scenario since these are the lowest concentrations allowed among adults and children and are based on a target risk of 10^{-6} for benzene and a hazard quotient of 1 for the non-carcinogenic compounds. As will be shown below, none of the TEX compound soil vapor concentrations collected from 3 feet bgs were greater than these RBSLs. However, Boring SV-1 had a benzene concentration of 0.17 µg/L at a depth of 3 feet. This concentration is slightly above the RBSL of 0.038 µg/L for a target risk level of 10^{-6}.

SOIL VAPOR INVESTIGATION RESULTS

All soil data collected from the site during the investigation was gathered following the protocols set forth in the *Work Plan* and with the ACHCSA changes. The resulting soil vapor TPH-g and BTEX concentrations collected from 3, 6, and 9 feet bgs are presented in Table 1. The physical soil data is presented in Table 2 and the soil analytical data is presented in Table 3. The soil boring logs are presented as Attachment C. Figures 3 through 7 present a graphical representation of the soil vapor BTEX concentrations from each boring plus the amount of oxygen and carbon dioxide collected from Borings SV-1 and SV-2.

As seen on Table 1, the maximum 3 feet bgs soil vapor concentration of benzene was 0.17 µg/L from Boring SV-1, which is located in the former UST complex. Borings SV-2 through SV-5 had no detectable benzene vapor concentrations at 3 feet bgs. The maximum 3 feet bgs soil vapor concentration of toluene was also collected from Boring SV-1, while the 3 feet bgs maximum soil vapor concentrations of ethylbenzene was from Boring SV-3 (1.5 µg/L), xylenes from Boring SV-3 (12 µg/L), and TPH from Boring SV-1 (360 µg/L). The overall maximum soil vapor concentrations of the BTEX compounds and TPH, including each depth, was distributed as follows:

- Maximum benzene: 65 µg/L from Boring SV-1 at 6 feet bgs
- Maximum toluene: 730 µg/L from Boring SV-1 at 9 feet bgs
- Maximum ethylbenzene: 340 µg/L from Boring SV-1 at 9 feet bgs
- Maximum xylenes: 1,400 µg/L from Boring SV-1 at 9 feet bgs
- Maximum TPH: 50,000 µg/L from Boring SV-1 at 6 feet bgs

As shown by the above data and Table 1, the highest soil vapor concentrations of BTEX compounds and TPH are located near the former UST complex.

The graphs presented on Figures 3 through 7 indicate the large degree of bioremediation and natural attenuation that occurs as the petroleum hydrocarbons volatilize upwards. All of the graphs indicate that at 3 feet bgs there are relatively insignificant concentrations of the compounds remaining. The fluctuations of oxygen and carbon dioxide also indicate that bioremediation is occurring at some of the sample locations, such as Boring SV-1 at 6 feet bgs. Bioremediation would be expected to cause a reduction in oxygen and an increase in carbon dioxide; this is seen very clearly in SV-1. On Figure 3, at 6 feet bgs the oxygen concentration dips to 18.97% from 20.97% at 3 feet, while the carbon dioxide concentration increases from 0.87% at 3 feet to 1% at 6 feet bgs. It is clear from the carbon dioxide and oxygen data, plus the soil vapor and soil analytical data, that the largest amount of bioremediation is occurring at approximately 6 feet bgs. Above this, the soil vapor concentrations are relatively minor while below 6 feet bgs the water content of the soil increases to a point where it appears that there is limited bioremediation.

SOIL VAPOR RISK ANALYSES

In order to determine the actual indoor air inhalation risk posed by the remaining petroleum hydrocarbons at the site, the maximum soil vapor concentration of each BTEX compound from 3 feet bgs was utilized in the above mentioned model. The risk to adults and children (ages 1 to 16 years) were calculated and the results are presented in Attachment D.

Model Parameters and Risk Levels

Since benzene is a carcinogen, the risk for indoor air inhalation from benzene was calculated using California's slope factor of 0.1 $(mg/kg\text{-}day)^{-1}$. This slope factor was used in the model to determine if the risk to human health and safety was greater than the target risk level of 10^{-6}. All other BTEX compounds were analyzed for their risk using a hazard quotient of 1. The exposure parameters for adults and children used within the model, such as exposure duration and inhalation rate, were based on ASTM's residential exposure parameters as set forth in the RBCA guidelines (Table X2.4) and by Groundwater Service's Inc. (GSI's) *RBCA Tool Kit*. The building parameters, such as the indoor air exchange rate and indoor volume/infiltration area ratio were also based on ASTM's RBCA guidelines (Table X2.6), as were all of the chemical-specific data, such as the diffusion coefficient for each BTEX compound in air and water (Table X2.7).

Physical Soil Data

The site-specific physical data used in the models are presented on Table 2. The physical soil data used in the model were calculated by averaging the data from Borings SV-1 (2.5 feet bgs) and SV-3 (3.5 feet bgs). Since the model determined the risk posed by vapors at 3 feet bgs, only physical soil data collected near 3 feet bgs were used in the model. The overall average and the vadose zone averages (one at 3.5 feet bgs, the other at 6 feet bgs) are presented in Table 2. The vadose zone average of 6 feet was not utilized in the models since the water content of the physical soil samples increased dramatically with depth and would have produced a less conservative risk analysis if used in the model.

Model Results

The results of the soil vapor flux to indoor air inhalation model determined that the maximum soil vapor BTEX concentrations from the 3 feet bgs depth did not pose a risk above 10^{-6} for benzene, nor did it pose a risk above a hazard quotient of 1 for the TEX compounds.

	Benzene	Toluene	Ethylbenzene	Xylenes
Adult Risk	6.53^{-6}	1.19^{-2}	3.79^{-3}	4.16^{-3}
Child Risk	6.96^{-6}	2.38^{-2}	7.57^{-3}	8.32^{-3}

When the hazard quotients for the non-carcinogenic compounds are added together, the total is 1.99^{-2} for adults and 3.99^{-2} for children. Thus the model outcomes are within the acceptable target risk level of 10^{-6} for benzene, according to the May 6, 1997 ACHCSA's letter, and below the hazard quotient of 1 for the non-carcinogens even when the individual hazard quotients are added together. Therefore, the site is suitable for redevelopment as a residential housing complex.

Uncertainty

It is important to note that a slab on grade building would be suitable for the site as shown by the above risk data, however if another type of building (i.e., with a crawlspace or deep foundation) were to be built, remedial action may be required. Possible remedial action may include the removal of soil in the former UST complex where the largest concentrations of petroleum hydrocarbon vapors were observed.

DERMAL EXPOSURE ROUTE

Per the *Work Plan*, the exposed surficial soil (following development) at the site will be excavated to a depth of 3 feet bgs in order to minimize dermal contact. The risk to a residential population by any petroleum hydrocarbon impacted surficial soils that may be exposed (i.e., landscaped areas) will be minimized by being excavated and replaced with clean fill.

CONSTRUCTION WORKER RISK

Using the physical soil data collected from the site, a Tier 2 RBCA analysis was performed using GSI's *RBCA Tool Kit* to determine the allowable BTEX compound concentrations in surficial soil considering inhalation of dust and particles and dermal contact as the routes of exposure. Again the vadose zone averages (from 3.5 feet) of porosity and moisture content were used in the calculations. The results of the models indicate that 320 milligrams per kilogram (mg/kg) benzene is the maximum allowable concentration for surficial soil exposures with a target risk of 10^{-5}, and for the remaining BTEX compounds, the selected risk level (hazard quotient = 1) is not exceeded for the pure compound present at any concentration. The highest benzene concentration found during this investigation was 86 mg/kg in Boring SV-4 at 9 feet bgs. Therefore, based on the soil analytical data collected during this investigation, no benzene concentrations are above the maximum allowed (320 mg/kg) at the site. Thus the surficial and subsurface soil at the site do not pose a risk to construction workers.

All other concerns regarding the remaining petroleum hydrocarbons at the site, and construction worker safety, will be addressed in a detailed site health and safety plan. Waiting for more details regarding the actual building techniques will allow a more thorough and complete assessment of any risks posed to the construction workers during the building of the residential housing complex.

CONCLUSIONS

Based on the soil vapor data, the site poses no indoor air inhalation risk to adults or children who may live at the site in the proposed residential housing complex at the specified risk level of 10^{-6} and with a hazard quotient of 1. The Tier 2 RBCA modeling and the soil analytical data also indicate that the site does not pose a risk to construction workers.

Once there is a definitive layout for the proposed housing complex it would be beneficial to examine what the use of the former UST complex will be and evaluate if limited excavation in that area may be advantageous. For instance, if the proposed housing plan has the former UST area in use as a parking area, then there would be no advantage to excavate since the soil would be covered. However, if that area is to be overlaid with a residence it may be beneficial to remove the surficial soil in the former UST area.

If you have any questions regarding this letter, please call.

Sincerely,

Pacific Environmental Group, Inc.

Michelle S. Gracia
Senior Staff Scientist

Ross Tinline
Project Geologist
RG 5860

Attachments:
- Table 1 - Soil Vapor Data
- Table 2 - Physical Soil Data
- Table 3 - Analytical Soil Data
- Figure 1 - Site Location Map
- Figure 2 - Site Map with Boring Locations
- Figure 3 - SV-1 Soil Vapor Data
- Figure 4 - SV-2 Soil Vapor Data
- Figure 5 - SV-3 Soil Vapor Data
- Figure 6 - SV-4 Soil Vapor Data
- Figure 7 - SV-5 Soil Vapor Data
- Attachment A - Certified Analytical Reports and Chain-of-Custody Documentation
- Attachment B - Soil Vapor Model and RBSL Tables
- Attachment C - Soil Boring Logs
- Attachment D - Soil Vapor Model Results

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Table 2
Benzene Child (1 to 16 years) Carcinogenic Risk
maximum concentration from 3 feet below ground surface
SV-1 = 0.17 μg/L

Former Signal Service Station
800 Center Street
Oakland, California

$D^{eff}s$ = Effective diffusion coefficient in soil based on vapor-phase concentration		
$D^{eff}s = ((D^{air} * (\theta as^{3.33}/\theta T^{2}))+((D^{wat}*1/H*(\theta ws^{3.33}/\theta T^{2})))$		
$D^{eff}s$ =	0.0112 (cm^2/s)	
D^{air} = diffusion coefficient in air =	0.093 (cm^2/s)	
Θ_{as} = volumetric air content of vadose zone soils =	0.33	
Θ_{ws} = volumetric water content of vadose zone soils	0.124	
Θ_T = total soil porosity =	0.4557	
D^{wat} = diffusion coefficient in water =	1.10E-05 (cm^2/s)	
H = Henry's law constant =	0.22 (L - H_2O/L - air)	
F_{max} = Diffusive vapor flux predicted by benzene concentration in soil vapor		
$F_{max} = D^{eff}s^* (Cv/d)$ =	2.08E-08 (μg/cm2 - sec)	
Cv = maximum benzene concentration in vapor =	0.00017 (μg/cm^3) or	0.17 (μg/L)
d = depth of vapor sample =	91.44 (cm) or	3 (ft)
C_{indoor} = Indoor benzene concentration		1 cm³ = .00017
$C_{indoor} = F_{max}/ER_{air\text{-}indoor} * L_B$	7.41E-07 (μg/cm^3)	1000 cm³ = 1 L
$ER_{air\text{-}indoor}$ = indoor air exchange rate =	0.00014 (sec^{-1})	
L_B = indoor volume/infiltration area ratio =	200 (cm)	
Dose = C_{indoor}*$IR_{air\text{-}indoor}$*EF*ED =	62 (mg)	
C_{indoor} =	7.41E-01 (μg/m^3) or	7.41E-07 (μg/cm^3)
$IR_{air\text{-}indoor}$ = Daily indoor inhalation rate =	15 (m^3/day)	
EF = exposure frequency =	350 (days/year)	
ED = exposure duration =	16 (years)	
Risk = ((Dose*SF)/(BW*AT))	6.96E-06	
Dose =	62.261 (mg)	
SF = Slope factor =	0.1 $(mg/kg\text{-}day)^{-1}$	
BW = Body weight =	35 (kg)	
AT = Averaging time =	25550 (70 years * 365 days)	

Therefore, child carcinogenic risk from maximum benzene soil vapor at 3 feet is 6.96E-06