ENVIRONMENTAL
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RISK ASSESSMENT FOR E-Z SERVE PETROLEUM MARKETING COMPANY OF CALIFORNIA FORMER STATION #100877 HAYWARD, CALIFORNIA

Brown and Caldwell
May 9, 1995

Brown and Caldwell
Consultants

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May 9, 1995

Mr. Brian Cobb
E-Z Serve Petroleum Marketing
Company of California
2550 North Loop West, Suite 600
Houston, Texas 77292-2021

11-1564-02/5

Subject: Transmittal of Risk Assessment for
E-Z Serve Petroleum Marketing Company's Former Station #100877,
525 West A Street, Hayward, California

Dear Mr. Cobb:

Attached is a copy of the Risk Assessment for E-Z Serve Petroleum Marketing Company of California's Former Station #100877 located at 525 West A Street in Hayward, California.

If you have any questions or comments, please call me at (510) 210-2278.

Sincerely,

BROWN AND CALDWELL

Todd Miller

Todd Miller
Project Manager

TM:lkg

Attachment

cc: Mr. Jon Wactor, Luce, Forward, Hamilton & Scripps
Ms. Madhulla Logan, Alameda County Department of Environmental Health

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EXECUTIVE SUMMARY

This report presents the results of a human health risk assessment for petroleum hydrocarbons in soil and groundwater in the vicinity of E-Z Serve Petroleum Marketing Company of California's (E-Z Serve) Former Station #100877 located at 525 West A Street, Hayward, California (Site). This risk assessment was conducted at the request of the Regional Water Quality Control Board-San Francisco Bay Region (RWQCB) in their *Legal Request of Submittal of a Technical Report* dated May 26, 1994 in accordance with *Risk Assessment Guidelines for Superfund, Volume I, Human Health Evaluation Manual (Part A)*, (EPA 1989).

Samples collected from soil and groundwater from on- and off-site locations were analyzed for total petroleum hydrocarbons as gasoline and benzene, toluene, ethylbenzene, and xylenes. All of these compounds have been identified as chemicals of potential concern for this Site.

Three exposure scenarios were evaluated in this risk assessment: current exposure, future exposure and hypothetical groundwater use. Hypothetical groundwater use, which evaluates residential use of groundwater, is recommended by the State of California to evaluate a worst-case scenario. The following exposure pathways were identified for residents in the vicinity of the Site. Exposure pathways are ways in which people can come into contact with the chemicals of potential concern:

Current Exposure
- Inhalation of vapors which have volatilized from groundwater and migrated through the soil and entered a house through a crack in the foundation

Future Exposure (additional)
- Ingestion of soil
- Dermal contact with soil
- Inhalation of soil

Hypothetical Groundwater Use
- Ingestion of groundwater
- Dermal contact with groundwater
- Inhalation of groundwater while bathing
- Ingestion of homegrown produce irrigated with groundwater

The risk assessment indicates that current and future use of the site by children and adults does not represent a concern for adverse health effects. The current risk of $1x10^{-6}$ for adults, associated with inhalation of vapors from groundwater migrating through the soil and into a house, is within USEPA's acceptable risk range. The future risk of $4x10^{-6}$ for adults, which includes direct contact with soil, is within EPA's acceptable risk range. However, there is an unacceptable risk associated with the residential use of groundwater. The probability of an increase in the individual cancer risk for these pathways is 1×10^{-2} for adults. These risks are well above the range of acceptable risk established for the Superfund program by the EPA.

CHAPTER 1

INTRODUCTION

This report presents the results of a human health risk assessment for petroleum hydrocarbons in soil and groundwater in the vicinity of E-Z Serve Petroleum Marketing Company of California's (E-Z Serve) Former Station #100877 located at 525 West A Street, Hayward, California (Site). This risk assessment was conducted at the request of the Regional Water Quality Control Board-San Francisco Bay Region (RWQCB) in their *Legal Request of Submittal of a Technical Report* dated May 26, 1994, in accordance with *Risk Assessment Guidelines for Superfund, Volume I, Human Health Evaluation Manual (Part A)*, (EPA 1989). Data used in this risk assessment are taken from Associated Soils Analysis's *Site Assessment Study for Petroleum Constituents in Soil and Groundwater* (ASA, 1993), Associated Soils Analysis's *Site Assessment Study for Petroleum Constituents Present in the Soil and Groundwater* (ASA, 1992), Brown and Caldwell's *Step 5, Phase II Site Investigation Report* (Brown and Caldwell, 1995), and Brown and Caldwell's *First Quarter 1995, Groundwater Monitoring Report* (Brown and Caldwell, 1995a)

Human health risk assessment is a process that estimates whether chemicals in the environment represent a concern for the health of people who might come in contact with them. This process is based on conservative assumptions about the quantity of chemicals that people come into contact with during their daily activities and the potential for adverse health effects. Consequently, the risk assessment is designed to overestimate the potential for adverse health effects so that the results are protective of human health. The actual health risks will, in all likelihood, be much lower.

The Site was operated as a service station from 1966 until 1990 with one 10,000-gallon diesel and three 10,000-gallon gasoline underground storage tanks (USTs). A discrepancy in the inventory reconciliation and tank tightness tests in November 1986 resulted in the investigation of soil and groundwater beneath the Site and eventual removal of all fueling equipment. Neither the volume of product lost nor the duration of the leak are known. The Site is currently not in use. The only structures on the Site are the canopy over the former dispenser islands and some lights. The Site is surrounded by a chain link fence with a locked gate.

This risk assessment is presented in eight chapters:

Chapter 1 Introduction -- This chapter presents a summary of how the work was performed.

Chapter 2 Site Characterization -- This chapter presents a brief description of the site and an overview of investigations and studies at the Site, land use, geology and hydrogeology for the area around the Site.

Chapter 3 Data Evaluation -- This chapter reviews the analytical data and identifies the chemicals of potential concern. The results of the analyses of chemical concentrations in groundwater are then used in Chapters 4, 5, and 6 to estimate potential health risks.

Chapter 4 Exposure Assessment -- This chapter evaluates the ways that people could be exposed to chemicals in the groundwater and soil and identifies the people who could be exposed now or in the future. This chapter also includes a conservative estimation of the concentration of the chemical to which people could be exposed (exposure concentration) and the quantity taken into their bodies each day (chronic daily intake).

Chapter 5 Toxicity Assessment -- This chapter discusses the basis and sources for the toxicity factors used in this risk assessment.

Chapter 6 Risk Characterization -- This chapter shows how the exposure and toxicity information are combined to evaluate the potential for adverse health effects. The potential health risks associated with each chemical are estimated for both carcinogenic and noncarcinogenic health effects.

Chapter 7 Uncertainty Analysis -- This chapter discusses the various sources of uncertainty in the risk assessment and the conservative assumptions that were used.

Chapter 8 References -- This chapter presents all references used in this risk assessment.

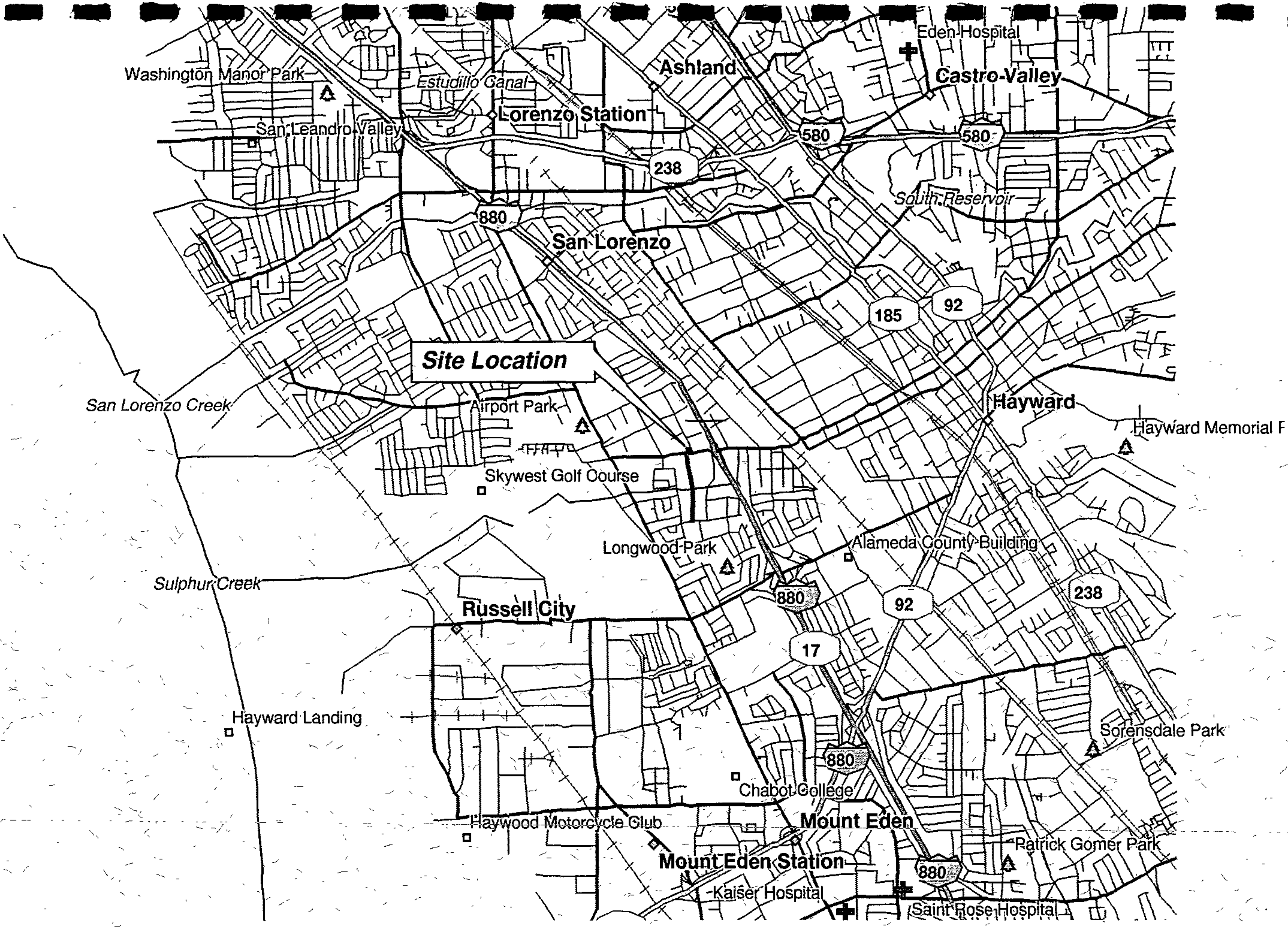

Figure 2-1 Site Location
Former E-Z Serve Station #100877, 4901 425 West A Street, Hayward, California

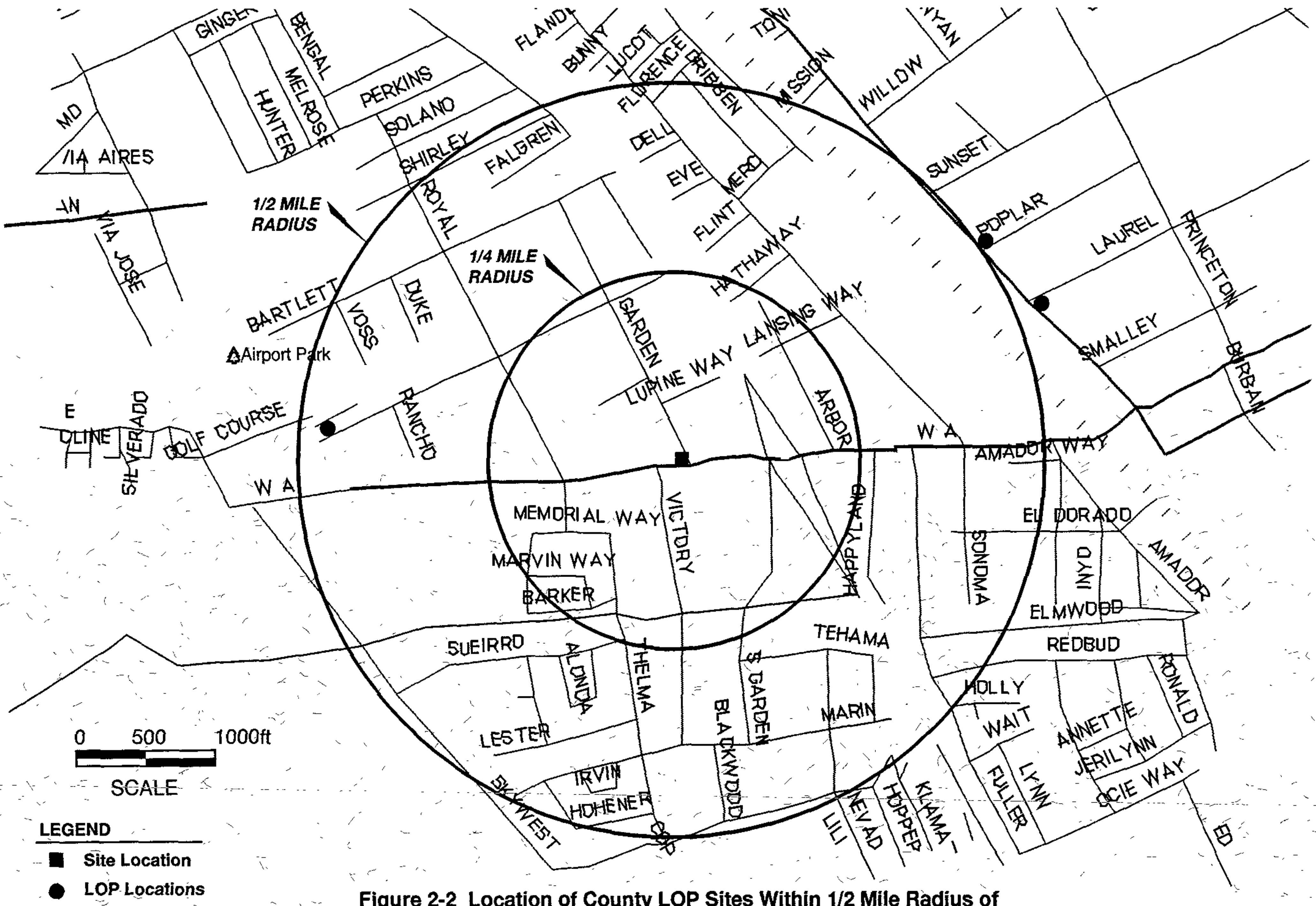

Figure 2-2 Location of County LOP Sites Within 1/2 Mile Radius of Former E-Z Serve Station #100877, 525 West A Street, Hayward, California

CHAPTER 2

SITE CHARACTERIZATION

This chapter presents pertinent background information including the Site description, Site history, geology and hydrogeolgy.

Site Description

The Site is located on the northwest corner of West A Street and Garden Avenue in the City of Hayward, County of Alameda, State of California's Township 3 South, Range 2 West, Mount Diablo Base and Meridian (Figure 2-1). The Assessor's Parcel Number for the Site is 432-0016-026-03. The Site is currently not in use. The only structures on the Site are the canopy over the former dispenser islands and some lights. The Site is surrounded by a chain link fence with a locked gate.

Site History

The Site was operated as a service station from 1966 until 1990 with one 10,000-gallon diesel and three 10,000-gallon gasoline underground storage tanks (USTs). A discrepancy in the inventory reconciliation and tank tightness tests in November 1986 resulted in the investigation of soil and groundwater beneath the Site and eventual removal of all fueling equipment. Neither the volume of product lost nor the duration of the leak are known.

Converse conducted an initial Phase II Site assessment for E-Z Serve in December of 1986. Three soil borings were drilled on Site and converted into groundwater monitoring wells. Analytical laboratory results of samples collected during that initial investigation indicated that soil and groundwater had been impacted by petroleum hydrocarbon constituents. Converse implemented Step 2 of the Phase II Site assessment in June of 1987. Step 2 included the installation of three additional on-Site groundwater monitoring wells. Results of the Step 2 investigation indicated that petroleum hydrocarbons had impacted the soil and groundwater beneath the Site to the property boundary.

The USTs, dispenser islands, and associated piping were excavated and removed from the property on June 15, 1990. During this phase of work Wells MW-3, MW-5, and MW-6 were destroyed and Wells MW-1, MW-2, and MW-4 were damaged.

During October 1991, ASA abandoned two of the three remaining on-site wells (Wells MW-2 and MW-4), reconstructed the wellhead of Well MW-1 and redesignated the well as Well MW-1a, and installed four additional on-Site wells as Step 3 of the Phase II Site investigation. ASA prepared a Site Assessment Report dated March 2, 1992, which summarized that investigation. That report concluded that the lateral extent of the petroleum hydrocarbon affected groundwater remained undefined.

ASA performed Step 4 of the Phase II Site investigation between June 21 and June 24, 1993. ASA installed Wells MW-7 through MW-10, north, east, west, and south of the Site boundaries. The Site investigation activities and results were described in ASA's July 10, 1993, *Site Assessment Study of Petroleum Hydrocarbon Constituents In Soil and Groundwater at E-Z Serve Location #100877, 525 West "A" Street, Hayward, California*. ASA concluded in that report that the lateral extent of the petroleum hydrocarbon affected groundwater still remained undefined.

Brown and Caldwell was retained by E-Z Serve during June 1994 to continue delineating the lateral extent of hydrocarbon plume (Step 5, Phase II) and to move the Site into Phase III (remediation) as quickly as possible. During the February 1995 investigation, four off-site groundwater monitoring wells were installed to further delineate the lateral extent of the impacted groundwater. Also at that time, an off-site underground utility investigation and a local well survey were conducted.

Geology and Hydrogeology

silty + clayey sands

The Site lies within the San Leandro cone, a low gradient alluvial fan which originates at the mouth of Castro Valley and spreads westward onto the Bay Plain. This cone consists of alluvial sediments which overlie marine clay, terrigenous sand and silt of intertidal provenances. The sediments directly under the site consist primarily of silty- and clayey-sands with occasional sandy-silt or sandy-clay layers. Groundwater is generally encountered between 13 and 17 feet below ground surface.

The shallowest regional aquifer in the area is a permeable, water-bearing alluvial sand named the Newark Aquifer. This aquifer is a series of laterally discontinuous saturated lenses of coarse to fine sediments 10 to 100 feet thick at depths less than 200 feet. The regional hydraulic gradient is westward, from the mouth of Castro Valley towards the San Francisco Bay. Groundwater directly under the site flows towards the west under an average hydraulic gradient of 0.005 feet per foot. The nearest point of release for the shallow aquifer to the surface water in the westerly direction (direction of groundwater gradient) is San Francisco Bay about 3 miles from the Site. Figure 2-3 illustrates the groundwater flow direction in the vicinity of the site and Table 3-1 presents groundwater elevation data.

A list of private, industrial, and agricultural wells for this area was not available from either the County or the State. Therefore, Brown and Caldwell reviewed the Alameda County Department of Environmental Health's local oversight program list and the State of California Department of Toxic Substance Control hazardous waste sites list to identify wells near the Site.

Review of the lists identified 3 facilities with monitoring wells within ½-mile of the Site. A review did not identify water supply wells within ½-mile of the Site. The locations of the properties, relative to the Site, are illustrated on Figure 2-2.

Extent and Nature of Contamination

Analytical results of soil samples collected from on-site borings indicate that the soil within the vadose zone beneath the site contains between 0.1 and 28 milligrams per kilogram (mg/kg) of total petroleum hydrocarbon as gasoline (TPHg) and between 0.001 and 2.7 mg/kg benzene. Lab analyses of off-site soil samples indicates that TPHg and benzene exist within the capillary fringe and beneath the static groundwater level.

?

TPHg constituents have reached the groundwater via infiltration and percolation. Analytical results have identified TPHg and benzene constituents in the groundwater samples collected from on-site and off-site groundwater monitoring wells. On-site concentrations have been identified as ranging from 290 to 2,100 micrograms per liter (μg/L) TPHg and 56 to 5,600 μg/L benzene from May 1994 through March 1995. Off-site, in the downgradient direction (west), TPHg and benzene in Wells MW-9 and MW-11 range in concentration from 6,000 to 18,000 μg/L TPHg and 140 to 5,900 μg/L benzene. Off-site, to the north, TPHg and benzene in Wells MW-7, MW-12 and MW-14 range in concentration from <50 to 12,000 μg/L TPHg and <0.5 to 630 μg/L benzene. Off-site, to the south, TPHg and benzene in Wells MW-10 and MW-13 range in concentration from <50 to 2,800 μg/L TPHg and <0.5 to 52 μg/L benzene.

7,200

6000 & 18,000 ug/L ✓

TPHg and benzene appear to have migrated at least 150 feet to the north and south and approximately 600 feet to the west (Figure 2-3). Concentrations identified in the monitoring wells seem to attenuate as you move away from the site. Figure 2-3 presents analytical data from the last round of quarterly sampling, March 15, 1995.

Data collected during the in-situ groundwater investigation conducted by Brown and Caldwell in February 1995, identified non-detectable concentrations of TPHg and benzene in the groundwater in the vicinity of Well MW-11. However, quarterly sampling data indicates relatively high concentrations of TPHg and benzene in the groundwater samples collected from this well. The reason for the discrepancy in this data is unknown at this time and therefore the data collected from Well MW-11 is being included in this risk assessment.

Land Use

Within 1 mile of the Site, the land adjacent to the Site and downgradient from the Site is primarily residential and with some small business. The land upgradient is primarily small businesses with some residential properties.

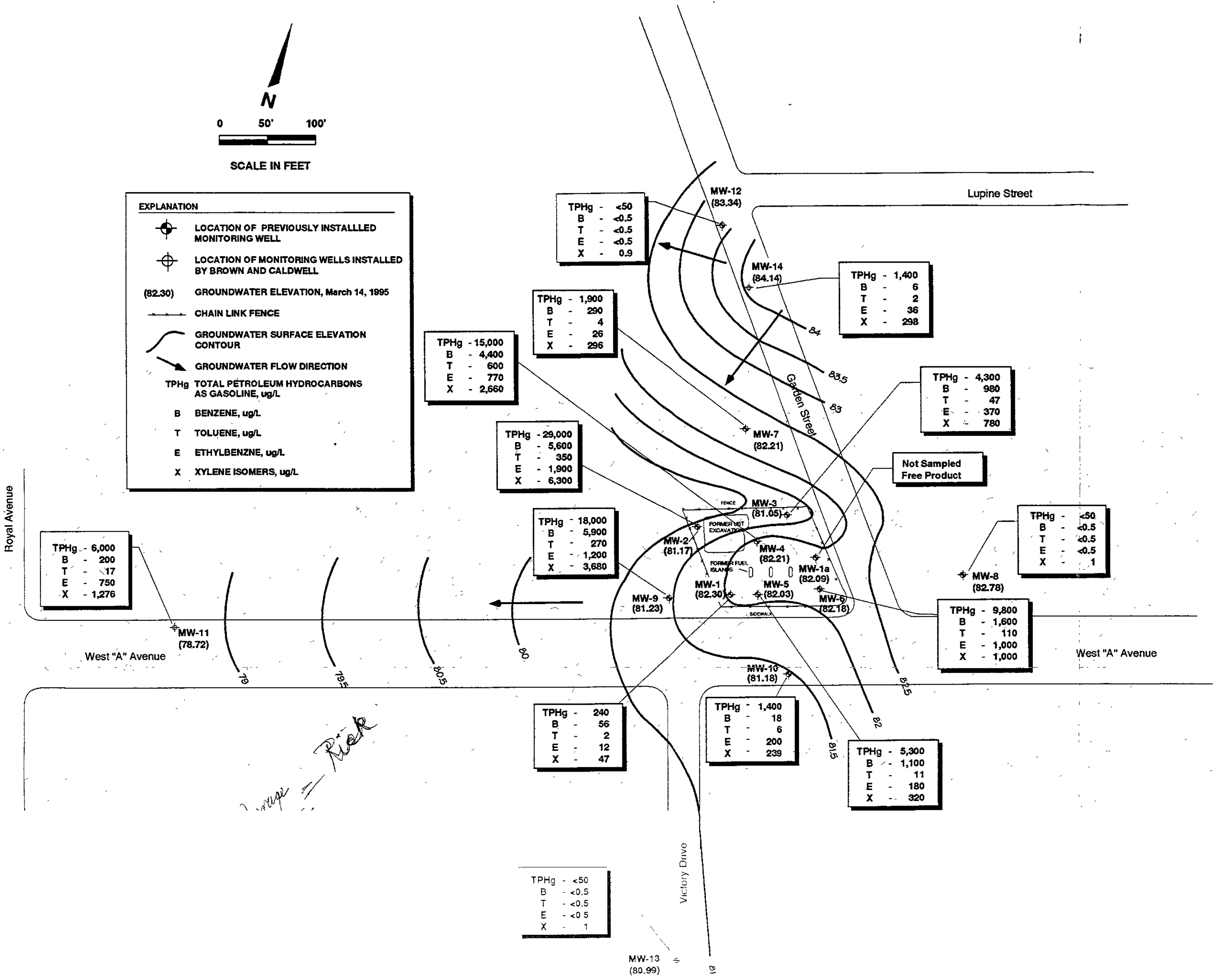

Figure 2-3 Groundwater Surface Elevation Contour and Petroleum Hydrocarbon Constituent Distribution Map, March 14, 1995
Former E-Z Serve Station #100877 4901 525 West A Street, Hayward, California

CHAPTER 3

DATA EVALUATION

The objective of the data evaluation is to identify chemicals of potential concern found in the groundwater and soil. Chemicals of potential concern are chemicals identified as representative of Site-related releases. This chapter presents the methodology and results of the process used to select chemicals of potential concern. Chemicals of potential concern are then further evaluated in the risk assessment to determine if their presence could result in adverse health effects to people.

The analytical results of environmental samples collected at and near the Site were compiled and evaluated. The samples include groundwater from monitoring wells and soil from the installation of the monitoring wells. Groundwater data from samples collected by Associated Soils Analysis (ASA) in May and July of 1994, and by Brown and Caldwell in September and December 1994, and March 1995, (Table 3-1) were selected as most representative of current groundwater conditions. Soil data used in this risk assessment include soil samples collected during the installation of the fourteen monitoring wells. Samples were collected by ASA in January 1992, and June 1993, and by Brown and Caldwell in February 1995 (Table 3-2).

Data for blanks and quantitation limits were evaluated in accordance with data review procedures for risk assessment data (EPA, 1989). This review identifies any data that are suspect because the chemicals may have been inadvertently introduced during sample collection or other issues with analyses.

Data Usability

In the first part of a data evaluation, the analytical data are compiled and data of usable quality are selected. The usable data are selected based on three criteria: comparison with blank samples, evaluation of samples quantitation limits, and analysis of duplicate samples. The data are then used to select chemicals of potential concern.

Comparison with Blanks. Blank samples provide a measure of contamination that has been inadvertently introduced into a sample set either in the field while the samples were being collected, during transportation to the laboratory, or in the laboratory during sample preparation or analysis. To prevent the inclusion of non-Site related contaminants in the risk assessment, the concentrations of chemicals detected in blanks are compared with concentrations of the same chemicals detected in Site samples. For this risk assessment, blank samples were collected during the September and December 1994 and March 1995 rounds of groundwater monitoring (Table 3-1).

Because no chemicals were identified in the blank samples, no chemicals could be eliminated on this basis.

Sample Quantitation Limits (SQLs). Due to one or more sample-specific conditions, SQLs for a particular chemical in some samples may be unusually high, sometimes exceeding the positive results reported for the same chemical in other samples from the data set. If the SQLs cannot be reduced by re-analyzing the sample, the samples are excluded from the risk assessment if the SQL is greater than the maximum detected concentration for a particular data set (EPA, 1989).

No samples were eliminated on this basis.

Analyses of Duplicates. Duplicate samples were collected during groundwater monitoring to provide information on sampling techniques and for comparison with samples taken at the same location. If the values of the samples and its duplicate are not similar, then there may have been quality problems during sampling.

No discrepancies were found, therefore no samples were eliminated on this basis.

Selection of Chemicals of Potential Concern

All chemicals identified in at least one sample were included as chemicals of potential concern for evaluation in this risk assessment. The five chemicals of potential concern in groundwater and soil are:

1. Benzene
2. Toluene
3. Ethylbenzene
4. Xylenes
5. Total Petroleum Hydrocarbons as gasoline

Table 3-1 Summary of Groundwater Elevation Data and Analytical Laboratory Results for Groundwater Samples Collected at Former E-Z Serve Station # 100877 Between 1994 and 1995
525 West A Street, Hayward, California

Well I.D.	Date Sampled	Well Elevation (feet)[1]	Depth to Water (feet)[2]	Product Thickness (feet)	Groundwater Elevation (feet)[1]	EPA Methods 8015 and 8020 Concentration (μg/L)				
						TPHg[3]	Benzene	Toluene	Ethylbenzene	Xylenes
MW-1	2-May-94	96.73	17.26		79.47	7,200	2,100	29	490	520
MW-1	1-Jul-94		17.60		79.13	13,000	3,700	150	550	12,000
MW-1	20-Sep-94		20.59		76.14	10,000	3,100	75	440	870
MW-1	5-Dec-94		17.83		78.90	8,700	3,700	87	520	950
MW-1	10-Mar-95		14.67		82.06					
MW-1	15-Mar-95		14.43		82.30	290	56	2	12	47
MW-1A	2-May-94	97.59	18.35	0.09	79.33	Well Not Sampled				
MW-1A	1-Jul-94		18.45		79.14	12,000	1,100	<1	920	1,100
MW-1A	20-Sep-94		21.72	0.22	76.09	Well Not Sampled				
MW-1A	5-Dec-94		18.87	0.07	78.79	Well Not Sampled				
MW-1A	10-Mar-95		15.83		81.76	Well Not Sampled				
MW-1A	14-Mar-95		15.55	0.05	82.09	Well Not Sampled				
MW-2	2-May-94	98.06	19.84		78.22	18,000	3,800	260	1,100	3,500
MW-2	1-Jul-94		19.18		78.88	18,000	3,700	510	870	2,600
MW-2	20-Sep-94		22.17		75.89	19,000	4,500	300	1,200	4,000
MW-2	6-Dec-94		19.37		78.69	22,000	4,700	340	1,400	4,500
MW-2	10-Mar-95		16.33		81.73	Well Not Sampled				
MW-2	15-Mar-95		16.89		81.17	29,000	5,600	350	1,900	6,300
MW-3	2-May-94	97.66	18.30		79.36	4,200	680	48	310	540
MW-3	1-Jul-94		18.63		79.03	4,600	600	63	240	470
MW-3	20-Sep-94		21.64		76.02	8,200	2,200	130	670	930
MW-3	6-Dec-94		19.15		78.51	4,000	640	34	290	480
MW-3	10-Mar-95		15.86		81.80	Well Not Sampled				
MW-3	15-Mar-95		16.61		81.05	4,300	980	47	370	780

Table 3-1 Summary of Groundwater Elevation Data and Analytical Laboratory Results for Groundwater Samples Collected at Former E-Z Serve Station # 100877 Between 1994 and 1995
525 West A Street, Hayward, California

Well I.D.	Date Sampled	Well Elevation (feet)[1]	Depth to Water (feet)[2]	Product Thickness (feet)	Groundwater Elevation (feet)[1]	EPA Methods 8015 and 8020 Concentration (μg/L)				
						TPHg[3]	Benzene	Toluene	Ethylbenzene	Xylenes
MW-4	2-May-94	97.10	17.81		79.29	10,000	2,200	440	470	1,200
MW-4	1-Jul-94		18.13		78.97	8,200	2,000	370	350	930
MW-4	20-Sep-94		21.13		75.97	7,200	2,000	360	380	1,000
MW-4	6-Dec-94		18.36		78.74	9,000	2,300	400	440	1,100
MW-4	10-Mar-95		15.25		81.85	Well Not Sampled				
MW-4	15-Mar-95		14.89		82.21	15,000	4,400	600	770	2,660
MW-5	2-May-94	96.73	17.50		79.23	8,000	1,300	29	440	770
MW-5	1-Jul-94		17.79		78.94	10,000	1,700	97	600	1,400
MW-5	20-Sep-94		20.77		75.96	8,400	1,600	54	650	1,400
MW-5	20-Sep-94					9,300	1,700	56	670	1,600
MW-5	5-Dec-94		18.02		78.71	10,000	1,800	<50	620	1,400
MW-5	10-Mar-95		14.93		81.80	Well Not Sampled				
MW-5	15-Mar-95		14.70		82.03	5,300	1,100	11	180	320
MW-6	2-May-94	97.09	17.74		79.35	5,300	930	54	610	240
MW-6	1-Jul-94		18.09		79.00	10,000	1,500	160	850	690
MW-6	20-Sep-94		21.05		76.04	11,000	2,000	140	1,200	760
MW-6	6-Dec-94		18.33		78.76	8,600	1,300	87	980	610
MW-6	10-Mar-95		15.35		81.74	Well Not Sampled				
MW-6	15-Mar-95		14.91		82.18	9,800	1,600	110	1,000	1,000
MW-7	2-May-94	97.44	18.11		79.33	5,700	630	13	660	400
MW-7	1-Jul-94		18.72		78.72	3,100	180	99	160	520
MW-7	20-Sep-94		21.41		76.03	6,100	540	6	750	730
MW-7	5-Dec-94		18.66		78.78	3,700	280	<10	430	350
MW-7	5-Dec-94					3,900	310	<10	540	540
MW-7	10-Mar-95		15.72		81.72	Well Not Sampled				
MW-7	14-Mar-95		15.23		82.21	1,900	290	4	26	296
MW-7	14-Mar-95					1,000	330	5	30	339

Table 3-1 Summary of Groundwater Elevation Data and Analytical Laboratory Results for Groundwater Samples Collected at Former E-Z Serve Station # 100877 Between 1994 and 1995

525 West A Street, Hayward, California

Well I.D.	Date Sampled	Well Elevation (feet)^1	Depth to Water (feet)^2	Product Thickness (feet)	Groundwater Elevation (feet)^1	EPA Methods 8015 and 8020 Concentration ($\mu g/L$) TPHg^3	Benzene	Toluene	Ethylbenzene	Xylenes
MW-8	2-May-94	97.61	18.11		79.50	<100	<1	3	<1	7
MW-8	1-Jul-94		18.43		79.18	300	18	48	19	37
MW-8	20-Sep-94		21.43		76.18	<100	<1	<1	<1	<1
MW-8	5-Dec-94		18.72		78.89	<50	<0.5	<0.5	<0.5	<0.5
MW-8	10-Mar-95		18.69		78.92	Well Not Sampled				
MW-8	14-Mar-95		14.83		82.78	<50	<0.5	<0.5	<0.5	1
MW-9	2-May-94	95.41	16.24		79.17	17,000	5,400	270	1,300	4,700
MW-9	1-Jul-94		16.59		78.82	10,000	2,100	120	450	1,300
MW-9	20-Sep-94		19.61		75.80	7,500	2,200	97	400	1,200
MW-9	5-Dec-94		16.85		78.56	10,000	2,700	130	530	1,600
MW-9	10-Mar-95		NR			Well Not Sampled				
MW-9	14-Mar-95		14.18		81.23	18,000	5,900	270	1,200	3,680
MW-10	2-May-94	97.11	17.83		79.28	710	16	6	85	62
MW-10	1-Jul-94		18.17		78.94	2,000	52	43	120	210
MW-10	20-Sep-94		21.15		75.96	2,800	34	16	270	560
MW-10	5-Dec-94		18.43		78.68	2,700	30	13	260	430
MW-10	10-Mar-95		15.37		81.74	Well Not Sampled				
MW-10	14-Mar-95		15.93		81.18	1,400	18	6	200	239
MW-11	10-Feb-95	92.68	11.80		80.88	7,000	140	22	600	1,000
MW-11	10-Mar-95		11.58		81.10	Well Not Sampled				
MW-11	14-Mar-95		13.96		78.72	6,000	200	17	750	1,276
MW-12	10-Feb-95	99.03	16.30		82.73	<50	<0.5	<0.5	<0.5	<0.5
MW-12	10-Mar-95		16.37		82.66	Well Not Sampled				
MW-12	14-Mar-95		15.69		83.34	<50	<0.5	<0.5	<0.5	0.9

Table 3-1 Summary of Groundwater Elevation Data and Analytical Laboratory Results for Groundwater Samples Collected at Former E-Z Serve Station # 100877 Between 1994 and 1995
525 West A Street, Hayward, California

Well I.D.	Date Sampled	Well Elevation (feet)[1]	Depth to Water (feet)[2]	Product Thickness (feet)	Groundwater Elevation (feet)[1]	EPA Methods 8015 and 8020 Concentration (µg/L)				
						TPHg[3]	Benzene	Toluene	Ethylbenzene	Xylenes
MW-13	10-Feb-95	96.80	14.45		82.35	<50	<0.5	<0.5	<0.5	<0.5
MW-13	10-Mar-95		14.30		82.50	Well Not Sampled				
MW-13	14-Mar-95		15.81		80.99	<50	<0.5	<0.5	<0.5	1
MW-14	10-Feb-95	99.01	16.28		82.73	12,000	42	8	740	2,100
MW-14	10-Feb-95					12,000	48	<10	800	2,300
MW-14	10-Mar-95		16.33		82.68	Well Not Sampled				
MW-14	14-Mar-95		14.87		84.14	1,400	6	2	36	298
QA/QC										
Field Blank	20-Sep-94					<100	<1	<1	<1	<1
Trip Blank	5-Dec-94					<50	<0.5	<0.5	<0.5	<0.5
Field Blank	5-Dec-94					<50	<0.5	<0.5	<0.5	<0.5
Trip Blank	10-Feb-95					<50	<0.5	<0.5	<0.5	<0.5
Field Blank	10-Feb-95					<50	<0.5	<0.5	<0.5	<0.5
Trip Blank	14-Mar-95					<50	<0.5	<0.5	<0.5	<0.5
Field Blank	14-Mar-95					<50	<0.5	<0.5	<0.5	<0.5

[1] Relative to lower mean sea level.
[2] Below ground surface.
[3] Total Petroleum Hydrocarbons as gasoline.

Table 3-2 Summary of Analytical Laboratory Results for Soil Samples Collected at Former E-Z Serve Station # 100877
525 West A Street, Hayward, California

Soil Boring/ Soil Sampling Depth (feet)	Date Sampled	EPA Methods 8015 and 8020 Concentration (µg/Kg)				
		TPHg[1]	Benzene	Toluene	Ethylbenzene	Xylenes
MW-1-11'	28-Jan-92	<500	120	<5	7.3	5.3
MW-1-16'	28-Jan-92	19,000	980	13	170	350
MW-2-11'	28-Jan-92	<500	<5	<5	<5	<5
MW-2-16'	28-Jan-92	5,400	<5	<5	1,100	57
MW-3-11'	28-Jan-92	5,600	690	<5	48	13
MW-3-16'	28-Jan-92	6,400	1,000	<5	130	78
MW-4-6'	28-Jan-92	28,000	35	<24	400	1,600
MW-4-11'	28-Jan-92	5,700	220	76	170	640
MW-4-16'	28-Jan-92	15,000	2,700	1,200	390	1,800
MW-5-11'	29-Jan-92	790	300	<5	49	19
MW-5-16'	29-Jan-92	7,200	660	16	160	550
MW-6-11'	29-Jan-92	<500	7.6	<5	<5	5.2
MW-6-16'	29-Jan-92	550	170	<5	16	21
MW-7-5'	21-Jun-93	<500	<5	<5	<5	<15
MW-7-10'	21-Jun-93	<500	<5	<5	<5	<15
MW-7-15	21-Jun-93	500	12	<5	38	<15
MW-8-5'	22-Jun-93	<500	<5	<5	<5	<15
MW-8-10'	22-Jun-93	<500	<5	<5	<5	<15
MW-8-15	22-Jun-93	<500	<5	<5	<5	<15
MW-9-5'	22-Jun-93	<500	<5	<5	<5	<15
MW-9-10'	22-Jun-93	<500	15	<5	<5	<15
MW-9-15	22-Jun-93	9,000	130	27	190	760
MW-10-5'	22-Jun-93	<500	<5	<5	<5	<15
MW-10-10'	22-Jun-93	<500	16	<5	<5	<15
MW-10-15	22-Jun-93	590	8.9	<5	51	15
MW-11-10'	6-Feb-95	<100	<1	<1	2	5
MW-11-15'	6-Feb-95	100	<1	<1	2	5
MW-12-10'	6-Feb-95	310	<1	<1	1	4
MW-12-15'	6-Feb-95	<100	<1	<1	<1	1
MW-13-10'	7-Feb-95	<100	<1	<1	<1	<1
MW-13-15'	7-Feb-95	<100	<1	<1	<1	1
MW-14-10'	7-Feb-95	<100	<1	<1	<1	<1
MW-14-15'	7-Feb-95	760	1	<1	1	9

[1] Total Petroleum Hydrocarbons as gasoline.

CHAPTER 4

EXPOSURE ASSESSMENT

This chapter identifies pathways by which people could potentially be exposed to chemicals in groundwater and soil, now or in the future, from the Site. The characteristics of the chemicals that would be released from the Site and how they might move or be transported in the environment are evaluated. The concentration of a chemical which a person would be exposed to is also calculated. Further, the potentially exposed human populations are identified, and the assumptions used to estimated how much of a chemical people could come into contact with are presented. Table 4-1 presents exposure pathways and potentially exposed populations.

Chemical Assessment

Chemical assessment discusses the properties of the chemicals of potential concern related to their movement in the environment. These properties determine the migration pathways that could bring the chemicals into contact with human populations.

The majority of the chemicals of potential concern are volatile organic chemicals (benzene, toluene, ethylbenzene, and xylenes (BTEX)). These chemicals tend to volatilize or evaporate upon exposure to the air and dissolve in the groundwater to some extent. Dissolved in the groundwater, these chemicals will move with the groundwater but at a much slower rate. The rate is slower because the chemicals tend to sorb or bind to soil particles as the groundwater passes through the soil.

These chemicals do not tend to persist in surface soil because of their tendency to evaporate when in contact with the air. BTEX chemicals are degraded by natural soil bacteria when present in low concentrations in soil and groundwater.

Identification of Exposure Pathways

Exposure pathways include all the various ways in which humans can come in contact with the chemicals of potential concern, either currently or at some time in the future. Risk assessors evaluate exposure pathways by first considering the potential for chemicals to migrate from one medium to another. In theory, four potential media for chemical contact are available: air, soil, surface water and groundwater. Each of these media is evaluated further to determine the likelihood that the chemicals will be transported in these media and may, therefore, have the potential for human contact now or in the future, both on- and off-Site.

Presently there is no potential for exposure to chemicals in soil on- or off-site for two reasons: the soil within the area of the tank backfill has been removed and replaced with clean fill, and the Site is fenced and locked. Exposure to soil in the future is also unlikely because the remaining impacted soil is at a depth of approximately 10 feet. Pathways involving exposure to soil are evaluated, however, due to the event of intrusive activities such as the construction of a swimming pool. These exposure pathways include ingestion of soil, dermal contact with soil, and inhalation of soil.

Exposure to chemicals in the groundwater is currently occurring via only one route: inhalation of vapors which have volatilized from groudwater and migrated through the soil and entered a house through a crack in the foundation. There is no current direct contact with groundwater. Off-Site residents are not exposed to the impacted water because there are no water supply wells within 1/2 mile of the Site. Nearby residents obtain their water from the City water supply.

The State of California frequently recommends that risk assessors evaluate a worst-case scenario which assumes that a household water supply well is installed in groundwater containing the highest levels of chemicals. It is highly unlikely that these exposure pathways would ever be completed. The risk assessment evaluated the hypothetical situation in which groundwater is used for residential purposes as a worst-case scenario.

Hypothetical exposure to chemicals in household water is modeled via four routes: ingestion, inhalation, dermal contact, and ingestion of homegrown produce irrigated with impacted groundwater. Ingestion occurs when people drink water, use it to prepare drinks or foods, and accidentally ingest water during bathing and showering. Inhalation occurs when chemicals in the household water volatilize during showering, bathing, or general use such as washing clothes, and collect in indoors. Dermal contact occurs largely during showering and bathing. Volatile chemicals such as benzene and toluene can transfer through wet skin.

Based on the above information, the following exposure pathways were selected for quantification in this risk assessment:

Current Exposure

- Inhalation of vapors which have volatilized from groundwater and migrated through the soil and entered a house through a crack in the foundation

Future Exposure (additional)

- Ingestion of soil
- Dermal contact with soil
- Inhalation of soil particulates

Hypothetical Groundwater Use

- Ingestion of groundwater
- Dermal contact with groundwater
- Inhalation of groundwater while bathing
- Ingestion of homegrown produce irrigated with groundwater

Identification of Potentially Exposed Human Populations

Two human populations are evaluated: children and adults. These two populations represent a residential scenario.

Exposure Assumptions

The risk assessment process uses a series of assumptions to describe how people come into contact with the chemicals of potential concern. These exposure assumptions are based on studies of how much water and soil people take into their bodies each day. There are two important aspects to remember about these assumptions. First, these assumptions are based on information taken from the general population and do not necessarily reflect the behavior of this population. Second, the assumptions are designed to be protective of public health and accordingly, overestimate the levels of potential exposure.

For this risk assessment, standard default exposure assumptions from *Risk Assessment Guidance for Superfund* (USEPA 1989), *Exposure Factors Handbook* (USEPA 1989a) and *Air Toxics "Hot Spots" Program* (CAPCOA 1993) were used. Exposure assumptions used in this risk assessment are presented in Table 4-2.

Exposure Concentrations

Exposure concentrations represent a conservative estimate of how much of a chemical is in the groundwater and soil. Exposure concentrations are calculated by combining all available analytical data into one hypothetical concentration which is assumed to remain constant for the entire exposure period. EPA recommends using a statistical estimate of a reasonable maximum concentration, the 95 percent upper bound confidence interval of the mean as an estimate of reasonable maximum exposure (RME) to determine the exposure point concentration. Tables 4-3 and 4-4 present the RME concentrations for chemicals in groundwater and soil, respectively. The RME concentration represents the highest average concentration that is likely to be found if hundreds of samples were collected from the Site. Use of the RME concentration to predict public health risk is recommended in state and federal risk assessment guidance documents when estimating exposure to chemicals. This protocol reflects the health protective nature of risk assessment protocols.

A key issue in calculating the RME is the method used to incorporate nondetected results. When analytical results do not show a chemical as being present above a certain level in a sample, the laboratory reports the chemical as nondetected. The chemical may be present, but at a concentration that is below the detection limit reported. It is also possible that the chemical was not present in the sample.

There are several approaches to incorporating data for chemicals reported as nondetected. The data can be dropped from that analyses, listed as zero, or listed as one-half the detection limit. For this risk assessment, we calculated the average concentrations using one-half the detection limit for values reported as less than the detection limit. At this time, this is the preferred method for handling nondetected data in the State of California.

Chronic Daily Intakes

The exposure assumptions and exposure concentrations are used to calculate the amount of chemical taken into the body each day which is called the chronic daily intake (CDI) and is measure in milligrams of chemical per kilogram of body weight per day (mg/kg/day).

CDIs are presented in Chapter 6 along with the risk calculations.

You need to tell us if the data follows normal or log-normal distribution.

Table 4-1 Exposure Pathways and Exposure Populations
Former E-Z Serve Station #100877
525 West A Street, Hayward, California

Exposure Pathway	Adults	Children
Current Exposure Pathways		
Inhalation of Indoor Air Through Crack in Foundation	x	x
Future Exposure Pathways (additional)		
Ingestion of Soil	x	x
Dermal Contact with Soil	x	x
Inhalation of Soil	x	x
Hypothetical Groundwater Use		
Ingestion of Groundwater	x	x
Dermal Contact with Groundwater While Bathing	x	x
Inhalation of Groundwater While Bathing	x	x
Ingestion of Homegrown Produce Via Irrigation	x	x

Table 4-2 Exposure Assumptions
Former E-Z Serve Station #100877
525 West A Street, Hayward, California

Parameter	Adult	Child	Reference
General Assumptions for all Pathways			
Body Weight, kg	70	16	EPA, 1989
Exposure Frequency, days/year	365	365	EPA, 1989
Exposure Duration, years	30	⑤	Site Specific ? 6 yrs ✓
Averaging time for carcinogenic risk, days	25,550 70 X 365		EPA, 1989
Averaging time for noncarcinogenic risk, days	30 X 365	1,825	EPA, 1989
Inhalation of Indoor Air Through a Crack in the Foundation			
Inhalation Rate, m^3/day	20	15	EPA, 1989
Calculation of Indoor Air Concentration	Chemical Specific		Tables 6-3 and 6-4
Ingestion of Soil			
Ingestion Rate, mg/day	100	200	EPA, 1989
Fraction Ingested	1	1	EPA, 1989
Dermal Contact with Soil			
Surface Area, cm^2	3,120	1,580	EPA, 1989
Absorption Factor	1	1	EPA, 1989
Adherence Factor, mg/cm^2	1.45	1.45	CAPCOA, 1993 ?
Inhalation of Soil			
Inhalation Rate, m^3/day	20	15	EPA, 1989
Calculation of the Volatilization Factor	Chemical Specific		Table 6-8
Ingestion of Groundwater			
Ingestion Rate, L/day	2	1	EPA, 1989
Dermal Contact with Groundwater While Bathing			
Exposure Time, hours/day	0.2	0.2	EPA, 1989
Surface Area, cm^2	18,150	8,223	EPA, 1989
Permeability Coefficient, cm/hr	Chemical Specific		EPA, 1988 and 1992
Inhalation of Groundwater While Bathing			
Inhalation Rate, m^3/day	20	15	EPA, 1989
Volatilization factor, L/m^3	0.5	0.5	EPA, 1989
Ingestion of Homegrown Produce			
Ingestion Rate, kg/day	0.25	0.25	CAPCOA, 1993
Fraction of Plant Homegrown	0.3	0.3	CAPCOA, 1993
Gastrointestinal absorption factor	1	1	CAPCOA, 1993

Table 4-3 Calculation of Reasonable Maximum Exposure Concentration (RME) for Groundwater Samples Collected at Former E-Z Serve Station # 100877 Between 1994 and 1995

525 West A Street, Hayward, California

Parameter	EPA Methods 8015 and 8020 Concentration (μg/L)				
	TPHg[1]	Benzene	Toluene	Ethylbenzene	Xylenes
Number of Positive Results	55	55	51	55	59
Number of Anlayses	63	63	63	63	63
Minimum Positive Result	290	6	2	12	1
Maximum Positive Result	29,000	5,900	600	1,900	12,000
Number of Anlayses [2]	59	59	59	59	59
Average	7,423	1,521	111	507	1,295
Standard Deviation	6,293	1,645	147	424	1,935
t	1.672	1.672	1.672	1.672	1.672
Reasonable Maximum Exposure	8,793	1,879	143	599	1,716

[1] Total Petroleum Hydrocarbons as gasoline.

[2] For this number, samples were averaged with their duplicates.

Reasonable Maximum Exposure (RME) = Average + t(standard deviation / SQRT(Number of Analyses))

Table 4-4 Calculation of Reasonable Maximum Exposure Concentration (RME) for Soil Samples Collected at Former E-Z Serve Station # 100877
525 West A Street, Hayward, California

	EPA Methods 8015 and 8020 Concentration (µg/Kg)				
Parameter	TPHg[1]	Benzene	Toluene	Ethylbenzene	Xylenes
Number of Positive Results	16	17	5	18	20
Number of Anlayses	33	33	33	33	33
Minimum Positive Result	100	1.0	13	1	1
Maximum Positive Result	28,000	2,700	1,200	1,100	1,800
Number of Anlayses	33	33	33	33	33
Average	3,277	215	42	90	182
Standard Deviation	6,338	526	208	209	438
t	1.694	1.694	1.694	1.694	1.694
Reasonable Maximum Exposure	5,146	370	104	151	311

[1] Total Petroleum Hydrocarbons as gasoline.

Reasonable Maximum Exposure (RME) = Average + t(standard deviation / SQRT(Number of Analyses))

CHAPTER 5

TOXICITY ASSESSMENT

This toxicity assessment presents the toxicity values used to estimate potential lifetime health effects. Toxicity values are chemical-specific numbers developed by the State of California, the USEPA and other governmental agencies that reflect the toxicity of the chemicals. As described in more detail in the following sections, the toxicity value for carcinogenic effects is a slope factor, and the toxicity value for noncancerous health effects is a reference dose. Chemicals that show a potential for both carcinogenic and noncarcinogenic health effects could have both a slope factor and reference dose. Table 5-1 presents the slope factor and reference dose toxicity values for both inhalation and oral exposures used in this risk assessment. Oral toxicity values are also used to evaluate dermal exposure pathways. Table 5-2 describes the "weight of evidence" classification system for carcinogenicity which describe the evidence that the chemical will cause cancer in people.

Lifetime health effects fall into two categories: those that could potentially cause cancer (called "carcinogens") and those that cause other types of health effects, such as liver damage (called "noncarcinogens").

The State of California's official list of slope factors is updated periodically and is compiled by the Standards and Criteria Work Group, which is composed of staff from the boards, departments and office of CAL/EPA. For Sites in California, this list is used first and then the USEPA's Integrated Risk Information System (IRIS) is referred to.

USEPA's official list of toxicity values is maintained by IRIS. Listing a chemical in IRIS involves an extensive peer review of the data to verify the information used to derive slope factors and references doses.

The toxicity values are combined with the chronic daily intake to calculate a numerical estimate of cancer risk and/or noncarcinogenic adverse health effects in Chapter 6, Risk Characterization.

Toxicity Values for Carcinogenic Effects

The toxicity value for carcinogens is known as the slope factor. The units for the slope factor are (milligrams per kilogram of body weight per day)$^{-1}$, (mg/kg/day)$^{-1}$. Slope factors for most chemicals are developed with a mathematical model that uses data from laboratory animals, exposed to high doses for relatively short periods of time, to predict potential increases of cancer in humans who are exposed to low doses for long periods of time.

For carcinogens, risk assessment protocol assumes that a single exposure to a chemical has the potential to cause cancer and there is no threshold. That is, no dose or threshold exposure is thought to be risk-free.

Toxicity Values for Noncancer Health Effects

The potential for noncarcinogenic adverse health effects is estimated with a toxicity value known as a reference dose. A reference dose is an estimate of a daily exposure level for the human population (including sensitive sub-populations) that is likely to be without an appreciable risk of adverse health effects during a lifetime. Each reference dose is developed for the most sensitive or critical adverse health effect, based in part on the assumption that if the critical adverse health is prevented, all adverse health effects will be prevented.

The current scientific view assumes that there is a concentration for noncarcinogens, or a threshold, below which there is little potential for adverse health effects over a lifetime of exposure. The reference dose is designed to represent this threshold dose.

The reference dose is calculated from the highest chronic (long term) exposure level that did not cause adverse effects in the laboratory animals tested. A safety factor is applied to this level to allow for any uncertainty, such as using data from animals to predict effects on humans. These factors range up to 10,000, based on the confidence level associated with the data. The resulting reference dose (mg/kg of body weight per day) is used to characterize the noncarcinogenic adverse health effects.

Toxicity Values for Total Petroleum Hydrocarbons as Gasoline (TPHg)

TPHg will not be quantitatively evaluated in this risk assessment as there are no toxicity values. However, benzene, toluene, ethylbenzene and xylenes which have toxicity values are generally considered to be representative of TPHg.

Table 5-1 Summary of Toxicity Factors
Former E-Z Serve Station #100877
525 West A Street, Hayward, California

	Slope Factors, (mg/kg/day)-1		Reference Doses, mg/kg/day	
	Inhalation	Oral	Inhalation	Oral
Benzene[1]	1.0E-01	1.0E-01	-	-
Toluene[2]	-	-	1.0E-01	2.0E-01
Ethylbenzene[2]	-	-	3.0E-01	1.0E-01
Xylenes[2]	-	-	-	2.0E+00[3]

[1] From CalEPA "California Cancer Potency Factors: Update", November 1, 1994

[2] From Integrated Risk Information System (IRIS)

[3] To calculate risks due to inhalation exposure, the oral RfD was used.

Table 5-2 EPA Weight-of-Evidence Classification System for Carcinogenicity
Former E-Z Serve Station #100877
525 West A Street, Hayward, California

Group	Description
A	Human Carcinogen
B1 or B2	Probable Human Carcinogen B1 indicates that limited human data are available. B2 indicates sufficient evidence in animals and inadequate or no evidence in humans.
C	Possible Human Carcinogen
D	Not classifiable as to human carcinogenicity
E	Evidence of noncarcinogenicity for humans

CHAPTER 6

RISK CHARACTERIZATION

The final step in a risk assessment is to characterize the risk. The chronic daily intake is combined with the toxicity value to calculate a numerical representation of the individual excess cancer risks or potential for noncancer health effects. This section discusses how these numbers are calculated, the meaning of the numbers, and the results for this risk assessment. Table 6-1 presents the summary of the risks for each pathway. Tables 6-2 through 6-12 preseent the risk calculations for each pathway.

This risk assessment calculates three exposure scenarios:

- Current exposure for inhalation of vapors from groundwater migrating through the soil and into a house.
- Potential future exposure for exposure to deeper soil during intrusive activities to depths of 10 feet or more.

what about soil surface

- Hypothetical use of groundwater for household purposes.

It is highly unlikely that the exposure pathways associated with direct exposure to groundwater would ever be completed.

Cancer risks were calculated for adults only. Exposure to a carcinogen is averaged over a lifetime, therefore adults are the best representatives for the long term health impacts. Hazard quotients were calculated for children only. Exposure to a noncarcinogen is averaged over a short exposure period, therefore children are the best representatives for the short term impacts.

Cancer Risk

Individual excess cancer risk (cancer risk) is expressed as a probability. A risk of 1×10^{-6} means that each individual has a probability of 1 in a million of increased incidence of cancer during their lifetime above the baseline or normal cancer rate. The USEPA interprets this number to mean that the excess risk is estimated to be no greater than 1 in a million, and is likely to be less, and, in fact, may be zero.

The EPA has established a range of acceptable cancer risks of 1×10^{-4} to 1×10^{-6} for Superfund Sites. This means that cancer risk levels should be between an upper limit of 1 in 10,000 probability to a lower limit of 1 in 1,000,000. These acceptable risk ranges are consistent with those for other federal agencies that make risk-based decisions. A review of criteria for foods, pesticide use, and occupational safety shows that other agencies such as the

Food and Drug Administration and the Occupational Safety and Health Organization frequently make risk-based decisions within this range (Rodericks, et al., 1987).

Cancer risks for the same exposure pathways are added together to assess the overall potential for excess cancer posed by more than one chemical. Also, cancer risks for each exposure pathway are added together to determine the risk associated with exposure to all the chemicals and routes of exposure posed by the Site. The total risk value must also be within EPA's acceptable cancer risk range of $1x10^{-4}$ to $1x10^{-6}$.

Current Risk. The current risk of $1x10^{-6}$ for adults, associated with inhalation of vapors from groundwater migrating through the soil and into a house, is within USEPA's acceptable risk range.

Future Risk. The future risk of $4x10^{-6}$ for adults, which includes direct contact with soil, is within EPA's acceptable risk range.

Hypothetical Groundwater Use. There is an unacceptable risk associated with the residential use of groundwater. The probability of an increase in the individual cancer risk for these pathways is 1×10^{-2} for adults. These risks are well above the range of acceptable risk established for the Superfund program by the EPA.

The highest total potential cancer risk, under the EPA standard pathway, is based on the inhalation of benzene in groundwater while bathing. The risk estimate for this groundwater use is calculated to be $1x10^{-2}$ for adults.

Noncancer Health Effects

This section presents the methods, interpretation, and results for long-term noncarcinogenic adverse health effects via all exposure pathways. The numerical value for characterizing noncarcinogenic adverse health effects, a Hazard Quotient, is the ratio between the chronic daily intake and the reference dose. The reference dose is defined as a level of daily exposure that is unlikely to result in noncarcinogenic adverse health effects over a lifetime of exposure. Hence, hazard quotients greater than 1 indicate that exposure is greater than the recommended level, while hazard quotients less than 1 show that exposure is lower than the recommended level.

Hazard Quotients are not probabilities, but a ratio of an actual exposure level to a calculated, acceptable level. The EPA has not established specific guidance for acceptable Hazard Quotients. However, since a Hazard Quotient value of 1 indicates that exposure has limited potential for causing an adverse effect in sensitive populations, values that are less than 1 are generally considered acceptable by the EPA. Values greater than 1 are usually given closer attention.

Hazard Quotients for the same exposure pathway are added together to assess the overall potential for noncarcinogenic adverse health effects posed by more than one chemical. The resulting value is called the Hazard Index, or the sum of the Hazard Quotients. Hazard Indices for each pathway are added together to assess the overall potential for noncarcinogenic adverse health effects posed by the Site.

Current Hazard Index. The total Hazard Index of 0.0001 for children, associated with inhalation of vapors from groundwater migrating through the soil and into a house, is below EPA's acceptable value of 1.

Future Hazard Index. The total Hazard Index of 0.0007 for children, which includes direct contact with soil, is below EPA's acceptable value of 1.

Hypothetical Groundwater Use. The total Hazard Index of 2 for children, which is associated with the use of groundwater for residential purposes, is above USEPA's acceptable level of 1. The highest total hazard index, under these exposure pathways, is based on the inhalation of groundwater while bathing. The hazard index for this pathway is calculated to be 2 for children. Ethylbenzene is responsible for the majority of the hazard index.

Table 6-1 Summary of Risks
Former E-Z Serve Station #100877
525 West A Street, Hayward, California

Exposure Pathway	Risk	Hazard Index
Current Risk		
Inhalation of Indoor Air Through Crack in Foundation	1E-06	0.0001
Total	1E-06	0.0001
Future Risk		
Ingestion of Soil	2E-08	0.00003
Dermal Contact with Soil	1E-06	0.0003
Inhalation of Soil	1E-06	0.0002
Total	4E-06	0.0007
Hypothetical Groundwater Use		
Ingestion of Groundwater	2E-03	0.5
Dermal Contact with Groundwater While Bathing	4E-04	0.08
Inhalation of Groundwater While Bathing	1E-02	2
Ingestion of Homegrown Produce Via Irrigation	2E-04	0.2
Total	1E-02	2

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Table 6-2 Inhalation of Indoor Air Through a Crack in the Foundation
Former E-Z Serve Station #100877
525 West A Street, Hayward, California

Calculation of Cancer Risk for Adults

Compound	Ciac mg/m^3	IR m^3/day	EF days/year	ED yr	BW kg	AT days	Intake mg/kg/day	Inhalation Slope Factor $(mg/kg/day)^{-1}$	Cancer Risk
Benzene	1.01E-04	20	365	30	70	25550	1.24E-05	1.00E-01	1E-06
Toluene	9.02E-06	20	365	30	70	25550	1.10E-06	-	-
Ethylbenzene	1.78E-05	20	365	30	70	25550	2.18E-06	-	-
Xylenes	7.09E-05	20	365	30	70	25550	8.68E-06	-	-
Total Individual Excess Cancer Risk									1E-06

Calculation of Hazard Quotient for Children

Compound	Ciac mg/m^3	IR m^3/day	EF days/year	ED yr	BW kg	AT days	Intake mg/kg/day	Inhalation RfD mg/kg/day	Hazard Quotient
Benzene	1.01E-04	15	365	5	16	1825	9.48E-05	-	-
Toluene	9.02E-06	15	365	5	16	1825	8.46E-06	0.1	0.000085
Ethylbenzene	1.78E-05	15	365	5	16	1825	1.67E-05	0.3	0.000056
Xylenes	7.09E-05	15	365	5	16	1825	6.65E-05	-	-
Hazrd Index									0.00014

Chronic Daily Intake = (Ciac x IR x EF x ED)/(BW x AT)

Where
Ciac = Concentration in air
IR = Inhalation rate
EF = Exposure frequency
ED =Exposure duration
BW = Body weight
AT = Averaging time

Cancer Risk = Intake x Slope Factor
Hazard Quotient = Intake / Reference Dose

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Table 6-3 Calculation of Indoor Air Concentration
Based on Chemical Conentrations in Groundwater and Soil
Former E-Z Serve Station #100877
525 West A Street, Hayward, California

Parameter	Benzene	Toluene	Ethylbenzene	Xylenes
Pa, unitless	0.35	0.35	0.35	0.35
Pt, unitless	0.5	0.5	0.5	0.5
Do, cm^2/sec	0.08195	0.07367	0.06274	0.06742
Ds, cm^2/sec	0.0099	0.0089	0.0076	0.0082
T, K[1]	288	288	288	288
R, (atm x m^3)/(mole x K)	8.20E-05	8.20E-05	8.20E-05	8.20E-05
Cw, mg/L	1.879	0.143	0.599	1.716
H, (atm x m^3)/mole	5.59E-03	6.37E-03	6.43E-03	7.04E-03
Csg, mg/cm^3 (from GW)	4.45E-04	3.86E-05	1.63E-04	5.11E-04
Cs, mg/Kg	0.370	0.104	0.151	0.311
H'	0.23	0.26	0.27	0.29
B	1.8	1.8	1.8	1.8
Kd	0.166	0.6	2.2	0.48
Ow	0.1	0.1	0.1	0.1
Oa	0.22	0.22	0.22	0.22
Csg, mg/cm^3 (from soil)	3.41E-04	3.93E-05	1.78E-05	1.58E-04
total Csg, mg/cm^2	7.86E-04	7.80E-05	1.81E-04	6.69E-04
Ca, mg/cm^3	0	0	0	0
L, cm	488	488	488	488
J, mg/(cm^2 x sec)	1.60E-08	1.43E-09	2.82E-09	1.12E-08
A, cm^2	790	790	790	790
VR, sec	3600	3600	3600	3600
V, m^3	450	450	450	450
IAC, mg/m^3	1.01E-04	9.02E-06	1.78E-05	7.09E-05

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[1] for Newark, from "Climatological Data Annual Summary, California 1993", V97 N13, NOAA

Table 6-4 Calculation of Indoor Air Concentration Based on Chemical Concentration in Groundwater and Soil
Former E-Z Serve Station #100877
525 West A Street, Hayward, California

(phat modified
version

IAC = (J x A x VR)/V
- IAC = Indoor air concentration, mg/m^3
- J = Flux rate, mg/cm^2 x sec
- A = Area of exposed soil, cm^2
- VR = Indoor air residence time, sec
- V = Indoor volume, m^3

A = 790 cm^2 of exposed soil
- 0.5 cm crack along one side of a 2000 ft^2 home

VR = 3600 sec (one change per hour)

V = 4.5E+02 m^3
- 2000 ft^2 home with 8 ft ceilings built on a concrete slab
- 2000 ft^2 x 8 ft x 2.83E+04 cm^3/ft^3 x 10-6 m^3/cm^3 = 4.5E+02 m^3

Flux at Soil Surface (Karimi, et al, 1987)

J = (Ds(Ca - Csg))/L
- J = Vapor flux, mg/(cm^2 x sec)
- Ds = Effective vapor phase diffusion coefficient, cm^2/sec
- L = Depth to groundwater, cm
- Ca = Concentration of vapor at surface, set = 0
- Csg = Concentration of vapor in soil gas, mg/cm^3

Csg is estimated from concentrations in water (Cw) and soil (Cs)

Soil Gas Concentration from groundwater(EPA 1988)

Csg = (H x Cw)/(R x T x 1000)
- H = Henry's Law Constant, (atm x m^3)/mole
- Cw = Concentration in groundwater, mg/L
- R = Gas constant (8.2E-05 atm x m^3/(mole x K)
- T = Mean annual air temperature, K

Soil Gas Concentration from soil (TNRCC)

Csg = (Cs x H' x B)/(Kd x B+Ow+Oa x H')
- Csg = Soil Vapor Concentration, mg/L (mg/L x 1E-03L/cm^3 = mg/cm^3)
- Cs = Bulk soil concentration, mg/kg
- H' = Henry's Law Constant, unitless, H/R x T, H x 41.57
- R = Gas constant, 0.0000824 atm-m^3/mole-K
- T = Absolute temperature, 273K + C, at 10 C
- B = Dry soil bulk density, 1.8 kg/L
- Kd = Soil water aprtition coefficient, Koc x Foc
- Koc = Oragnic carbon partition coefficient
- Foc = Soil organic carbon fraction, 0.002
- Ow = Water content, 0.1
- Oa = Air fill soil porosity, O-Ow
- O = total soil porosity, 1 - B/Pb, where Pb = particle density, 2.65 kg/L

Total Soil Gas Concentration = that from groundwater + that from soil

Effective Diffusion Coefficient (Karimi, et al, 1987)

Ds = Do(Pa^3.33/Pt^2)
- Do = Vapor phase diffusion coefficient at 18 C, cm^2/sec
- Pt = Total porosity, unitless, 0.5
- Pa = Air filled porosity, unitless, 0.35

Table 6-5 Ingestion of Soil
Former E-Z Serve Station #100877
525 West A Street, Hayward, California

Calculation of Cancer Risk for Adults

Compound	Cs mg/kg	IR mg/day	CF kg/mg	FI -	EF days/year	ED yr	BW kg	AT days	Intake mg/kg/day	Oral Slope Factor (mg/kg/day)-^{1}	Cancer Risk
Benzene	0.370	100	1E-06	1	365	30	70	25550	2.27E-07	1.00E-01	2E-08
Toluene	0.104	100	1E-06	1	365	30	70	25550	6.37E-08	-	-
Ethylbenzene	0.151	100	1E-06	1	365	30	70	25550	9.24E-08	-	-
Xylenes	0.311	100	1E-06	1	365	30	70	25550	1.90E-07	-	-
Total Individual Excess Cancer Risk											2E-08

Calculation of Hazard Index for Children

Compound	Cs mg/kg	IR mg/day	CF kg/mg	FI -	EF days/year	ED yr	BW kg	AT days	Intake mg/kg/day	Oral Reference Dose mg/kg/day	Hazard Quotient
Benzene	0.370	200	1E-06	1	365	5	16	1825	4.63E-06	-	-
Toluene	0.104	200	1E-06	1	365	5	16	1825	1.30E-06	0.2	0.00001
Ethylbenzene	0.151	200	1E-06	1	365	5	16	1825	1.89E-06	0.1	0.00002
Xylenes	0.311	200	1E-06	1	365	5	16	1825	3.89E-06	2	0.000002
Hazard Index											0.00003

Chronic Daily Intake = (Cs x IR x CF x FI x EF x ED)/(BW x AT)

Where
Cs = Concentration in soil
IR = Ingestion rate
CF = Conversion factor
FI = Fraction ingested, assume 100%
EF = Exposure frequency
ED =Exposure duration
BW = Body weight
AT = Averaging time

Cancer Risk = Intake x Slope Factor
Hazard Quotient = Intake / Reference Dose

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Table 6-6 Dermal Contact with Soil
Former E-Z Serve Station #100877
525 West A Street, Hayward, California

Calculation of Cancer Risk for Adults

Compound	Cs mg/kg	SA cm^2	AF mg/cm^2	CF kg/mg	ABS -	EF days/year	ED yr	BW kg	AT days	Intake mg/kg/day	Oral Slope Factor $(mg/kg/day)^{-1}$	Cancer Risk
Benzene	0.370	3120	1.45	1.00E-06	1	365	30	70	25550	1.02E-05	1.00E-01	1E-06
Toluene	0.104	3120	1.45	1.00E-06	1	365	30	70	25550	2.88E-06	-	-
Ethylbenzene	0.151	3120	1.45	1.00E-06	1	365	30	70	25550	4.18E-06	-	-
Xylenes	0.311	3120	1.45	1.00E-06	1	365	30	70	25550	8.61E-06	-	-
Total Individual Excess Cancer Risk												1E-06

Calculation of Hazard Index for Children

Compound	Cs mg/kg	SA cm^2	AF mg/cm^2	CF kg/mg	ABS -	EF days/year	ED yr	BW kg	AT days	Intake mg/kg/day	Oral RfD mg/kg/day	Hazard Quotient
Benzene	0.370	1580	1.45	1.00E-06	1	365	5	16	1825	5.30E-05	-	-
Toluene	0.104	1580	1.45	1.00E-06	1	365	5	16	1825	1.49E-05	0.2	0.0001
Ethylbenzene	0.151	1580	1.45	1.00E-06	1	365	5	16	1825	2.16E-05	0.1	0.0002
Xylenes	0.311	1580	1.45	1.00E-06	1	365	5	16	1825	4.45E-05	2	0.00002
Total Hazard Index												0.0003

Chronic Daily Intake = (Cs x SA x AF x ABS x ED x EF x CF)/(BW x AT)

Where
Cs = Chemical concentration in water
SA = Skin surface area available for contact, hands and arms
AF = Adherence Factor, 1.45 potting soil, 2.77 kaolin clay
ABS = Absorption Factor
EF = Exposure frequency
ED = Exposure duration
CF = Conversion factor
BW = Body weight
AT = Averaging time

Cancer Risk = Intake x Slope Factor
Hazard Quotient = Intake / Reference Dose

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Table 6-7 Inhalation of Soil
Former E-Z Serve Station #100877
525 West A Street, Hayward, California

Calculation of Cancer Risk for Adults

Compound	Cs mg/Kg	IR m³/day	EF days/yr	ED yr	VF m³/kg	PEF m³/kg	BW kg	AT days	Intake mg/kg/day	Inhalation Slope Factor (mg/kg/day)-¹	Cancer Risk
Benzene	0.370	20	365	30	3536	4.63E+09	70	25550	1.28E-05	1.00E-01	1E-06
Toluene	0.104	20	365	30	6705	4.63E+09	70	25550	1.90E-06	-	-
Ethylbenzene	0.151	20	365	30	13892	4.63E+09	70	25550	1.33E-06	-	-
Xylenes	0.311	20	365	30	5954	4.63E+09	70	25550	6.40E-06	-	-
Total Individual Excess Cancer Risk											1E-06

Calculation of Hazard Index for Children

Compound	Cs mg/Kg	IR m³/day	EF days/yr	ED yr	VF m³/kg	PEF m³/kg	BW kg	AT days	Intake mg/kg/day	Inhalation Reference Dose mg/kg/day	Hazard Quotient
Benzene	0.370	15	365	5	3536	4.63E+09	16	1825	9.81E-05	-	-
Toluene	0.104	15	365	5	6705	4.63E+09	16	1825	1.45E-05	0.1	0.0001
Ethylbenzene	0.151	15	365	5	13892	4.63E+09	16	1825	1.02E-05	0.3	0.00003
Xylenes	0.311	15	365	5	5954	4.63E+09	16	1825	4.90E-05	-	-
Hazard Index											0.0002

Chronic Daily Intake = (Cs x IR x EF x ED (1/VF + 1/PEF))/(BW x AT)

Where
Cs = Concentration in soil
IR = Ingestion rate
EF = Exposure frequency
ED = Exposure duration
VF = Volatilization factor
PEF = Particulate emission factor
BW = Body weight
AT = Averaging time

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Table 6-8 Calculation of the Volatilization Factor (VF)
Former E-Z Serve Station #100877
525 West A Street, Hayward, California

Compound	LS	V	DH	A	ps	o	T	Di	Dei	E	H	foc	Koc	Kd	Kas	VF
Benzene	45	2.25	2	20,250,000	2.65	1.58E-03	7.90E+08	0.08195	0.0580	0.35	5.59E-03	0.02	83	1.66	0.138	3,536
Toluene	45	2.25	2	20,250,000	2.65	4.57E-04	7.90E+08	0.07367	0.0521	0.35	6.37E-03	0.02	300	6.00	0.044	6,705
Ethylbenzene	45	2.25	2	20,250,000	2.65	1.08E-04	7.90E+08	0.06274	0.0444	0.35	6.43E-03	0.02	1100	22.00	0.012	13,892
Xylenes	45	2.25	2	20,250,000	2.65	5.76E-04	7.90E+08	0.06742	0.0477	0.35	7.04E-03	0.02	240	4.80	0.060	5,954

VF = ((LS x V x DH)/ A) x ((3.14 x o x T)^1/2)/(2 x Dei x E x Kas x 10^-3)
Where
LS = Length of side of contaminated area, m, 45m
V = Wind speed in mining zone, m/s, 2.25 m/s
DH = Diffusion height, m, 2m
A = Area of contamination, cm^2, 20,250,000 cm^2
o =
T = Exposure interval, s, 7.90E+08 s
Dei = Effectifve diffusivity, cm^2/s
E = True soil porosity, 0.35
Kas = Soil-air partition coefficient, g-soil/cm^3-air

o = (Dei x E)/(E + (ps) x (1-E)/Kas)
Where
ps = True soil density or particle density,g/cm^3, 2.65 g/cm^3

Dei = Di x (E^0.33)
Where
Di = Diffusivity in air

Kas = (H/Kd) x 41
Where
H = Henry's Law Constant, atm-m^3/mol
Kd = Soil-water partition coefficient, cm^3/g

Kd = Koc x foc
Where
Koc = Organic carbon partition coefficient, cm^3/g
foc = fraction organic carbon content of soil, 0.02

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Table 6-9 Ingestion of Groundwater
Former E-Z Serve Station #100877
525 West A Street, Hayward, California

Calculation of Cancer Risk for Adults

Compound	Cw mg/L	IR L/day	EF days/year	ED yr	BW kg	AT days	Intake mg/kg/day	Oral Slope Factor (mg/kg/day)$^{-1}$	Cancer Risk
Benzene	1.88	2	365	30	70	25550	2.30E-02	1.00E-01	2E-03
Toluene	0.14	2	365	30	70	25550	1.75E-03	-	-
Ethylbenzene	0.60	2	365	30	70	25550	7.34E-03	-	-
Xylenes	1.72	2	365	30	70	25550	2.10E-02	-	-
Total Individual Excess Cancer Risk									2E-03

Calculation of Hazard Index for Children

Compound	Cw mg/L	IR L/day	EF days/year	ED yr	BW kg	AT days	Intake mg/kg/day	Oral Reference Dose mg/kg/day	Hazard Quotient
Benzene	1.88	1	365	5	16	1825	1.17E-01	-	-
Toluene	0.14	1	365	5	16	1825	8.95E-03	0.2	0.04
Ethylbenzene	0.60	1	365	5	16	1825	3.74E-02	0.1	0.37
Xylenes	1.72	1	365	5	16	1825	1.07E-01	2	0.05
Hazard Index									0.47

Chronic Daily Intake = (Cw x IR x EF x ED)/(BW x AT)

Where
Cw = Concentration in water
IR = Ingestion rate
EF = Exposure frequency
ED =Exposure duration
BW = Body weight
AT = Averaging time

Cancer Risk = Intake x Slope Factor
Hazard Quotient = Intake / Reference Dose

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Table 6-10 Dermal Contact with Groundwater while Bathing
Former E-Z Serve Station #100877
525 West A Street, Hayward, California

Calculation of Cancer Risk for Adults

Compound	Cw mg/L	SA cm²	PC cm/hour	CF 1L/1000 cm³	ET hr/day	EF days/year	ED yr	BW kg	AT days	Intake mg/kg/day	Oral Slope Factor (mg/kg/day)⁻¹	Cancer Risk
Benzene	1.88	18150	0.1	0.001	0.2	365	30	70	25550	4.18E-03	1.00E-01	4E-04
Toluene	0.14	18150	0.1	0.001	0.2	365	30	70	25550	3.18E-04	-	-
Ethylbenzene	0.60	18150	0.1	0.001	0.2	365	30	70	25550	1.33E-03	-	-
Xylenes	1.72	18150	0.1	0.001	0.2	365	30	70	25550	3.81E-03	-	-
Total Individual Excess Cancer Risk												4E-04

Calculation of Hazard Index for Children

Compound	Cw mg/L	SA cm²	PC cm/hour	CF 1L/1000 cm³	ET hr/day	EF days/year	ED yr	BW kg	AT days	Intake mg/kg/day	Oral RfD mg/kg/day	Hazard Quotient
Benzene	1.88	8223	0.1	0.001	0.2	365	5	16	1825	1.93E-02	-	-
Toluene	0.14	8223	0.1	0.001	0.2	365	5	16	1825	1.47E-03	0.2	0.007
Ethylbenzene	0.60	8223	0.1	0.001	0.2	365	5	16	1825	6.16E-03	0.1	0.06
Xylenes	1.72	8223	0.1	0.001	0.2	365	5	16	1825	1.76E-02	2	0.009
Total Hazard Index												0.08

Chronic Daily Intake = (Cw x SA x PC x ED x ET x EF x CF)/(BW x AT)

Where

Cw = Chemical concentration in water
SA = Skin surface area available for contact
PC = Permeability coefficient
ET = Exposure time
EF = Exposure frequency
ED = Exposure duration
CF = Conversion factor
BW = Body weight
AT = Averaging time

Cancer Risk = Intake x Slope Factor
Hazard Quotient = Intake / Reference Dose

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Table 6-11 Inhalation of Groundwater While Bathing
Former E-Z Serve Station #100877
525 West A Street, Hayward, California

Calculation of Cancer Risk for Adults

Compound	Cw mg/L	K L/m^3	IR m^3/day	EF days/year	ED yr	BW kg	AT days	Intake mg/kg/day	Inhalation Slope Factor (mg/kg/day)$^{-1}$	Cancer Risk
Benzene	1.88	0.50	20	365	30	70	25550	1.15E-01	1.00E-01	1E-02
Toluene	0.14	0.50	20	365	30	70	25550	8.76E-03	-	-
Ethylbenzene	0.60	0.50	20	365	30	70	25550	3.67E-02	-	-
Xylenes	1.72	0.50	20	365	30	70	25550	1.05E-01	-	-
Total Individual Excess Cancer Risk										1E-02

Calculation of Hazard Quotient for Children

Compound	Cw mg/L	K L/m^3	IR m^3/day	EF days/year	ED yr	BW kg	AT days	Intake mg/kg/day	Inhalation RfD mg/kg/day	Hazard Quotient
Benzene	1.88	0.50	15	365	5	16	1825	8.81E-01	-	-
Toluene	0.14	0.50	15	365	5	16	1825	6.71E-02	0.1	0.67
Ethylbenzene	0.60	0.50	15	365	5	16	1825	2.81E-01	0.3	0.94
Xylenes	1.72	0.50	15	365	5	16	1825	8.04E-01	-	-
Hazrd Index										1.61

Chronic Daily Intake = (Cw x K x IR x EF x ED)/(BW x AT)

Where
Cw = Concentration in water
K = Volatilization factor
IR = Inhalation rate
EF = Exposure frequency
ED = Exposure duration
BW = Body weight
AT = Averaging time

Cancer Risk = Intake x Slope Factor
Hazard Quotient = Intake / Reference Dose

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Table 6-12 Ingestion of Homegrown Produce Via Irrigation
Former E-Z Serve Station #100877
525 West A Street, Hayward, California

Input Parameters

Compound	Ksp	log Ksp	Kd	log Kow	log Koc	Foc
Benzene	2.30	0.36	8.32	2.12	1.92	0.1
Toluene	1.02	0.01	30.20	2.73	2.48	0.1
Ethylbenzene	0.59	-0.23	109.65	3.15	3.04	0.1
Xylenes	0.51	-0.30	23.99	3.26	2.38	0.1

Calculation of Cancer Risk for Adults

Compound	Cw mg/L	Cs mg/kg	Cp mg/kg	IR[1] kg/day	GI -	L[2] -	EF days/yr	ED yr	BW kg	AT days	Chronic Daily Intake mg/kg/day	Oral Slope Factor (mg/kg/day)-1	Cancer Risk
Benzene	1.88	7.82E+00	3.60E+00	2.50E-01	1	0.30	365	30	70	25550	1.65E-03	1.00E-01	2E-04
Toluene	0.14	2.16E+00	4.42E-01	2.50E-01	1	0.30	365	30	70	25550	2.03E-04	-	-
Ethylbenzene	0.60	3.28E+01	3.84E+00	2.50E-01	1	0.30	365	30	70	25550	1.77E-03	-	-
Xylenes	1.72	2.06E+01	2.08E+00	2.50E-01	1	0.30	365	30	70	25550	9.55E-04	-	-
Total Individual Excess Cancer Risk													2E-04

Calculation of Hazard Index for Children

Compound	Cw mg/L	Cs mg/kg	Cp mg/kg	IR[1] kg/day	GI -	L[2] -	EF days/yr	ED yr	BW kg	AT days	Chronic Daily Intake mg/kg/day	Oral Reference Dose (mg/kg/day)	Hazard Quotient
Benzene	1.88	7.82E+00	3.60E+00	2.50E-01	1	0.30	365	5	16	1825	1.69E-02	-	-
Toluene	0.14	2.16E+00	4.42E-01	2.50E-01	1	0.30	365	5	16	1825	2.07E-03	0.2	0.01
Ethylbenzene	0.60	3.28E+01	3.84E+00	2.50E-01	1	0.30	365	5	16	1825	1.80E-02	0.1	0.2
Xylenes	1.72	2.06E+01	2.08E+00	2.50E-01	1	0.30	365	5	16	1825	9.75E-03	2	0.005
Hazard Index													0.2

Concentration in surface soil, Cs = Cw x Kd x 0.5

where:
Cw = Concentration in water
Kd = Soil to water partition coefficient
0.5 =

Concentration in plants, Cp = 0.2 x Ksp x Cs

where:
Cs = Concentration in soil
Ksp = Soil to plant partition coefficient
0.2 =

Chronic Daily Intake = (Cp x IR x GI x L x ED x EF) / (BW x AT)

where:
Cp = Concentration in plant
IR = Ingestion rate
GI = Gastrointestinal absorption factor
L = Fraction of plant homegrown
BW = Body weight
ED = Exposure duration
EF = Exposure frequency
AT = Averaging time

Cancer Risk = Chronic Daily Intake x Slope Factor
Hazard Quotient = Chronic Daily Intake / Reference Dose

Parameter	Reference
Ksp	
log Ksp	1.588-0.578*logKow (LLNL Risk Assessment)
Kd	Koc*Foc
log Kow	Superfund Public Health Evaluation Manual, October 1986
log Koc	Groundwater Chemicals Desk Reference, John H. Montgomery and Linda M. Welkom, 1990
Foc	Default from CAPCOA

[1] The value for vine crops was chosen for the ingestion rate as it is more conservative than the value for root or leafy crops when combined with the interception fraction for vine crops.

[2] EPA 1989. Exposure Factors Handbook, EPA/600/8-89/043, May 1989, Value for worst case scenario.

where:
Kow = octanol:water partition coefficeint
Koc = organic:carbon partition coefficient
foc = fraction organic carbon in soil
Ksp = soil:plant partion coefficient

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CHAPTER 7

UNCERTAINTY ANALYSES

This section provides a discussion of uncertainties associated with risk assessment. The estimated cancer risks and non-cancer hazard quotients are based on numerous assumptions, most of which are considered conservative and will therefore overestimate the risk. These assumptions include how people can be exposed to chemicals in the environment, how long they will be exposed, how chemicals will act in the environment, how long they will remain in the environment at the concentration measured, and how toxic the chemicals may be.

As a result of the cumulative effect of these conservative assumptions, the estimated risks are likely to overestimate actual risks. The resultant risk estimates are, thus, not intended to represent actual risks, but are intended to provide an indication, in a relative sense, the chemical(s) or pathway(s) that are contributing the greatest to risk. As a decision-making tool, quantitative risk assessments are used to help determine if the risks associated with exposure to a given chemical or chemical mixture exceeds a threshold level for regulatory action. Such decisions depend not only on the calculated risk estimates, but also on the uncertainties and assumptions incorporated into the risk estimates. Accordingly, we provide a discussion of some of the more important uncertainties.

The uncertainties associated with each chapter in the risk assessment and their potential effects on the numerical risk estimates are discussed below.

Data Evaluation

Factors that may introduce uncertainty of Site environmental data are as follows:

- Sample collection methods
- Accurate characterization of area geology and hydrology
- Representativeness and completeness of data
- Adequacy of data to describe Site conditions
- Analytical methods, detection limits, and quality control/quality assurance procedures

Uncertainties are associated with the collection, analysis, and evaluation of environmental data regarding the chemicals of potential concern selected for use in the risk assessment.

Sampling programs are necessarily limited in space and time. The location of sampling wells and timing of sampling events may not accurately reflect groundwater conditions.

Environmental sampling may or may not have accurately characterized concentrations of chemicals. Sampling volatile chemicals could result in loss of chemicals during collection and handling. Comparing duplicate samples collected in the field is a method used to evaluate variability in sampling. If the duplicates are similar in concentration of chemicals, then the uncertainty associated with sampling is reduced. Data from duplicate groundwater samples had a high percentage of matching samples.

The procedures used to analyze chemicals in environmental media may have introduced errors. A series of laboratory blank samples and other samples are designed to detect errors introduced in this manner. All data used in this assessment were evaluated and found to be of acceptable quality.

Data evaluation involves using statistics to summarize the data and selecting chemicals of potential concern. The reasonable maximum exposure (RME) was derived for the concentration of each chemical. All sample values for a specific medium were used to calculate this confidence level, the RME, regardless of where or when the sample was originally collected. The chemical was assumed present at one half the detection limit in samples where no chemical was identified. Thus, there were no "zero" values used. The RME value was then used to represent the concentration at which exposure could occur (each chemical was assumed to be in the same location).

Exposure Assessment

The chemical concentrations were assumed to remain constant for the entire exposure duration, however a review of the analytical data show that concentrations of volatile organic compounds are already decreasing. The chemicals detected in the groundwater are undergoing physical and chemical transformation processes (volatilization, microbial degradation, etc.) that reduce the concentration over time. Volatile organic chemicals undergo degradation in the atmosphere and have relatively short half-lives. The uncertainty of the rate and amount of chemical reduction leads to the assumption of constant concentration and adds uncertainty to the risk estimates.

Another area of uncertainty in exposure assessment is the prediction of human activities that lead to contact with environmental media and exposures to chemicals. Activities that differ from those used in the exposure assumptions could lead to higher or lower risks than those estimated. If some of the activities do not occur or occur for shorter periods of time than the estimates used in this assessment, the risks presented here would be higher than "true" risks. In addition, the assumption that all exposures occur concurrently introduces an uncertainty into the resulting risk estimates. To compensate for this uncertainty, conservative estimates of exposure were used. A constant rate of exposure was assumed for 365 days each year. This value represents the highest possible rate.

In the exposure evaluation, the primary routes of potential exposure were evaluated, as well as the potential magnitude, duration, and/or frequency of contact. A source of uncertainty in estimating exposures is the assumption that all individuals within a particular receptor group will receive the same dose. Biological variability in absorption, ingestion rates, breathing rates, frequency and duration will exist, even in a narrowly-defined age group or identified-sensitive population group.

Toxicity Assessment

Use of cancer slope factors and reference doses are subject to several types of uncertainties. Typically, the studies from which these values are derived involve conditions that are not identical to the types of exposures of interest involving chemicals in the environment. Extrapolations from animal experiments are frequently required to derive a toxicity value for use in risk assessments.

In addition, the actual mechanism of toxic action in laboratory animals of some chemicals may not be the same as in humans. For example, trichloroethene is known to be metabolized to carcinogenic chemicals in the liver of laboratory animals, but such metabolites are not produced at the same rates in humans. Slope factors are calculated assuming that humans are equally sensitive to the carcinogenic effects of chemicals as laboratory animals. This represents a large source of uncertainty.

Factors influencing toxicity and, consequently, the evaluation of risk based on animal data are listed below:

- Choice of species, strain, age, and sex of animals
- Number of animals in the study
- Individual variation within animal species
- Similarity in the routes of exposure between the tested species and route of interest in humans
- Purity of test compound
- Decay of test compound
- Selection of dose levels and use of control groups

- Distribution of animals among dose levels
- Similarity between test animals and humans in terms of metabolism and pharmacokinetics
- Proper histopathological examination of animals
- Proper animal husbandry and dietary considerations
- Experimental surroundings
- Selection of proper endpoint in animal studies
- Latency periods
- Synergism or antagonism between chemicals
- Species to species extrapolation of dose levels
- High to low dose extrapolations and choice of model to describe dose-response curve for carcinogenic chemicals (i.e., all chemicals are assumed to be carcinogenic in the same way)
- Statistical evaluation of confidence intervals and methods used to analyze data

The information on animal responses to carcinogens is constantly changing. The EPA revises their official list of carcinogens frequently. New chemicals are added to the EPA carcinogen data base as new information becomes available. Sometimes, new information also causes a chemical to be removed from the list. Many times, chemicals appearing on the list are removed for further consideration. In this case EPA is reviewing the numerical estimate of cancer potency. When a chemical is removed from the list, EPA is uncertain about the accuracy of the cancer potency slope.

The methods used to derive slope factors and reference doses are intended to be conservative in recognition of uncertainties. For noncarcinogens, uncertainty factors are applied to either the "no observed effect" levels or even the "lowest observed effect" levels to obtain a reference dose. For carcinogens, a slope factor at the estimated 95 percent upper confidence limit is used. Carcinogenic slope factors assume no threshold for effects; if there are, in fact, thresholds for carcinogenicity, the slope factor could be altered considerably.

The overall quality of the toxicology database contains numerous uncertainties including: lack of consistency between different experimental studies; small numbers of studies; lack of available information on multiple species and multiple routes of administration; lack of a demonstration of a clear dose-response relationship; lack of plausible biological mechanisms of action and especially lack of direct evidence of effects in humans.

For ingestion exposures, the availability of chemicals in the body is assumed to be the same as that in the studies from which toxicity factors were developed. Most toxicity parameter values are calculated to be used with administered doses rather than absorbed doses but still reflect the bioavailability in the as-administered form. The risks are likely to be overestimated if bioavailability from media is less than from the form of administered doses in toxicological studies.

Dermal toxicity values are not available for use in estimating risk from direct contact. Oral toxicity values were used in the estimation of risk through the dermal pathway. As stated above, oral values are predominantly based on an administered dose whereas dermal intake is expressed as an absorbed dose. The oral toxicity values for trichloroethene are an exception to this as they are based on absorbed dose. Oral toxicity values may be adjusted and expressed as an absorbed dose if information on absorption is available. Such data are not readily available and oral toxicity values were not adjusted in this assessment. This introduces uncertainty in the estimates of risk through dermal exposure.

Toxicity of each chemical was assumed to be additive. Interactions between chemicals, synergisms or antagonisms, were not accounted for due to the limited toxicity information on these types of interactions. Interactions could result in over- or underestimations of the risks.

Risk Characterization

Uncertainties associated with risk characterization are primarily those that have been built into the process of deriving risk estimates. The statistical or mathematical nature of risk characterization is a result of combining a series of numbers selected to represent a reasonable maximum estimate. We construct a hypothetical situation in order to portray a "worst case" scenario.

Calculations of chemical intakes can provide considerable uncertainty in a risk assessment. Intake assumptions include, for example, inhalation rates, dermal contact rates, ingestion rates, skin surface areas, and absorption factors. The assumptions used to calculate intakes are conservative based upon the best available scientific literature and/or assumed values. Intake assumptions are often debated in the scientific community. The range of uncertainty in the values quoted by various researchers can make a substantial difference in the results of a risk assessment. The intake assumptions used in this evaluation were obtained both from peer-reviewed scientific literature and from EPA guidance documents. Uncertainties in the assessments may exist from the use of these assumptions.

Additionally, the linear risk equations used in this risk assessment is only valid at risk levels below 0.01. An alternate equation was also used, however there were no changes in the outcome.

In summary, every effort has been made to reduce the inherent uncertainties. To reduce uncertainties, directly measured concentrations (e.g., groundwater concentrations) were used to evaluate risk. Conservative assumptions regarding the toxicity of the compounds have also been used in the assessment. As indicated in the previous sections, it is expected that any uncertainties in this risk assessment would, therefore, tend to err on the conservative side. Through the use of conservative assumptions, the actual risks from exposure to the chemicals of concern are not likely to exceed risks from the RME case and are, in fact, likely to be much lower than the risks predicted from this evaluation.

CHAPTER 8

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