GEOMATRIX

REMEDIAL INVESTIGATION AND BASELINE RISK ASSESSMENT REPORT
I-880 REALIGNMENT CORRIDOR
West Oakland and Desert Rail Yards
Oakland, California

VOLUME I OF III

Prepared for

Union Pacific Railroad
1416 Dodge Street
Omaha, Nebraska 68179

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EXECUTIVE SUMMARY

This report presents the findings of a Remedial Investigation (RI) and Baseline Risk Assessment (RA) for portions of the Southern Pacific Transportation Company (SPTCo; now Union Pacific Railroad) West Oakland and Desert Rail Yards in Oakland California (the site). The site includes approximately 75 acres transferred from SPTCo to California Department of Transportation (Caltrans) for the Interstate 880 freeway realignment and construction project. This report has been prepared by Geomatrix Consultants, Inc. (Geomatrix), on behalf of SPTCo in response to Sections 5.5 and 5.6 of Imminent or Substantial Endangerment (I&/SE) Order No. 93-94-018 (the Order) issued to SPTCo by California Environmental Protection Agency - Department of Toxic Substances Control (DTSC) on 20 June 1994. The Baseline RA (included in Appendix A of this report) has been prepared by Center for Toxicology and Environmental Health to assess health risk associated with portions of the site where both "elevated" and "at-grade" sections of the freeway will be located. Health risk associated with several parcels located along Third Street were not assessed in the Baseline RA; these parcels will be addressed by Caltrans because they are currently planned to be developed by Caltrans as a park.

The objectives of the report are to (1) present the results of the RI field investigation, (2) characterize the nature and extent of chemicals in soil and groundwater, and (3) present the evaluation of the risk to human health and the environment posed by chemicals detected in soil or groundwater at the site. The data used to accomplish these objectives include those previously collected by others and data collected by Geomatrix during the RI.

The site has been operated as a rail yard for at least 90 years, with portions of the West Oakland Rail Yard developed as early as the 1870s. The rail yards have been used primarily for railroad car storage and repair and consist of railroad tracks and buildings that have been used for various rail yard support operations. Previous soil and groundwater data have been collected during site-wide investigations conducted in 1991/1992 and in 1993. Additional soil and groundwater data were collected by Geomatrix during the RI field investigation conducted during February through May 1995.

The hydrogeologic data collected at the site indicate that the upper 15 feet of subsurface sediments generally consist of 3 to 4 feet of fill material underlain by native material. Depths to groundwater are approximately 4 to 8 feet below ground surface (bgs). Based on data from the site vicinity, historical horizontal hydraulic gradients in the native material have been relatively low in magnitude (0.001 to 0.004 foot/foot). Gradient directions are generally toward San Francisco Bay but may be locally affected by dewatering or other influences.

Analytical results for soil samples collected at the site indicate that high-boiling petroleum hydrocarbons are frequently present in vadose-zone soil (fill material). These data also indicate that low concentrations of polynuclear aromatic hydrocarbons (PNAs) and aromatic and aliphatic volatile organic compounds (VOCs) are occasionally present in vadose-zone soil. Average concentrations of metals for soil samples collected at the site generally are similar to concentrations found elsewhere within the greater Bay Area. Lead concentrations in site soil may be higher than levels typically found in greater Bay Area soil, but may be similar to concentrations found in soil over the general area of West Oakland.

Analytical results for groundwater samples collected at the site indicate that most constituents detected in soil do not significantly affect groundwater. Both aromatic and aliphatic VOCs have been detected in groundwater at isolated locations within the site. Most notably, elevated concentrations of aromatic VOCs (alkylated benzenes and chlorobenzenes) were detected in groundwater samples from three areas within the northern elevated section of the future freeway, and elevated concentrations of aliphatic VOCs (PCE, TCE, 1,1-DCA, cis-1,2-DCE, and vinyl chloride) were detected in groundwater near the car lighting shop. These chemicals in groundwater appear to be limited in extent and do not appear to be migrating off site.

The results of the Baseline RA indicate that chemicals present in soil and groundwater at the site would be unlikely to pose unacceptable health risks, as defined by U.S. EPA and DTSC. Exposure scenarios were evaluated based on the knowledge that this area would have future use as a freeway. The future potential receptors identified who are most likely to have the greatest exposure are a child at play beneath elevated portions of the freeway and a utility worker who works in either elevated or at-grade portions of the freeway. Exposure of either receptor to chemicals in soil or groundwater would be unlikely to result in adverse noncarcinogenic health effects or excess theoretical cancer risks above the range that generally is considered acceptable by U.S. EPA ($1x10^{-4}$ to $1x10^{-6}$).

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BASELINE RISK ASSESSMENT REPORT
I-880 REALIGNMENT CORRIDOR
West Oakland and Desert Rail Yards
Oakland, California

1.0 INTRODUCTION

This report has been prepared on behalf of Southern Pacific Transportation Company (SPTCo; now Union Pacific Railroad) by Geomatrix Consultants, Inc. (Geomatrix), and responds to Sections 5.5 and 5.6 of Imminent or Substantial Endangerment (I&/SE) Order No. 93-94-018 (the Order) issued to SPTCo by the California Environmental Protection Agency - Department of Toxic Substances Control (DTSC) on 20 June 1994. The Order addresses portions of the SPTCo West Oakland and Desert Rail Yards that are within the I-880 realignment corridor, as well as the former Bobo's Junkyard, which has been identified as a separate operable unit. This Remedial Investigation (RI) and Baseline Risk Assessment (RA) Report has been prepared to address portions of the West Oakland and Desert Rail Yards within the I-880 realignment corridor (the site; Figure 1). Although not required by the Order, the Baseline RA is included herein (Appendix A) because the data presentation and discussion in this RI are used to support the Baseline RA. A separate RI and Baseline RA Report that addressed Bobo's Junkyard was submitted on 27 November 1995 and approved by the DTSC on 25 January 1996.

This RI summarizes data collected from all property transferred from SPTCo to California Department of Transportation (Caltrans), exclusive of Bobo's Junkyard. However, the Baseline RA does not include several parcels located along Third Street (Figure 2) as agreed in a 31 March 1995 meeting among representatives from the DTSC, SPTCo, Terranext (formerly Industrial Compliance), Geomatrix, Caltrans, and Environmental Solutions (consultant to Caltrans). Health risk associated with these parcels will be addressed by Caltrans and their consultant because these portions of the property will be included in an area currently planned to be developed by Caltrans as a park (South Prescott Park). The Baseline RA Report has been prepared by Center for Toxicology and Environmental Health (CETH); it is included in Appendix A and summarized in Section 6.0 of this report.

1.1 OBJECTIVE OF REPORT

The overall objective of this report as stated in the Order is to characterize the site for the purposes of defining risk to public health and the environment. Specific objectives of the report are to (1) document results of an RI that was performed to address data needs identified in the RI Scoping Document (Geomatrix, 1994a) and the Addendum to RI Scoping Document (Geomatrix, 1994b), (2) use data collected during the RI and previous investigations to characterize the nature and extent of chemicals in soil and groundwater, and (3) evaluate risk to human health and the environment.

1.2 REPORT ORGANIZATION

This report is generally organized following U.S. Environmental Protection Agency (U.S. EPA) guidance, as appropriate (U.S. EPA, 1988). The following sections describe (1) site background information (Section 1.3), (2) site physical characteristics (Section 2.0), (3) remedial investigation activities including soil and grab groundwater sampling (Section 3.0), (4) the nature and extent of chemicals in soil and groundwater (Section 4.0), (5) chemical fate and transport (Section 5.0), and (6) findings of the Baseline RA prepared by CTEH (Section 6.0).

1.3 BACKGROUND

The following subsections present background information about the site including site description, site history, and a summary of previous investigations.

1.3.1 Site Description

The site is situated in an industrial area of west Oakland, California, and consists of portions of the SPTCo West Oakland and the Desert Rail Yards (approximately 75 acres) sold by SPTCo to Caltrans for the I-880 realignment corridor (Figure 1). Site facilities include trackage and various maintenance shops and storage buildings (Figure 2). The surrounding facilities include the Oakland Naval Supply Center to the west, Port of Oakland operations to the west and south, and the Oakland Army Terminal to the south. Residential neighborhoods are within 600 feet of the site to the east. Based on 1990 census information, 6,457 people live within a 1-mile radius of the site (DTSC, 1994). The current construction plans for the I-880 freeway across the former SPTCo property consist of two elevated sections and an at-grade section (Figure 2). In addition, Seventh Street will be sub-grade, or depressed, as it crosses under the new alignment of the I-880 freeway.

1.3.2 Site History

The early history of the site is not well documented; however, some information is contained in a recent archaeological report prepared on behalf of Caltrans for the I-880 realignment project (Praetzellis, 1994). According to maps presented in Praetzellis (1994) and other published geologic maps (Radbruch, 1957; McDonald, et al., 1978), at the time of Oakland's early settlement in the 1850s, the portion of the West Oakland Yard within the realignment corridor was marshland adjacent to the Oakland estuary and much of the area that is now the Desert Yard was within San Francisco Bay. The area that is within the West Oakland Yard appears to have remained largely undeveloped until at least 1870 However, by 1878, the area was occupied by a railyard for the Central Pacific Railway, predecessor to Southern Pacific (Praetzellis, 1994). It is not clear when the area that is now the Desert Yard, which was not included in the Praetzellis study, was filled and developed.

Since the two areas were developed as rail yards, they have been used primarily for railroad car storage and repair. Thirteen buildings currently on the property have been used for various rail yard support operations. These buildings are shown on Figure 2 and a description of their former use, and identification of chemical constituents that may have been used or stored is presented in Table 1.

Potentially hazardous substances commonly associated with routine rail yard operations include lubricating oils, fuel oils, paints, and metals. Heavy, high-boiling lubricating oils have been used at the Desert Yard throughout its operations. This oil, known as journal box (JB) oil, was fed along the tracks in the switching yards from a pressurized steel pipe buried about 2 feet below grade. According to SPTCo, the oil is generally about 90 weight and highly viscous. Available data previously collected indicate a wide distribution of high-boiling petroleum hydrocarbons in site soil. Lead is also known to be present in shallow soil along the trackage. Low-boiling petroleum hydrocarbons and aromatic and aliphatic volatile organic compounds are not routinely used in rail yard operations and generally have not been detected at elevated concentrations at the site.

Two discrete properties, 1912 7th Street and 721 Cedar Street, are undergoing investigation and remedial activities related to former fuel underground storage tanks (USTs). These sites have been closed (721 Cedar Street) or are in the process of being closed (1912 7th Street) by Alameda County Health Care Services Agency (ACHCSA) and are not discussed in this report. Another former UST site at the Desert Yard (called Tank 9) was investigated by SPTCo and Caltrans, soil and groundwater data were submitted to ACHCSA, and ACHCSA has not required any further action with respect to this tank.

1.3.3 Previous Investigations

Most previous soil and groundwater chemical data were collected at the site during two phases of investigation. CH2M Hill collected data throughout the entire site between December 1991 and January 1992 (CH2M Hill, 1992). Industrial Compliance (IC; now Terranext) collected data between August and November 1993 from portions of the site that are to be elevated freeway (IC, 1994a). The IC and CH2M Hill samples appear to have been collected in accordance with U.S. Environmental Protection Agency (EPA) SW-846 guidance (U.S. EPA, 1986) and, therefore, are considered acceptable for the purposes of this RI. Further, the analytical results for these samples form the foundation of the Scoping Document and Addendum (GMX 1994a, 1994b) previously approved by DTSC. Soil and groundwater sample locations from these investigations are shown on Figure 2, and analytical results are tabulated in Appendix B. In addition to these two site-wide investigations, area-specific investigations have been conducted by IC and Environmental Solutions, consultant to Caltrans. IC collected limited additional data in April 1995 from seven borings drilled south of Bobo's Junkyard (borings ICP-4 through ICP-10, Figure 2). Environmental Solutions has collected soil and groundwater samples from property in the vicinity of the proposed South Prescott Park (near Third Street) and from Contract Area A (eastern elevated section).

CH2M Hill collected soil samples from 110 borings that were 2 to 4 feet deep throughout the entire site; samples were also collected in the vicinity of the Seventh Street overpass from five borings that were 16.5 to 30 feet deep. Generally, two to four samples were collected from each of the shallow borings, and five to seven samples were collected from the deeper borings. A Hydropunch was used to collected grab groundwater samples from 66 of the borings.

IC collected soil samples from 358 borings, typically drilled to depths of 10 feet, at footing locations in the site sections that are to be elevated freeway (Figure 2). Generally, three borings were drilled at each footing location, and samples from given depth intervals (typically 0.5 to 1.0, 2.0 to 2.5, and 4.0 to 4.5 feet) were composited by the analytical laboratory (IC, 1994f). Grab groundwater samples were collected from one boring in each footing (89 total) using a bailer lowered directly into the borehole or into a PVC screen temporarily placed in the borehole. Additionally, IC collected soil samples from seven borings (ICP-4 through ICP-10, Figure 2) that were drilled in April 1995 to assess pesticides in soil near Bobo's Junkyard; soil samples generally were collected from each boring at depths of 0.5, 2, 4, and 6 feet.

Additional soil and groundwater data have been collected in the corridor by Environmental Solutions from an area west of the southern "elevated" section where a ramp was to be constructed (called the surcharge area; Environmental Solutions, 1994a) and from freeway footings in the southern "elevated" section (called Contract Area A; Environmental Solutions, 1994b). Environmental Solutions soil samples from the surcharge area (no groundwater samples were collected) were non-detect for most constituents; if constituents were detected, concentrations were considerably lower than maximum concentrations detected elsewhere in the corridor by CH2M Hill, IC, and/or Geomatrix. Most of the Environmental Solutions soil samples from Contract Area A footings (no groundwater samples were collected) were collected at depths of 5 feet or greater in order to characterize deeper soil for soil management purposes during freeway construction. The CTEH risk assessment (Appendix A) only used data from soil samples collected up to a depth of 5 feet because it was assumed that potential future receptors would not likely be exposed to deeper soil after the freeway is constructed. For the samples that were collected at depths shallower than 5 feet, maximum concentrations of constituents detected were (1) lower than maximum concentrations detected elsewhere in the corridor by CH2M Hill, IC, and Geomatrix, and/or (2) below applicable USEPA Region IX preliminary remediation goals (PRGs; USEPA, 1996) and, therefore, would have been excluded from the risk assessment. For these reasons, the site characterization for this RI is based on the data collected by CH2M Hill, IC, and Geomatrix as proposed in the Scoping Document and Field Sampling Plan (FSP; Geomatrix, 1994a, 1994c) and as approved by DTSC. Soil and groundwater data from site investigations conducted by CH2M Hill, IC, and Geomatrix are tabulated in Appendix B.

2.0 SITE PHYSICAL CHARACTERISTICS

This section presents a discussion of the physical system at and near the site, including physiography, geology, and hydrogeology.

2.1 PHYSIOGRAPHY

The site is located on the East Bay Plain of the Coast Ranges geomorphic province, which consists of lowlands composed of tidal flats and alluvial deposits formed by streams carrying sediments from the mountains to the east. The East Bay Plain is bound by the Berkeley/Oakland Hills to the east, the San Francisco Bay to the west, the City of Albany on the north, and the City of Hayward on the south (Alameda County Flood Control and Water Conservation District [ACFCWCD, 1993], Figure 3).

The site has an approximate elevation between 5 and 10 feet above mean sea level based on the U.S. Geological Survey Oakland West 7.5 minute quadrangle. The only surface water body within a mile of the site is the San Francisco Bay (the Oakland inner and outer harbors), which is 0.6 mile from the site at its closest point. Lake Merritt, a saline lake, is approximately 1.25 miles to the east of the site.

2.2 GEOLOGY

Regional Geology

As described by ACFCWCD (1993), the San Francisco Bay region is characterized by a structural trough that contains Quaternary-age sediments up to 1100 feet thick that overlie Jurassic- and Cretaceous-age bedrock. The region is characterized by many faults and folds, which now exist in a dominantly strike-slip environment. Pre-Holocene age Quaternary sediments of the East Bay Plain were shed westward from the Diablo Range.

The surficial sediments throughout the west Oakland area include Holocene-age Bay Mud and Pleistocene-age Merritt Sand; inland of these sediments is older Pleistocene-age alluvium (Radbruch, 1957). The Bay Mud is a marine clay to silty clay with organic material that is exposed at the surface near the bay margin and ranges in thickness from less than a foot to about 120 feet beneath the bay. The Bay Mud overlies the Merritt Sand near the bay margin but the latter is exposed in a relatively small area immediately inland of the Bay Mud. The Merritt Sand is a part of the San Antonio Formation and it consists of eolian, fine- to medium-grained sands that are silty and become more consolidated with depth. The Merritt Sand is about 65 feet thick and relatively restricted in aerial extent. Underlying the Merritt Sand are about 1100 feet of older Pleistocene-age sediments.

The older Pleistocene-age units are the lower portion of the San Antonio Formation and include the Old Bay Mud or Yerba Buena Mud, and the Alameda Formation (ACFCWCD, 1993). They consist of marine and non-marine sediments that are predominantly clays with lenses of silt, sand, and gravel. The Alameda Formation unconformably overlies the Franciscan bedrock. The Franciscan Formation consists of sandstone, shale, chert, some volcanic rocks, and serpentine. These rocks have undergone intense deformation, showing fractures and shears where exposed at the surface.

Site Geology

Based on borings drilled by Geomatrix during the RI, the upper 15 feet of sediments consist of fill material underlain by native material. Boring logs from this investigation are presented in

Appendix C. According to Radbruch (1957), the fill material consists of sediments dredged from the bay and the Oakland estuary; however, it is likely that fill material also came from other sources. Based on information presented in Praetzellis (1994), fill in some portions of the West Oakland Yard likely came from cuttings along Southern Pacific's East Bay lines in Contra Costa County and Niles Canyon (Alameda County). If fill came from various sources, it would be expected to have a variable lithology, which is consistent with the nature of the fill observed by Geomatrix. The fill material generally appears to extend to a depth of 3 to 4 feet below ground surface (bgs) and is heterogeneous with varying amounts of sand, gravel, and fines; it often contains glass, brick, and wood fragments.

At the West Oakland Yard, the native material encountered beneath the fill generally consists of black silty sand that extends to depths of 7 to 12 feet bgs and becomes lighter in color (dark gray to gray) with increasing depth. This unit has been called Bay Mud by Canonie (1989); however, the term "Bay Mud" is generally used to describe a unit that is predominantly comprised of silt or clay. The black silty sand may be a stratigraphic equivalent to the Bay Mud. These observations are consistent with Radbruch (1957) and McDonald, et al. (1978), which both show no Bay Mud throughout most of the West Oakland Yard within the realignment corridor. In most borings, a dark yellowish brown silty sand was encountered beneath the black silty sand; this unit has been interpreted by Canonie as the Merritt Sand. Based on deeper borings drilled by CH2M Hill in the vicinity of the Seventh Street depression, the Merritt Sand extends at least to a depth of 30 feet bgs at the site.

At the Desert Yard, the native material encountered beneath the fill generally consists of very dark brown to black silt or lean clay containing shell fragments that extends to depths of 6 to 15 feet (or greater) bgs; this unit is considered to be Bay Mud. At some locations, the Bay Mud was thin or absent, and a dark gray to black, poorly-graded sand was encountered; these sands may represent channel deposits within the Bay Mud. Beneath the Bay Mud, a black to yellowish brown silty sand was encountered; this unit is considered to be the Merritt Sand. The approximate lateral extent of Bay Mud in the West Oakland and Desert Rail Yards is shown on Figure 2.

2.3 HYDROGEOLOGY

Regional Hydrogeology

The groundwater basin that underlies the East Bay Plain consists of predominantly fine-grained sediments with intercalated lenses of coarse-grained sediments. ACFCWCD (1993) estimates that, in the Oakland area, the percentages of aquifers and aquitards are 25 and 75, respectively. The water-yielding properties of the Merritt Sand and other coarser lenses are expected to be moderate with little yield from the finer-grained units. The generalized groundwater movement direction is bayward. The velocity of groundwater movement through the basin is expected to be slow because of the generally low hydraulic gradient magnitude, the predominance of fine-grained sediments, and the discontinuous nature of the coarse-grained sediments. Near the bay margin, tidal fluctuations may influence gradient direction and magnitude; however, such influences are not likely to occur at the site, which is 0.6 mile from the Bay at its closest point.

Shallow groundwater is not used for municipal or domestic purposes in west Oakland. In accordance with State of California Department of Water Resource regulations, ACFCWCD Zone 7 Water Agency requires a minimum 50-foot sanitary seal for municipal and industrial water supply wells, and a 20-foot sanitary seal for domestic and irrigation wells.

Site Hydrogeology

Based on data from monitoring wells near or at the site (Figure 4), shallow groundwater generally occurs at depths of 4 to 8 feet below ground surface (bgs) in one or two water-bearing zones, depending on whether the Bay Mud is present. During the RI investigation, groundwater was encountered in some borings at shallower depths, probably due to significant rainfall during the months proceeding the investigation. The water-bearing zones encountered during the RI are the surficial fill and the Merritt Sand. Figure 4 shows the location of nearby sites where hydraulic information is available.

Groundwater in the fill is unconfined. Hydraulic conductivity of the fill is expected to be variable due to its heterogeneous character. Two slug tests performed on shallow wells screened in the fill at the West Oakland Yard yielded hydraulic conductivity values of approximately 4.0 x 10^{-3} centimeters per second (cm/s) (Canonie, 1989). Horizontal hydraulic gradients in the fill range from 0.003 to 0.013 foot per foot (ft/ft). Gradient directions are generally towards the bay based on data from nearby sites including the West Oakland Yard, and some observed fluctuations or gradient reversals may be due to tidal influences or dewatering projects. Overall, groundwater movement through the fill is likely slow due to the heterogeneous nature of the fill, low hydraulic gradients, and locally fluctuating gradient directions.

The Bay Mud, where present, acts as an aquitard between the fill and the Merritt Sand. Seven laboratory permeability tests on cores of the Bay Mud collected at the West Oakland Yard yielded vertical hydraulic conductivity values of 1 x 10^{-7} to 6 x 10^{-8} cm/s (Canonie, 1989).

Groundwater in the Merritt Sand occurs in unconfined to confined conditions. The hydraulic conductivity of the Merritt Sand is moderate because it consists of silty to clayey fine-grained sand. Nine slug tests performed on wells screened in the Merritt Sand in the "at-grade" section of the site yielded hydraulic conductivity values of 2.9 x 10^{-3} to 5.8 x 10^{-2} cm/s (Dames & Moore, 1992). A 48-hour, constant-rate pumping test of the Merritt Sand at the West Oakland Yard yielded a hydraulic conductivity of 6.6 x 10^{-2} cm/s (Site 8, Figure 4; Canonie, 1989). Horizontal hydraulic gradients determined for the Merritt Sand range from 0.001 to 0.004 ft/ft (Canonie, 1989, and other references shown on Figure 4). Gradient directions are generally towards the bay. Near the bay, the potentiometric surface is likely affected by tidal loading. Groundwater movement through the Merritt Sand is likely slow because of the low hydraulic gradient and local gradient reversals due to tidal loading.

The shallow groundwater beneath and in the vicinity of the Corridor is not likely suitable for municipal or domestic water supply in accordance with State Water Resources Control Board (SWRCB) Resolution No. 88-63 because total dissolved solids (TDS) values are likely to be greater than 3000 mg/l, based on data from nearby sites. At the Oakland Army Base (Site 1, Figure 4), TDS values ranged from 3800 to 11,000 mg/l in samples from four monitoring wells (IC, 1994c). At the former impoundment area of the West Oakland Yard (Site 8, Figure 4), TDS values ranged from 660 to 32,200 mg/l in samples from four monitoring wells (IC, 1994d). Finally, at Bobo's Junkyard (Site 7, Figure 4), TDS values ranged from 2120 to 5580 mg/l in samples from four monitoring wells (Geomatrix, 1995d). TDS data are not available from sites 4, 5, and 6, shown on Figure 4.

3.0 REMEDIAL INVESTIGATION ACTIVITIES

Soil and/or grab groundwater samples were collected from 40 borings (B-1 through B-40) drilled by Geomatrix between 7 February and 1 March 1995. Samples were collected from locations selected to complete the characterization of the lateral and vertical extent of chemicals in soil and groundwater as discussed in the FSP (Geomatrix, 1994c). As specified in the FSP Addendum (Geomatrix, 1995a), soil and groundwater samples were collected from borings drilled at potential source areas at nine buildings where chemicals may have been used or stored. Sampling locations are presented on Figure 2, and analyses performed on samples collected at each building are summarized in Table 2.

After review of the data generated from the 40 sampling locations, we concluded that collection of additional grab groundwater samples was warranted for the purposes of completing site characterization. On 17 and 19 April 1995, additional grab groundwater samples were collected in the vicinity of the Car Lighting Shop (borings B-41 through B-44; Figure 2) and adjacent to boring B-32 (boring B-32b). Because of quality assurance/quality control (QA/QC) issues associated with these samples (see Section 3.4), resampling was performed on 16 May 1995 (borings B-41A, B-43A, and B-44A), and two additional borings were drilled and sampled (B-45 and B-46; Figure 2). These resampling locations are shown on Figure 2 and are within 10 feet of the original boring locations.

Boreholes were drilled using the direct-push technology described in the FSP Addendum, and grab groundwater samples were collected using the temporary well method described in the FSP. The work was performed in accordance with the FSP (Geomatrix, 1994c), the FSP Addendum (Geomatrix, 1995a), the Quality Assurance Project Plan (QAPP; Geomatrix, 1995b), and the Site Health and Safety Plan (HSP; Geomatrix, 1995c) and is summarized below.

3.1 SOIL SAMPLING

Prior to drilling, a drilling permit was obtained from Zone 7 Water Agency. Underground Service Alert (USA) was notified and an underground utility search was conducted by a private locator at each borehole location.

Boreholes were drilled by Precision Sampling, Inc. of San Rafael, California, using a direct-push technology. A hydraulic hammer was used to advance 2.5-inch-diameter drive casing containing a 3-foot-long core barrel lined with 6-inch-long, 1.75-inch-diameter, stainless-steel liners. After advancing the casing and filling the core barrel, the core barrel was retrieved on rods while the drive casing remained in the borehole. The stainless-steel liners containing soil were removed from the core barrel, selected liners were submitted for chemical analysis, and soil in the remaining liners was used to prepare lithologic logs (Appendix C). The procedure was repeated until the total depth of the borehole was reached, thereby providing a continuous core of the borehole. Soil was visually classified by a Geomatrix geologist using the Unified Soil Classification System (USCS) and lithologic logs were prepared as described in the FSP. In general, boreholes were advanced to a total depth of approximately 5 feet if only soil samples were collected and to a total depth of approximately 15 feet if grab groundwater samples were collected. All downhole equipment was decontaminated prior to each use, either by steam cleaning or by washing with an Alconox-water solution and rinsing once with municipal water and twice with deionized water.

As proposed in the FSP, two soil samples generally were collected from each boring at approximate depths between 0.5 and 1 foot and between 3 and 5 feet. The shallow samples appeared to consist of fill material, whereas the deeper samples generally appeared to consist of native material. Exceptions to this sampling approach are as follows:

- In the Desert Yard, additional samples often were collected at intermediate depths (1.5 to 3.0 feet) for polynuclear aromatic hydrocarbons (PNA) analysis because the highest concentrations of total petroleum hydrocarbon (TPH) previously have been found within this depth interval (IC, 1994).

- Shallow samples occasionally were collected at depths between 1 to 1.5 feet if the upper 0.5 foot consisted of material that likely would be removed during freeway construction (concrete, asphalt, or railroad ballast).

- Deeper samples were occasionally collected below a depth of 5 feet if there was no shallower sample recovery (borings B-2, B-7, and B-19).

- At the drop table shed (boring B-11), a soil sample was also collected at a depth interval of 13 to 13.5 feet because this boring was drilled adjacent to an approximate 11.5-foot-deep concrete trench. This sample was collected to assess whether chemicals were present in soil beneath the trench.

- At the wheel shop, boring B-12 was drilled adjacent to an approximate 6-foot-deep concrete sump, which is below a railwheel lathe. No soil samples were collected because the upper 10 feet of the boring consisted entirely of gravel fill material and no soil samples were recovered. A second boring was drilled to a depth of 13.5 feet adjacent to the first, and only gravel fill material was again encountered. Because no soil samples could be recovered, this area was assessed on the basis of the grab groundwater sample.

Stainless-steel liners containing soil to be submitted for chemical analysis were sealed with Teflon sheeting, plastic end caps, and silicone tape. Soil samples were then labeled, stored in an ice-cooled chest and delivered under Geomatrix chain-of-custody procedures to Quanterra Environmental Services (Quanterra) of West Sacramento, California, a State of California-certified laboratory. Samples generally were picked up by a laboratory representative on each day of sampling; if samples were sent by overnight delivery or courier service, the coolers were sealed with custody tape. Field QA/QC soil samples included at least one matrix spike (MS) and MS duplicate (MSD) every twenty samples for each analysis performed. QA/QC results are discussed in Section 3.4.

After soil and groundwater samples were collected, boreholes were backfilled to the surface with a cement/bentonite grout that was placed through a 1-inch-diameter PVC tremie pipe. Investigation-derived soil and decontamination water were contained in 55-gallon drums that were labeled and stored in an enclosed area (stockpile management area number 3). Because of the small volume of soil generated during the investigation (one drum), a composite sample was collected to assess disposal. Analytical results from the composite soil sample indicated that the soil was non-hazardous, and it was managed in accordance with the Stockpile Management Plan (IC, 1994b). Analytical results from groundwater samples indicated that the decontamination water could be processed through SPTCo's waste water treatment plant.

3.2 GRAB GROUNDWATER SAMPLING

Grab groundwater samples were collected from boreholes using the temporary well method described in the FSP in conjunction with the direct-push drilling methods described above. After drive casing was advanced to a total depth of 15 feet, a 1-inch-diameter temporary PVC well consisting of a 10-foot-long, 0.01-inch-slot well screen was placed inside the drive casing. Although it was proposed in the FSP that boreholes would be advanced to depths of approximately 5 feet below the water table and temporary wells with 5-foot-long screens would be installed in the boreholes, this depth and well screen length were found to yield inadequate recharge for groundwater sampling requirements; therefore, boreholes were drilled to a greater depth (approximately 10 feet below the average historical water table) and a longer well screen was used. After a temporary well was installed in a cased borehole, the drive casing was withdrawn, thereby exposing the screen to the water-yielding sediments.

Groundwater purging and sampling equipment was decontaminated prior to each use, either by steam cleaning or by washing with an Alconox-water solution and rinsing once with municipal water and twice with deionized water. If recharge was adequate, approximately 1 gallon (2 to 3 casing volumes) of water was purged from the temporary wells with a peristaltic pump or PVC bailer before collecting groundwater samples.

Groundwater samples were collected and containerized according to the volatility of target analytes. Groundwater to be analyzed for volatile organic compounds (VOCs; aromatic and aliphatic VOCs and total petroleum hydrocarbons as gasoline [TPHg]) was collected first with a 0.75-inch-diameter PVC bailer that was slowly lowered and raised into the temporary wells with a stainless steel cable; groundwater from the bailer was slowly drained down the sides of 40-milliliter (ml) HCl-acidified volatile organic analysis (VOA) vials using a bottom-emptying device with a stopcock. Groundwater to be analyzed for semivolatile compounds (PNAs) was collected next by raising and lowering PVC tubing with a ball check valve on the bottom; this procedure allowed a large volume of water to be collected (as per analytical requirements) without aeration. New, clean tubing was used at each borehole to manually "pump" groundwater directly into 1-liter amber bottles. Finally, groundwater to be analyzed for non-volatile compounds (total petroleum hydrocarbons as diesel [TPHd], metals, pesticides and polychlorinated biphenyls [PCBs]) was collected using a peristaltic pump equipped with PVC tubing; new, clean tubing was used at each borehole to pump groundwater directly into 1-liter amber bottles (for TPHd and pesticide/PCB analysis) or 1-liter, nitric-acidified, plastic bottles (for metals analysis). Groundwater for metals analysis was field-filtered during collection using an in-line, positive-pressure, 0.45-micron filter before acidification. Sample containers were labeled, stored in an ice-cooled chest and delivered to Quanterra following the custody procedures described in Section 3.1.

Field QA/QC samples were collected as specified in the FSP Addendum and QAPP and included (1) one blind equipment blank on each day of sampling for all analyses to be performed on samples collected that day, (2) one travel blank per cooler for VOC analyses, (3) at least one blind field sample duplicate every ten samples for each analysis performed, and (4) at least one MS/MSD sample every twenty samples for each analysis performed. Travel blanks were analyzed only if VOCs were detected in the associated equipment blank. The project QA/QC program and results are discussed in Section 3.4.

Purge water and equipment decontamination water was contained in 55-gallon drums, which were labeled and stored in stockpile management area number 3. Based on sample analytical results, the water was processed through SPTCo's wastewater treatment plant.

3.3 ANALYTICAL METHODS

Soil and groundwater samples were analyzed by Quanterra following the procedures described in the QAPP. When samples were received at the laboratory, the information on the chain-of-custody form was checked to verify that it corresponded to that on the sample labels. The physical condition of the samples and internal temperature of the sample chest(s) were recorded on the chain-of-custody form.

As specified in the QAPP, samples were analyzed using EPA methods that would achieve reporting limits equal to or less than potential applicable or relevant and appropriate requirements (ARARs) for compounds previously found in soil or groundwater (target analytes). The ARARs considered were Tri-Regional Board Staff guidelines for TPH, benzene, toluene, ethylbenzene, and xylenes (BTEX) in groundwater (RWQCB, 1990), Maximum Contaminant Levels (MCLs) for other target analytes in groundwater (California Code of Regulations, 1995), and U.S. EPA Region IX residential Preliminary Remediation Goals (PRGs) for target analytes in soil (U.S. EPA, 1995). It should be noted that concentrations of constituents in groundwater will not be compared to MCLs in this RI because shallow groundwater at the site likely contains total dissolved solid (TDS) levels that exceed water quality criteria for municipal or domestic water supply (Section 2.3). The analytical methods used are summarized as follows:

- total petroleum hydrocarbons (TPH) - EPA Method 8015 modified. As specified in the FSP (Geomatrix, 1994c), soil samples were analyzed for TPHg, TPHd, and TPH as motor oil (TPHmo) for soil samples collected near buildings or TPH as JB oil (TPHjb) for soil samples collected elsewhere in the corridor; groundwater samples were analyzed for TPHg and TPHd only.

- aromatic VOCs - EPA Method 8020 for water samples and EPA Method 8260 for soil samples

- aliphatic VOCs - EPA Method 8260

- PNAs - EPA Method 8310

- pesticides and PCBs - EPA Method 8080

- cadmium, chromium, nickel, and zinc - EPA Method 6010A; arsenic - EPA Method 7060; hexavalent chromium - EPA Method 7196; and lead - EPA Method 7421.

For soil samples submitted for TPH analysis, a silica gel cleanup was requested from the laboratory if the sample was suspected to contain significant amounts of non-petroleum organic material because such materials has been shown to cause positive interference in analytical results. In addition, selected soil sample splits were submitted to Friedman & Bruya, Inc. (F&B), of Seattle, Washington, for hydrocarbon fingerprint analyses. F&B is a State of California-certified laboratory.

Laboratory QA/QC samples included (1) at least one method blank with each analytical batch, (2) at least one laboratory control sample (LCS; called single control sample by Quanterra) and LCS duplicate (LCSD; called duplicate control sample by Quanterra) with each analytical batch, and (3) a laboratory surrogate spike added to every sample if required by the analytical method. Laboratory QA/QC results are summarized in Section 3.4.

3.4 QA/QC SUMMARY

Analytical results for field and laboratory quality control samples are discussed below in terms of sample preservation and handling, reporting limits, field and laboratory blank results, accuracy, precision, and completeness. Laboratory quality control sample results are presented in the laboratory reports (Appendix D). The number of soil and groundwater samples collected for each analysis and the number of associated field quality control samples are summarized in Table 3.

3.4.1 Sample Preservation and Handling

All sample preservation and handling requirements were met, with one exception. Soil samples from boring B-1 collected on 22 February 1995 were not analyzed for VOCs using EPA Method 8260 within the 14-day holding time. Therefore, resampling was performed on 28 March 1995, and the new samples were analyzed within the proper holding time.

3.4.2 Reporting Limits

Reporting limit goals presented in the QAPP were met, except when samples were diluted because of high analyte concentrations or when sample matrix caused interference with analyte quantification. In addition to these exceptions, the best achievable reporting limits for ethylene dibromide (EDB) and 1,2-dibromo-3-chloropropane (DBCP) for analysis of water samples using EPA Method 8260 (0.33 micrograms per liter [µg/l] and 0.39 µg/l, respectively) were slightly higher than the reporting limit goals listed in the QAPP (0.2 µg/l).

These instances of increased reporting limits are not considered to affect the use of the data. The reporting limit goals specified in the QAPP for target analytes were established assuming that very conservative reporting limits would be required for the purpose of completing the Baseline RA; the raised reporting limits did not affect the Baseline RA because the assessment was performed on the basis of the maximum concentrations detected. Furthermore, it should be noted that the analytical laboratory could not control the factors that required raising the reporting limits (high analyte concentrations and sample matrix effects).

3.4.3 *Blank Results*

Laboratory Blanks

No analytes were detected in laboratory blanks for soil and groundwater analyses, thereby meeting QAPP goals.

Field Equipment and Travel Blanks

Results for all equipment blanks were reported as below detection limits, with two exceptions. Toluene and zinc were detected in an equipment blank (J-52) collected on 16 February 1995, and trichloroethylene (TCE) was detected in all equipment blanks and trip blanks submitted during supplemental groundwater sampling performed on 17 and 19 April 1995. These exceptions are discussed below.

Equipment blank J-52 was reported with 1.5 µg/l toluene and 0.042 milligrams per liter (mg/l) zinc. As specified in the QAPP, the travel blank that accompanied this shipment (J-72) was analyzed for aromatic VOCs and no analytes were detected. Blank J-52 was collected after sampling GB-3 (at Bobo's Junkyard), which was reported to contain 8900 µg/l toluene, indicating a likely source for toluene in the equipment blank. Groundwater sample B-19 was collected immediately after this equipment blank and was reported with 0.6 µg/l toluene, which may be totally or partially due to constituent carryover in the sampling equipment. Although the source of zinc in this equipment blank is unknown, zinc was not detected in groundwater sample B-19 or GB-3.

After the primary phase of sampling was completed in February 1994, grab groundwater samples were collected from five supplemental borings on 17 and 19 April 1995. Samples were collected from borings B-41 through B-44 to assess the extent of aliphatic VOCs (TCE; PCE (tetrachloroethylene); cis-1,2-dichloroethene [cis-1,2-DCE]; 1,1-dichloroethane [1,1-DCA]; and vinyl chloride) detected in the grab groundwater sample from boring B-15 near the Car Lighting Shop; a sample also was collected from boring B-32 to confirm the presence of isopropylbenzene detected in groundwater samples collected by IC in the Desert Rail Yard. TCE was detected in both equipment blanks associated with these sampling events at concentrations of 8.6 µg/l (J-101 collected on 17 April) and 3.6 µg/l (J-102 collected on 19 April 1995). As specified in the QAPP, the laboratory-prepared travel blanks that accompanied these shipments (J-111 and J-112, respectively) were analyzed for aliphatic VOCs, and TCE also was detected in these blanks at concentrations of 17 and 23 µg/l, respectively. TCE was detected at similar concentrations (8 to 14 µg/l) in most environmental samples submitted with these blanks (samples from borings B-32 and its duplicate [J-121], B-41, B-42, and B-44) and at a somewhat higher concentration (76 µg/l) in the sample from boring B-43. The source of TCE in this batch of samples and blanks was investigated but could not be established.

Because it appeared that all samples collected on 17 and 19 April were contaminated with TCE from an unknown external source, the resulting data were therefore judged not valid, and grab groundwater samples were again collected at three of the locations on 16 May 1995 (B-41A, B-43A, and B-44A). No analytes were detected in the field or travel blanks collected during the May sampling event and the data from this event were considered valid. Resampling was not performed at location B-32 because TCE was not detected in grab groundwater samples previously collected from this area by IC. Resampling also was not performed at boring B-42 for logistical reasons; although all or part of the low concentration of TCE detected in this sample (9.2 µg/l) may be due to external contamination, the data from this sample sufficiently serves the purpose of establishing the extent of aliphatic VOCs in groundwater near the Car Lighting Shop.

3.4.4 Accuracy Sample Results

Accuracy of the analytical methods was assessed by the percent recovery of analytes from LCSs, surrogates, and MS/MSDs. LCS samples are laboratory-prepared blanks spiked with known concentrations of certain analytes to be quantified. Surrogates are known concentrations of unusual compounds added to every sample. MS/MSDs are environmental samples spiked with known concentrations of the compounds requested for analysis. The results of these samples are discussed below.

Laboratory Control Standard Recoveries

Accuracy goals for LCS samples and duplicates were met for all soil and water analyses. These samples are called duplicate control samples (DCS) in the laboratory reports.

Surrogates

Surrogate recovery goals were generally met, with a few exceptions. Surrogate recoveries were slightly above recovery goals for a few soil and groundwater samples analyzed for aliphatic VOCs using EPA Method 8260. These samples were reanalyzed, and surrogate recoveries were again outside of the recovery goals. Therefore, Quanterra concluded that these recoveries were due to matrix interference. In each of these cases, the surrogate recoveries in laboratory single control samples (a laboratory blank spiked with surrogate compounds) met the QAPP goals, thereby validating the method accuracy for the analytical batch. These surrogate recovery exceptions are not considered likely to affect data interpretation because (1) generally these recoveries were only slightly outside the recovery goals, (2) the matrix interference resulted in elevated sample recoveries, and (3) most of these samples had no VOCs detected.

Surrogate recoveries were also occasionally above or below recovery goals for soil samples analyzed for TPH using modified EPA Method 8015. In these cases, the laboratory had difficulty quantifying the surrogate compound due to interference (coelution) with hydrocarbons in the sample matrix. The TPH data are considered valid because when no hydrocarbons were present in the sample matrix, surrogate recoveries were within recovery goals.

Matrix Spike Recoveries

Matrix spike recovery goals were also met, with three exceptions discussed below.

- Cr^{+6} matrix spikes were not detected in sample B-11 (4.0-4.5). The samples were spiked after the leach and filtration, a few hours prior to analysis. After-spikes (hexavalent chromium spiked in the sample during analysis) as well as duplicate control samples, which accompanied this analysis, had recoveries within QAPP goals. The fact that this sample matrix appears to convert Cr^{+6} to Cr^{+3} within a few hours indicates that this matrix is not conducive to long-term persistence of Cr^{+6}.

- Gasoline matrix spike recoveries in soil were slightly below recovery goals for one sample (B-11[4.0-4.5]; both MS and MSD) and above recovery goals for one sample (B-18[4.0-4.5; MS only). LCS results met the QAPP goals, indicating that these MS/MSD results were likely due to matrix effects. Matrix interference was not considered to affect data interpretation because TPH as gasoline was not detected in any soil samples.

- TCE recoveries in one MS/MSD pair (sample B-12 [GW]) was slightly high, which may suggest a slightly high bias for TCE quantification in this sample, due to matrix effects. However, TCE was not detected in this sample and, therefore, this bias is not considered significant.

3.4.5 Precision Sample Results

Precision of the laboratory and field methods was assessed by calculating the relative percent difference (RPD) for LCS, MS, and field duplicate samples. RPDs for LCS and MS duplicate samples are in the analytical reports; RPDs for field duplicate samples are summarized in Table 4. The results of these samples are discussed below.

Laboratory Control Standard Duplicates

Precision goals for LCS duplicate pairs were met for all soil and water analyses.

Matrix Spike Duplicates

Precision goals for MS/MSD samples were all met, with one exception. The RPD between the MS and MSD recoveries for TPHg analysis in soil sample B-18 (4.0-4.5) was 40 percent, which is above the goal of 24 percent. Variation in matrix spike duplicate recoveries is not unexpected given that the MS and MSD samples are separate aliquots from the soil sample and results likely reflect matrix variability. This variation was not considered likely to affect sample results because gasoline was not detected in this sample.

Field Duplicates

The RPDs for field duplicates were all within QAPP precision goals, as shown in Table 4.

3.4.6 Completeness

The data generated are considered complete in that they adequately represent soil and groundwater conditions at the time of sampling. Quality control sample results indicate overall validity of the analytical data generated for this RI.

4.0 NATURE AND EXTENT OF CHEMICALS

This section summarizes the results of chemical analyses performed on soil and groundwater samples collected along the I-880 realignment corridor during previous investigations conducted by IC and CH2M Hill and during the RI conducted by Geomatrix; sample locations and selected data are presented on Figures 5 through 16. The IC and CH2M Hill data were previously summarized in the Scoping Document (Geomatrix, 1994a) and the Geomatrix data were collected to address data needs identified in the Scoping Document. The combined data are used herein to delineate the nature and extent of chemicals in soil and groundwater at the site. Ultimately, this information will be used to assess risk posed by the site conditions.

To facilitate discussion of the data, the following sections are organized by chemical family and then by media (soil or groundwater). Further, the discussion includes references to selected concentration thresholds, which are not intended to be action levels or cleanup goals for the site; they are provided only to simplify data presentation. Tables summarizing all analytical data discussed herein are presented in Appendix B. Laboratory analytical reports for soil and groundwater samples collected by Geomatrix are presented in Appendix D.

4.1 TOTAL PETROLEUM HYDROCARBONS

The following subsections summarize the occurrence and extent of total petroleum hydrocarbons (TPH) in site soil and groundwater.

4.1.1 Soil

A total of 611 soil samples collected by CH2M Hill, IC, and Geomatrix have been analyzed for TPH. Sample locations are shown on Figure 5. CH2M Hill collected 220 samples (including 13 duplicate samples) throughout the entire site that were analyzed for TPHg and TPHd using modified EPA Method 8015; eight additional samples (including 1 duplicate sample) were analyzed for oil and grease (O&G) using EPA Method 418.1. IC collected 331 samples from footing locations in the "elevated" sections of the site. These samples were analyzed for TPHg and TPHd using EPA Method 8260 and TPHmo using EPA Method 8270. According to staff at the laboratory that performed the analyses on the IC samples (Coast to Coast Analytical Services in San Jose, California), their TPHd analysis quantified purgeable hydrocarbons up to C18, and the TPHmo analysis quantified extractable hydrocarbons between C8 and C34.

A total of 52 soil samples were collected by Geomatrix to address data needs identified in the Scoping Document (Geomatrix, 1994a). Geomatrix collected 35 samples from the "at-grade" section of the site that were analyzed for high-boiling petroleum hydrocarbons because previous samples collected from this area by CH2M Hill were only analyzed for low- and middle-boiling petroleum hydrocarbons. These samples were analyzed using fresh journal box (JB) oil as the calibration standard because JB oil was considered likely to be a primary component of high-boiling petroleum hydrocarbons detected previously in soil at the site (referred to as TPHjb analysis). Geomatrix also collected 17 samples near buildings at the site as specified in the FSP Addendum (Geomatrix, 1995a); these samples were analyzed for low-, middle-, and high-boiling petroleum hydrocarbons quantified as TPHg, TPHd, and TPHmo, respectively, because any of these hydrocarbon types could have been used at these buildings. Five soil sample splits (B-4[0.5-1.0], B-6[0.5-1.0], B-19[1.0-1.5], B-25b[1.0-1.5], B-27[3.0-3.5]) also were submitted to F&B for hydrocarbon fingerprint analyses. The results for soil samples collected by Geomatrix are presented in Table 5.

Available site data indicate a predominance of high-boiling petroleum hydrocarbons present in the soil. Low-boiling petroleum hydrocarbons quantified as TPHg were detected in only 3 of the 568 soil samples collected (0.5 percent). Middle-boiling petroleum hydrocarbons quantified as TPHd were detected in only 38 of 567 samples (6.7 percent). High-boiling petroleum hydrocarbons quantified as TPHmo, TPHjb, or O&G were detected in 267 of the 391 samples (68.3 percent).

Although high-boiling petroleum hydrocarbons were detected in a large number of the samples collected (68 percent), only a small percentage of the samples (5 percent) had concentrations at or greater than 1000 mg/kg. Results for soil samples with TPHjb, TPHmo, or O&G concentrations at or greater than 1000 mg/kg are summarized in Table 6 and presented on Figure 5. In the Desert Rail Yard, elevated TPHjb or TPHmo concentrations were detected most commonly at a depth of approximately 2.0 feet, which is the depth that JB lines were located, thereby suggesting that these hydrocarbons may be primarily JB oil. It should be noted that a TPH concentration of 1000 mg/kg should not be considered as an action level or cleanup goal; it is simply an arbitrary value used to simplify data presentation and discussion for the purpose of this report. By way of reference, it should be noted that recent RWQCB guidance allows for leaving in place soil containing up to 1000 mg/kg TPHd associated with leaking home heating oil tanks (RWQCB, 1994).

Eighteen of the thirty-five soil samples collected by Geomatrix and analyzed for TPHjb had detectable concentrations of high-boiling TPH. The petroleum hydrocarbons in four of these samples (B-7[1.0-1.5], B-8[0.5-1.0], B-17[1.0-1.5], and B-28[0.5-1.0]) were called "JB oil" by Quanterra because the chromatograms showed good agreement with the fresh JB oil standard. In the remaining 14 samples, the petroleum hydrocarbons were called "unknown hydrocarbon" by Quanterra because there was not precise agreement with the JB oil standard. Splits from three of these samples with the highest TPH concentrations (B-4[0.5-1.0], B-6[0.5-1.0], and B-27[3.0-3.5]) were submitted to F&B for hydrocarbon fingerprint analysis; F&B also was provided with a sample of JB oil from an existing underground pipe in the Desert Rail Yard (presumably old or weathered JB oil, called JB-1) and unused JB oil (called JB-2). F&B concluded that samples JB-1 and JB-2 likely had original formulation differences based on the GC/FID trace and that JB-1 was likely weathered due to the absence of additives and the probable presence of oxidized material based on the GC/ECD trace. F&B also concluded that the petroleum hydrocarbons in the sample from B-27 compared very favorably to JB-1 (weathered JB oil) whereas the samples from B-3 and B-6 compared less favorably to JB oil, possibly because of original formulation differences or presence of other hydrocarbons. From these results, we conclude that the high-boiling TPH identified by Quanterra as "unknown hydrocarbon" may be (1) weathered JB oil that did not match the fresh JB oil standard, (2) a JB oil product with different characteristics from the standard due to original formulation differences, and/or (3) other petroleum hydrocarbons such as lubricating or motor oils that may have been used at the site or may have been present in fill material when it was emplaced.

Two additional sample splits were submitted to F&B for hydrocarbon fingerprint analysis because a hydrocarbon odor was noted when the samples were collected. Sample B-19(1.0-1.5) was collected from the boring drilled at 721 Cedar Street and sample B-25b(1.5-2.0) was collected from the boring drilled near the Garage/Car Cleaning Building. According to F&B, the sample from boring B-19 contained small amounts of material likely to be diesel and motor oil, although the "motor oil" may be biogenic material. The sample from boring B-25b had a chromatogram indicative of motor oil and lubricating oil. The products tentatively identified in soil near these buildings appear to be consistent with products that may have been used locally at these buildings. The F&B hydrocarbon characterization results are included in Appendix E.

It should be noted that based on interim guidance recently issued by the RWQCB, petroleum hydrocarbons in site soil meet the criteria defining a "low risk soil case"; the management strategy recommended by the RWQCB is that low risk soil cases should be closed because remediation will be accomplished through natural biodegradation processes (RWQCB, 1996). The interim guidance is based on a recent Lawrence Livermore National Laboratory (LLNL) report (LLNL, 1995). The site meets the criteria defining a low risk soil case because (1) there is not ongoing source of constituents that degrade water quality, (2) the site has been adequately characterized, (3) there is little or no groundwater impact due to petroleum hydrocarbons, (4) there are not water wells, deeper drinking water aquifers, surface water or other sensitive receptors likely to be impacted, (5) the site poses no significant risk to human health (see Section 6.1), and (6) the site poses no significant risk to the environment (see Section 6.2).

4.1.2 Groundwater

A total of 69 grab groundwater samples (including 6 duplicate samples) were analyzed for TPHg and 79 samples (including 7 duplicates) were analyzed for TPHd; samples from monitoring wells MW-1 and MW-6 at 330 Cypress Street have been analyzed for TPHg and TPHd on a quarterly basis. Sample locations are shown on Figure 6. CH2M Hill collected 48 groundwater samples that were analyzed for TPHg and TPHd; 12 additional samples were analyzed for TPHg only. IC collected 18 groundwater samples (including 2 duplicates) that were analyzed for TPHd only; these samples were quantified up to C25. Because there is a good distribution of grab groundwater samples collected by CH2M Hill and IC that have been analyzed for TPHg and TPHd, Geomatrix only collected 11 samples (including 2 duplicates) at buildings where petroleum hydrocarbons are known or suspected to have been used, and one sample each near footings C10L and B12[rt] where TPHd was detected in grab groundwater samples collected previously by IC. Analytical results for grab groundwater samples collected by Geomatrix are presented in Table 7. No grab groundwater samples have been analyzed for high-boiling petroleum hydrocarbons because they tend to have very low solubility and are not likely to affect groundwater. All analyses were performed using modified EPA Method 8015.

The data collected indicate that shallow groundwater at the site is generally unaffected by petroleum hydrocarbons. The results for samples with detectable concentrations of TPH are shown on Figure 6. Low-boiling petroleum hydrocarbons were detected in only 1 of 69 samples (1.4 percent) analyzed for TPHg (0.076 mg/l in sample GW29; Figure 5). Middle-boiling petroleum hydrocarbons were only detected in 11 of 79 samples (13.5 percent) analyzed for TPHd.

Nine of the eleven detections of middle-boiling petroleum hydrocarbons were at very low concentrations (0.051 to 0.4 mg/l) and occurred in samples collected by Geomatrix; these concentrations are all below the reporting limits used by IC and CH2M Hill (0.5 mg/l) and may be associated with non-dissolved petroleum hydrocarbons adhered to particles within the grab groundwater sample and/or soluble biogenic material. The remaining two detections were in grab groundwater samples collected by IC from footings C10L and B12(right) (4.1 and 4.9 mg/l, respectively). As requested by DTSC in a 27 October 1994 meeting, Geomatrix collected grab groundwater samples from borings near these footings (boring B-38 near footing C10L and boring B-39 near footing B12[right]) to further assess TPHd detected in the IC samples; the Geomatrix samples from these two borings were analyzed only for TPHd. The very low concentrations of TPHd detected in the Geomatrix samples (0.4 mg/l in B-38[GW] and 0.066 mg/l in B-39[GW]) supports our previous conclusion that the TPHd detected in the IC samples is limited in extent.

4.2 AROMATIC VOLATILE ORGANIC COMPOUNDS

The following subsections summarize the occurrence and extent of aromatic VOCs (benzene and related compounds) in site soil and groundwater.

4.2.1 Soil

A total of 456 soil samples (including 19 duplicate samples) were collected from the site and analyzed for aromatic VOCs. Sample locations are shown on Figure 7. CH2M Hill collected 63 soil samples from 15 borings drilled in the vicinity of the Seventh Street depression and south of the scrapyard at Third and Lewis Streets. Fifty-nine of the CH2M Hill soil samples were analyzed for aromatic VOCs using EPA Methods 8240 and 8020, and 4 were analyzed for BTEX using EPA Method 8020. IC collected a total of 324 soil samples from 110 footing locations in the "elevated" sections of the site. The IC samples were analyzed for BTEX using modified EPA Method 8260.

Geomatrix collected 69 soil samples from 33 borings that were analyzed for aromatic VOCs using EPA Method 8260 to address data needs identified in the Scoping Document (Geomatrix 1994a). Geomatrix collected samples from borings in the "at-grade" section of the site because few soil samples from this area previously had been analyzed for aromatic VOCs; several of these borings were situated near buildings where petroleum hydrocarbons may have been used. Geomatrix also collected soil samples from the northern "elevated" section where chlorobenzenes or alkylated benzenes had been detected in grab groundwater samples collected by IC to assess whether these constituents also are present in soil; previous soil samples from the northern "elevated" section had been analyzed for BTEX but not for these other aromatic VOCs that were detected in groundwater samples. The areas where aromatic VOCs had been detected in groundwater include footing B11(right), footing C10L, and several footings along the eastern portion of this area where isopropylbenzene was detected in groundwater samples.

The existing data indicate that soil at the site is not significantly affected by aromatic VOCs. BTEX compounds were detected in only 37 of the 456 samples (8.1 percent) analyzed; these samples came from various locations throughout the corridor. Benzene was detected in 10 of the 456 samples analyzed (2.2 percent) with a maximum concentration of only 0.018 mg/kg. Toluene was detected in 33 samples (7.2 percent) with a maximum concentration of 0.25 mg/kg. Ethylbenzene was detected in only 1 sample (0.2 percent) at a concentration of 0.033 mg/kg and total xylenes were detected in 19 samples (4.2 percent) with a maximum concentration of 0.071 mg/kg. No aromatic compounds were detected in the 69 samples collected by Geomatrix (Appendix B), and, therefore, no significant source of chlorobenzenes and alkylated benzenes (which were detected in groundwater samples) was identified in site soil. Detected aromatic VOCs are summarized in Table 8 and indicated on Figure 7.

4.2.2 Groundwater

A total of 135 grab groundwater samples (including 15 duplicate samples) were collected from the site and analyzed for aromatic VOCs including BTEX. Sample locations are shown on Figure 8. CH2M Hill collected 3 samples from the Seventh Street depression that were analyzed using EPA Method 8240. IC collected 94 samples (including 10 duplicate samples) from footing locations in the "elevated" portions of the site. Unlike the IC soil samples, which were analyzed only for BTEX, groundwater samples collected in this study were analyzed for a standard suite of aromatic compounds using EPA Method 8260. IC also has collected samples from monitoring wells MW-1 and MW-6 near 330 Cypress Street that have been analyzed for aromatic VOCs using EPA Methods 8020 or 8240.

Geomatrix collected 28 grab groundwater samples (including 3 duplicate samples) from borings in the "at-grade" section of the site because few samples had previously been collected from this area; several of these borings were situated near buildings where petroleum hydrocarbon products may have been used. Geomatrix also collected one sample from boring B-32 in the northern "elevated" section of the site to confirm the presence of isopropylbenzene in groundwater in this area as previously indicated by samples collected by IC. The Geomatrix samples were analyzed for BTEX using EPA Method 8020 and other aromatic compounds using EPA Method 8260; ten additional samples collected by Geomatrix (including 2 duplicates) were analyzed for aromatic VOCs (except BTEX) using EPA Method 8260. Results for the Geomatrix samples are summarized in Table 9.

Analytical results indicate that groundwater is not significantly affected by aromatic VOCs. Results for samples with detectable concentrations of aromatic VOCs are summarized on Table 10 and shown in Figure 8. BTEX constituents were detected in only 11 of the 135 grab groundwater samples analyzed (8 percent). Several of the Geomatrix samples that contained low concentrations of BTEX were collected near buildings where there may have been isolated use of petroleum products containing BTEX. As previously described in the Scoping Document (Geomatrix, 1994a), alkylated benzenes (primarily isopropylbenzene) and chlorobenzenes were detected in samples collected by IC from ten footings in the central portion of the northern "elevated" section of the site (Figure 8). Isopropylbenzene also was detected in the sample (and its duplicate) collected from this area by Geomatrix (boring B-32), thereby confirming the results of the IC groundwater samples. Because Bay Mud is present in this area, the vertical extent of alkylated benzenes in groundwater is likely limited.

4.3 POLYNUCLEAR AROMATIC HYDROCARBONS

The following subsections summarize the occurrence and extent of PNAs in site soil and groundwater.

4.3.1 Soil

A total of 110 soil samples collected by CH2M Hill and Geomatrix have been analyzed for PNAs. CH2M Hill analyzed 62 samples (including 17 duplicate samples) from 19 locations for PNAs using EPA Method 8100 or 8270. Of these samples, 48 were from 5 borings drilled near the Seventh Street depression, 6 samples were from near the scrapyard at Third and Lewis Streets, and 8 samples were from other locations along the corridor. PNAs detected in these samples are summarized in Table 11. Because of the relatively sparse distribution of the samples previously collected, Geomatrix collected 48 additional samples from 21 borings along the entire corridor; these samples were analyzed for PNAs using EPA Method 8310. An additional 69 Geomatrix soil samples were analyzed only for the PNA naphthalene as part of EPA Method 8260 analyses. Several of the Geomatrix borings were situated near buildings where petroleum products are known or suspected to have been used. Results for samples collected by Geomatrix are presented in Table 12. Sample locations and detected concentrations of PNAs are shown on Figure 9.

Geomatrix has previously indicated that PNAs are not likely to be significant components of JB oil, the principal petroleum hydrocarbon product thought to have affected soil at the site (Geomatrix, 1994). In order to assess PNAs in JB oil, Geomatrix submitted two JB oil samples to F&B for PNA analysis, one from an abandoned JB oil line in the Desert Yard (called JB-1) and one from a drum of unused JB oil (called JB-2). PNAs were not detected in either sample above the reporting limit of 10 mg/kg; analytical data sheets are included in Appendix E. To further assess PNAs in JB oil, Geomatrix collected six soil samples in the Desert Yard from an intermediate depth interval (1.5 to 3.0 feet) in addition to shallower (0.5 to 1.0 foot) and deeper (4.0 to 4.5 feet) samples because (1) JB oil lines were located at this intermediate depth in the Desert Yard and (2) the highest TPH concentrations detected in soil samples collected by IC in the Desert Yard were typically from a depth interval of 2.0 to 2.5 feet (See Section 4.1).

Analytical results indicate that PNAs were detected at relatively low concentrations in several of the soil samples. Generally, the PNA detections were in the shallowest samples collected (0.5 to 1.5 feet), while PNAs were rarely detected in deeper samples (2.0 to 5.0 feet). This finding further supports the conclusion that PNAs are not likely to be significant components of JB oil. PNAs detected in shallow soil may be associated with the site's location in an urban setting because concentrations are similar to those considered "background" in other urban settings (Bradley, et. al., 1994; Ecology and Environment, 1993).

4.3.2 Groundwater

A total of 34 grab groundwater samples (including 4 duplicate samples) were analyzed for a full suite of PNAs using EPA Methods 8270, 625, and/or 8310. Sample locations are shown on Figure 10. CH2M Hill collected 3 samples from the Seventh Street depression that were analyzed for PNAs using EPA Method 8270. IC collected 16 samples (including 2 duplicate samples) from footing locations in the "elevated" portions of the site that were analyzed for PNAs using EPA Method 625; IC samples with detectable concentrations of PNAs are summarized in Table 13. Groundwater samples from monitoring wells MW-1 and MW-6 near 330 Cypress Street also have been analyzed for PNAs using EPA Method 8270. Geomatrix collected 15 samples (including 2 duplicate samples) from borings in the "at-grade" section, where a limited number of samples had previously been collected by others; several of these borings were situated near buildings where petroleum products may have been used. The Geomatrix samples were analyzed for PNAs using EPA Method 8310. Results for groundwater samples collected by Geomatrix are summarized in Table 14. Additionally, 78 groundwater samples collected by IC (including 8 duplicates) and 38 samples collected by Geomatrix (including 5 duplicates) were analyzed only for the PNA naphthalene using EPA Method 8260 (naphthalene is the only PNA compound included in an EPA Method 8260 analysis). These additional naphthalene data are relevant because (1) naphthalene is the most water-soluble PNA and, therefore, the most likely to affect groundwater, and (2) the additional data show the extent of naphthalene where it has been detected in groundwater.

Analytical results indicate that groundwater at the site is generally unaffected by PNAs. PNAs were detected in only 3 of the 34 grab samples (8.8 percent) analyzed (samples from footing C10L, borings B-28 and B-20) and in samples from monitoring well MW-6. Naphthalene was detected in only 2 of the additional samples analyzed for naphthalene using EPA Method 8260 (samples from footings B11[right] and CR21[right]). Analytical results for groundwater samples containing detectable concentrations of PNAs are presented on Figure 10.

4.4 ALIPHATIC VOLATILE ORGANIC COMPOUNDS

The following subsections summarize the occurrence and extent of aliphatic VOCs in site soil and groundwater. The analytical results for DBCP and EDB are presented in Section 4.6 because these compounds are common pesticides.

4.4.1 Soil

A total of 128 soil samples (including 19 duplicate samples) were collected from the site and analyzed for aliphatic VOCs. Sample locations are shown on Figure 11. CH2M Hill collected 59 soil samples (including 19 duplicate samples) from 13 borings completed in the vicinity of the Seventh Street depression and south of the scrapyard at Third and Lewis Street; these samples were analyzed using EPA Method 8240. IC collected approximately 324 soil samples from footing locations in the "elevated" sections of the site. The IC samples were analyzed for 1,2-dichloroethane (1,2-DCA) and EDB only, using modified EPA Method 8260.

Geomatrix collected 69 soil samples from borings drilled throughout the corridor because there were a limited number of samples previously collected from the "at-grade" section and previous samples from the "elevated" sections had only been analyzed for 1,2-DCA and EDB; these samples were analyzed using EPA Method 8260. To assess the eastern extent of 1,2-DCA detected in soil samples collected by IC from footings CL19(left) and CL19(right) in the southern elevated section, Geomatrix collected samples from one boring drilled immediately east of this area (boring B-1, Figure 11).

The existing data indicate that soil at the site is generally unaffected by aliphatic VOCs. Aliphatic VOCs were detected at low concentrations in only 8 (including 1 duplicate pair) of the 128 soil samples analyzed (6.3 percent)[1]. As discussed above, 1,2-DCA was detected at concentrations up to 0.2 mg/kg in three IC samples from footings CL19(left) and CL19(right) in the southern "elevated" section; 1,2-DCA was not detected in soil samples from Geomatrix boring B-1 nor in IC soil samples from other footing locations in this area, thereby indicating that the extent of 1,2-DCA in soil in this area is limited. Low concentrations of 1,1,1-trichloroethane (1,1,1-TCA) were detected in two CH2M Hill samples (up to 0.026 mg/kg) from near the scrapyard at Third and Lewis Street. TCE and methyl ethyl ketone (MEK) were each detected in one sample (MEK was detected in a duplicate pair) at low concentrations of 0.043 and 0.038 mg/kg, respectively; each of these samples was collected near a building and their presence in soil may be associated with isolated chemical use at the buildings. In summary, aliphatic VOCs have rarely been detected in site soil and when detected, are present at very low concentrations and appear to be limited in extent. Aliphatic VOCs detected in soil are summarized in Table 15 and presented on Figure 11.

4.4.2 Groundwater

A total of 135 grab groundwater samples (including 15 duplicate samples) were analyzed for a full suite of aliphatic VOCs. Sample locations are shown on Figure 12. CH2M Hill collected 3 samples from the Seventh Street depression that were analyzed for aliphatic VOCs using EPA Method 8240. IC collected 94 samples (including 10 duplicate samples) from footing locations in the "elevated" portions of the site that were analyzed using EPA Method 8260. IC has also

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[1] As discussed in the Scoping Document and Scoping Document Addendum (Geomatrix, 1994a and 1994b), acetone and methylene chloride were reported at low concentrations in all soil samples collected and analyzed by CH2M Hill. The presence of these compounds is attributed to laboratory contamination because the laboratory reports indicate that acetone and methylene chloride were also detected in the laboratory method blanks associated with these samples. Methylene chloride also was detected in Geomatrix soil sample B-19 (1.0-1.5) and was considered likely to be laboratory contamination (see Quanterra case narrative in Appendix D).

collected samples from monitoring wells MW-1 and MW-6 near 330 Cypress Street that have been analyzed for aliphatic VOCs using EPA Methods 8010, 624, or 8240. Geomatrix collected a total of 38 samples (including 5 duplicate samples) from borings in the "at-grade" section because a limited number of samples had previously been collected in this area; several of these borings were situated near buildings where aliphatic VOCs may have been used. Samples collected by Geomatrix were analyzed using EPA Method 8260.

Analytical results indicate that groundwater is generally unaffected by aliphatic VOCs except in the vicinity of certain buildings where there may have been isolated use of these constituents. Aliphatic VOCs were detected in only 11 (including 2 duplicate samples) of the 135 samples (8.1 percent) collected. Very low concentrations of aliphatic VOCs were detected in groundwater samples from the Wheel Shop (boring B-12) and the Carpenter, Upholstery, Test Shop (boring B-13). Elevated concentrations (up to 210 µg/l) of several aliphatic VOCs (PCE, TCE, 1,1-DCA, cis-1,2-DCE, and vinyl chloride) were detected in a groundwater sample from boring B-15 near the Car Lighting Shop. In April and May 1995, Geomatrix collected several additional grab groundwater samples from borings in this area (borings B-41A through B-46) to assess the lateral extent of aliphatic VOCs in groundwater. Based on results for these samples, aliphatic VOCs in groundwater near the Car Lighting Shop are limited in extent.

The only other location where aliphatic VOCs have been detected in groundwater is footing CL19(right) in the southern "elevated" section. 1,2-DCA was detected at 19 and 20 µg/l in a sample duplicate pair from this footing; as discussed above, 1,2-DCA also was detected in soil samples from this area. 1,2-DCA was not detected in groundwater samples from Geomatrix boring B-1 nor in IC samples from other footing locations in this area, thereby indicating that the extent of 1,2-DCA in groundwater in this area is limited.

4.5 METALS

The following subsections summarize the occurrence and extent of metals in site soil and groundwater.

4.5.1 Soil

A total of 599 soil samples (including 28 duplicate samples) were analyzed for lead; of these, 275 samples were also analyzed for other metals. Sample locations are presented on Figure 13. CH2M Hill collected 207 samples (including 12 duplicate samples) throughout the entire site except the easternmost portion of the southern "elevated" section; these samples were analyzed for cadmium, chromium, nickel, lead, and zinc using EPA Method 6010. CH2M Hill also collected 47 additional samples (including 16 duplicate samples) that were analyzed for a full metal scan using EPA Method 6010, including 40 samples (including 15 duplicates) from four borings near the Seventh Street depression and 7 samples (including 1 duplicate) from south of the scrapyard at Third and Lewis Streets. IC collected 324 composite samples from footing locations in the "elevated" sections; these samples were analyzed only for lead using EPA Method 7420.

Geomatrix collected a total of 21 soil samples that were analyzed for metals (arsenic, cadmium, chromium, lead, nickel, and zinc) and 18 samples that were analyzed for hexavalent chromium. Geomatrix samples were collected for metals analysis from the easternmost portion of the southern “elevated” section where previous samples had only been analyzed for lead (borings B-1 through B-3) and near buildings at the site where metals may have been used. Geomatrix samples analyzed for hexavalent chromium were collected from specific locations requested by DTSC (borings B-1, B-3, B-10, B-11, B-15, B-21, B-25, and B-32). Results for samples collected by Geomatrix are summarized in Table 18.

Because inorganic constituents are an inherent component of soil, average metal concentrations in soil samples from the site were compared to average concentrations in other Bay Area soils to assess whether concentrations at the site are elevated with respect to concentrations typically found in off-site soil. Average metal concentrations in soil samples from the site are similar to concentrations found in soil elsewhere in the Bay Area or within the general area of West Oakland. In Table 19, the average metal concentrations in soil samples from the site are compared to (1) average concentrations for ten background samples collected near a site in San Leandro, Alameda County (Harding Lawson Associates [HLA], 1995), (2) average metal concentrations for more than 100 background soil samples collected in northern Santa Clara County (Scott, 1991), (3) average concentrations for five background samples collected near a site in Union City, Alameda County (SEC Donohue, 1992), (4) average concentrations for background samples collected near a site in Hercules, Contra Costa County (McLaren Hart, 1991), and (5) average lead concentrations for 26 soil samples collected near Interstate 880 in Alameda County (Coltrin et al., 1993).

The average lead concentration in soil samples collected from the site is approximately 134 mg/kg. This concentration is greater than that found in San Leandro (Alameda County) (HLA, 1995), northern Santa Clara County (Scott, 1991), Union City (Alameda County) (SEC Donohue, 1992), and Hercules (Contra Costa County) (McLaren Hart, 1991), but is less than the average concentration found in samples collected near Interstate 880 in Alameda County (568 to 618 mg/kg). The elevated concentrations of lead in soil near Interstate 880 were attributed to emissions from vehicles that use the freeway (Coltrin et al., 1993). This comparison suggests that while average lead concentrations in site soil may be higher than naturally occurring levels typically found in soil, they may be similar to concentrations found in soil over the general area of West Oakland.

Lead concentrations greater than 1000 mg/kg were detected in only 9 (including 1 duplicate sample) of the 599 samples analyzed for lead (1.5 percent) and lead concentrations greater than 5000 mg/kg were only detected in 1 of these 9 samples (12,000 mg/kg in the 0.5 to 1.0 foot sample from footing EU20). Results for these 9 samples are shown on Figure 13 and summarized in Table 20. Lead at concentrations greater than 1000 mg/kg most commonly occurs in shallow soil and has a limited vertical extent. For example, the highest lead concentration at the site (12,000 mg/kg) was detected in a sample collected from 0.5 to 1.0 foot at footing EU20; lead was only detected at a concentration of 170 mg/kg in the sample collected at 2 to 2.5 feet at this location. It should be noted that soil containing this elevated lead concentration was removed during construction of footing EU20. The lateral distribution of elevated lead in soil is sporadic throughout the site and not confined to a single area; however, where elevated lead concentrations have been detected in soil, the lateral extent is limited based on additional nearby samples. It should be noted that a lead concentration of 1000 mg/kg should not be considered as an action level or clean-up goal; it is simply an arbitrary value used to simplify data presentation and discussion for the purposes of this report.

Hexavalent chromium was not detected in any of the 18 samples collected by Geomatrix. These results indicate that chromium detected in soil at the site is likely in the trivalent state and will therefore be considered as such for the purpose of the Baseline RA.

4.5.2 Groundwater

A total of 35 filtered grab groundwater samples (including 2 duplicates) have been collected and analyzed for metals. IC collected 19 samples from the "elevated" sections that were analyzed for arsenic, cadmium, chromium, lead, mercury, nickel and zinc using various EPA methods; IC sample results are summarized in Table 21. Geomatrix collected 16 samples (including 2 duplicates) from the "at-grade" section (including near various buildings as specified in the FSP Addendum) that were analyzed for arsenic, cadmium, chromium, lead, nickel, and zinc using EPA methods described in Section 3.3; Geomatrix sample results are summarized in Table 22. Additionally, IC has collected groundwater samples from monitoring wells MW-1 and MW-6 near 330 Cypress Street that have been analyzed for dissolved metals. Sample locations and detected concentrations of metals are presented on Figure 14. Although 153 additional unfiltered grab groundwater samples collected by IC and CH2M Hill also were analyzed for metals, results from these samples are not considered in this report because the samples were not filtered and the total metal concentrations include particulates not dissolved in groundwater and not available for transport.

The analytical data indicate that groundwater is generally unaffected by metals. Lead and mercury were not detected in any samples, while very low concentrations of other metals were occasionally detected. Cadmium and nickel were each detected in only one sample, arsenic was detected in two samples, chromium in three samples, and zinc in eight samples. These few detections were generally only slightly above the analytical reporting limits. The pH of the grab groundwater samples collected by Geomatrix ranged from 6.2 to 7.4 (Table 23), thereby indicating that groundwater at the site has a neutral pH.

4.6 PESTICIDES AND POLYCHLORINATED BIPHENYLS

The following subsections summarize the occurrence and extent of organochlorine pesticides and PCBs in site soil and groundwater. In addition, the analytical results for aliphatic VOCs that are commonly used as pesticides (DBCP and EDB) are discussed in this section.

4.6.1 Soil

A total of 42 soil samples (no duplicate samples) were collected from 21 boring locations and analyzed for pesticides and PCBs. The sample locations are shown on Figure 15. CH2M Hill collected 14 samples, including 7 south of the scrapyard at Third and Lewis Streets and 7 from elsewhere along the corridor. IC collected 28 samples from 7 borings located south of Bobo's Junkyard (ICP-04 through ICP-10). All soil samples were analyzed for organochlorine pesticides and PCBs using EPA Method 8080. Additionally, 393 soil samples collected by Geomatrix and IC were analyzed for EDB using EPA Method 8240 or modified EPA Method 8260 and 69 soil samples collected by Geomatrix were analyzed for DBCP using EPA Method 8260 (Figure 11). Geomatrix did not collect additional samples for standard pesticide/PCB analysis because these constituents were not typically used in railyard operations. Although pesticides/PCBs may have been associated with junkyard operations, soil samples have previously been collected near such areas (Bobo's Junkyard and the scrapyard at Third and Lewis Streets) by CH2M Hill and IC.

Existing data indicate that soil at the site generally is not affected by pesticides and is only slightly affected near Bobo's Junkyard and the scrapyard at Third and Lewis Streets. Pesticides were detected in only 4 of the 42 samples analyzed for organochlorine pesticides (10 percent), 2 collected near Bobo's and 2 collected near the scrapyard at Third and Lewis Streets. EDB was detected at very low concentrations (up to 0.028 mg/kg) in only 3 of the 393 samples analyzed for EDB (0.8 percent). These three samples were from two adjacent footings in the southern elevated section (CL19 [right] and CL19 [left]) and the extent of EDB in soil in this area appears to be limited based on data from other nearby footings and Geomatrix boring B-1 (Figure 15). DBCP was not detected in any of the 69 samples analyzed during this study, and PCBs also were not detected in any of the 42 samples analyzed. Results for samples with detectable concentrations of pesticides are summarized in Table 24 and presented on Figure 15.

4.6.2 Groundwater

A total of 16 grab groundwater samples (including 2 duplicates) were collected for pesticide and PCB analysis by IC from footing locations in the "elevated" portions of the site only; samples were analyzed for organochlorine pesticides and PCBs using EPA Method 8080. IC also has collected groundwater samples from monitoring wells MW-1 and MW-6 near 330 Cypress Street that have been analyzed for pesticides/PCBs. As requested by DTSC in a 27 October 1994 meeting, Geomatrix collected 1 grab groundwater sample from boring B-40 to further assess PCBs detected in an IC sample from footing H1(middle) at 0.7 µg/l. Sample locations are shown on Figure 16. Additionally, 132 grab groundwater samples (including 14 duplicate samples) collected by IC and Geomatrix were analyzed for EDB and DBCP using EPA Method 8240 or 8260; locations of these samples also are shown on Figure 16.

Analytical data indicate that groundwater is generally unaffected by pesticides or PCBs at the locations tested. Organochlorine pesticides were not detected in any of the groundwater samples analyzed using EPA Method 8080. Of the 132 grab groundwater samples analyzed for EDB and DBCP, the two compounds were only detected in a duplicate sample pair from footing CL19(right) located east of Bobo's Junkyard; EDB also was detected in a soil sample from this footing. EDB and DBCP in groundwater at this location is isolated, and its extent is well constrained by groundwater samples from surrounding footings and Geomatrix boring B-1 that contained no detectable concentrations of EDB or DBCP (Figure 16). Because Bay Mud is present in this area, the vertical extent of EDB and DBCP in groundwater at this location is likely limited.

PCBs were detected in only one groundwater sample (footing H1[middle]) at a low concentration (0.7 µg/l); however, a grab groundwater sample collected by Geomatrix from this location (boring B-40) did not confirm the presence of PCBs in groundwater. We conclude that if PCBs are present in groundwater near footing H1(middle), they are likely limited in extent. Samples with detectable concentrations of pesticides/PCBs are summarized in Table 25 and presented on Figure 16.

5.0 CHEMICAL FATE AND TRANSPORT

This section describes the fate and transport of chemicals detected in soil or groundwater at the site. Section 5.1 identifies potential routes of migration for these chemicals and Section 5.2 describes the persistence of these chemicals and how they are likely to migrate in the environment, based on their physical properties.

5.1 POTENTIAL ROUTES OF MIGRATION

When chemicals are released to the environment, they can potentially migrate through three media: soil, water, and air. The following discussion considers potential routes of migration via these three media.

Soil

Migration of chemicals in unsaturated soil can be a function of several parameters including soil permeability, soil organic content, chemical solubility, and a chemical's tendency to sorb or bind to soil (or organic) particles. Water-soluble chemicals are more likely than relatively insoluble chemicals to migrate downward in soil because infiltrating water provides a mechanism for downward movement of dissolved chemicals. Volatile chemicals may migrate in soil due to diffusion of vapor phase. The unsaturated soil at the site (fill material) likely has a relatively low permeability and high organic content, which tends to minimize chemical migration, even for water-soluble chemicals (Lyman, et al., 1992).

Water

Chemicals may migrate via surface water or groundwater. As described in Section 2.1, there are no surface water bodies or water courses at or near the site. Rainwater tends to pond in surface depressions and evaporate or infiltrate into the subsurface. Therefore, chemicals that may occur in rainwater runoff are not likely to migrate from the site.

Chemicals dissolved in groundwater migrate by three mechanisms: advection (movement by flow of groundwater), chemical diffusion (caused by chemical concentration gradients), and mechanical dispersion (associated with advection through heterogeneous porous media). Typically the primary mechanism for migration of dissolved chemicals is advection, by which chemicals move at the average lineal velocity of groundwater flow (e.g., Freeze and Cherry, 1979; Bear and Verruijt, 1987; Anderson and Woessner, 1992). Groundwater flow is controlled by the hydraulic conductivity of the sediments and the direction and magnitude of the hydraulic gradient. Advective transport of dissolved chemicals is not likely to be significant at the site because of the relatively low hydraulic conductivity of the saturated sediments (Canonie, 1989), and the low horizontal hydraulic gradient (0.001 to 0.01 ft/ft). This conclusion is supported by the distribution of chemicals in groundwater as described in Section 4.0; areas of affected groundwater are restricted in extent and appear to be self-limiting.

Air

Chemicals can migrate in air via volatilization or windborne transport of particulate material. Volatile chemicals can vaporize directly from other media into air. Non-volatile chemicals that tend to adhere to soil may become airborne (as dust) under windy conditions or during activities that cause soil disturbance.

5.2 CHEMICAL PERSISTENCE AND MIGRATION

For the purposes of this section, chemical persistence and migration are discussed by chemical family because chemicals within these families tend to have similar physical properties and, therefore, behave similarly in the environment.

Total Petroleum Hydrocarbons

TPH is a non-specific (aggregate) measurement of any of a number of individual petroleum constituents falling into several broad categories of widely varying physical, chemical, and toxicological properties; these categories include alkanes, alkenes, and aromatics. TPH is usually characterized by boiling point range and performance criteria for various products. Examples of different TPH fractions include low-boiling mixtures such as gasoline, which contain abundant aromatics and small alkanes; medium-boiling mixtures such as diesel fuel, which contain abundant alkanes and fewer aromatics; and high-boiling mixtures such as JB oil, lubricating oils, and motor oils, which contain mostly large alkanes and large aromatics (Zemo, et al., 1995; ASTM, 1994). The low-boiling hydrocarbons are the relatively volatile and water-soluble fraction and, therefore, are considered somewhat mobile if released into the environment. Conversely, the high-boiling fractions tend to be relatively non-volatile and virtually insoluble and, therefore, are significantly less mobile in the environment (e.g., Barker, et al., 1987; NRC, 1983).

When petroleum hydrocarbons are released into the environment, they weather by three major processes: (1) evaporation (volatilization), (2) water solubilization, and (3) oxidation (chemical and biological). Evaporation is the loss of the volatile constituents; the smaller molecular weight, low-boiling constituents are lost first and the higher-boiling constituents are lost more slowly. Evaporative weathering results in a shift in aggregate composition of the petroleum toward larger, less volatile molecules (Zemo, et al., 1995). Water solubilization removes the relatively few water-soluble constituents within petroleum by dissolution. Research has shown that the water-soluble fraction of petroleum is limited to the small alkanes and the aromatics with 14 or fewer carbons in their molecular structure (Bruya and Friedman, 1992; Thomas and Delfino, 1991; Zemo and Synowiec, 1995). Accordingly, the C_6 alkanes, BTEX, akylated benzenes, and the C_{10} to C_{14} PNAs: naphthalenes, fluorenes, acenaphthenes, phenanthrenes, and anthracenes would be removed by water solubilization, if present in the released petroleum, and not the larger alkanes or PNAs (e.g., chrysene or benzo(a)pyrene) (Zemo, et al., 1995; Zemo and Synowiec, 1995).

Oxidation of petroleum constituents is accomplished via chemical and biological transformations; biodegradation of petroleum is a predominant process. In general, the smaller, more water-soluble constituents or constituents with simple molecular structures are biodegraded first (Testa and Winegardner, 1991).

As a result of these weathering processes, residual petroleum in the environment becomes over time increasingly less volatile, less water soluble, and composed of proportionately more higher-boiling, longer-chain complex molecules. Therefore, the mobility of petroleum in the environment is controlled by the original composition of the released petroleum and its degree of weathering.

This understanding of the chemical nature of TPH is consistent with the distribution of TPH found at the site. As described in Section 4.1, primarily high-boiling hydrocarbons have been detected in soil samples collected throughout the site; these hydrocarbons were not detected or were only detected at very low concentrations in groundwater samples, probably because of their low solubility.

Aromatic VOCs: Benzene, Toluene, Ethylbenzene, Xylenes, and Other Alkylated Benzenes

These monoaromatics represent a group of single-ring petroleum hydrocarbon constituents that are common components of low-boiling and medium-boiling petroleum products. The chemical and physical characteristics of BTEX (e.g., high vapor pressure, moderate water solubility, and low octanol-water partition coefficient [K_{ow}]) indicate that these chemicals are relatively water-soluble and volatile and, therefore, relatively mobile once released into the environment. However, they are also highly susceptible to biodegradation and are not considered persistent (ASTM, 1994; Zemo et al., 1995; NRC, 1993). Several other alkylated benzenes also were detected in samples from the site (e.g., 1,2,4-trimethylbenzene and isopropylbenzene). These compounds have chemical and physical characteristics similar to those for BTEX, although they are somewhat less volatile and water soluble, and would be expected to bind somewhat more tightly to organic matter in soil due to their higher K_{ow}.

This understanding of the chemical nature of aromatic VOCs is consistent with the distribution of aromatic VOCs found at the site. As described in Section 4.2, aromatic VOCs have been detected in a few soil samples from throughout the property; aromatic VOCs also have been detected in groundwater samples at various locations, probably because of their relatively high solubility. The extent of aromatic VOCs in groundwater generally appears to be restricted probably due to limited potential for advective transport at the site and their high susceptibility to biodegradation.

Polynuclear Aromatic Hydrocarbons

PNAs represent a group of polycyclic (i.e., multiple rings) compounds that are common components of high-boiling petroleum products. Based on their molecular structure, low vapor pressure, and high K_{ow}, the majority of the PNAs are relatively non-volatile and immobile in soil, although a number of the smaller PNAs (e.g., naphthalene) have sufficiently high vapor pressures to volatilize. PNAs range from slightly water soluble (primarily naphthalene) to virtually insoluble, with solubility decreasing and K_{ow} increasing with increasing molecular size. PNAs are also subject to biodegradation, although more slowly than BTEX, and are considered moderately persistent in the environment (ASTM, 1994; Testa and Winegardner, 1991).

This understanding of the chemical nature of PNAs is consistent with the distribution of PNAs found at the site. As described in Section 4.3., PNAs appear to be confined to shallow soil and, with the exception of naphthalene (the most soluble PNA), generally are not detected in groundwater.

Aliphatic Volatile Organic Compounds

The aliphatic VOCs detected in soil or groundwater at the site are primarily chlorinated compounds (e.g., PCE, TCE, 1,1,1-TCA, cis-1,2-DCE, 1,1-DCA, 1,2-DCA, and vinyl chloride). The aliphatic VOCs EDB and DBCP (also detected in site soil and groundwater) are common pesticides, but they behave more similarly to other aliphatic VOCs than to most pesticides. Therefore, the following discussion on chemical persistence and migration also applies to EDB and DBCP.

The fate and transport of aliphatic VOCs in the environment has been the subject of extensive research and publication over the last 10 years. Several recent publications provide excellent summaries for this information (e.g., Barbee, 1994; Cohen and Mercer, 1993; NRC, 1994). These compounds are relatively volatile and tend to be water soluble. As a result, this family of compounds is considered to be relatively mobile once released to the environment (e.g., Olsen and Davis, 1990; Mercer and Cohen, 1990; NRC, 1994).

Degradation of chlorinated compounds in the environment can occur by chemical breakdown (oxidation under aerobic conditions or reductive dehalogenation under anaerobic conditions) or biodegradation. These processes often result in the transformation of one halogenated compound into another (e.g., PCE will degrade to TCE, which will degrade to an isomer of DCE, which in turn will degrade to vinyl chloride, which finally will degrade to ethylene). Because degradation of chlorinated compounds is a relatively slow process, they are considered moderately persistent in the environment (Barbee, 1994; Davis and Olsen, 1990; Mercer and Cohen, 1990; NRC, 1994).

This understanding of the chemical nature of aliphatic VOCs is consistent with the distribution of aliphatic VOCs found at the site. As described in Section 4.4, aliphatic VOCs (primarily TCE and PCE) have been detected at elevated concentrations in groundwater samples from near the Car Lighting Shop, indicating their relatively high solubility. The extent of aliphatic VOCs in groundwater is restricted, probably due to limited potential for advective transport at the site and natural in-situ chemical degradation processes. In-situ degradation of PCE and TCE is further indicated by the presence of low concentrations of typical suites of degradation or breakdown (dehalogenated) compounds in most groundwater samples from this area.

Metals

Metals represent a large group of chemicals that occur naturally in the environment and may also be introduced artificially. Soil and/or groundwater samples from the site have been analyzed for several metals, including arsenic, cadmium, chromium, lead, mercury, nickel, and zinc. In general, the mobility of these and other metals in the environment is dependent on pH.

Under acidic conditions, metals generally become more soluble and can be mobilized through soil by infiltrating water or dissolved directly into groundwater if present in the saturated zone. Otherwise, metals may be relatively immobile in soil and generally exhibit low water solubility. Metals are not subject to biodegradation and will persist in one form or another in the environment (NRC, 1994; Freeze and Cherry, 1979).

This understanding of the chemical nature of metals is consistent with the distribution of metals found at the site. Metals are pervasive in the fill material at the site and in the site vicinity. Groundwater at the site, which has a neutral pH, generally is not affected by dissolved metals.

Pesticides

As described in the Scoping Document (Geomatrix, 1994a), the possible use of pesticides or PCBs is believed to be limited to the Bobo's Junkyard property, and the scrapyard at Third and Lewis Streets, which is supported by the data collected. The following discussion only pertains to the portions of the Realignment Corridor adjacent to these properties, where low concentrations of pesticides have been detected in soil. The aliphatic VOCs EDB and DBCP, which are commonly used as pesticides, were included in the discussion of aliphatic VOCs above and are not included here. PCBs were detected at a very low concentration in only one groundwater sample and the detection could not be confirmed with a second sample.

As a group, the organochlorine pesticides are non-volatile, virtually insoluble in water, and bind very strongly to organic matter in soil. Therefore, they have very low mobility in the environment. They are generally resistant to biodegradation and are considered persistent in the environment.

PCBs are a family of compounds that contain a total of 209 possible congeners resulting from partial or total chlorination of biphenyl. Although the physical, chemical, and biological properties of PCBs vary widely depending on the degree of chlorination, PCBs also are considered relatively immobile and persistent in the environment because they are relatively non-volatile, relatively non-water soluble, adhere strongly to organic matter in soil, and are relatively resistant to biodegradation (Feenstra, et al., 1991; Cohen and Mercer, 1993).

This understanding of the chemical nature of pesticides is consistent with their distribution in the two areas where they have been detected. As described in Section 4.6, pesticides appear to be confined to shallow soil and do not appear to affect groundwater.

6.0 SUMMARY OF BASELINE RISK ASSESSMENT

The following sections summarize the Baseline RA prepared by CTEH, which is presented in Appendix A. As discussed previously, risk posed by parcels along Third Street that are included in the proposed South Prescott Park will be assessed by Caltrans. The assessment includes the remaining property that will be in both "elevated" and "at grade" (including the Seventh Street depression) sections of the freeway. Procedures for completing the Baseline RA were presented in a workplan submitted to DTSC by IC on 5 April 1995. The workplan outlined methods and assumptions for all sections of the Baseline RA. DTSC approved the workplan, with additional suggestions, on 17 April 1995.

6.1 HUMAN HEALTH EVALUATION

The following sections summarize the results of the human health evaluation, including the identification of potential chemicals of concern (COCs), the assessment of potential exposure scenarios, the identification of methods for assessing the toxicity of the potential COCs, and the risk characterization.

6.1.1 Identification of Chemicals of Concern

Section 2.0 of the Baseline RA identifies potential COCs detected in soil and/or groundwater at the site. All volatile chemicals detected in groundwater were considered potential COCs. Although the future land use of the corridor will be a freeway and not residential property, chemicals in soil were considered to be potential COCs if the maximum detected concentration exceeded the USEPA Region IX residential PRG (USEPA, 1996). The following chemicals were retained as potential COCs in soil:

- petroleum hydrocarbons
- PNAs
- ethylene dibromide (EDB, subsurface soil in elevated sections only)
- lead

6.1.2 Exposure Assessment

Section 3.0 of the Baseline RA identifies potential pathways for human exposure to the potential COCs in soil and groundwater after the freeway is constructed. It should be noted that the Baseline RA did not asses exposure during freeway construction activities because Caltrans has a contractual responsibility to protect workers and nearby residents from potential exposure to chemicals during such activities. It is SPTCo's position that Caltrans must therefore assess human health risk resulting from their construction activities. Documentation supporting this position is included in Attachment A of the Baseline RA (Appendix A).

The future receptors who are most likely to have the greatest exposure to chemicals in soil or groundwater are a child playing beneath the elevated portions of the freeway and a utility worker involved in trenching for utilities or pipelines along any portion of the freeway (either "elevated" or "at grade" sections). The possible routes of exposure to chemicals in soil for these receptors include ingestion, dermal contact, and inhalation. For groundwater, the only possible exposure route is inhalation of vapors emitted by volatile chemicals. The potentially complete exposure pathways identified for each receptor are as follows:

<u>Child at Play ("Elevated" Sections Only)</u>

- incidental ingestion of surface soil (0 to 1 foot)
- dermal contact with surface soil
- inhalation of volatile chemicals in surface soil and chemicals released from surface soil as fugitive dust
- inhalation of volatile chemicals in groundwater that migrate through vadose soil to the ground surface

Utility Worker (both "Elevated" and "At-Grade" Sections)

- incidental ingestion of surface and subsurface soil (0 to 5 feet)
- dermal contact with surface and subsurface soil
- inhalation of volatile chemicals in surface and subsurface soil and chemicals released from this soil as fugitive dust
- inhalation of volatile chemicals in groundwater that accumulates in an open construction trench.

The assumptions pertaining to these exposure scenarios are detailed in Section 3.0 of the Baseline RA (Appendix A).

6.1.3 Toxicity Assessment

Section 4.0 of the Baseline RA identifies the toxicity criteria and associated methodologies for completing the risk characterization. For all potential COCs except lead and petroleum hydrocarbons, the USEPA reference doses (RfDs) were used for assessing potential non-carcinogenic health risks and the USEPA or DTSC cancer slope factors were used for assessing carcinogenic risks. The USEPA and DTSC have not identified RfDs or cancer slope factors for lead and aggregate petroleum hydrocarbon mixtures. Instead, the DTSC lead exposure model was used to assess potential health risks associated with exposure to this chemical. As recommended by DTSC, three different methods were used for assessing potential health risks associated with petroleum hydrocarbon mixtures, including two approaches that use indicator chemicals (the American Society for Testing and Materials [ASTM] method and the American Petroleum Institute [API] Risk/Exposure Assessment Decision Support System) and a third method that combines elements of the indicator chemical approach and a "whole mixture" approach (the Massachusetts Department of Environmental Protection [MDEP] method). These methods are described in Section 4.0 of the Baseline RA (Appendix A).

6.1.4 Risk Characterization

Section 5.0 of the Baseline RA estimates human health risks associated with potential COCs detected in soil or groundwater samples from the site. The characterization includes estimates of both noncarcinogenic and carcinogenic health risks. As described above, lead and petroleum hydrocarbons are assessed separately because unique evaluation methods are required for performing their respective assessments.

Characterization of Potential Noncarcinogenic Health Risks

The assessment of noncarcinogenic health risks indicates that aggregate exposure to the COCs in soil or groundwater would be unlikely to result in adverse health effects. The method used to assess noncarcinogenic risks involves calculating the hazard index (HI) for the site; potentially adverse health effects may occur if the HI is greater than one. The HIs for a child at play are 0.022 for exposure to COCs in surface soil and 0.0022 for exposure to COCs in groundwater. The HIs for a utility worker are 0.021 ("elevated" sections) and 0.0073 ("at-grade" section) for exposure to COCs in surface and subsurface soil and 0.331 ("elevated" sections) and 0.000049 ("at-grade" section) for exposure to COCs in groundwater.

Characterization of Potential Carcinogenic Health Risks

The assessment of carcinogenic health risks indicates that the aggregate exposure to potentially carcinogenic COCs in soil and groundwater for the child at play scenario and the utility worker scenario are within generally acceptable limits. By most standards, a theoretical excess cancer risk of 1×10^{-6} (1 in 1,000,000) is considered acceptable and in many cases a theoretical excess cancer risk of 1×10^{-4} (1 in 10,000) is considered acceptable (USEPA, 1990a, 1990b). The assessment for the site concluded that the aggregate theoretical excess cancer risk for COCs in soil is 1×10^{-6} (1 in 1,000,000) for a child at play and 5×10^{-7} (5 in 10,000,000 for the "elevated" section) and 4×10^{-7} (4 in 10,000,000 for the "at-grade" sections) for a utility worker. The aggregate theoretical excess cancer risk for COCs in groundwater is 2×10^{-9} (2 in 1,000,000,000) for a child at play and 1×10^{-7} (1 in 10,000,000 for the "elevated" sections) and 3×10^{-8} (3 in 100,000,000 for the "at-grade" section) for a utility worker.

Characterization of Potential Health Risks from Lead

The assessment indicates that lead concentrations in soil at the site are unlikely to pose a health risk to a child at play or to a utility worker. The highest average lead concentration was in surface soil (0 to 1 foot) from the southern "elevated" section; the 95% upper confidence limit of the arithmetic mean concentration of lead in this soil is 605 mg/kg. For a child at play, exposure to this soil would result in a 99th percentile blood lead concentration of approximately 7.6 micrograms per deciliter (µg/dL) based on DTSC's lead exposure model (LEADSPREAD). This is below the DTSC blood lead level target threshold of 10 µg/dL for a child.

For a utility worker, exposure to the 95% upper confidence limit of the arithmetic mean concentration of lead in surface and subsurface soil (361 mg/kg) would result in a 99th percentile blood lead concentration of approximately 5.8 µg/dL based on the DTSC's exposure model. By comparison, California Code of Regulations Title 8 (Section 1532.1) indicates that a utility worker should not have a blood lead level greater than 30 µg/dL as a "health protection goal"; a blood lead level of 40 µg/dL triggers several employee notification requirements, and a blood lead level of 50 µg/dL requires worker removal.

Characterization of Potential Health Risks from Petroleum Hydrocarbons

As recommended by DTSC in a 17 April 1995 letter to IC, three different methods were used to assess human health risk from petroleum hydrocarbons, including the ASTM, API, and MDEP methods. As described in the Baseline RA, the results from all three methods indicate that petroleum hydrocarbons at the site do not pose a significant risk to human health.

The Baseline RA uses the ASTM method by comparing the maximum concentration of specific indicator chemicals (BTEX and several PNAs) to residential screening levels. The comparison was made for both soil and groundwater samples. Maximum concentrations of all indicator chemicals in groundwater were below the residential screening levels while maximum concentrations of all but five indicator chemicals in soil (all PNAs) were below these screening levels. As discussed in the Baseline RA, these exceptions are not considered significant because the residential screening levels used in the ASTM method are not appropriate since the site will be a freeway in the future.

Application of the API model suggests that petroleum hydrocarbons in soil at the site would not cause noncarcinogenic adverse health effects nor cause a theoretical excess cancer risk greater than 1×10^{-6} (1 in 1,000,000). The model uses 25 chemicals considered to be indicators of petroleum hydrocarbons in the environment. The calculated HI for a child at play is 0.000022 and the HIs for a utility worker are 0.028 ("elevated" sections) and 0.027 ("at-grade" section), thereby indicating that noncarcinogenic adverse health effects are unlikely. The respective calculated theoretical excess cancer risks are 1×10^{-6} (1 in 1,000,000) for a child at play and 2×10^{-7} (2 in 10,000,000 for the "elevated" sections) and 1×10^{-6} (1 in 1,000,000 for the "at-grade" section) for a utility worker.

Application of the MDEP methodology also suggests that petroleum hydrocarbons in soil at the site would not cause noncarcinogenic adverse health effects. It should be noted that two very conservative assumptions were made when applying the model. First, CTEH assumed that all petroleum hydrocarbons detected have a toxicity similar to the most toxic fraction of petroleum as identified by MDEP (C9 to C32 aromatics/alkenes). Second, the method uses the maximum concentration of total petroleum detected in soil for calculating the average daily intake. The calculated HI for a child at play is 0.022 and the HIs for a utility worker are 0 016 ("elevated" sections) and 0.0073 ("at-grade" section).

6.2 ENVIRONMENTAL EVALUATION

A qualitative evaluation of potential exposures of ecological receptors to site-related chemicals was conducted for the Corridor. This evaluation relied upon information provided in the environmental evaluation conducted for the Environmental Impact Statement/Report (EIS/EIR) for the Route I-880 Replacement Project (U.S. DOT and Caltrans, 1991) and an evaluation of the current and likely future habitat conditions within the Corridor. This evaluation resulted in the following points, which characterize the potential for significant chemical exposure at the site.

- The EIS/EIR did not identify any wildlife habitat on or in the immediate vicinity of the site with exception of two small seasonal wetlands (Wetland A and Wetland B) adjacent to the western side of the northern terminus of the corridor;

- The EIS/EIR reports that wildlife habitat along the freeway corridor will be improved to some unspecified degree in the future by landscaping with native tree species. However, landscaping will not exist beneath elevated portions of the freeway;

- The EIS/EIR evaluated the potential presence of endangered or threatened species in the proposed freeway corridor and none were identified;

- It is anticipated that following completion of the elevated portions of the freeway, marginal roosting habitat for pigeons (Columbidae) or other common urban bird species will exist.

The two wetlands, designated Wetland A (23,000 sq. ft.) and Wetland B (10,000 sq. ft.), are characterized as seasonal freshwater emergent marsh (U.S. DOT and Caltrans, 1991). These small wetlands are located adjacent to the western edge of the Corridor at its northern terminus near footings I4, I5, I6, and I7 (Figure 2). The two wetlands are separated by a single railroad track. These wetland areas are reported to support limited hydrophytic vegetation (i.e., willows [*Salix hindsiana*] and cattails [species not specified]) and are utilized by waterfowl (mallard) and other birds (red-wing blackbird and mourning doves). Red-wing blackbirds were assumed to be nesting in the area. Only minor activity was reported for Wetland B.

These wetland areas may receive surface water runoff from the adjacent portions of the Corridor. An evaluation of the soil and shallow groundwater data collected from locations adjacent to the wetlands was conducted to determine if COCs may be present at levels that may pose a hazard to the ecology of the wetlands. The chemical data from all sampling locations within 200 feet of the wetlands was reviewed (i.e., borings GW-50, B-30, SB24, and SB26 and footings I4, I5, I6, and I7). The soil samples were analyzed for metals, polynuclear aromatic hydrocarbons, volatile organic hydrocarbons, and total petroleum hydrocarbons. The groundwater samples were also analyzed for these constituents and pesticides and PCBs. These data indicate that chemicals are not present in soil or groundwater at concentrations that would likely impact environmental receptors at the wetlands.

Based on this qualitative evaluation, it is concluded that chemical concentrations in soil and groundwater adjacent to two wetlands do not pose a threat to potential receptors at the wetlands, and no endangered or threatened species exist on the site. Therefore, ecological risks were not addressed further in the Baseline RA.

7.0 CONCLUSIONS

Upon completion of the RI and Baseline RA, several conclusions can be made about the nature and extent of chemicals detected in soil or groundwater at the I-880 Realignment Corridor and the potential health risk posed by these chemicals under future child at play or construction worker scenarios.

Nature and Extent of Chemicals

- the nature and extent of chemicals in soil and groundwater at the site is defined for the purposes of the RI
- chemicals found in groundwater (primarily aromatic and aliphatic VOCs) are limited in extent, probably because of their chemical nature and the site hydrogeologic conditions
- chemicals in groundwater at the site do not appear to be migrating off-site towards the San Francisco Bay
- elevated concentrations of chemicals are detected locally in soil; however, their extent does not appear to be widespread

Potential Health Risks

- exposure to chemicals in groundwater on the site would be unlikely to pose an unacceptable noncarcinogenic or carcinogenic health risk
- exposure to chemicals in soil on the site would be unlikely to result in adverse noncarcinogenic health effects
- exposure to chemicals in surface and subsurface soil at the site would be unlikely to pose theoretical excess cancer risks above the acceptable range ($1x10^{-4}$ to $1x10^{-6}$)
- exposure to lead in soil would be unlikely to pose unacceptable health risks based on results using DTSC's lead exposure model (LEADSPREAD)
- exposure to petroleum hydrocarbons in soil would be unlikely to pose unacceptable noncarcinogenic or carcinogenic health risks based on results of three different assessment methods (ASTM, API, and MDEP methods).

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TABLE 1

SUMMARY OF BUILDING USE

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Building Name	Building Use	Constituents Possibly Used or Stored
Communications Storage	Storage of communications parts; formerly sheet metal and pipe shop.	Petroleum hydrocarbons Aromatics VOCs PNAs Aliphatic VOCs Metals
Paint Shop	Used to paint furniture and small parts of railroad cars.	Petroleum hydrocarbons Aromatic VOCs Aliphatic VOCs Metals
Drop Table Shed	Used to remove rail wheel sets from passenger cars. Contains hydraulic lift.	Petroleum hydrocarbons Aromatic VOCs Aliphatic VOCs Metals
Wheel Shop	Repairing and reshaping wheels. Contains rail wheel lathe.	Petroleum hydrocarbons Aromatic VOCs Aliphatic VOCs Metals
Carpenter, Upholstery, Test Shop	Furniture repair, air brake testing. Painting may have been performed.	Petroleum hydrocarbons Aromatic VOCs Aliphatic VOCs Metals
Car Lighting Shop	Rail car lighting and battery repair.	Petroleum hydrocarbons Aromatic VOCs PNAs Aliphatic VOCs Metals Acids
Laundry Shop/ Master Mechanic	Washing passenger car linens. Offices/Lockers for master mechanic.	None
Commissary	Bakery, food service support, food storage.	None
Automotive and Work Equipment Repair (721 Cedar Street)	Manufacture of portable cement and asphalt batch plants. Track and construction equipment repair.	Petroleum hydrocarbons Aromatic VOCs PNAs Aliphatic VOCs Metals
Roadmaster, B&B, and Water Service (1912 7th Street)	Telephone and communication equipment repair. Auto repair.	Petroleum hydrocarbons Aromatic VOCs PNAs Aliphatic VOCs
Locker Building	Lockers and offices.	None
Garage/Car Cleaning Building	Lockers and storage of vehicles. Possible auto repair.	Petroleum hydrocarbons Aromatic VOCs PNAs Aliphatic VOCs
Car Department Building	Lockers and offices.	None

TABLE 2

ANALYSES PERFORMED ON SOIL AND GRAB GROUNDWATER SAMPLES FROM BUILDINGS

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Building Name	Analyses Performed (Soil and Groundwater Samples)					
	TPH	Aromatic VOCs	PNAs	Aliphatic VOCs	Metals[1]	pH
Communications Storage (Boring B-9)	X[2]	X	X	X	X	--[2]
Paint Shop (Boring B-10)	X	X	--	X	X[3]	--
Drop Table Shed (Boring B-11)	X	X	--	X	X[3]	--
Wheel Shop (Boring B-12)[3]	X	X	--	X	X[3]	--
Carpenter Upholstery, Test Shop (Boring B-13)	X	X	X	X	X	--
Car Lighting Shop (Boring B-15)	X	X	X	X	X[3]	X
Automotive and Work Equipment Repair (721 Cedar Street) (Boring B-19)	X	X	X	X	X	--
Roadmaster, B&B, Water Service (1912 7th Street) (Boring B-18)	X	X	X	X	--	--
Garage/Car Cleaning Building (Boring B-25)	X	X	X	X	X[4,5]	--

Notes:

[1] Metals include As, Cd, Cr, Pb, Ni, Zn.

[2] "X" indicates analysis performed; "--" indicates no analysis performed.

[3] No soil sample was collected because only gravel fill material was encountered in the boring. Therefore this area was assessed on the basis of a grab groundwater sample.

[4] Soil sample also analyzed for hexavalent chromium as requested by the DTSC.

[5] A water sample from this location was proposed for metals analysis in FSP. Although metals are not known to have been used at this building, this location was selected within the context of obtaining a good distribution of data from the corridor.

TABLE 3

FIELD QA SAMPLES[1]

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Analytical Method	Matrix	No. of Remedial Investigation Samples	Equipment Blanks[2]		Travel Blanks[3]		Field Duplicates		MS/MSD	
			No. of Blanks	Sample I.D.	No. of Blanks	Sample I.D.	No. of Duplicates	Sample I.D.	No. of MS/MSDs	Sample I.D.
Total *Petroleum* Hydrocarbons:[4]										
TPHd/TPHmo	Soil	17/21	NA[5]	NA	NA	NA	NA	NA	3	B-11-4.0 B-18-4.0 B-25-3.5
TPHg	Soil	17	NA	NA	NA	NA	NA	NA	3	B-11-4.0 B-18-4.0 B-25-3.5
TPHjb	Soil	35	NA	NA	NA	NA	NA	NA	2	B-17-4.5 B-22-4.0
TPHd	Groundwater	11	3	J-20 J-23 J-24	NA	NA	2	B-9/J-31 B-19/J-34	1	B-12
TPHg	Groundwater	9	4	J-20 J-21 J-23 J-24	3	J-40 J-41 J-44	1	B-9/J-31	1	B-12

TABLE 3

FIELD QA SAMPLES[1]

Analytical Method	Matrix	No. of Remedial Investigation Samples	Equipment Blanks[2]		Travel Blanks[3]		Field Duplicates		MS/MSD	
			No. of Blanks	Sample I.D.	No. of Blanks	Sample I.D.	No. of Duplicates	Sample I.D.	No. of MS/MSDs	Sample I.D.
Aromatic VOCs:[6]	Soil 8260	69	NA	NA	NA	NA	NA	NA	4	B-11-4.0 B-17-4.0 B-18-4.0 B-25-3.5
	Groundwater 8020	25	8	J-20 J-21 J-23 J-24 J-25 J-55 J-56 J-57	6	J-40 J-41 J-44 J-45 J-75 J-77	3	B-9/J-31 B-26/J-35 B-28/J-33	2	B-12 B-19
Aliphatic VOCs:[7]	Soil 8260	69	NA	NA	NA	NA	NA	NA	4	B-11-4.0 B-17-4.0 B-18-4.0 B-25-3.5
	Groundwater 8260	33	9	J-20 J-21 J-23 J-24 J-25 J-55 J-56 J-57 B-54	7	J-40 J-41 J-44 J-45 J-75 J-77 B-50	5	B-9/J-31 B-26/J-35 B-28/J-33 B-32/J-121 B-43A/B-52	3	B-12 B-19 B-45

TABLE 3

FIELD QA SAMPLES[1]

Analytical Method	Matrix	No. of Remedial Investigation Samples	Equipment Blanks[2]		Travel Blanks[3]		Field Duplicates		MS/MSD	
			No. of Blanks	Sample I.D.	No. of Blanks	Sample I.D.	No. of Duplicates	Sample I.D.	No. of MS/MSDs	Sample I.D.
PNAs:[8]										
8310	Soil	48	NA	NA	NA	NA	NA	NA	3	B-11-4.0 B-18-4.0 B-25-3.5
	Groundwater	13	4	J-20 J-21 J-23 J-24	NA	NA	2	B-9/J-31 B-28/J-33	1	B-12
Metals:[9]										
	Soil (As, Cd, Cr, Cu, Pb, Ni, Zn)	21	NA	NA	NA	NA	NA	NA	2	B-11-4.0 B-25-3.5
	Soil (Cr^{+6})	18	NA	NA	NA	NA	NA	NA	2	B-11-4.0 B-25-3.5
	Groundwater (As, Cd, Cr, Cu, Pb, Ni, Zn)	14	4	J-20 J-23 J-24 J-25	NA	NA	2	B-9/J-31 B-28/J-33	1	B-12
Pesticides and PCBs:[10]										
	Groundwater	1	1	J-59	NA	NA	0[11]	NA	0[11]	NA

TABLE 3

FIELD QA SAMPLES[1]

Notes:

[1] Samples were collected from 7 February 1995 through 16 May 1995.

[2] Equipment blanks were collected for each analyte at a rate of one per day or one in ten groundwater samples, whichever was more conservative, for each bailer used.

[3] One travel blank for each volatile groundwater analyte requested for the shipment was collected for each cooler of samples shipped to the laboratory. Travel blanks were analyzed only if volatile compounds were detected in the corresponding equipment blanks.

[4] Total Petroleum Hydrocarbons (TPH) were analyzed using modified EPA Method 8015; mo = motor oil; d = diesel; g = gasoline; and jb = journal box oil.

[5] NA = not applicable.

[6] Aromatic volatile organic compounds (VOCs) were analyzed using EPA Method 8020 for groundwater and EPA Method 8260 for soil.

[7] Aliphatic VOCs were analyzed using EPA Method 8260.

[8] Polynuclear aromatic hydrocarbons (PNAs) were analyzed using EPA Method 8310.

[9] Metals were analyzed using EPA Methods 6010A/7000A series.

[10] Pesticides and PCBs were analyzed using EPA Method 8080.

[11] Only one groundwater sample was collected from the corridor for EPA Method 8080 analysis. This sample was considered part of the batch of three groundwater samples from Bobo's Junkyard analyzed for pesticides/PCBs. A duplicate groundwater sample and one MS/MSD sample were collected at Bobo's (Geomatrix, 1995).

GEOMATRIX

TABLE 4

GROUNDWATER FIELD DUPLICATE SAMPLES

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Analytical Methods	Sample I.D.	Duplicate I.D.	Sample Concentration	Duplicate Concentration	RPD[1]	RPD Goal (%)
TPH (modified 8015)						
Diesel	B-19	J-34	<50 µg/l	<50 µg/l	NC[2]	30
Diesel	B-9	J-31	<50 µg/l	<50 µg/l	NC	30
unknown HC[3]	B-9	J-31	59 µg/l	70 µg/l	NC	30
TPH gasoline	B-9	J-31	<50 µg/l	<50 µg/l	NC	30
Aromatic VOCs (8020)	B-9	J-31	All ND[4]	All ND	NC	30
	B-26	J-35	All ND	All ND	NC	30
	B-28	J-33	All ND	All ND	NC	30
Aliphatic VOCs (8260)	B-9	J-31	All ND	All ND	NC	30
	B-26	J-35	All ND	All ND	NC	30
	B-28	J-33	All ND	All ND	NC	30
Trichloroethene	B-43A	B-52	160 µg/l	150 µg/l	6.4%	30
Tetrachloroethene	B-43A	B-52	73 µg/l	65 µg/l	11.6%	30
Trichloroethene	B-32	J-121	8.0 µg/l	8.5 µg/l	6.0%	30
Isopropylbenzene	B-32	J-121	3.6 µg/l	3.8 µg/l	5.4%	30
PNAs (8310)	B-9	J-31	All ND	All ND	NC	30
Benzo(a)pyrene	B-28	J-33	<0.2 µg/l	0.33 µg/l	NC	30
Indeno(1,2,3-cd)pyrene	B-28	J-33	<0.2 µg/l	0.3 µg/l	NC	30
Metals (6010A/7000A series)						
Arsenic	B-9	J-31	0.016 mg/l	<0.005 mg/l	NC	20
Cadmium	B-9	J-31	<0.005 mg/l	<0.005 mg/l	NC	25
Chromium	B-9	J-31	<0.01 mg/l	<0.01 mg/l	NC	20
Lead	B-9	J-31	<0.01 mg/l	<0.01 mg/l	NC	25
Nickel	B-9	J-31	<0.04 mg/l	<0.01 mg/l	NC	25
Zinc	B-9	J-31	<0.02 mg/l	0.023 mg/l	NC	25
Pesticides PCBs (8080)	None[5]	None	---	---	---	---

Notes:

[1] RPD = Relative Percent Difference = difference between duplicates divided by the mean of the duplicates.

[2] NC = Not calculated because detected concentrations were not greater than five times the reporting limit.

[3] Concentration of unidentified hydrocarbon in diesel range.

[4] ND = Not detected.

[5] Only one groundwater sample was collected from the Corridor for EPA Method 8080 analysis. This sample was considered part of the batch that included three groundwater samples from Bobo's Junkyard that were analyzed for pesticides/PCBs using this method. A duplicate groundwater sample was collected at Bobo's (Geomatrix, 1995).

TABLE 5

SUMMARY OF TPH RESULTS FOR SOIL SAMPLES COLLECTED BY GEOMATRIX[1]

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Concentrations in milligrams per kilogram (mg/kg)

Boring I.D.	Sample Depth (feet bgs)[2]	TPH as Gasoline	Unknown Hydrocarbon (gasoline range)	TPH as Diesel	Unknown Hydrocarbon (diesel range)	TPH as Motor Oil	TPH as JB Oil	Unknown Hydrocarbon (JB range)
B-4	0.5-1.0[3]	NA[4]	NA	NA	NA	NA	<300	1600
	4.0-4.5	NA	NA	NA	NA	NA	<50	<50
B-5	0.5-1.0	NA	NA	NA	NA	NA	<50	70
	4.0-4.5	NA	NA	NA	NA	NA	<50	150
B-6[5]	0.5-1.0[3]	NA	NA	NA	NA	<300	<300	1100
	4.0-4.5	NA	NA	NA	NA	<50	<50	<50
B-7	1.0-1.5	NA	NA	NA	NA	NA	34	<50
	3.5-4.0	NA	NA	NA	NA	NA	<50	200
	5.5-6.0	NA	NA	NA	NA	NA	<50	<50
B-8[5]	0.5-1.0	NA	NA	NA	NA	NA	31	<50
	4.0-4.5	NA	NA	NA	NA	NA	<50	<50
B-9 (Communication Storage)	1.5-2.0	<1	<1	<10	260	<50	NA	NA
	4.0-4.5	<1	<1	<1	2.3	<50	NA	NA
B-10 (Paint Shop)	1.0-1.5	<1	<1	<5	9.7	<50	NA	NA
	3.5-4.0	<1	<1	<1	<1	<50	NA	NA
B-11 (Drop Table Shed)[5]	1.0-1.5	<1	<1	<10	92	<50	NA	NA
	3.5-4.0	<1	<1	<1	<1	<50	NA	NA
	13.0-13.5	<1	<1	<1	<1	<50	NA	NA

TABLE 5

SUMMARY OF TPH RESULTS FOR SOIL SAMPLES COLLECTED BY GEOMATRIX[1]

Concentrations in milligrams per kilogram (mg/kg)

Boring I.D.	Sample Depth (feet bgs)[2]	TPH as Gasoline	Unknown Hydrocarbon (gasoline range)	TPH as Diesel	Unknown Hydrocarbon (diesel range)	TPH as Motor Oil	TPH as JB Oil	Unknown Hydrocarbon (JB range)
B-13b (Carpentry, Upholstery, Test Shop)	1.0-1.5	<1	<1	<10	87	<50	NA	NA
B-13	4.0-4.5	<1	<1	<5	29	<50	NA	NA
B-14	0.5-1.0	NA	NA	NA	NA	NA	<50	<50
	4.5-5.0	NA	NA	NA	NA	NA	<50	<50
B-15 (Car Lighting Shop)	1.0-1.5	<1	<1	<1	61	<50	NA	NA
	4.0-4.5	<1	<1	<1	3.6	<50	NA	NA
B-16	1.0-1.5	NA	NA	NA	NA	NA	<50	120
	4.0-4.5	NA	NA	NA	NA	NA	<50	65
B-17	1.0-1.5	NA	NA	NA	NA	<50	82	<50
	4.0-4.5	NA	NA	NA	NA	<50	<50	<50
B-18 (1912 Seventh Street)	0.5-1.0	<1	<1	<10	37	<50	NA	NA
	3.5-4.0	<1	<1	<1	<1	<50	NA	NA
B-19 (721 Cedar Street)	1.0-1.5[3]	<1	<1	<5	30	<50	NA	NA
	6.5-7.0	<1	1	<1	11	<50	NA	NA
B-20	0.5-1.0	NA	NA	NA	NA	NA	<50	70
	3.5-4.0	NA	NA	NA	NA	NA	<50	<50
B-22	0.5-1.0	NA	NA	NA	NA	NA	<50	<50
	4.0-4.5	NA	NA	NA	NA	NA	<50	<50
B-23	0.5-1.0	NA	NA	NA	NA	NA	<75	560
	4.0-4.5	NA	NA	NA	NA	NA	<50	<50
B-24	0.5-1.0	NA	NA	NA	NA	NA	<50	190
	4.0-4.5	NA	NA	NA	NA	NA	<50	<50

TABLE 5

SUMMARY OF TPH RESULTS FOR SOIL SAMPLES COLLECTED BY GEOMATRIX[1]

Concentrations in milligrams per kilogram (mg/kg)

Boring I.D.	Sample Depth (feet bgs)[2]	TPH as Gasoline	Unknown Hydrocarbon (gasoline range)	TPH as Diesel	Unknown Hydrocarbon (diesel range)	TPH as Motor Oil	TPH as JB Oil	Unknown Hydrocarbon (JB range)
B-25b (Garage, Car Cleaning)	1.0-1.5[3]	<1	<1	<10	94	<50	NA	NA
	3.0-3.5	<1	<1	<1	1.8	<50	NA	NA
B-26	0.5-1.0	NA	NA	NA	NA	NA	<50	200
	4.0-4.5	NA	NA	NA	NA	NA	<50	<50
B-27	0.5-1.0	NA	NA	NA	NA	NA	<50	310
	3.0-3.5[3]	NA	NA	NA	NA	NA	<300	6200
	4.0-4.5	NA	NA	NA	NA	NA	<50	<50
B-28	0.5-1.0	NA	NA	NA	NA	NA	76	<50
	4.0-4.5	NA	NA	NA	NA	NA	<50	<50
B-29	0.5-1.0	NA	NA	NA	NA	NA	<50	<50
	2.5-3.0	NA	NA	NA	NA	NA	<50	370
	4.0-4.5	NA	NA	NA	NA	NA	<50	<50

Notes:

[1] Samples analyzed for total petroleum hydrocarbons (TPH) by modified EPA Method 8015. Detected analytes are shaded.

[2] bgs = below ground surface.

[3] Hydrocarbon fingerprint analysis performed by Friedman & Bruya on sample split.

[4] NA = not analyzed for constituent indicated.

[5] Boring drilled in proposed South Prescott Park area; data not included in Baseline Risk Assessment (Appendix A).

TABLE 6

SUMMARY OF SOIL SAMPLES WITH TPH CONCENTRATIONS AT OR GREATER THAN 1000 MG/KG

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Concentrations in milligrams per kilogram (mg/kg)

Sample or Boring Identification	Sample Depth (Feet bgs[1])	Gasoline	Diesel	Motor Oil or Oil and Grease	Unknown Hydrocarbon (JB oil range)
Samples Collected by IC[2]					
CL19 (left)	4.0-4.5	<1	1700[3]	1500[3]	NA[4]
CL22 (left)	0.5-1.0	<1	<5	1500	NA
CL23 (left)	0.5-1.0	10[5]	<5	1000[6]	NA
CL23 (right)	0.5-1.0	<1	17[7]	1700[6]	NA
CR20 (left)	0.5-1.0	<1	<5	1300	NA
	2.0-2.5	<1	<5	1700	NA
EU23	0.5-1.0	<1	<5	2100[5]	NA
OU20	4.0-4.5	<1	8[7]	4400	NA
C1L	4.0-4.5	<1	<5	3800	NA
C7L	2.0-2.5	<1	<5	1900	NA
SC43	2.0-2.5	<1	<5	2000	NA
A15R	2.0-2.5	<200	1700[8]	870[8]	NA
B1	2.0-2.5	<1	<5	4800	NA
B12 (right)	3.5-4.0	<40	2000	570[9]	NA
Samples Collected by CH2M Hill[10]					
SP1-SB05A-0225	2.0-2.5	NA	NA	1610	NA
SP1-SB11A-0225	2.0-2.5	NA	NA	52,400	NA
	Duplicate	NA	NA	50,800	
SP1-SB41A-0225	2.0-2.5	NA	NA	6040	NA
SP1-SS46A-0225	2.0-2.5	NA	NA	9420	NA

TABLE 6

SUMMARY OF SOIL SAMPLES WITH TPH CONCENTRATIONS AT OR GREATER THAN 1000 MG/KG

Concentrations in milligrams per kilogram (mg/kg)

Sample or Boring Identification	Sample Depth (Feet bgs[1])	Gasoline	Diesel	Motor Oil or Oil and Grease	Unknown Hydrocarbon (JB oil range)
Samples collected by Geomatrix[11]					
B-4	0.5-1.0	NA	NA	NA	1600
B-6[12]	0.5-1.0	NA	NA	NA	1100
B-27	3.0-3.5	NA	NA	NA	6200

Notes:

[1] bgs = below ground surface.

[2] Samples collected by IC were analyzed for TPHg and TPHd using EPA Method 8260, and TPHmo using EPA Method 8270.

[3] Hydrocarbon pattern identified a possible combination of diesel (eluting between C13 and C20) and motor oil (eluting between C20 and C36).

[4] NA = not analyzed for constituent indicated.

[5] Hydrocarbon pattern elutes between C8 and C18. TPH quantitated against diesel primarily consists of naphthalene and substituted naphthalene isomers.

[6] Hydrocarbon pattern elutes between C13 and C36.

[7] Hydrocarbon pattern is similar to diesel and eluted between C8 and C18.

[8] Hydrocarbon pattern identified as combination of diesel and motor oil.

[9] Hydrocarbon pattern is similar for mixtures of diesel and motor oil and elutes between C8 and C30.

[10] Samples collected by CH2M Hill were analyzed for oil and grease using EPA Method 413.1.

[11] Samples collected by Geomatrix were analyzed for petroleum hydrocarbons quantified as JB oil using modified EPA Method 8015.

[12] Boring drilled in proposed South Prescott Park area; data not included in Baseline Risk Assessment (Appendix A).

TABLE 7

SUMMARY OF TPH RESULTS FOR GROUNDWATER SAMPLES COLLECTED BY GEOMATRIX[1]

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Concentrations in milligrams per liter (mg/l)

Boring Identification	Gasoline	Unknown Hydrocarbon (gasoline range)	Diesel	Unknown Hydrocarbon (diesel range)
B-9 (Communication Storage)	<0.05	<0.05	<0.05	0.059
B-9 Duplicate (J-31)	<0.05	<0.05	<0.05	0.07
B-10 (Paint Shop)	<0.05	<0.05	<0.05	0.051
B-11 (Drop Table Shed)[2]	<0.05	<0.05	<0.05	<0.05
B-12 (Wheel Shop)	<0.05	<0.05	<0.05	0.12
B-13 (Carpenter, Upholstery, Test Shop)	<0.05	<0.05	<0.05	0.1
B-15 (Car Lighting Shop)	<0.05	<0.05	<0.05	0.17
B-18 (1912 Seventh Street)	<0.05	<0.05	<0.05	<0.05
B-19 (721 Cedar Street)	<0.05	<0.05	<0.05	<0.05
B-19 Duplicate (J-34)	NA[3]	NA	<0.05	<0.05
B-25 (Garage, Car Cleaning Building)	<0.05	<0.05	<0.05	0.15
B-38 (Footing C10L)	NA	NA	<0.05	0.4
B-39 (Footing B12 [right])	NA	NA	<0.05	0.066

Notes:

[1] Samples analyzed for total petroleum hydrocarbons by modified EPA Method 8015. Detected analytes are shaded.

[2] Boring drilled in proposed South Prescott Park area; data not included in Baseline Risk Assessment (Appendix A).

[3] NA = Not analyzed for constituent indicated

TABLE 8

SUMMARY OF AROMATIC VOCS DETECTED IN SOIL SAMPLES[1]

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Concentrations in milligrams per kilogram (mg/kg)

Sample ID	Sample Depth (feet bgs[2])	Benzene	Toluene	Ethyl-benzene	Total Xylenes
Samples Collected by IC[3]					
CL20 (right)	0.5 - 1.0	<0.005	0.018	<0.005	<0.005
	2.0 - 2.5	0.018	0.052	<0.005	0.016
	4.0 - 4.5	0.005	0.019	<0.005	<0.005
CL21 (left)	0.5 - 1.0	0.013	0.072	<0.005	0.022
	2.0 - 2.5	0.017	0.065	<0.005	0.028
	3.5 - 4.0	0.007	0.032	<0.005	0.013
CL21 (right)	2.0 - 2.5	<0.005	<0.005	<0.005	0.026
	4.0 - 4.5	<0.005	<0.005	<0.005	0.071
CL22 (left)	0.5 - 1.0	<0.005	0.008	<0.005	<0.005
CL23 (left)	0.5 - 1.0	<0.005	<0.005	<0.005	0.014
	3.5 - 4.0	<0.005	0.008	<0.005	<0.005
CL23 (right)	0.5 - 1.0	<0.005	0.015	<0.005	0.012
CL25 (right)	0.5 - 1.0	<0.005	0.006	<0.005	<0.005
CR21 (left)	0.5 - 1.0	<0.005	0.011	<0.005	0.005
	2.0 - 2.5	0.007	0.023	<0.005	<0.005
	4.0 - 4.5	0.015	0.046	<0.005	0.014
CR21 (right)	0.5 - 1.0	<0.005	0.010	<0.005	<0.005
	2.0 - 2.5	<0.005	0.030	<0.005	0.009
	4.0 - 4.5	<0.005	0.016	<0.005	0.006
CR22 (right)	0.5 - 1.0	<0.005	0.018	<0.005	0.015
	2.0 - 2.5	0.006	0.024	<0.005	0.007
	3.5 - 4.0	0.012	0.058	<0.005	0.025
EU20	0.5 - 1.0	<0.005	0.008	<0.005	<0.005
EU22	0.5 - 1.0	<0.005	0.019	<0.005	0.007
	2.0 - 2.5	<0.005	0.010	<0.005	0.008
A4R	0.5 - 1.0	<0.005	0.009	<0.005	<0.005
A5R	0 - 0.5	<0.005	0.028	<0.005	<0.005
A6R	0.0 - 0.5	<0.005	0.041	<0.005	<0.005
	2.0 - 2.5	<0.005	0.010	<0.005	<0.005

TABLE 8

SUMMARY OF AROMATIC VOCS DETECTED IN SOIL SAMPLES[1]

Concentrations in milligrams per kilogram (mg/kg)

Sample ID	Sample Depth (feet bgs[2])	Benzene	Toluene	Ethyl-benzene	Total Xylenes
C4L (left)	0.0 - 0.5	<0.005	0.006	<0.005	<0.005
C10L	0.5 - 1.0	<0.005	0.22	<0.005	0.014
SC41 (right)	0.0 - 0.5	<0.005	0.037	<0.005	0.007
	4.0 - 4.5	<0.005	<0.005	0.033	<0.005
B17 (mid)	0.5 - 1.0	<0.005	0.25	<0.005	<0.005
H1 (right)	0.5 - 1.0	<0.005	0.007	<0.005	<0.005
H2 (right)	0.5 - 1.0	<0.005	0.017	<0.005	<0.005
Sample Collected by CH2M Hill[4]					
CB3A	2.0 - 2.5	0.006	0.007	<0.005	<0.005

Notes:

[1] Detections previously reported by others that are below the laboratory reporting limit (J values) are not shown here. No analytes were detected above the reporting limit in samples collected by Geomatrix.

[2] bgs = below ground surface.

[3] Samples collected by IC were analyzed using EPA Method 8260.

[4] Samples collected by CH2M Hill were analyzed using EPA Method 8240.

TABLE 9

SUMMARY OF AROMATIC VOC RESULTS FOR GROUNDWATER SAMPLES COLLECTED BY GEOMATRIX[1]

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Concentrations in micrograms per liter (µg/l)

Boring I.D.	Benzene	Toluene	Ethyl-benzene	Xylenes
B-4	<0.5	<0.5	<0.5	<0.5
B-5	<0.5	<0.5	<0.5	<0.5
B-6[2]	<0.5	<0.5	<0.5	<0.5
B-7	<0.5	<0.5	<0.5	<0.5
B-8[2]	<0.5	<0.5	<0.5	<0.5
B-9 (Communication Storage)	<0.5	<0.5	<0.5	<0.5
B-9 Duplicate	<0.5	<0.5	<0.5	<0.5
B-10 (Paint Shop)	<0.5	<0.5	<0.5	<0.5
B-11 (Drop Table Shed)[2]	<0.5	<0.5	<0.5	<0.5
B-12 (Wheel Shop)	<0.5	<0.5	<0.5	<0.5
B-13 (Carpenter, Upholstery, Test Shop)	<0.5	0.84	<0.5	<0.5
B-14	<0.5	<0.5	<0.5	<0.5
B-15 (Car Lighting)	<0.5	0.72	<0.5	<0.5
B-16	0.55	0.68	<0.5	<0.5
B-17 (721 Cedar Street)	<0.5	<0.5	<0.5	<0.5
B-18 (1912 7th Street)	<0.5	<0.5	<0.5	<0.5
B-19	<0.5	0.6	<0.5	<0.5
B-20	2	<0.5	1	1.8
B-22	<0.5	<0.5	<0.5	<0.5
B-23	<0.5	<0.5	<0.5	<0.5
B-24	<0.5	<0.5	<0.5	<0.5
B-25 (Garage/Car Cleaning)	<0.5	<0.5	0.62	3.2
B-26	<0.5	<0.5	<0.5	<0.5
B-26 Duplicate (J-35)	<0.5	<0.5	<0.5	<0.5

TABLE 9

SUMMARY OF AROMATIC VOC RESULTS FOR GROUNDWATER SAMPLES COLLECTED BY GEOMATRIX[1]

Boring I.D.	Benzene	Toluene	Ethyl-benzene	Xylenes
B-27	<0.5	<0.5	<0.5	<0.5
B-28	<0.5	<0.5	<0.5	<0.5
B-28 Duplicate (J-33)	<0.5	<0.5	<0.5	<0.5
B-29	<0.5	<0.5	<0.5	<0.5
B-32	See Note 3	See Note 3	See Note 3	See Note 3
B-32 Duplicate (J-121)	See Note 3	See Note 3	See Note 3	See Note 3

Notes:

[1] Samples analyzed for BTEX using EPA Method 8020 and for other aromatic VOCs using EPA Method 8260. Detected analytes are shaded. Only BTEX compounds were detected in the Geomatrix samples.

[2] Boring drilled in proposed South Prescott Park area; data not included in Baseline Risk Assessment (Appendix A).

[3] Sample B-32 and its duplicate were analyzed for aromatic and aliphatic VOCs using EPA Method 8260 but not for BTEX using EPA Method 8020. This sample was collected to confirm the presence of isopropylbenzene previously detected in groundwater samples collected from this area by IC Isopropylbenzene was detected at 3.6 and 3.8 μg/l in sample B-32 (GW) and its duplicate, respectively.

TABLE 10

SUMMARY OF AROMATIC VOCS DETECTED IN GROUNDWATER

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Concentrations in micrograms per liter (µg/l)

Boring or Sample I.D.	Benzene	Toluene	Ethyl-benzene	Total Xylenes	Isopropyl-benzene	1,3,5-Trimethyl-benzene	1,2,4-Trimethyl-benzene	n-Propyl-benzene	T-Butyl-benzene	S-Butyl-benzene	Chloro-benzenes
Samples Collected by IC[1]											
EU 22-3	<1	3.4	<1	<1	<1	<1	<1	<1	<1	<1	<1
A5R-right	<5	<5	<5	<5	38	<5	<5	<5	<5	<5	<5
A6R-3	<5	<5	<5	<5	44	<5	<5	<5	<5	<5	<5
A6R-3 (dup)	<5	<5	<5	<5	30	<5	<5	<5	<5	<5	<5
A7R-1	<5	<5	<5	<5	180	<5	<5	<5	<5	<5	See Note 2
A8R-1	<5	<5	<5	<5	100	<5	<5	<5	<5	<5	<5
A9R-1	<5	<5	<5	<5	55	<5	<5	<5	<5	<5	<5
A10R-2	<5	<5	<5	<5	53	<5	<5	<5	<5	<5	<5
C10L-4	<5	45	11	<5	2800	58	65	18	26	18	See Note 3
NC44-1	<5	<5	<5	<5	43	<5	<5	<5	<5	<5	<5
NC44-1 (dup)	<5	<5	<5	<5	33	<5	<5	<5	<5	<5	<5
NC46-2	<5	<5	<5	<5	31	<5	<5	<5	<5	<5	<5
SC42-2	<0.5	9.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
I5	<0.5	73.1	0.8	3.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
B11 (right)-2[4]	<1	7.9	28	37	<1	10	<1	<1	<1	<1	See Note 5

TABLE 10

SUMMARY OF AROMATIC VOCS DETECTED IN GROUNDWATER

Concentrations in micrograms per liter (μg/l)

Boring or Sample I.D.	Benzene	Toluene	Ethyl-benzene	Total Xylenes	Isopropyl-benzene	1,3,5-Trimethyl-benzene	1,2,4-Trimethyl-benzene	n-Propyl-benzene	T-Butyl-benzene	S-Butyl-benzene	Chloro-benzenes
Samples Collected by Geomatrix[6]											
B-13	<0.5	0.84	<0.5	<0.5	<1	<1	<1	<1	<1	<1	<1
B-15	<0.5	0.72	<0.5	<0.5	<10	<10	<10	<10	<10	<10	<10
B-16	0.55	0.68	<0.5	<0.5	<1	<1	<1	<1	<1	<1	<1
B-19	<0.5	0.6	<0.5	<0.5	<1	<1	<1	<1	<1	<1	<1
B-20	2	<0.5	1	1.8	<1	<1	<1	<1	<1	<1	<1
B-25	<0.5	<0.5	0.62	3.2	<1	<1	<1	<1	<1	<1	<1
B-32	NA	NA	NA	NA	3.6	<1	<1	<1	<1	<1	<1
B-32 Duplicate (J-121)	NA	NA	NA	NA	3.8	<1	<1	<1	<1	<1	<1

Notes:

[1] Samples collected by IC were analyzed using EPA Method 8260. Detected analytes are shaded.
[2] Sample A7R-1 contained 19 μg/l 1,2-dichlorobenzene.
[3] Sample C10L-4 contained 160 μg/l 1,2-dichlorobenzene and 28 μg/l 1,4-dichlorobenzene.
[4] Sample B11 (right) also contained 25 μg/l styrene.
[5] Sample B11 (right)-2 contained 86 μg/l 1,2,4-trichlorobenzene.
[6] Samples collected by Geomatrix were analyzed for BTEX using EPA Method 8020 and other aromatic VOCs using EPA Method 8260.

TABLE 11

SUMMARY OF PNAs DETECTED IN SOIL SAMPLES COLLECTED BY CH2M HILL[1]

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Sample Identification	Depth (Feet bgs[2])	Constituent[3]	Concentration (mg/kg)
SP1-SS65-0225[4]	2.0-2.5	Acenaphthylene	1.7
		Fluorene	1.1
		Anthracene	2.1
		Benzo(a)anthracene	7.5
		Chrysene	9.3
		Benzo(b)fluoranthene	7.5
		Benzo(k)fluoranthene	5.4
		Benzo(a)pyrene	9.5
		Indeno(1,2,3-cd)pyrene	5.9
		Benzo(g,h,i)perylene	8.0
SP1-SS67-0225[4]	2.0-2.5	Naphthalene	0.69
		2-Methylnaphthalene	1.0

Notes:

[1] Samples analyzed using EPA Method 8270.

[2] bgs = below ground surface.

[3] Detections previously reported by others that are below the laboratory reporting limit (J values) are not shown here.

[4] Boring drilled in proposed South Prescott Park area; data not included in Baseline Risk Assessment (Appendix A).

TABLE 12

SUMMARY OF PNA RESULTS FOR SOIL SAMPLES COLLECTED BY GEOMATRIX[1]

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Concentrations in milligrams per kilogram (mg/kg)

Boring I.D.	Sample Depth (feet bgs[2])	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenzo(a,h)anthracene	Indeno(1,2,3-cd)pyrene	Napthalene
B-2	1-1.5	<0.06	<0.5	<0.2	<1	<0.2	<0.5	<0.4	<0.1	<1
	5.5-6	<0.06	<0.06	<0.06	<1	<0.06	<0.06	<0.06	<0.06	<1
B-3	1-1.5	<0.5	0.54	0.78	2.5	<0.2	<0.5	<2	1.9	<5
	4-4.5	<0.06	<0.06	<0.06	<1	<0.06	<0.1	<0.06	<0.06	<1
B-4	0.5-1	<1	<1	<0.4	<1.6	<0.4	<1	<4	<1	<1
	4-4.5	<0.001	<0.06	<0.06	<1	<0.06	4.4	<0.06	<0.06	<1
B-6[3]	0.5-1	<1	<1	<0.4	<1.6	<0.4	<1	<4	<1	<1
	4-4.5	<0.06	<0.06	<0.06	<1	<0.06	<0.06	<0.06	<0.06	<1
B-9	1.5-2	<0.06	<1	<0.4	<1.6	<0.4	<1	<4	<1	<1
	4-4.5	<0.06	<0.06	<0.06	<1	<0.06	<0.06	<0.06	<0.06	<1
B-11[3]	1-1.5	<0.1	0.12	0.091	<1	<0.06	<0.1	<0.06	<0.06	<1
	3.5-4	<0.06	<0.06	<0.06	<1	<0.06	1.3	<0.06	<0.06	<1
	13-13.5	<0.06	<0.06	<0.06	<1	<0.06	<0.06	<0.06	<0.06	<1
B-13	1-1.5	1.1	2	1.3	1	0.74	1.5	0.83	1.4	<1
	4-4.5	<0.06	<0.06	<0.06	<1	<0.06	<0.5	<0.06	<0.06	<1
B-15	1-1.5	<0.5	<0.5	<0.2	<1	<0.2	<0.5	<2	<0.5	<5
	4-4.5	<0.06	<0.1	<0.06	<1	<0.06	<0.06	<0.4	<0.06	<1
B-17	1-1.5	<0.2	0.47	0.3	<1	<0.08	0.43	<0.8	0.26	<2
	4-4.5	<0.06	<0.06	<0.06	<1	<0.06	<0.06	<0.06	<0.06	<1
B-18	0.5-1	<0.1	<0.1	<0.06	<1	<0.06	<0.1	<0.4	<0.1	<1
	3.5-4	<0.06	<0.06	<0.06	<1	<0.06	<0.06	<0.06	<0.06	<1
B-19	1-1.5	<0.1	0.42	0.4	<1	0.19	<0.4	<0.4	0.32	<1
	6.5-7	<0.06	<0.06	<0.06	<1	<0.06	<0.06	<0.06	<0.06	<1
B-20	0.5-1.5	<0.06	0.16	0.14	<1	0.071	<0.06	<0.4	0.26	<1
	3.5-4	<0.06	<0.06	<0.06	<1	<0.06	<0.06	<0.06	<0.06	<1
B-25	1-1.5	<0.1	<0.1	<0.06	<1	<0.06	<0.5	<0.4	<0.1	<1
	3-3.5	<0.06	<0.06	<0.06	<1	<0.06	<0.1	<0.06	<0.06	<1
B-27	3-3.5	<1	<1	<0.4	<1.6	<0.4	<1	<4	<1	<10
B-28	0.5-1	<0.06	<0.06	<0.06	<1	<0.06	<0.06	<0.08	<0.06	<1
	4-4.5	<0.06	<0.06	<0.06	<1	<0.06	<0.06	<0.06	<0.06	<1

TABLE 12

SUMMARY OF PNA RESULTS FOR SOIL SAMPLES COLLECTED BY GEOMATRIX[1]

Concentrations in milligrams per kilogram (mg/kg)

Boring I.D.	Sample Depth (feet bgs[2])	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenzo(a,h)anthracene	Indeno(1,2,3-cd)pyrene	Napthalene
B-30	0.5-1	<0.06	<0.06	<0.06	<1	<0.06	<0.06	<0.08	<0.06	<1
	2-2.5	<0.06	<0.06	<0.06	<1	<0.06	<0.06	<0.06	<0.06	<1
	4-4.5	<0.06	<0.06	<0.06	<1	<0.06	<0.06	<0.06	<0.06	<1
B-34	0.5-1	0.16	0.32	0.25	<1	0.14	0.3	<0.4	0.27	<1
	2-2.5	<0.1	0.13	<0.06	<1	0.1	<0.1	<0.4	<0.1	<1
	4-4.5	<10	<10	<4	<16	<4	<10	<40	<10	<100
B-35	0.5-1	<0.2	0.37	0.26	<1	0.14	0.26	<0.4	0.33	<1
	2-2.5	<0.1	0.1	0.087	<1	<0.06	<0.1	<0.4	<0.1	<1
	4-4.5	<0.1	<0.1	<0.06	<1	<0.06	<0.1	<0.4	<0.1	<1
B-37	0.5-1	<0.2	<0.2	<0.08	<1	<0.08	<0.2	<0.8	<0.2	<2
	1.5-2	<0.2	<1	<0.4	<1.6	<0.4	<0.2	<4	<0.2	<2
	4-4.5	<0.06	<0.06	<0.06	<1	<0.06	<0.06	<0.06	<0.06	<1
B-38	0.5-1	0.14	0.34	0.24	<1	0.14	0.25	<0.4	0.3	<1
	2-2.5	<0.06	<0.06	<0.06	<1	<0.06	<0.06	<0.08	<0.06	<1
	4-4.5	<0.06	<0.06	<0.06	<1	<0.06	<0.06	<0.08	<0.06	<1
B-40	0.5-1	<0.1	<0.1	0.11	<1	<0.06	0.17	<0.4	<0.1	<1
	3-3.5	<0.06	<0.06	<0.06	<1	<0.06	<0.1	<0.06	<0.06	<1
	4-4.5	<0.06	<0.06	<0.06	<1	<0.06	<0.1	<0.06	<0.06	4.9

Notes:

Samples analyzed using EPA Method 8310. Detected analytes are shaded. PNAs that were analyzed for but not detected in soil samples are not included in this table but are tabulated in Appendix B.

bgs = below ground surface.

Boring drilled in proposed South Prescott Park area; data not included in Baseline Risk Assessment (Appendix A).

TABLE 13

SUMMARY OF PNA RESULTS FOR GROUNDWATER SAMPLES COLLECTED BY IC

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Sample Identification	Constituent[1]	Concentration (μg/l)
C10L[2]	Naphthalene	10
	2-Methyl naphthalene	9
	Phenanthrene	6
	Benzidine	17
B11 (right)[3]	Naphthalene	576
CR21 (right)[3]	Naphthalene	78

Notes:

[1] Detections previously reported that are below the laboratory reporting limit (J values) or attributed to laboratory contamination (detected in blank) are not shown here.

[2] Sample analyzed using EPA Method 625.

[3] Sample analyzed using EPA Method 8260. Naphthalene was the only PNA included in analysis.

TABLE 14

SUMMARY OF PNA RESULTS FOR GROUNDWATER SAMPLES COLLECTED BY GEOMATRIX[1,2]

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Concentrations in micrograms per liter (µg/l)

Boring I.D.	Acenaphthylene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene
B-4	<2	<0.2	<0.2	<2	<2
B-6[3]	<2.2	<0.22	<0.22	<2.2	<2
B-9 (Communication Storage)	<4	<0.2	<0.2	<2	<2
B-9 Duplicate (J-31)	<2.3	<0.21	<0.23	<2.3	<2
B-11 (Drop Table Shed)[3]	<2	<0.2	<0.2	<2	<2
B-12 (Wheel Shop)	<2.5	<0.2	<0.2	<2.5	<2
B-13 (Carpenter, Upholstery, Test Shop)	<2	<0.2	<0.2	<2	<2
B-15 (Car Lighting Shop)	<5.4	<0.2	<0.2	<5.4	<2
B-17	<2	<0.2	<0.2	<2	<2
B-18 (1912 South Street)	<2	<0.2	<0.2	<2	<2
B-19 (721 Cedar Street)	<2	<0.2	<0.2	<2	<2
B-20	12	<0.57	<0.57	430[4]	2.2
B-25 (Garage/Car Cleaning)	<2	<0.2	<0.2	<5.4	<2
B-28	<4.8	<0.2	<0.2	<4.8	<2
B-28 Duplicate (J-33)	<5.1	0.33	0.31	<5.1	<2

[1] Samples analyzed using EPA Method 8310. Detected analytes are shaded.

[2] PNAs that were analyzed for but not detected in groundwater samples are not included in this table but are tabulated in Appendix B.

[3] Boring drilled in proposed South Prescott Park area; data not included in Baseline Risk Assessment (Appendix A).

[4] Naphthalene also was detected at 580 µg/l using EPA Method 8260.

TABLE 15

SUMMARY OF ALIPHATIC VOCS DETECTED IN SOIL SAMPLES[1]

Southern Pacific Transportation Company
1-880 Realignment Corridor
Oakland, California

Concentrations in milligrams per kilogram (mg/kg)

Sample I.D.	Sample Depth (feet bgs[2])	1,2-DCA[3]	1,1,1-TCA[4]	MEK[5]	TCE[6]
Samples Collected by IC[7]					
CL19 (left)	2.0 - 2.5	0.200	NA[8]	NA	NA
CL19 (left)	4.0 - 4.5	0.018	NA	NA	NA
CL19 (right)	2.0 - 2.5	0.005	NA	NA	NA
Samples Collected by CH2M Hill[9]					
SS10-0225	2.0 - 2.5	<0.005	<0.005	0.035	<0.005
SS10-0225 (dup)	2.0 - 2.5	<0.005	<0.005	0.038	<0.005
SS67-0115[10]	1.0 - 1.5	<0.005	0.026	<0.01	<0.005
SS69-1520[10]	1.5 - 2.0	<0.005	0.010	<0.01	<0.005
Samples Collected by Geomatrix[11]					
B-15	1.0 - 1.5	<0.005	<0.005	NA	0.043

Notes:

[1] Detected analytes are shaded.
[2] bgs = below ground surface.
[3] 1,2-DCA = 1,2-dichloroethane.
[4] 1,1,1-TCA = 1,1,1-trichloroethane.
[5] MEK = methylethylketone = 2-butanone.
[6] TCE = trichloroethene.
[7] Samples collected by IC analyzed using modified EPA Method 8260 (includes only the halogenated VOCs: ethylene dibromide and 1,2-dichloroethane).
[8] NA = not analyzed.
[9] Samples collected by CH2M Hill analyzed using EPA Method 8240. Detections reported that are below the laboratory reporting limits (J values) are not shown here.
[10] Boring drilled in proposed South Prescott park area; data not included in Baseline Risk Assessment (Appendix A)
[11] Samples collected by Geomatrix analyzed using EPA Method 8260.

TABLE 16

SUMMARY OF ALIPHATIC VOC RESULTS FOR GROUNDWATER SAMPLES COLLECTED BY GEOMATRIX[1,2]

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Concentrations in micrograms per liter (μg/l)

Boring I.D.	1,1,1-TCA[3]	1,1-DCA[4]	1,1-DCE[5]	Cis-1,2-DCE[6]	PCE[7]	TCE[8]	Vinyl Chloride
B-1	<1	<1	<1	<1	<1	<1	<0.5
B-4	<1	<1	<1	<1	<1	<1	<0.5
B-5	<1	<1	<1	<1	<1	<1	<0.5
B-6[9]	<1	<1	<1	<1	<1	<1	<0.5
B-7	<1	<1	<1	<1	<1	<1	<0.5
B-8[9]	<1	<1	<1	<1	<1	<1	<0.5
B-9 (Communication Storage)	<1	<1	<1	<1	<1	<1	<0.5
B-9 Duplicate (J-31)	<1	<1	<1	<1	<1	<1	<0.5
B-10 (Paint Shop)	<1	<1	<1	<1	<1	<1	<0.5
B-11 (Drop Table Shed)[9]	<1	<1	<1	<1	<1	<1	<0.5
B-12 (Wheel Shop)	<1	<1	<1	<1	1.2	<1	<0.5
B-13 (Carpentry, Upholstery, Test Shop)	<1	2.5	<1	2.3	<1	<1	1.6
B-14	<1	<1	<1	<1	<1	<1	<0.5
B-15 (Car Lighting Shop)	<10	32	<10	210	36	120	45
B-16	<1	<1	<1	<1	<1	<1	<0.5
B-17	<1	<1	<1	<1	<1	<1	<0.5
B-18 (1912 Seventh Street)	<1	<1	<1	<1	<1	<1	<0.5
B-19 (721 Cedar Street)	<1	<1	<1	<1	<1	<1	<0.5
B-20	<1	<1	<1	<1	<1	<1	<0.5
B-22	<1	<1	<1	<1	<1	<1	<0.5
B-23	<1	<1	<1	<1	<1	<1	<0.5
B-24	<1	<1	<1	<1	<1	<1	<0.5
B-25 (Garage/Car Cleaning)	<1	<1	<1	<1	<1	<1	<0.5

TABLE 16

SUMMARY OF ALIPHATIC VOC RESULTS FOR GROUNDWATER SAMPLES COLLECTED BY GEOMATRIX[1,2]

Concentrations in micrograms per liter (μg/l)

Boring I.D.	1,1,1-TCA[3]	1,1-DCA[4]	1,1-DCE[5]	Cis-1,2-DCE[6]	PCE[7]	TCE[8]	Vinyl Chloride
B-26	<1	<1	<1	<1	<1	<1	<0.5
B-26 Duplicate (J-35)	<1	<1	<1	<1	<1	<1	<0.5
B-27	<1	<1	<1	<1	<1	<1	<0.5
B-28	<1	<1	<1	<1	<1	<1	<0.5
B-28 Duplicate (J-33)	<1	<1	<1	<1	<1	<1	<0.5
B-29	<1	<1	<1	<1	<1	<1	<0.5
B-32	<1	<1	<1	<1	<1	See Note 10	<0.5
B-32 Duplicate (J-121)	<1	<1	<1	<1	<1	See Note 10	<0.5
B-41A (Car Lighting Shop)	3.8	13	2.1	9.8	21	13	<0.5
B-42 (Car Lighting Shop)	<1	2.5	<1	2.8	<1	9.2[9]	<0.5
B-43 (Car Lighting Shop)	<10	<10	<10	<10	73	160	<5
B-43A Duplicate (B-52)	<10	<10	<10	<10	65	150	<5
B-44A (Car Lighting Shop)	<1	<1	<1	<1	<1	<1	<0.5
B-45 (Car Lighting Shop)	<10	<10	<10	<10	57	150	<5
B-46	<1	1.4	<1	2.7	<1	3.5	0.95

Notes:

[1] Samples analyzed using EPA Method 8260. Detected analytes are shaded.

[2] Constituents that were not detected in groundwater samples were not included in this table but are tabulated in Appendix B.

[3] 1,1,1-TCA = 1,1,1-trichloroethane.

[4] 1,1-DCA = 1,1-dichoroethane.

[5] 1,1-DCE = 1,1-dichloroethene.

[6] cis-1,2-DCE = cis-1,2-dichloroethene.

[7] PCE = tetrachloroethene.

[8] TCE = trichloroethene.

[9] Boring drilled in proposed South Prescott Park area; data not included in Baseline Risk Assessment (Appendix A).

[10] TCE result is not considered valid due to QA/QC issues discussed in Section 3.4 of this report.

TABLE 17

SUMMARY OF ALIPHATIC VOCs DETECTED IN GROUNDWATER SAMPLES[1]

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Concentrations in micrograms per liter (μg/l)

Boring or Sample I.D.	1,1,1-TCA[2]	1,1-DCE[3]	1,2-DCA[4]	Vinyl Chloride	Cis-1,2-DCE[5]	1,1-DCA[6]	PCE[7]	TCE[8]
Samples Collected by IC[9]								
CL19 (right)-3	<1	<1	20	<1	<1	<1	<1	<1
CL19 (right)-3 (dup)	<1	<1	19	<1	<1	<1	<1	<1
Samples Collected by Geomatrix[10]								
B-12	<1	<1	<0.5	<0.5	<1	<1	1.2	<1
B-13	<1	<1	<0.5	1.6	2.3	2.5	<1	<1
B-15	<10	<10	<5	45	210	32	36	120
B-41A	3.8	2.1	<0.5	<0.5	9.8	13	21	13
B-42	<1	<1	<0.5	<0.5	2.8	2.5	<1	9.2[11]
B-43	<10	<10	<5	<5	<10	<10	73	160
B-43A duplicate (B-52)	<10	<10	<5	<5	<10	<10	65	150
B-45	<10	<10	<5	<5	<10	<10	57	150
B-46	<1	<1	<0.5	0.95	2.7	1.4	<1	3.5

Notes:

[1] Detected analytes are shaded.
[2] 1,1,1-TCA = 1,1,1-trichloroethane.
[3] 1,1-DCE = 1,1-dichloroethene.
[4] 1,2-DCA = 1,2-dichloroethane.
[5] cis-1,2-DCE = cis-1,2-dichloroethene.
[6] 1,1-DCA = 1,1-dichloroethane.
[7] PCE = tetrachloroethene.
[8] TCE = trichloroethene.
[9] Groundwater samples collected by IC analyzed using EPA Method 8260.
[10] Groundwater samples collected by Geomatrix analyzed using EPA Method 8260.
[11] TCE result not considered valid due to QA/QC issues discussed in Section 3.4 of this report

TABLE 18

SUMMARY OF METALS RESULTS FOR SOIL SAMPLES COLLECTED BY GEOMATRIX[1]

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Concentrations in milligrams per kilogram (mg/kg)

Boring I.D.	Sample Depth (feet bgs)[2]	Arsenic	Cadmium	Hexavalent Chromium	Total Chromium	Lead	Nickel	Zinc
B-1	0.5-1.0	2.7	<0.5	<0.05	20.4	30.5	31.6	36.5
	4.0-4.5	8.8	<0.5	<0.05	42.8	7.1	39.6	74.7
B-2	1.0-1.5	<0.3	<0.5	NA[3]	24.3	5.2	45.5	46.3
	5.5-6.0	2.7	<0.5	NA	51.5	6.2	66.9	49.4
B-3	1.0-1.5	<0.6	<0.5	<0.05	41.7	220	43.1	111
	4.9-4.5	<0.3	<0.5	<0.05	31.3	6.5	18.6	25.1
B-9	1.5-2.0	8.5	<0.5	NA	33.5	168	32	82.4
	4.0-4.5	1.3	<0.5	NA	27.3	4.4	16.6	16.6
B-10	1.0-1.5	1.9	<0.5	<0.05	19.8	278	28.8	122
	3.5-4.0	1.7	<0.5	<0.05	28.5	5.6	16.9	17.2
B-11[4]	1.0-1.5	16.6	<0.5	<0.05	41.3	288	47.4	133
	3.5-4.0	1.4	<0.5	<0.05	30.4	2.3	18	15.5
	13.0-13.5	2	<0.5	<0.05	45.7	<5	34.9	20.6
B-13b	1.0-1.5	6.4	1	NA	30.1	265	27.3	156
B-13	4.0-4.5	1.9	<0.5	NA	26.7	50.6	16.6	41.6
B-15	1.0-1.5	4.5	<0.5	<0.05	36.7	446	43.2	78.4
	4.0-4.5	1.2	<0.5	<0.05	23.8	5.8	14.7	11.8
B-19	1.0-1.5	8.1	<1	NA	161	1710	72.9	619
	6.5-7.0	3.1	<0.5	NA	31.9	157	16.4	59.7
B-21	0.5-1.0	NA	NA	<0.05	NA	NA	NA	NA
	4.0-4.5	NA	NA	<0.05	NA	NA	NA	NA
B-25b	1.0-1.5	3.6	0.76	<0.05	46.9	64.5	47.2	96.1
	3.0-3.5	4.2	<0.5	<0.05	25.2	42.6	20.4	60.9
B-32	0.5-1.0	NA	NA	<0.05	NA	NA	NA	NA
	2.0-2.5	NA	NA	<0.05	NA	NA	NA	NA
	4.0-4.5	NA	NA	<0.05	NA	NA	NA	NA

---

[1] Samples analyzed for arsenic using EPA Method 7060, lead using EPA method 7421, cadmium, total chromium, nickel, and zinc using EPA Method 6010, and hexavalent chromium using EPA Method 7196.

[2] bgs = below ground surface.

[3] NA = Not analyzed for constituent indicated.

[4] Boring drilled in proposed South Prescott Park area; data not included in Baseline Risk Assessment (Appendix A).

TABLE 19

AVERAGE METAL CONCENTRATIONS FOR SOIL SAMPLES COLLECTED AT SITE COMPARED TO AVERAGE CONCENTRATIONS ELSEWHERE IN BAY AREA

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Average metal concentrations in milligrams per kilogram (mg/kg)

Constituent	No. of Samples from Site	Site (Realignment Corridor[1])	San Leandro[2]	Northern Santa Clara County[3]	Union City[4]	Hercules[5]	I-880 Alameda County[6]
Antimony	47[7]	1.8	ND[8]	3.5	2.5	NA[9]	NA
Arsenic	68[10]	3.5	1.2	2.9	8.5	8.3	NA
Barium	47[7]	83.9	125.0	NA	228	NA	NA
Beryllium	47[7]	0.1	0.4	0.9	0.5	NA	NA
Cadmium	275[11]	0.6	0.2	NC[12]	0.8	1	NA
Chromium	275[11]	28.4	33.4	51.3	72.6	10	NA
Hexavalent Chromium	18[13]	ND	NA	NA	NA	NA	NA
Cobalt	47[7]	5.7	8.8	NA	9.5	NA	NA
Copper	47[7]	56.1	22.7	35.6	37	22	NA
Lead	599[14]	134.3	7.4	11.4	65	32.4	567.7[15] 618.3[16]
Mercury	47[7]	0.3	ND	NC	0.14	0.14	NA
Nickel	275[11]	27.2	22.5	73.5	43	16	NA
Selenium	47[7]	0.1	0.4	NC	0.3	NA	NA
Silver	47[7]	0.3	ND	NC	0.3	NA	NA
Thallium	47[7]	0.1	0.6	NC	0.3	NA	NA
Vanadium	47[7]	31.5	27.8	NA	46.9	NA	NA
Zinc	275[11]	92.8	39.9	65.3	281.6	65	NA

Notes:

[1] Averages for soil samples from the Realignment Corridor were calculated using one-half of the reporting limit for samples with no detectable analyte concentrations.

[2] From "Area 2 Investigation Completion Report, Roberts Landing Development Site, San Leandro, California" (Harding Lawson Associates, 1995). Average background concentrations calculated from 10 soil samples using one-half of the reporting limit for samples with no detectable analyte concentration.

[3] From "Background Metal Concentration in Soils in Northern Santa Clara County, California" (Scott, 1991). The number of samples analyzed ranged from 104 to 158. Samples with no detectable analyte concentration were omitted from the statistical calculation of the mean concentration.

TABLE 19 (continued)

AVERAGE METAL CONCENTRATIONS FOR SOIL SAMPLES COLLECTED AT SITE COMPARED TO AVERAGE CONCENTRATIONS ELSEWHERE IN BAY AREA

Notes (continued):

[4] From "Site Wide Remedial Investigation, Pacific States Steel Corporation, Union City, California" (SEC Donohue, 1992). Average metals concentrations calculated from five off-site background samples using one-half the reporting limit for samples with no detectable analyte concentration.

[5] From "Remedial Investigation Report, Hercules Properties, Inc., Hercules, California" (McLaren Hart, 1991). Average metals concentrations calculated in off-site background samples using one-half the reporting limit for samples with no detectable analyte concentration.

[6] From "A Survey of Lead Contamination in Soil Along Interstate 880, Alameda County, California" (Coltrin et al., 1993).

[7] Includes 40 samples collected by CH2M Hill from 5 borings near Seventh Street depression and 7 samples collected from south of a scrapyard at Third and Lewis Streets. These samples were also analyzed for aluminum, calcium, iron, potassium, magnesium, manganese, and sodium; data for these analytes are included in Appendix B but not tabulated here because (1) they are primary components of minerals in soil, and (2) they are of minimal toxicological concern.

[8] ND indicates constituent not detected in any samples.

[9] NA indicates no analysis made for constituent.

[10] Includes 47 samples collected by CH2M Hill (see Note 7) and 21 samples collected by Geomatrix.

[11] Includes 254 samples collected by CH2M Hill from throughout the Realignment Corridor and 21 samples collected by Geomatrix.

[12] NC indicates average concentration not calculated because the number of samples without detectable concentrations of the analyte was greater than 50 percent of the total number of samples.

[13] Samples collected by Geomatrix.

[14] Includes 324 samples collected by IC, 254 samples collected by CH2M Hill, and 21 samples collected by Geomatrix.

[15] Average lead concentration for 13 samples collected in upper 0.5 to 0.75 inch of soil.

[16] Average lead concentration for 13 samples collected at depths of 3 to 8 inches below the surface.

TABLE 20

SUMMARY OF SOIL SAMPLES WITH LEAD CONCENTRATIONS AT OR GREATER THAN 1000 MG/KG

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Boring or Sample Identification	Depth (Feet bgs[1])	Lead Concentration (mg/kg)
Samples Collected by IC[2]		
CR26	0.5-1.0	1000
EU20	0.5-1.0	12,000
C3L (right)	0.0-0.5	1200
C6L	0.0-0.5	4200
C10L	0.5-1.0	1000
Samples Collected by CH2M Hill[3]		
SP1-SS15-0225	2.0-2.5	1010
SP1-SS15-0225D[4]	2.0-2.5	1010
SP1-SS57-0225	2.0-2.5	1250
Samples Collected by Geomatrix[5]		
B-19	1.0-1.5	1710

Notes:

[1] bgs = below ground surface.
[2] Samples collected by IC were analyzed for lead using EPA Method 7420.
[3] Samples collected by CH2M Hill were analyzed for lead using EPA Method 6010.
[4] D indicates duplicate sample.
[5] Samples collected by Geomatrix were analyzed for lead using EPA Method 7421.

TABLE 21

SUMMARY OF DISSOLVED METAL CONCENTRATIONS IN GROUNDWATER SAMPLES COLLECTED BY IC[1]

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Concentrations in milligrams per liter (mg/l)

Sample Identification	Arsenic	Cadmium	Chromium	Lead	Mercury	Nickel	Zinc
CL21 (left)-3	<0.07	<0.01	<0.02	<0.06	<0.002	<0.03	<0.02
CL23 (left)-1	<0.03	<0.01	<0.02	<0.06	<0.002	<0.03	0.02
CL24 (mid-left)-3	<0.03	<0.01	<0.02	<0.06	<0.002	<0.03	0.06
CL27-2	<0.07	<0.01	0.08	<0.06	<0.002	<0.03	<0.02
EU22-3	<0.03	<0.01	<0.02	<0.06	<0.002	<0.03	0.05
EU23-3	<0.03	<0.01	<0.02	<0.06	<0.002	<0.03	<0.02
CR20 (right)-1	<0.07	<0.01	<0.02	<0.06	<0.002	<0.03	<0.02
OU20-3	<0.07	<0.01	<0.02	<0.06	<0.002	<0.03	<0.02
A4R-right	<0.03	<0.01	<0.02	<0.06	<0.002	<0.03	<0.02
A5R-right	<0.04	<0.01	<0.02	<0.06	<0.002	<0.03	<0.02
NC39-1	<0.04	<0.01	0.02	<0.06	<0.002	<0.03	<0.02
NC41-2	<0.03	<0.01	<0.02	<0.06	<0.002	<0.03	<0.02
NC45-1	<0.04	<0.01	<0.02	<0.06	<0.002	<0.03	<0.02
NC48-1	<0.03	<0.01	<0.02	<0.06	<0.002	<0.03	<0.02
I4-2	<0.03	<0.01	0.02	<0.06	<0.002	<0.03	0.04
C14L-2	<0.03	<0.01	<0.02	<0.06	<0.002	<0.03	<0.02
B12 (right)-1	<0.03	<0.01	<0.02	<0.06	<0.002	<0.03	<0.02
B17 (mid)-2	<0.03	<0.01	<0.02	<0.06	<0.002	<0.03	<0.02
A15R-2	<0.03	0.02	<0.02	<0.06	<0.002	<0.03	<0.02

Note:

[1] Samples were analyzed using various EPA methods. Detected analytes are shaded.

TABLE 22

SUMMARY OF DISSOLVED METALS CONCENTRATIONS IN GROUNDWATER SAMPLES COLLECTED BY GEOMATRIX[1]

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Concentrations in milligrams per liter (mg/l)

Boring Identification	Arsenic	Cadmium	Chromium	Lead	Nickel	Zinc
B-5	<0.005	<0.005	<0.01	<0.01	<0.04	0.027
B-9 (Communication Storage)	0.016	<0.005	<0.01	<0.01	<0.04	<0.02
B-9 Duplicate (J-31)	<0.005	<0.005	<0.01	<0.01	<0.04	0.023
B-10[2] (Paint Shop)	<0.005	<0.005	<0.01	<0.01	<0.04	<0.02
B-11[2,3] (Drop Table Shed)	<0.005	<0.005	<0.01	<0.01	<0.04	<0.02
B-12 (Wheel Shop)	<0.005	<0.005	<0.01	<0.01	<0.04	<0.02
B-13 (Carpentry, Upholstery, Test Shop)	<0.005	<0.005	<0.01	<0.01	<0.04	<0.02
B-14	<0.005	<0.005	<0.01	<0.01	<0.04	<0.02
B-15 (Car Lighting Shop)	<0.005	<0.005	<0.01	<0.01	0.089	<0.02
B-16	<0.005	<0.005	<0.01	<0.01	<0.04	<0.02
B-17	<0.005	<0.005	<0.01	<0.01	<0.04	0.022
B-19 (721 Cedar Street)	<0.005	<0.005	<0.01	<0.01	<0.04	<0.02
B-20	0.0053	<0.005	<0.01	<0.01	<0.04	<0.02
B-25 (Garage/Car Cleaning)	<0.005	<0.005	<0.01	<0.01	<0.04	<0.02
B-28	<0.005	<0.005	<0.01	<0.01	<0.04	<0.02
B-28 Duplicate (J-33)	<0.005	<0.005	<0.01	<0.01	<0.04	0.056

Notes:

[1] Samples filtered in the field and then acidified with nitric acid. Samples analyzed for cadmium, chromium, nickel, and zinc using EPA Method 6010, for arsenic using EPA Method 7060, and for lead using EPA Method 7421. Detected analytes are shaded.

[2] Sample also analyzed for copper by laboratory, although copper analysis was not requested. Copper was not detected in the sample above the reporting limit of 0.1 mg/l.

[3] Boring drilled in proposed South Prescott Park area; data not included in Baseline Risk Assessment (Appendix A).

TABLE 23

pH OF GROUNDWATER SAMPLES COLLECTED BY GEOMATRIX[1]

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Boring I.D.	Date	pH
B-1	2/22/95	7.1
B-4	2/7/95	7.0
B-5	2/14/95	6.7
B-6	2/7/95	7.2
B-7	2/22/95	6.8
B-8	2/22/95	6.7
B-9	2/8/95	6.9
B-10	2/9/95	6.8
B-11	2/9/95	6.8
B-12	2/9/95	6.2
B-13	2/10/95	6.8
B-14	2/14/95	7.1
B-15	2/13/95	6.7
B-17	2/13/95	6.7
B-18	2/9/95	7.1
B-19	2/16/95	6.7
B-22	2/23/95	7.0
B-23	2/23/95	6.8
B-24	2/23/95	6.7
B-25	2/10/95	7.1
B-26	2/24/95	6.9
B-27	2/24/95	7.4
B-28	2/13/95	7.1
B-29	2/24/95	7.2
B-32	4/17/95	7.2
B-38	2/27/95	7.1
B-39	2/27/95	7.3
B-40	2/28/95	7.1
B-41	4/17/95	7.3
B-42	4/19/95	7.2
B-43	4/17/95	6.9
B-44	4/17/95	7.4
B-45	5/16/95	6.8

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[1] pH measured in the field with a pH meter at the time of sample collection.

TABLE 24

SUMMARY OF PESTICIDES AND PCBs DETECTED IN SOIL SAMPLES[1]

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Concentrations in milligrams per kilogram (mg/kg)

Sample I.D.	Sample Depth (Feet bgs[2])	PCBs[3]	DDD-Family[4]	Dieldrin	Endrin	Endosulfan Family[5]	Aldrin	EDB[6]
Samples Collected By IC								
CL19 (left)	2.0-2.5[7]	NA[8]	NA	NA	NA	NA	NA	0.028
	4.0-4.5[7]	NA	NA	NA	NA	NA	NA	0.015
CL19 (right)	2.0-2.5[7]	NA	NA	NA	NA	NA	NA	0.014
ICP-08	2.0-2.5	<0.005	0.001	<0.001	<0.001	<0.005	<0.001	NA
ICP-10	2.0-2.5	<0.005	0.017	<0.001	<0.001	<0.001 to <0.005	<0.001	NA
Samples Collected by CH2M Hill								
SP1-S02-0115[9]	1.0-1.5	<0.016 to <0.080	<0.0027 to <0.008	0.020	<0.004	<0.0027 to <0.008	<0.0027	NA
SP1-SS69-0225[9]	2.0-2.5	<0.016 to <0.080	.0299	<0.0013	<0.004	<0.0027 to <0.008	0.0028	NA

Notes:

[1] Samples analyzed using EPA Method 8080. Detected analytes are shaded.
[2] bgs = below ground surface.
[3] PCBs = polychlorinated biphenyls.
[4] DDD-family = sum of 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT.
[5] Endosulfan family = sum of endosulfan I, endosulfan II, and endosulfan sulfate.
[6] EDB = ethylene dibromide = 1,2-dibromoethane.
[7] Samples analyzed for EDB using modified EPA Method 8260.
[8] NA = not analyzed
[9] Boring drilled in proposed South Prescott Park area; data not included in Baseline Risk Assessment (Appendix A).

TABLE 25

SUMMARY OF PESTICIDES AND PCBs DETECTED IN GROUNDWATER SAMPLES[1]

Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Concentrations in micrograms per liter (μg/l)

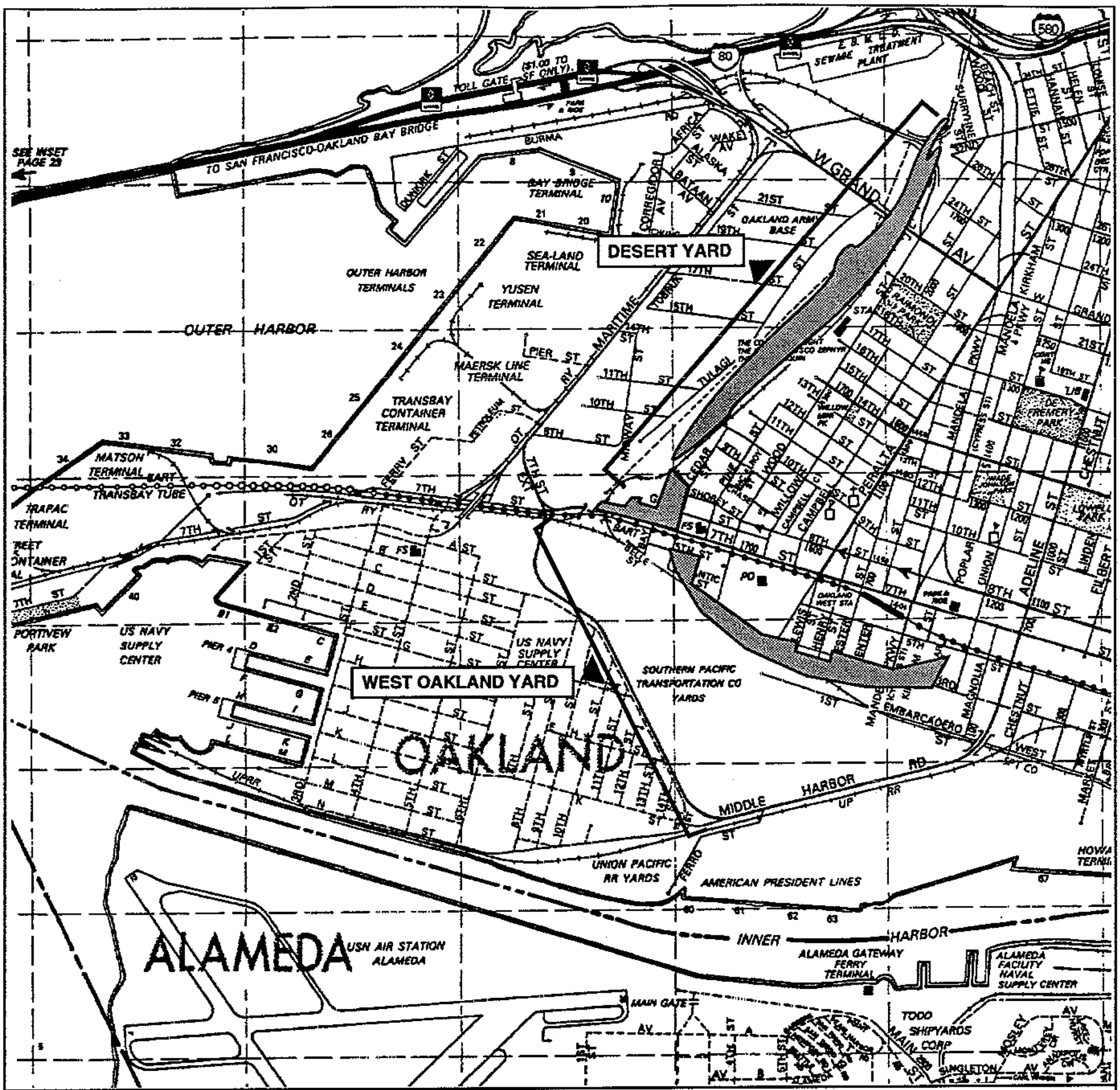
Sample I.D.	PCBs[2]	EDB[3]	DBCP[4]
CL19 (right)-3	NA[5]	59	5.9
CL19 (right)-3 (dup)	NA	57	5.9
HI (middle)-3	0.7[6]	ND[7]	ND

Notes:

[1] Samples were collected by IC and analyzed for PCBs using EPA Method 8080. Samples were analyzed for EDB and DBCP using EPA Method 8260.
[2] PCBs = polychlorinated biphenyls.
[3] EDB = ethylene dibromide = 1,2-dibromoethane.
[4] DBCP = 1,2-dibromochloropropane.
[5] NA = not analyzed.
[6] Confirmation groundwater sample collected by Geomatrix at this location was non-detect for PCBs.
[7] ND = not detected above laboratory reporting limit (reporting limits for pesticide and PCB samples not available).

FIGURES

Larger Maps Available for Viewing at DTSC File Room.



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EXPLANATION

▨ Approximate location of the I-880 Realignment Corridor property sold by Southern Pacific Transportation Company to CalTrans.

0 2200 Feet

GEOMATRIX

SITE LOCATION MAP
Southern Pacific Transportation Company
I-880 Realignment Corridor
Oakland, California

Figure
1

Project No
2686AG

2686AG.001

APPENDIX A

Baseline Risk Assessment Prepared by Center for Toxicology and Environmental Health

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BASELINE RISK ASSESSMENT REPORT
I-880 REALIGNMENT CORRIDOR
West Oakland and Desert Rail Yards
Oakland, California

Prepared for

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July 21, 1997

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BASELINE RISK ASSESSMENT REPORT
I-880 REALIGNMENT CORRIDOR
West Oakland and Desert Rail Yards
Oakland, California

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EXECUTIVE SUMMARY

This risk assessment was prepared on behalf of Southern Pacific Transportation Company (SPTCo) by Terranext and responds to Sections 5.5 and 5.6 of the Imminent and Substantial Endangerment Order No. 93-94-018 (the Order) issued to SPTCo by the California Environmental Protection Agency - Department of Toxic Substances Control (DTSC) on 20 June 1994. The Order addresses portions of the SPTCo West Oakland and Desert Rail Yards that are within the I-880 realignment corridor as well as the former Bobo's Junkyard. A separate Remedial Investigation (RI) and Baseline Risk Assessment (RA) Report was prepared for the former Bobo's Junkyard and approved by the DTSC on 25 January 1996.

This risk assessment evaluates possible human health risks that may be associated with chemicals detected in soil and ground water in the 75-acre property referred to as the I-880 Realignment Corridor, exclusive of Bobo's Junkyard. Potential human exposures to chemicals in soil and ground water that could occur <u>after</u> reconstruction of the I-880 freeway are addressed in this assessment. Caltrans will address human health risks resulting from exposure conditions that may occur <u>during</u> reconstruction of the I-880 freeway. The methods used to prepare this risk assessment are based on a risk assessment workplan submitted to DTSC (IC, 1995a) and comments received from DTSC regarding the workplan (DTSC, 1995) and the approved risk assessment for the eastern portion of the former Bobo's Junkyard site (IC, 1995b; Geomatrix, 1995).

For the purpose of evaluating human exposure to chemicals in soil and shallow ground water, the I-880 Realignment Corridor is divided into areas that will an at grade section of the freeway ("At Grade Section") and elevated sections of the freeway ("Elevated Sections"). The Elevated Sections of the freeway (North and South Elevated Sections) are separated by the At-Grade Section of the freeway.

Shallow groundwater and soil data used in this risk assessment are taken from the Remedial Investigation (RI) (Geomatrix, 1997) for the I-880 Realignment Corridor. The RI summarizes chemical occurrence and concentration data for soil and ground water investigations performed by CH2MHill, Terranext (formerly Industrial Compliance), and Geomatrix. Chemical occurrence in soil and shallow ground water are reviewed in detail in the RI report that accompanies this risk assessment.

Chemicals of concern in soils of the Elevated and At-Grade Sections of the I-880 Corridor were conservatively selected by comparison of the maximum detected concentration of each chemical to USEPA Region IX residential preliminary remediation goals (PRGs). Surface soil (0 to 1 foot depths) and surface/subsurface soils (0 to 5 feet depths) were given separate consideration due to differences in the potential for human contact with surface and subsurface soils. Maximum detected soil concentrations of the following chemicals in I-880 Corridor soils exceeded their respective residential PRG concentrations:

Chemicals of Concern-Elevated Section Soils

Volatile organic chemicals	**Polynuclear aromatic hydrocarbons**	**Metals**
1,2-Dibromoethane (subsurface soils only)	Benzo(a)pyrene	Lead
	Benzo(b)fluoranthene	
	Indeno(1,2,3-cd)pyrene	

Chemicals of Concern-At-Grade Section Soils

Polynuclear aromatic hydrocarbons	**Metals**
Benzo(a)anthracene	Lead
Benzo(a)pyrene	
Benzo(b)fluoranthene	
Dibenz(a,h)anthracene	
Indeno(1,2,3-cd)pyrene	

In addition to the above chemicals that exceeded residential PRGs, total petroleum hydrocarbons (TPH) detected in soil and characterized as gasoline (low boiling hydrocarbon fraction similar to gasoline; TPH-gasoline), diesel (mid-boiling hydrocarbon fraction similar to diesel; TPH-diesel), and motor oil or journal box oil (high-boiling hydrocarbon fraction similar to motor oil or journal box oil; TPH-motor oil or journal box oil) were identified for further evaluation in the risk assessment.

Shallow ground water at the I-880 Corridor site is not likely potable. Thus, ingestion of chemicals detected in ground water was not evaluated. However, volatilization of chemicals from shallow ground water was considered to be a possible route of exposure. Thus, all volatile chemicals (chemicals with Henryís Law constants of 1×10^{-5} or greater and a vapor pressure of 0.001 mm Hg or greater) detected in ground water were considered for further evaluation in the risk assessment.

Possible pathways of the human exposure to the chemicals of concern in soil and shallow ground water in the future I-880 Corridor were evaluated under conditions that will exist after the freeway is built. The exposure assumptions used to evaluate human health risk are based on a workplan submitted to DTSC (IC, 1995) and comments received from DTSC regarding the workplan (DTSC, 1995) and the approved risk assessment for the eastern portion of the former Bobo's Junkyard site (IC, 1995b; Geomatrix, 1995). The Elevated Sections of the freeway were considered separately from the At-Grade Section of the freeway since possible casual human exposure could occur to surface soils in the Elevated Sections. Casual human exposure to surface soil in the At-Grade section of the freeway will be prevented by pavement and its use as an active freeway.

For Elevated Sections of the freeway, two possible receptors were identified that may be exposed to chemicals present in soil and shallow ground water. A child at play was considered to be potentially exposed to the chemicals of concern in Elevated Section surface soil (0-1í depth) via ingestion, skin contact, and inhalation of affected dusts and vapors. In addition, inhalation of the chemicals of concern volatilizing from shallow ground water through vadose zone soils was also assessed for a child at play in the Elevated Sections of the I-880 Corridor site. The child at play was assumed to be exposed to the chemicals of concern in surface soil and shallow ground water for 36 days per year for 7 years. In addition, a utility worker was also assumed to be exposed to the chemicals of concern in surface/subsurface soils (0-5') by the ingestion, skin contact, and inhalation routes of exposure in the Elevated Sections of the freeway. Due to the possibility that shallow ground water may pool in excavated trenches, utility worker inhalation of chemicals volatilizing from shallow ground water in the Elevated Sections was also assessed. The utility worker was assumed to be exposed to the chemicals of concern in soil and shallow ground water for 60 days (5 days per week for 12 weeks).

Secondly, utility worker exposure to the chemicals of concern in surface/subsurface soils in the At Grade Section of the I-880 Corridor site by the ingestion, skin contact, and inhalation routes of exposure were also assessed. Utility workers were assumed to have contact with surface/subsurface soils in the At-Grade Section as a result of road repair, excavation of utility trenches, or from other ground intrusive activities. Like the utility worker in the Elevated Sections of the freeway, the utility worker in the At-Grade Section was assumed to inhale chemicals volatilizing from shallow ground water. Like the utility worker in the Elevated Section exposure scenario, the utility worker in the At-Grade Section was assumed to be exposed to soil and shallow ground water for 60 days.

The child at play and the utility worker were assumed to be exposed to the chemicals of concern in soils and shallow ground water in the absence of any measures designed to protect against exposure (such as paving to prevent contact with soil or the use of respirators or protective clothing by utility workers).

Conservative California Department of Toxic Substances Control (DTSC) and United States Environmental Protection Agency (USEPA) exposure assumptions were used to assess a childís and utility workerís exposure to the chemicals of concern in soil and shallow ground water. The 95% upper confidence limit (UCL) on the arithmetic mean concentration was used as the exposure point concentration for chemicals in soil in the Elevated and At-Grade Sections. Because the Elevated Sections are separated into North and South Sections, the higher of the 95% UCLs calculated for the North and South Sections was used as the exposure point concentration for Elevated Section soils. Maximum detected concentrations of the volatile chemicals of concern in shallow ground water were used to assess exposure and risk for the child at play and the utility worker.

USEPA reference doses and DTSC and USEPA slope factors were used to assess potential noncarcinogenic and carcinogenic effects associated with chemical exposure.

Calculated noncancer health risks for the child at play (Elevated Sections only) and utility worker (Elevated and At Grade Sections) exposed to soil and chemicals volatilizing from shallow ground water were below one, indicating that exposure to soil and shallow ground water in the Elevated and At Grade Sections is unlikely to pose noncancer health risks.

As determined by calculating hazard indices, a child at play and a utility worker are unlikely to experience adverse health effects due to ingestion, dermal contact, and inhalation of chemicals in Elevated Section soils. The summed hazard indices for the ingestion, dermal contact, and inhalation exposure pathways for the child at play exposed to Elevated Section surface soils and the utility worker exposed to surface and subsurface soils in the Elevated Section are 0.022 and 0.021, respectively.

Similarly, a utility worker exposed to soils underneath the paved At Grade Section is unlikely to experience noncancer health effects. The summed hazard index for the ingestion, dermal contact, and inhalation exposure pathways is 0.0073.

The hazard index calculated for the child at play resulting from inhalation of chemicals released from shallow ground water in the Elevated Sections was acceptably low (0.0022). Similarly, the utility worker inhaling volatile chemicals released from pooled shallow ground water in excavated areas in the Elevated and At Grade Sections were also below one (0.33 and 0.000049, respectively).

Theoretical lifetime cancer risks calculated for the child at play exposed to chemicals in Elevated Section surface soils, the utility worker exposed to chemicals in Elevated Section surface and subsurface soils, and the utility worker exposed to chemicals in At Grade Section soils were 1 E-07, 5 E-07, and 4 E-07, respectively. These calculated theoretical lifetime cancer risks are at or below the most conservative lifetime cancer risk level in the range of theoretical lifetime cancer risks considered by the USEPA to be safe and protective of public health (1E-04 to 1E-06).

Theoretical lifetime cancer risk calculated for the child at play resulting from inhalation of volatile chemicals released from shallow ground water in Elevated Sections was 2 E-09. Theoretical lifetime cancer risks calculated for utility workers inhaling volatile chemicals released from shallow ground water in the Elevated and At Grade Sections are 1 E-07 and 3 E-08. These calculated theoretical lifetime cancer risks are below the most conservative lifetime cancer risk level in the range of theoretical lifetime cancer risks considered by the USEPA to be safe and protective of public health (1E-04 to 1E-06).

Risk posed by exposure to lead in soil was evaluated using the DTSCís lead exposure model. For the child at play, the higher of the 95% UCL on the arithmetic mean of the soil lead concentration of the North and South Elevated Sections (605 mg/kg; South Elevated Section) was used to perform the lead exposure calculation. Using the higher of the 95% UCL of the two sections was considered to be a more conservative approach to assessing risk to a child. The calculated blood lead concentrations associated with a child's exposure to 605 mg/kg lead in soil for 3 days per week were 3.4, 5.3, 6.0, 6.9, and 7.6 µg/dL for the 50th, 90th, 95th, 98th, and 99th percentile values, respectively. These concentrations are all below the DTSC's blood lead concentration of concern of 10 µg/dL, indicating that a child's exposure to surface soil in the Elevated Sections of the I-880 Corridor is unlikely to result in overexposure to lead.

Using the DTSC leadspread model, the calculated 50th, 90th, 95th, 98th, and 99th percentile blood lead concentrations for a utility worker exposed to surface and subsurface soils containing an average of 361 mg/kg lead (higher 95% UCL value for surface and subsurface soils from Elevated vs. At-Grade Sections) were 2.6, 4.0, 4.5, 5.2 and 5.8 µg/dL, respectively. Based on these calculations, utility worker exposure to lead in surface and subsurface soils is unlikely to result in a blood lead concentration that would exceed 10 µg/dL or a blood lead standard (40 µg/dL) or health protection goal (30 µg/dL) in CCR Title 8 ß 1532.1, the State of California Lead in Construction standard.

There are no universally accepted procedures established for assessing the risks posed by petroleum hydrocarbons in soil or ground water. As recommended by DTSC, risks posed by petroleum hydrocarbon mixtures and indicator chemicals of petroleum hydrocarbons (such as benzene, ethylbenzene, toluene, xylenes, and PNAs) were assessed using three different methods. These methods are the American Society for Testing and Materials method (ASTM method), the American Petroleum Institute Risk/Exposure Assessment Decision Support System method (API DSS method), and the Massachusetts Department of Environmental Protection Development of a Health-Based Alternative to the Total Petroleum Hydrocarbon (TPH) Parameter method (MDEP method). The ASTM and API DSS method deal specifically with selected indicator chemicals of petroleum hydrocarbons. The MDEP method evaluates the risks posed by petroleum hydrocarbons by identifying a chemical surrogate for the different subfractions of petroleum hydrocarbons present in gasoline, diesel fuel, and oil (motor oil and journal box oil).

The ASTM has calculated risk-based soil screening levels for benzene, ethylbenzene, toluene, xylenes, and the PNAs benzo(a)pyrene and naphthalene in soil and ground water for residential exposure conditions. Because residential exposure conditions are generally recognized as providing the lowest risk-based soil and ground water concentrations for these indicator chemicals, comparison of maximum detected concentrations of these chemicals in soil and ground water at the I-880 site to the ASTM risk-based levels is highly conservative. The ASTM risk-based soil screening levels for benzene and benzo(a)pyrene were also recalculated to reflect DTSC slope factors. Further, risk-based values were also calculated for potentially carcinogenic PNAs other than benzo(a)pyrene.

The results of the comparison of maximum detected soil concentrations of indicator chemicals to ASTM residential screening level concentrations indicated that in Elevated Section soils, benzo(a)pyrene and indeno(1,2,3-cd) pyrene exceeded their respective residential soil screening levels. In At-Grade Section soils, benzo(a)anthracene, benzo(a)pyrene benzo(b)fluoranthene, dibenz(a,h)anthracene and indeno(1,2,3-cd)pyrene exceeded their respective residential screening level concentration. No chemical detected in shallow ground water in either the Elevated or At-Grade Sections exceeded the applicable ASTM residential risk-based screening level for indicator chemicals. As discussed in Section 5.3.1, although the maximum detected concentrations of some petroleum indicator chemicals in Elevated Sections soil and At-Grade Section soil exceeded their respective ASTM residential risk based screening levels, these chemicals were not expected to pose significant risk under I-880 Corridor site exposure conditions (i.e., recreational/industrial).

The API DSS model was used to assess the risks of chemicals in soil detected at the I-880 Corridor site that are considered indicator chemicals for petroleum hydrocarbon mixtures. Calculated overall hazard indices for exposure to these indicator chemicals in soils for the ingestion, skin contact, and inhalation routes of exposure were 0.000022 and 0.028 for the child and utility worker, respectively, in the Elevated Sections and 0.027 and for the utility worker in the At Grade Section. These hazard indices are well below 1, indicating that exposure to API DSS indicator chemicals at the I-880 Corridor site is unlikely to be associated with noncarcinogenic adverse health effects.

Theoretical lifetime cancer risks calculated for API DSS indicator chemicals were 1 E-06 and 2 E-07 for the child at play and the utility worker, respectively, in the Elevated Sections and 1E-06 for the utility worker in the At Grade Section. These risks are at or below the lower end of theoretical lifetime cancer risk range considered by the USEPA to be safe and protective of public health (1 E-06).

The MDEP method was used to evaluate possible health risks associated with exposure to TPH-gasoline, TPH-diesel, and TPH-motor oil concentrations detected in surface and subsurface soils for the child at play and the utility worker. In the absence of hydrocarbon analyses specified by the MDEP, certain assumptions must be made with regard to the types of hydrocarbons present in soils at the site in order to apply the MDEP method. For example, the reference dose established for the most toxic hydrocarbon fraction (0.03 mg/kg/day for the C9 to C32 aromatic/alkene fraction) was used to assess the risks posed by chronic exposure to TPH-gasoline, TPH-diesel, and TPH-motor oil in soil for the child at play.

Because exposure was assumed to occur over a subchronic period of time (less than 7 years), a subchronic reference dose of 0.3 mg/kg/day was used to assess the noncarcinogenic risks posed by petroleum hydrocarbons in soil for the utility worker.

Overall hazard indices calculated for the child at play and the utility worker in the Elevated Sections were 0.022 and 0.016, respectively, and for the utility worker in the At Grade Section was 0.0073. These hazard indices indicate that exposure to TPH-gasoline, TPH-diesel, TPH-motor oil, and journal box oil in soils is unlikely to be associated with noncarcinogenic adverse health effects, particularly since the maximum detected concentrations of these petroleum hydrocarbons were used in calculating exposures.

In summary, assessment of potential health risks resulting from exposure to chemicals in soil and shallow ground water at the I-880 Corridor site indicates that:

- A child at play and a utility worker exposed to chemicals in soil or shallow ground water is unlikely to experience noncarcinogenic adverse health effects as a result of calculated levels of exposure.

- Overall theoretical lifetime cancer risks associated with soil exposure at the I-880 site were 1 E-06 for the child at play and 5 E-07 for the utility worker in the Elevated Sections and 4 E-07 for the utility worker in the At Grade Section. These theoretical lifetime cancer risks are at or below the 1 E-06 (one in one million) to 1 E-04 (one in ten thousand) target risk range USEPA considers safe and protective of public health. Theoretical lifetime cancer risks posed by calculated levels of exposure to chemicals detected in soils at the I-880 site are primarily associated with PNAs.

- Calculated blood lead concentrations for the child at play exposed to lead in surface soil are below the 10 µg/dL level of concern for children. For the unprotected utility worker exposed to lead in surface and subsurface soil, blood lead concentrations are unlikely to exceed the 10 µg/dL. This blood lead concentration is much less than the 30 µg/dL recommended limit and the blood lead concentrations of 40 to 49 µg/dL that trigger medical monitoring and employee notification in the California Title 8, ß 1532 Lead in Construction standard.

- Exposure to petroleum hydrocarbons or indicator chemicals of petroleum hydrocarbons is unlikely to result in noncarcinogenic health effects or theoretical lifetime cancer risks above 1 E-06 for the child at play or the utility worker.

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1.0 INTRODUCTION

1.1 Objectives

This risk assessment has been prepared on behalf of the Southern Pacific Transportation Company (SPTCo) by Terranext (formerly Industrial Compliance), and responds to Section 5.2.2(b) of the Imminent or Substantial Endangerment (I&/SE) Order No. 93-94-018 (the Order) issued to SPTCo by the California Environmental Protection Agency - Department of Toxic Substances Control (DTSC) on June 20, 1994. The methods used in preparing this risk assessment are based on a risk assessment workplan submitted to DTSC (IC, 1995a), comments received from DTSC regarding the workplan (DTSC, 1995), and the former Bobo's Junkyard Site risk assessment which was approved by DTSC January 26, 1996.

The objectives of this risk assessment are to evaluate possible human health risks that may be associated with chemicals detected in soil and groundwater on the 75-acre property transferred from SPTCo to the California Department of Transportation (Caltrans) (referred to as "I-880 Realignment Corridor"). It should be noted that this risk assessment addresses potential human exposures to chemicals in soil and ground water that could occur <u>after</u> reconstruction of the I-880 freeway is completed as per SPTCo/Caltrans agreement (Attachment A). This risk assessment also does not address possible environmental impacts that may result from the freeway itself such as noise or vehicular exhaust. Caltrans will address human health risks resulting from exposure conditions that may occur <u>during</u> construction of the realigned I-880 freeway.

This risk assessment has been prepared in conjunction with and is intended to be a portion of the remedial investigation (RI) report for the I-880 Realignment Corridor property (this volume). As such, the descriptions, figures, and tables presented elsewhere in the RI report are necessary for a proper understanding of the results of the risk assessment.

It should be noted that this risk assessment does not include selected parcels transferred from SPTCo to Caltrans (the former Bobo's Junkyard area and several other parcels located along Third Street). The former Bobo's Junkyard area has been designated an operable unit and human health risks associated with the eastern half of Bobo's Junkyard were previously addressed in risk assessments prepared by Tetra Tech, consultant to

Caltrans (construction phase; Tetra Tech, 1996a), and Terranext (post-construction; Geomatrix, 1995). DTSC previously has approved both of these risk assessments. As agreed in a 31 March 1995 meeting among representatives of DTSC, SPTCo, Terranext, Geomatrix, Caltrans and Environmental Solutions (consultant to Caltrans), health risk associated with the Prescott Park parcels (including the western half of Bobo's Junkyard) will be addressed by Caltrans and its consultant, A draft risk assessment of the proposed South Prescott Park area was prepared by Tetra Tech and submitted to Caltrans on May 28, 1996 (Tetra Tech, 1996b). The areas included in the I-880 Realignment Corridor that are addressed herein, as well as those areas previously evaluated (former Bobo's Junkyard Operable Unit and the South Prescott Park area) are shown in Figure 2 of the RI report.

1.2 Site Investigative History

The site is situated in west Oakland, California, and consists of property (approximately 75 acres) sold by SPTCo to CalTrans for the I-880 realignment corridor. These properties were formerly part of the SPTCo West Oakland Yard and the Desert Rail Yard. Additionally, the site included an approximately 2-acre parcel known as Bobo's Junkyard that was the subject of a separate risk assessment (IC, 1995b) as described above.

The site is located in an industrial area of west Oakland. The topography is flat, and the site is approximately 3300 feet east of the San Francisco Bay at its closest point. The surrounding facilities include the Oakland Naval Supply Center to the west, Port of Oakland operations to the west and south, and the Oakland Army Terminal to the south. Residential neighborhoods are within 600 feet of the site to the east. Based on 1990 census information, 6,457 people live within a 1-mile radius of the site (DTSC, 1994)

The current construction plans for the I-880 freeway across the former SPTCo property consist of two elevated sections (Elevated Sections) and an at-grade section (At-Grade Section). In addition, Seventh Street will be sub-grade, or depressed, as it crosses under the new alignment of the I-880 freeway. These areas are identified in Figure 2 of the RI report and other documents submitted by Geomatrix.

The risk assessment primarily uses soil and ground water data collected during two previous investigations conducted by CH2MHill and Industrial Compliance and data collected by Geomatrix during the RI. Soil and ground water samples have been analyzed for petroleum hydrocarbons, aromatic and aliphatic volatile organic chemicals (VOCs), polynuclear aromatic chemicals (PNAs), metals, and pesticides/PCBs. Results from these samples are summarized in Section 4 of the RI report. For the purposes of the risk assessment, data were combined into two main designations - "Elevated Sections" and "At-Grade Section".

2.0 IDENTIFICATION OF THE CHEMICALS OF CONCERN

The purpose of this section of the risk assessment is to determine the chemicals in soil and ground water that will be considered in the risk assessment. Soil and ground water data used in this risk assessment are from site investigations conducted from 1990 to 1995 by CH2MHill, Industrial Compliance and Geomatrix. These site investigations are summarized in greater detail elsewhere in the RI report (this volume). Data from these investigations are summarized for risk assessment purposes in Table 2-1 for surface soil (0-1' depth)--Elevated Sections, Table 2-2 for subsurface soil (1-5' depth)--Elevated Sections, Tables 2-3 and 2-4 for surface and subsurface soils (0-5' depths)--Elevated Sections and At Grade Section, respectively, and Tables 2-8 and 2-9 for shallow ground water--Elevated Sections and At Grade Sections, respectively. While a child-at-play was assumed to be exposed to only surface soil in the Elevated Sections, as discussed in Section 3, a utility worker was assumed to be exposed to both surface and subsurface soil during trenching activities in both the Elevated Sections and the At Grade Section. Therefore, surface and subsurface soil data were combined to assess exposure to chemicals in soil for a utility worker for the Elevated Sections and At Grade Section (Tables 2-3 and 2-4 respectively).

In accordance with the risk assessment workplan and comments received from the DTSC, the chemicals of concern in soil for the I-880 Corridor are determined based on a comparison to residential preliminary remediation goals (PRGs) published by USEPA Region IX (USEPA, 1995). The USEPA directs that if chemicals are detected infrequently, e.g., in less than 5% of samples collected from one or more environmental medium, it may be eliminated if it is considered to be an artifact of cross-contamination rather than related to the facility (USEPA, 1989a). Conservatively, chemicals in surface soils or subsurface soils are eliminated from this risk assessment only if the maximum detected concentration of the chemical in soil does not exceed the USEPA Region IX residential PRG.

This screening procedure should be considered quite conservative for two reasons. First, comparison of the maximum detected concentration is likely to exaggerate actual human exposure and risk due to the chemical in soil. Human exposure is better represented by incorporating all site soil data representing areas of both high and low concentrations of the chemical of concern. Secondly, the residential PRG accounts for exposure conditions that are associated with long-term residential exposure to soil. The USEPA Region IX residential PRGs assume that individuals will be exposed to soil 350 days per year for 30 years. Given the intended future use of the I-880 Corridor, it is more appropriate to compare chemical concentrations in site soils to industrial PRGs since the site will not be used for any residential use. However, to be very conservative, the residential PRG was used for eliminating chemicals from the risk assessment. Comparisons of the maximum detected soil concentrations to the USEPA Region IX residential and industrial PRGs are presented in Tables 2-5 and 2-6 for the Elevated Sections and in Table 2-7 for the At Grade Section.

In keeping with USEPA guidance, concentrations of inorganic constituents in Corridor soils were compared to average background concentrations of the constituent in Bay area soils. The USEPA (USEPA, 1989a) states that: "If inorganic chemicals are present at the site at naturally occurring levels, they may be eliminated from the quantitative risk assessment." Information concerning naturally present concentrations of inorganic constituents in soil is available for Bay area locations including San Leandro, northern Santa Clara County, Union City, and Hercules. Average soil metal concentrations for these Bay area locations are summarized in Table 19 of the RI report (this volume). Metals that exceeded PRGs were compared to average detected concentrations for Bay area locations. If the average detected metal concentration in Corridor soils was similar to the Bay area locations presented in Table 19 of the RI report, the metal was eliminated from the risk assessment in accordance with USEPA guidance.

Although comparison to typical urban concentrations is not used as a screening criterion in this risk assessment, comparison of chemical concentrations in site soils to typical urban concentrations provides an important perspective to chemicals that are commonly detected in urban soils. For example, lead and PNAs are known to be present in elevated concentration in urban soils (Bradley et al., 1994, ATSDR, 1993a, ATSDR, 1993b). Historically, lead and PNAs have been present in automobile emissions, resulting in elevated soil concentrations near roads and freeways. A summary of the findings of Bradley et al. (1994) is presented in the table below.

PNA Soil Concentrations in Urban New England Soil[a]

PNA	Reported PNA Concentrations for Urban New England Soils Minimum detect (mg/kg)	Maximum detect (mg/kg)	Arithmetic mean (mg/kg)	Upper 95% interval (mg/kg)	[b]Frequency of detection
2-Methylnaphthalene	0.017	0.64	0.151	0.173	19 / 62
Acenaphthene	0.024	0.34	0.201	0.306	30 / 62
Acenaphthylene	0.018	1.10	0.173	0.208	24 / 62
Anthracene	0.029	5.70	0.351	0.535	54 / 62
Benzo(a)anthracene	0.048	15.00	1.319	1.858	58 / 62
Benzo(a)pyrene	0.040	13.00	1.323	1.816	57 / 62
Benzo(b)fluoranthene	0.049	12.00	1.435	1.973	55 / 62
Benzo(g,h,i)perylene	0.200	5.90	0.891	1.195	36 / 62
Benzo(k)fluoranthene	0.043	25.00	1.681	2.522	59 / 62
Chrysene	0.038	21.00	1.841	2.693	60 / 62
Dibenzo(a,h)anthracene	0.020	2.90	0.388	0.521	32 / 62
Fluoranthene	0.110	39.00	3.047	4.444	60 / 62
Fluorene	0.022	3.30	0.214	0.317	35 / 62
Indeno(1,2,3-c,d)pyrene	0.093	6.00	0.987	1.293	43 / 62
Naphthalene	0.018	0.66	0.125	0.149	35 / 62
Phenanthrene	0.071	36.00	1.838	2.982	61 / 62
Pyrene	0.082	11.00	2.398	2.945	61 / 62

Adapted from Bradley et al. (1994)
a Surface soil = 0-1' depth
b Frequency of detection = number detected/number samples.

Studies of PNA concentrations in soils for California sites are also available for comparison. For example, Ecology and Environment reported that total PNA concentrations in background soils at the Midway Village portion of the Midway-Bayshore site range from 0.02 to 1.03 mg/kg (Ecology and Environment, 1993). PNAs were detected in 17 out of 19 background samples.

The procedure used to identify the chemicals of concern in soil and shallow groundwater for the I-880 Corridor is presented below.

2.1 Chemicals of Concern in Elevated Sections Soils

2.1.1 Surface Soil (0-1' Depth)

Chemicals detected in surface or near surface soils (0-1' depth) were considered separately from soil samples collected at greater depths (1'-5'). Following construction of the freeway, human contact with soils in the I-880 Corridor would likely be limited to soils beneath the elevated portions of the freeway. Soil data from 1' to 5' depths are reviewed in Section 2.1.2 for the purpose of assessing possible human exposure to surface and subsurface soils as a result of excavation or other ground-intrusive activity.

2.1.1.1 Volatile Organic Chemicals (VOCs)

As presented in Table 2-1, (VOCs) were detected in surface soil in the Elevated Sections of the I-880 Corridor. Based on a comparison to USEPA Region IX PRGs (Table 2-5), no VOC was present at a concentration sufficient to warrant further evaluation in the risk assessment as a chemical of concern.

2.1.1.2 Polynuclear Aromatic Hydrocarbons (PNAs)

Seven PNAs were detected in surface soils (Table 2-1). PRGs are established for six of the seven detected PNAs. Only the maximum detected concentrations of benzo(a)pyrene, benzo(b)fluoranthene, and indeno(1,2,3-c,d)pyrene exceeded residential PRGs (Table 2-5). There are no PRGs for benzo(g,h,i)perylene. Benzo(g,h,i)perylene is not considered to be a potential carcinogen by the State of California or the USEPA. The lowest (most conservative) PRG for a noncarcinogenic PNA is 2,000 mg/kg (pyrene). The maximum detected concentration of benzo(g,h,i)perylene (2.5 mg/kg) is 800 times lower than this value, indicating that benzo(g,h,i)perylene is unlikely to contribute significantly to the noncarcinogenic risks for the I-880 Corridor. For this reason, benzo(g,h,i)perylene was eliminated as a chemical of concern. PNAs detected at concentrations less than PRGs were eliminated from further consideration as potential chemicals of concern.

As a result of both anthropogenic and natural sources, PNAs are ubiquitous in soil. The highest concentrations of PNAs in soil are detected in urban versus agricultural or rural soils. As described in Section 4.3.1 of the RI report, PNAs (which were primarily detected in shallow soil) do not appear to be associated with petroleum hydrocarbons at the site (which were primarily detected in deeper soil), but may be associated with the site's location in an urban setting. Despite the suggestion that PNAs detected in I-880 Corridor soils are similar to concentrations typically detected in urban soils, benzo(a)pyrene, benzo(b)fluoranthene and indeno(1,2,3-cd)pyrene were conservatively retained as chemicals of concern for the Elevated Sections because local empirically-derived off-site reference concentrations were not available.

2.1.1.3 Petroleum hydrocarbons

Petroleum hydrocarbons have been characterized using several different analytical methods, resulting in reports of different "mixtures" of petroleum at the site. These differences relate primarily to the method of analysis and quantitation, the chemical composition of the petroleum product released (i.e., diesel fuel, gasoline, and motor oil), and the degree to which the product has undergone weathering. The process of weathering results in the selective loss of the most water-soluble, volatile, and degradable components of petroleum. Thus, petroleum found in the environment is chemically different from the original petroleum product. Further, analyses used for "total petroleum" quantitation do not identify the product present in the sample.

Based on the methods of analyses, which included gas chromatography (GC), gas chromatography/mass spectrometry (GC/MS), and non-specific gravimetric tests, petroleum hydrocarbons detected at the site includes very little of the low-boiling (e.g., gasoline) fraction; the majority of petroleum hydrocarbons detected represent the mid-boiling (e.g., diesel) and high-boiling (e.g., motor oil) fractions. Petroleum hydrocarbons were evaluated according to the fresh standard against which they are quantified. While some detections of petroleum hydrocarbons did not completely match the standard by which they were quantified, they were treated herein as though they were the material against which they were quantified because the quantified fraction likely has similar toxicological properties as the standards. The interpretation of petroleum hydrocarbon analyses is discussed in greater detail in Section 4.1.1 of the RI report.

Residential PRGs have not been developed for petroleum hydrocarbon mixtures because of their complexity and the effects of weathering on their composition. As such, all petroleum hydrocarbon detections described as journal box oil (JB-oil), TPH-diesel, TPH-gasoline, and TPH-motor oil are carried through the risk assessment for further evaluation.

Oil and grease and total recoverable petroleum hydrocarbons are widely regarded as "screening" type analyses and provide no information useful to the assessment of risk (MDEP, 1994). As such, these analyses are not used in the risk assessment and are presented in Tables 2-1, 2-2, 2-3, and 2-4 only for the sake of completeness.

2.1.1.4 Metals

Of the 6 detected metals, only lead was retained as a chemical of concern in the Elevated Section surface soils. Four metals (cadmium, total chromium, nickel, and zinc) were eliminated from further consideration because the maximum detected concentrations were below the residential PRGs. Arsenic and lead were detected at concentrations that exceeded their respective PRGs (Table 2-5). Although the detected concentration of arsenic exceeded the cancer-risk based PRGs, it did not exceed the 22 mg/kg noncancer-based residential PRG. As a second screening procedure, detected concentrations of arsenic and lead were compared to Bay area background concentrations (see Table 19 of the RI report).

Arsenic was eliminated as a chemical of concern in soil based on comparison to Bay area background arsenic concentrations. The detected concentration of arsenic in Elevated Section surface soils was 2.7 mg/kg. This concentration is comparable to average detected soil arsenic concentrations in San Leandro (1.2 mg/kg), northern Santa Clara County (2.9 mg/kg), Union City (8.5 mg/kg), and Hercules (8.3 mg/kg). For this reason, arsenic was eliminated as a chemical of concern in Elevated Section surface soil (refer to Table 19 in the RI report).

Lead was retained as a chemical of concern in Elevated Section surface soil based on detection at concentrations greater than PRG levels (Table 2-5) and because the average detected concentration of lead (318 mg/kg) was above the average lead concentration in Bay area soils (see Table 19 of the RI report).

2.1.1.5 Summary of Chemicals of Concern in Elevated Section Surface Soils

The following chemicals were retained as chemicals of concern for surface soils in the Elevated Sections of the I-880 Corridor.

Polynuclear aromatic hydrocarbons
Benzo(a)pyrene
Benzo(b)fluoranthene
Indeno(1,2,3-cd)pyrene

Petroleum hydrocarbons
Low-boiling hydrocarbons (TPH-gasoline)
Medium-boiling hydrocarbons (TPH-diesel)
High-boiling hydrocarbons (TPH-motor oil)

Metals
Lead

As suggested in USEPA Region IX guidance (USEPA, 1995), chemicals eliminated as chemicals of concern were further evaluated to ensure that elimination of these chemicals as a group would not result in significant underestimation of risk. To evaluate this possibility, eliminated chemicals were first segregated into groups of carcinogens and noncarcinogens. The maximum detected concentration of a carcinogen was divided by its respective PRG. The ratios of all carcinogens to their respective PRGs were then summed and the sum multiplied by 10^{-6}. The result was below 1 x 10^{-6}, indicating that elimination of these chemicals would not lead to significant underestimation of risk. For noncarcinogens eliminated as chemicals of concern, the maximum detected soil concentration was divided by the respective PRG. The sum of these ratios did not exceed one, indicating that elimination of these noncarcinogenic chemicals would not lead to significant underestimation of noncancer risk.

2.1.2 Subsurface Soils (1'-5' Depth)

2.1.2.1 VOCs

Six VOCs were detected in 1'-5' depth soils in the Elevated Sections. Based on a comparison to USEPA Region IX PRGs (Table 2-6), only 1 VOC, 1,2-dibromoethane, was present at a concentration sufficient to warrant further evaluation in the risk assessment as a chemical of concern. For this reason, only 1,2-dibromoethane was retained as a chemical of concern for subsurface soils in the Elevated Sections.

2.1.2.2 Polynuclear Aromatic Hydrocarbons

Four PNAs were detected in subsurface soils (Table 2-2). Of the four PNAs detected, only the maximum concentration of benzo[a]pyrene exceeded the residential PRG, therefore it was retained as a chemical of concern in subsurface soil in the Elevated Section

2.1.2.3 Petroleum Hydrocarbons

As discussed in Section 2.1.3, petroleum hydrocarbons in soil samples were measured using several different analytical methods, none of which provide identification of the product released. Detections include hydrocarbons in the low, middle and high-boiling fractions. As stated earlier, residential PRGs have not been developed for petroleum hydrocarbon mixtures. For this reason, all petroleum hydrocarbons detected in subsurface soils are carried through the risk assessment for further evaluation. As discussed in Section 2.1.3, oil and grease and total recoverable petroleum hydrocarbons were not considered further in the risk assessment because these analyses are considered to provide only screening level data and are thus not suitable for risk assessment purposes.

2.1.2.4 Pesticides/PCBs

Two pesticides, 4,4'-DDE and 4,4'-DDT were detected in subsurface soil from the Elevated Sections. Based on a comparison to USEPA Region IX PRGs (Table 2-5), both chemicals were eliminated as chemicals of concern in subsurface soils from the Elevated Sections.

2.1.2.5 Metals

Six metals were detected in subsurface soil from the Elevated Sections of the I-880 Corridor. With the exception of arsenic and lead, maximum detected concentrations of metals in subsurface soils were lower than their USEPA Region IX residential PRGs.

For reasons similar to those discussed in Section 2.1.1.4 of this report, arsenic was eliminated as a chemical of concern in Elevated Section subsurface soils. Although soil arsenic concentrations in Elevated Section subsurface soils exceeded cancer-based PRGs (Table 2-7), arsenic was eliminated as a chemical of concern based on a comparison of the average detected concentration of arsenic in Elevated Section subsurface soils (5.8 mg/kg) to Bay area soils (1.2 mg/kg to 8.5 mg/kg; see Table 19 of the RI report).

Based on exceedance of the residential PRG and Bay area background soil lead concentrations, lead was retained as a chemical of concern in subsurface soils in the Elevated Sections of the I-880 Corridor.

2.1.2.6 Summary of Chemicals of Concern in Subsurface Elevated Sections Soils (1'-5' Depth)

The following chemicals were retained as chemicals of concern for subsurface soils in the Elevated Sections of the I-880 Corridor.

Volatile organic chemicals	***Polynuclear aromatic* hydrocarbons**	***Petroleum* hydrocarbons**	**Metals**
1,2-Dibromoethane	Benzo(a)pyrene	Low-boiling hydrocarbons (TPH-gasoline) Medium-boiling hydrocarbons (TPH-diesel) High-boiling hydrocarbons (TPH-motor oil)	Lead

Using the procedure described in Section 2.1.1.5, eliminated chemicals were screened to ensure that elimination of these chemicals as a group would not lead to significant underestimation of carcinogenic or noncarcinogenic risk. Summed theoretical lifetime cancer risk for the eliminated carcinogens was less than 1 x 10^{-6}. The hazard index for eliminated noncarcinogens was below one. These calculations indicated that significant risk underestimation would not result from elimination of these chemicals as chemicals of concern.

2.1.3 Summary of Chemicals of Concern in Surface and Subsurface Elevated Sections Soils (0'-5' Depth)

Chemicals of concern detected in surface (0-1') and subsurface (greater than one-foot in depth) soil for Elevated Sections are summarized below:

Volatile organic chemicals	**Polynuclear aromatic hydrocarbons**	**Petroleum hydrocarbons**	**Metals**
1,2-Dibromoethane	Benzo(a)pyrene	Low-boiling hydrocarbons (TPH-gasoline)	Lead
	Benzo(b)fluoranthene	Medium-boiling hydrocarbons (TPH-diesel)	
	Indeno(1,2,3-cd)pyrene	High-boiling hydrocarbons (TPH-motor oil)	

2.2 Chemicals of Concern in At Grade Section Soils

Unlike Elevated Sections soils, chemicals detected in surface (0-1') and subsurface (greater than 1-foot in depth) in At Grade Section soils were considered together. The At Grade sections of the freeway will be paved, a condition that prevents human exposure to chemicals in soil. Thus, unlike the Elevated Sections, there would be no opportunity for human exposure to chemicals in soils in the At Grade sections of the freeway. However, given the possibility that pavement may be removed during future utility work under the freeway, utility worker exposure to surface (0-1') and subsurface (deeper than 1') soils was considered. As such, no distinction is made between chemicals detected in surface and subsurface soils detected in At Grade soils in the discussion below. At Grade section soil data are summarized in Table 2-4.

2.2.1 VOCs

Analyses of samples of soils from the At Grade Sections of the I-880 Corridor showed 6 VOCs detected (Table 2-4). None of the detected VOC maximum concentrations exceeded the USEPA Region IX residential PRGs (Table 2-7). For this reason, no VOCs in the At Grade Sections of the I-880 Corridor were retained as chemicals of concern.

2.2.2 Semivolatile Compounds and Polynuclear Aromatic Hydrocarbons

Only one semivolatile compound, bis(2-ethylhexyl)phthalate, was detected in soil from the At Grade Sections of the I-880 Corridor. Although this chemical is a common contaminant that is associated with laboratory or sampling equipment, it was compared to residential PRGs for completeness. The maximum detected concentration was lower than the USEPA Region IX residential PRG; therefore, bis(2-ethylhexyl)phthalate was eliminated as a chemical of concern in At Grade soil.

Eight PNAs were detected in At Grade Section soil. Five of the eight PNAs were detected at concentrations greater than the USEPA Region IX residential PRG and were retained as chemicals of concern in At Grade Section soils. Benzo(k)fluoranthene and chrysene maximum concentrations were below USEPA Region IX residential PRGs for these two chemicals and were not considered as chemicals of concern. Only one PNA, benzo(g,h,i)perylene, does not have a USEPA Region IX residential PRG. Benzo(g,h,i)perylene is not considered to be a potential carcinogen by the State of California or the USEPA. The lowest (most conservative) PRG for a noncarcinogenic PNA is 2,000 mg/kg (pyrene). The maximum detected concentration of benzo(g,h,i)perylene (1 mg/kg) is 2000 times lower than this value, indicating that benzo(g,h,i)perylene is unlikely to contribute significantly to the noncarcinogenic risks for the I-880 Corridor. For this reason, benzo(g,h,i)perylene was eliminated as a chemical of concern.

2.2.3 Petroleum Hydrocarbons

As discussed in Section 2.1.3, petroleum hydrocarbons in soil samples were measured using several different analytical methods, none of which provide identification of the product released. Detections include hydrocarbons in the low, middle and high-boiling fractions. As stated earlier, residential PRGs have not been developed for petroleum hydrocarbon mixtures. For this reason, all petroleum hydrocarbons detected in soils in the At Grade Section are carried through the risk assessment for further evaluation. As discussed in Section 2.1.3, oil and grease and total recoverable petroleum hydrocarbons were not considered further in the risk assessment because these analyses are considered to provide only screening level data and are thus not suitable for risk assessment purposes.

2.2.4 Metals

With the exception of arsenic, beryllium, and lead, maximum detected concentrations of metals in At Grade soils were lower than their USEPA Region IX residential PRGs (Table 2-7). In accordance with the screening procedure discussed in Section 2.0 of this report, average detected concentrations of these metals were compared to average background concentrations in Bay area soils.

Arsenic was eliminated as a chemical of concern in soil based on comparison to Bay area background arsenic concentrations. The average detected concentration of arsenic in At Grade Section soils was 4.7 mg/kg. This concentration is comparable to average detected soil arsenic concentrations in San Leandro (1.2 mg/kg), northern Santa Clara County (2.9 mg/kg), Union City (8.5 mg/kg), and Hercules (8.3 mg/kg). For this reason, arsenic was eliminated as a chemical of concern in At Grade Section soils (refer to Table 19 in the RI report).

Beryllium was detected in three of 20 At Grade soil samples at a maximum concentration of 0.2 mg/kg. This maximum concentration is below the average reported soil concentrations of beryllium in Bay area locations such as San Leandro (0.4 mg/kg), northern Santa Clara County (0.9 mg/kg), and Union City (0.5 mg/kg) (see Table 19 of the RI). Further, the maximum detected concentration is below the median (0.3 mg/kg) and mean (0.4 mg/kg) beryllium concentrations reported for US soils (ATSDR, 1993) and only slightly exceeds the 0.14 mg/kg USEPA Region IX residential PRG for beryllium. Based on these comparisons to typical background concentrations of beryllium in soil within the Greater Bay area, beryllium was eliminated as a chemical of concern for At Grade section soils. Elimination of a chemical based on similarity to natural background concentrations is in keeping with USEPA guidance (USEPA, 1989a).

Lead was retained as a chemical of concern in At Grade Section soils based on detection at concentrations greater than the residential PRG and because the average detected concentration exceeded average Bay area background soil lead concentrations (see Table 19 of the RI report).

2.2.5 Summary of Chemicals of Concern in At Grade Section Soils (0'-5' Depth)

The following chemicals were retained as chemicals of concern for surface/subsurface soils in the At Grade Section of the I-880 Corridor.

Polynuclear aromatic hydrocarbons	Petroleum hydrocarbons	Metals
Benzo(a)anthracene	Low-boiling hydrocarbons (TPH-gasoline)	Lead
Benzo(a)pyrene	Medium-boiling hydrocarbons (TPH-diesel)	
Benzo(b)fluoranthene	High-boiling hydrocarbons (TPH-motor oil)	
Dibenz(a,h)anthracene		
Indeno(1,2,3-cd)pyrene		

Using the procedure described in Section 2.1.1.5, eliminated chemicals were screened to ensure that elimination of these chemicals as a group would not lead to significant underestimation of carcinogenic or noncarcinogenic risk. Summed theoretical lifetime cancer risk for the eliminated carcinogens was less than 1 x 10^{-6}. The hazard index for eliminated noncarcinogens was below one. These calculations indicated that significant risk underestimation would not result from elimination of these chemicals as chemicals of concern.

2.3 Chemicals of Concern in Shallow Groundwater--Elevated Sections

All VOCs (i.e., chemicals with Henry's Law constants 1 x 10^{-5} or higher and a vapor pressure of 0.001 mm Hg and greater (DTSC, 1994a)) detected in shallow groundwater in the Elevated Sections of the I-880 Corridor (Table 2-8) were retained as chemicals of concern for the risk assessment. Metals, Aroclor 1260 and non-VOCs detected in shallow groundwater were eliminated as chemicals of concern in groundwater due to a lack of an exposure pathway; shallow ground water is not potable and constituents in ground water are not likely to migrate to a deeper drinking water aquifer (see Section 3.2).

2.4 Chemicals of Concern in Shallow Groundwater--At Grade Section

All volatile organic chemicals detected in shallow groundwater in the At Grade Section of the I-880 Corridor (Table 2-9) were retained as chemicals of concern for the risk assessment. Metals and non-volatile organic chemicals detected in shallow groundwater were eliminated as chemicals of concern in groundwater due to a lack of an exposure pathway (see Section 3.2).

Table 2-1 Data Summary Elevated Sections Surface Soil

Chemical	Number of times detected/ Number of times analyzed	Detected Concentrations (mg/kg)			Range of Detection Limits (mg/kg)		
		Average	Minimum	Maximum	Median	Minimum	Maximum
Volatile organic chemicals							
Benzene	1 / 121	na	na	1.3E-02	5E-03	5E-03	5E-03
Toluene	19 / 121	6.0E-02	6E-03	3.7E-01	5E-03	5E-03	5E-03
Xylenes (total)	8 / 109	1.2E-02	5E-03	2.2E-02	5E-03	5E-03	5E-03
Polynuclear aromatic hydrocarbons							
Benzo(a)anthracene	2 / 10	1.5E-01	1.4E-01	1.6E-01	2E-01	6E-02	5E-01
Benzo(a)pyrene	4 / 10	3.9E-01	3.2E-01	5.4E-01	2.7E-01	6E-02	5E-01
Benzo(b)fluoranthene	5 / 10	3.3E-01	1.1E-01	7.8E-01	2E-01	6E-02	3.3E-01
Benzo(g,h,i)perylene	1 / 10	na	na	2.5E+00	1E+00	3.3E-01	1E+00
Benzo(k)fluoranthene	3 / 10	1.4E-01	1.4E-01	1.4E-01	2E-01	6E-02	3.3E-01
Chrysene	4 / 10	2.5E-01	1.7E-01	3E-01	3.3E-01	6E-02	5E-01
Indeno(1,2,3-cd)pyrene	4 / 10	7E-01	2.7E-01	1.9E+00	1.5E-01	6E-02	3.3E-01
Metals							
Arsenic	1 / 3	na	na	2.7E+00	4.5E-01	3E-01	6E-01
Cadmium	3 / 6	5.3E-01	4E-01	7E-01	5E-01	5E-01	5E-01
Chromium, Total	6 / 6	2.88E+01	2.04E+01	4.17E+01	na	na	na
Lead	116 / 116	3.18E+02	4.8E+00	1.2E+04	na	na	na
Nickel	6 / 6	4.08E+01	2.86E+01	5.57E+01	na	na	na
Zinc	6 / 6	6E+01	3.65E+01	1.11E+02	na	na	na
Petroleum hydrocarbons							
TPH-Diesel	4 / 114	1E+01	1E+01	2E+01	5E+00	5E+00	1E+01
TPH-Gasoline	1 / 113	na	na	2E+00	1E+00	1E+00	1E+00
TPH-Motor oil	105 / 110	2.69E+02	1.1E+01	2.1E+03	1E+01	1E+01	5E+02
Oil & Grease	3 / 3	3E+04	2E+03	5E+04	na	na	na

na - not applicable
5.0E-3 is read 0.005

Table 2-2 Data Summary Elevated Sections Subsurface Soil

Chemical	Number of times detected/ Number of times analyzed	Detected Concentrations (mg/kg)			Range of Detection Limits (mg/kg)		
		Average	Minimum	Maximum	Median	Minimum	Maximum
Volatile organic chemicals							
Benzene	8 / 224	1.2E-02	5E-03	1.8E-02	5E-03	5E-03	1E+00
1,2-Dibromoethane (EDB)	3 / 224	1.9E-02	1.4E-02	2.8E-02	5E-03	5E-03	1E+00
1,2-Dichloroethane	3 / 224	7.4E-02	5E-03	2E-01	5E-03	5E-03	1E+00
Ethylbenzene	1 / 224	na	na	3.3E-02	5E-03	5E-03	1E+00
Toluene	13 / 224	3E-02	8E-03	6.5E-02	5E-03	5E-03	1E+00
Xylenes (total)	11 / 212	2E-02	6E-03	7.1E-02	5E-03	5E-03	1E+00
Polynuclear aromatic hydrocarbons							
Benzo(a)pyrene	2 / 14	1.2E-01	1E-01	1.3E-01	6E-02	6E-02	1E+01
Benzo(b)fluoranthene	1 / 14	na	na	8.7E-02	6E-02	6E-02	4E+00
Benzo(k)fluoranthene	1 / 14	na	na	1E-01	6E-02	6E-02	4E+00
Naphthalene	1 / 26	na	na	4.9E+00	1E+00	5E-03	1E+02
Pesticides							
4,4'-DDE	2 / 17	5E-03	9E-03	1E-03	1E-03	1E-03	2.7E-03
4,4'-DDT	1 / 17	na	na	8E-03	5E-03	5E-03	8E-03
Metals							
Arsenic	2 / 3	5.8E+00	2.7E+00	8.8E+00	3E-01	3E-01	3E-01
Cadmium	92 / 120	6.6E-01	2E-01	2.5E+00	2E-01	2E-01	5E-01
Chromium, Total	116 / 120	2.4E+01	8E-01	5.7E+01	6E-01	6E-01	6E-01
Lead	297 / 334	8.6E+01	1.2E+00	9.9E+02	3.6E+00	3.6E+00	3.6E+00
Nickel	117 / 120	2.4E+01	1.7E+00	6.7E+01	1.6E+00	1.6E+00	1.6E+00
Zinc	120 / 120	7.51E+01	7.9E+00	6.48E+02	na	na	na
Petroleum hydrocarbons							
TPH-Diesel	17 / 339	2.8E+02	4E+00	2E+03	5E+00	5E+00	2E+03
TPH-Gasoline	3 / 340	6.3E+02	2.9E+00	1.7E+03	1E+00	1E+00	2E+02
TPH-Motor oil	135 / 214	3.1E+02	1E+01	4.8E+03	1E+01	5E+00	5E+02
Journal box oil	1 / 2	na	na	3.7E+02	5E+01	5E+01	5E+01

na - not applicable

5.0E-3 is read 0.005

Table 2-3 Data Summary
Elevated Sections Surface and Subsurface Soil

Chemical	Number of times detected/ Number of times analyzed	Detected Concentrations (mg/kg)			Range of Detection Limits (mg/kg)		
		Average	Minimum	Maximum	Median	Minimum	Maximum
Volatile organic chemicals							
Benzene	9 / 345	1.2E-02	5.0E-03	1.8E-02	5E-03	5E-03	1E+00
1,2-Dibromoethane (EDB)	3 / 345	1.9E-02	1.4E-02	2.8E-02	5E-03	5E-03	1E+00
1,2-Dichloroethane	3 / 345	7E-02	5E-03	2E-01	5E-03	5E-03	1E+00
Ethylbenzene	1 / 345	na	na	3.3E-02	5E-03	5E-03	1E+00
Toluene	32 / 345	5E-02	6E-03	3.7E-01	5E-03	5E-03	1E+00
Xylenes (total)	19 / 321	2E-02	5E-03	7.1E-02	5E-03	5E-03	1E+00
Polynuclear aromatic hydrocarbons							
Benzo(a)anthracene	2 / 24	1.5E-01	1.4E-01	1.6E-01	8E-02	6E-02	1E+01
Benzo(a)pyrene	6 / 24	3E-01	1E-01	5.4E-01	6E-02	6E-02	1E+01
Benzo(b)fluoranthene	6 / 24	2.9E-01	8.7E-02	7.8E-01	6E-02	6E-02	4E+00
Benzo(g,h,i)perylene	1 / 24	na	na	2.5E+00	1E+00	3.3E-01	1.6E+01
Benzo(k)fluoranthene	4 / 24	1.3E-01	1E-01	1.4E-01	6E-02	6E-02	4E+00
Chrysene	4 / 24	2.5E-01	1.7E-01	3E-01	1E-01	6E-02	1E+01
Indeno(1,2,3-cd)pyrene	4 / 24	7E-01	2.7E-01	1.9E+00	8E-02	6E-02	1E+01
Naphthalene	1 / 48	na	na	4.9E+00	5E-03	5E-03	1E+02
Pesticides							
4,4'-DDE	2 / 23	5E-03	9E-03	1E-03	1E-03	1E-03	2E-02
4,4'-DDT	1 / 23	na	na	8E-03	5E-03	5E-03	1E-01
Metals							
Arsenic	3 / 6	4.7E+00	2.7E+00	8.8E+00	3E-01	3E-01	6E-01
Cadmium	95 / 126	6.5E-01	2E-01	2.5E+00	2E-01	2E-01	5E-01
Chromium, Total	122 / 126	2.5E+01	8E-01	5.7E+01	6E-01	6E-01	6E-01
Lead	413 / 450	1.5E+02	1.2E+00	1.2E+04	3.6E+00	3.6E+00	3.6E+00
Nickel	123 / 126	2.4E+01	1.7E+00	6.7E+01	1.6E+00	1.6E+00	1.6E+00
Zinc	126 / 126	7.44E+01	7.90E+00	6.48E+02	na	na	na

Table 2-3 Data Summary
Elevated Sections Surface and Subsurface Soil

Chemical	Number of times detected/ Number of times analyzed	Detected Concentrations (mg/kg)			Range of Detection Limits (mg/kg)		
		Average	Minimum	Maximum	Median	Minimum	Maximum
Petroleum hydrocarbons							
TPH-Diesel	21 / 453	2.1E+02	4E+00	2E+03	5E+00	5E+00	2E+03
TPH-Gasoline	4 / 453	4.8E+02	2E+00	1.7E+03	1E+00	1E+00	2E+02
TPH-Motor oil	240 / 324	2.9E+02	1E+01	4.8E+03	1E+01	5E+00	5E+02
Oil & Grease	5 / 10	2.1E+04	6E+01	5.2E+04	5E+01	5E+01	5E+01
Journal box oil	1 / 3	na	na	3.7E+02	5E+01	5E+01	5E+01

na - not applicable

5.0E-3 is read 0.005

Table 2-4 Data Summary
At-Grade Sections Soil

		Detected Concentrations (mg/kg)			*Range of Detection Limits (mg/kg)*		
Chemical	**Number of times detected/ Number of times analyzed**	**Average**	**Minimum**	**Maximum**	**Median**	**Minimum**	**Maximum**
Volatile organic chemicals							
Acetone	24 / 24	3.12E-02	4E-03	2E-01	na	na	na
Methylene chloride	25 / 69	1.5E-02	6.0E-03	4.6E-02	5E-03	5E-03	5E-03
Methyl ethyl ketone (2-Butanone)	2 / 24	3.7E-02	3.5E-02	3.8E-02	1E-02	1E-02	1E-02
Tetrachloroethene	1 / 69	na	na	1E-03	5E-03	5E-03	5E-03
Toluene	5 / 74	2E-03	1E-03	3E-03	5E-03	5E-03	2E-01
Trichloroethene	1 / 69	na	na	4.3E-02	5E-03	5E-03	5E-03
Semivolatile organic chemical							
Bis(2-ethylhexyl) phthalate	1 / 20	na	na	1.7E-01	3.3E-01	3.3E-01	3.3E-01
Polynuclear aromatic hydrocarbons							
Benzo(a)anthracene	1 / 49	na	na	1.1E+00	1.9E-01	1E-03	1E+00
Benzo(a)pyrene	5 / 49	6.3E-01	1.2E-01	2E+00	3.3E-01	6E-02	1E+00
Benzo(b)fluoranthene	5 / 49	4.5E-01	9.1E-02	1.3E+00	3.3E-01	6E-02	4E-01
Benzo(g,h,i)perylene	1 / 49	na	na	1E+00	3.3E-01	1.7E-01	1.6E+00
Benzo(k)fluoranthene	3 / 49	3.3E-01	7.1E-02	7.4E-01	2.7E-01	6E-02	4E-01
Chrysene	4 / 49	1.9E+00	4.3E-01	4.4E+00	3.3E-01	6E-02	1E+00
Dibenz(a,h)anthracene	1 / 49	na	na	8.3E-01	3.3E-01	6E-02	4E+00
Indeno(1,2,3-cd)pyrene	4 / 49	5.6E-01	2.6E-01	1.4E+00	3.3E-01	6E-02	1E+00
Metals							
Antimony	10 / 20	2.3E+00	1.7E+00	2.8E+00	1.6E+00	1.6E+00	1.6E+00
Arsenic	35 / 35	2.8E+00	6.8E-01	1.7E+01	na	na	na
Barium	20 / 20	5.8E+01	3.2E+01	7.7E+01	na	na	na
Beryllium	3 / 20	2E-01	2E-01	2E-01	2E-01	2E-01	2E-01
Cadmium	93 / 117	8.7E-01	2E-01	5.9E+00	5E-01	2E-01	1E+00
Chromium, Total	117 / 117	3.1E+01	3.8E+00	1.6E+02	na	na	na
Cobalt	20 / 20	6.2E+00	2.3E+00	7.8E+00	na	na	na
Copper	20 / 20	1.2E+01	5.3E+00	2.7E+01	na	na	na
Lead	101 / 117	1.6E+02	1.5E+00	1.7E+03	3.6E+00	3.6E+00	5E+00

Table 2-4 Data Summary
At-Grade Sections Soil

Chemical	Number of times detected/ Number of times analyzed	Detected Concentrations (mg/kg)			Range of Detection Limits (mg/kg)		
		Average	Minimum	Maximum	Median	Minimum	Maximum
Manganese	20 / 20	1.4E+02	9.5E+01	1.9E+02	na	na	na
Mercury	1 / 20	na	na	8E-02	0.6	0.6	0.6
Nickel	117 / 117	3.08E+01	2.9E+00	2.41E+02	na	na	na
Silver	10 / 20	4.7E-01	2E-01	8E-01	2E-01	2E-01	2E-01
Thallium	1 / 20	na	na	1.8E-01	1.8E-01	1.8E-01	1.8E-01
Vanadium	20 / 20	2.53E+01	1.65E+01	3.43E+01	na	na	na
Zinc	117 / 117	1.11E+02	1.14E+01	9.02E+02	na	na	na
Petroleum hydrocarbons							
TPH-Diesel	16 / 122	5.2E+01	1.8E+00	2.6E+02	1E+01	1E+00	1E+03
Journal box oil	15 / 56	6.6E+02	3.4E+01	6.2E+03	5E+01	5E+01	3E+02
Oil & Grease	4 / 5	4.2E+03	4.2E+02	9.4E+03	3E+02	3E+02	3E+02

na - not applicable
5.0E-3 is read 0.005

Table 2-5 Comparison to Preliminary Remediation Goals-
Elevated Sections Surface Soil

		USEPA Region IX		
Chemical	**Maximum Detected Soil Concentration (mg/kg)**	***Industrial* PRG** (mg/kg)	***Residential* PRG** (mg/kg)	**Does the Maximum Detected Soil Concentration Exceed the USEPA Residential PRG?**
Volatile organic chemicals				
Benzene	1.30E-02	3.20E+00	1.40E+00	no
Toluene	3.70E-01	2.80E+03	1.90E+03	no
Xylenes (total)	2.20E-02	9.90E+02	9.90E+02	no
Polynuclear aromatic hydrocarbons				
Benzo(a)anthracene	1.60E-01	2.60E+00	6.10E-01	no
Benzo(a)pyrene	5.40E-01	2.60E-01	6.10E-02	••Yes••
Benzo(b)fluoranthene	7.80E-01	2.60E+00	6.10E-01	••Yes••
Benzo(g,h,i)perylene	2.50E+00	na	na	na
Benzo(k)fluoranthene	1.40E-01	2.60E+01	6.10E+00	no
Chrysene	3.00E-01	2.40E+01	2.40E+01	no
Indeno(1,2,3-cd)pyrene	1.90E+00	2.60E+00	6.10E-01	••Yes••
Metals				
Arsenic	2.70E+00	*3.8E-01	*2.4E+00	*••Yes••
Cadmium	7.00E-01	8.50E+02	3.80E+01	no
Chromium, Total	4.17E+01	4.50E+02	2.10E+02	no
Lead	1.20E+04	1.00E+03	4.00E+02	••Yes••
Nickel	5.57E+01	3.40E+04	1.50E+03	no
Zinc	1.11E+02	1.00E+05	2.30E+04	no
Petroleum hydrocarbons				
TPH-Diesel	1.70E+01	na	na	na
TPH-Gasoline	2.00E+00	na	na	na
TPH-Motor oil	2.10E+03	na	na	na
Oil & Grease	5.24E+04	na	na	na

na - not applicable; no PRG was available for comparison

5.0E-3 is read 0.005

*The cancer-based residential (0.38 mg/kg) and industrial PRGs (2.4 mg/kg) for arsenic are at or below background arsenic concentrations for Bay area locations (see Table 19 of the RI report). For this reason, cancer-based PRGs were considered inappropriate for screening arsenic concentrations in soil. Instead, the average arsenic concentration in soil was compared to Bay area background concentrations

Arsenic was eliminated as a chemical of concern on the basis of similarity to Bay area background concentrations (see Section 2.1.1.4 of this report).

Table 2-6 Comparison to Preliminary Remediation Goals-
Elevated Sections Surface and Subsurface Soils

		USEPA Region IX		
Chemical	Maximum Detected Soil Concentration (mg/kg)	Industrial PRG (mg/kg)	Residential PRG (mg/kg)	Does the Maximum Detected Soil Concentration Exceed the USEPA Residential PRG?
Volatile organic chemicals				
Benzene	1.80E-02	3.20E+00	1.40E+00	no
1,2-Dibromoethane (EDB)	2.80E-02	2.10E-02	5.10E-03	••Yes••
1,2-Dichloroethane (EDC)	2.00E-01	9.80E-01	4.40E-01	no
Ethylbenzene	3.30E-02	6.90E+02	6.90E+02	no
Toluene	3.70E-01	2.80E+03	1.90E+03	no
Xylenes (total)	2.80E-02	9.90E+02	9.90E+02	no
Polynuclear aromatic hydrocarbons				
Benzo(a)anthracene	1.60E-01	2.60E+00	6.10E-01	no
Benzo(a)pyrene	5.40E-01	2.60E-01	6.10E-02	••Yes••
Benzo(b)fluoranthene	7.80E-01	2.60E+00	6.10E-01	••Yes••
Benzo(g,h,i)perylene	2.50E+00	na	na	na
Benzo(k)fluoranthene	1.40E-01	2.60E+01	6.10E+00	no
Chrysene	3.00E-01	2.40E+01	2.40E+01	no
Indeno(1,2,3-cd)pyrene	1.90E+00	2.60E+00	6.10E-01	••Yes••
Naphthalene	4.90E+00	8.00E+02	8.00E+02	no
Pesticides				
4,4'-DDE	1.00E-03	5.60E+00	1.30E+00	no
4,4'-DDT	8.00E-03	5.60E+00	1.30E+00	no
Metals				
Arsenic	8.80E+00	*	**2.20E+01	no
Cadmium	2.50E+00	8.50E+02	3.80E+01	no
Chromium, Total	5.73E+01	4.50E+02	2.10E+02	no
Lead	1.20E+04	1.00E+03	4.00E+02	••Yes••
Nickel	6.69E+01	3.40E+04	1.50E+03	no
Zinc	6.48E+02	1.00E+05	2.30E+04	no
Petroleum hydrocarbons				
TPH-Diesel	2.00E+03	na	na	na
TPH-Gasoline	1.70E+03	na	na	na
TPH-Motor oil	4.80E+03	na	na	na
Oil & Grease	5.24E+04	na	na	na
Journal box oil	3.70E+02	na	na	na

na - not applicable; no PRG was available for comparison

5.0E-3 is read 0.005

*The cancer-based residential (0.38 mg/kg) and industrial PRGs (2.4 mg/kg) for arsenic are at or below background arsenic concentrations for Bay area locations (see Table 19 of the RI report). For this reason, cancer-based PRGs were considered inappropriate for screening arsenic concentrations in soil. Instead, the average arsenic concentration in soil was compared to Bay area background concentrations.
Arsenic was eliminated as a chemical of concern on the basis of similarity to Bay area background concentrations

Table 2-7 Comparison to Preliminary Remediation Goals-
At Grade Sections Soil

Chemical	Maximum Detected Soil Concentration (mg/kg)	USEPA Region IX		Does the Maximum Detected Soil Concentration Exceed the USEPA Residential PRG?
		Industrial PRG	Residential PRG	
		(mg/kg)		
Volatile organic chemicals				
Acetone	2.00E-01	8.40E+03	2.00E+03	no
Methylene chloride	4.60E-02	2.50E+01	1.10E+01	no
Methyl ethyl ketone (2-Butanone)	3.80E-02	3.40E+04	8.70E+03	no
Tetrachloroethene	1.00E-03	2.50E+01	7.00E+00	no
Toluene	3.00E-03	2.80E+03	1.90E+03	no
Trichloroethene	4.30E-02	1.70E+01	7.10E+00	no
Semivolatile organic chemical				
Bis(2-ethylhexyl) phthalate	1.70E-01	1.40E+02	3.20E+01	no
Polynuclear aromatic hydrocarbons				
Benzo(a)anthracene	1.10E+00	2.60E+00	6.10E-01	••Yes••
Benzo(a)pyrene	2.00E+00	2.60E-01	6.10E-02	••Yes••
Benzo(b)fluoranthene	1.30E+00	2.60E+00	6.10E-01	••Yes••
Benzo(g,h,i)perylene	1.00E+00	na	na	na
Benzo(k)fluoranthene	7.40E-01	2.60E+01	6.10E+00	no
Chrysene	4.40E+00	2.40E+01	2.40E+01	no
Dibenz(a,h)anthracene	8.30E-01	2.60E-01	6.10E-02	••Yes••
Indeno(1,2,3-cd)pyrene	1.40E+00	2.60E+00	6.10E-01	••Yes••
Metals				
Antimony	2.80E+00	6.80E+02	3.10E+01	no
Arsenic	1.66E+01	*3.80E-01	*2.40E+00	*••Yes••
Barium	7.72E+01	1.00E+05	5.30E+03	no
Beryllium	2.00E-01	1.10E+00	**1.40E-01	**••Yes••
Cadmium	5.90E+00	8.50E+02	3.80E+01	no
Chromium, Total	1.61E+02	4.50E+02	2.10E+02	no
Cobalt	7.80E+00	9.70E+04	4.60E+03	no
Copper	2.65E+01	6.30E+04	2.80E+03	no
Lead	1.71E+03	1.00E+03	4.00E+02	••Yes••
Manganese	1.85E+02	7.80E+03	3.80E+02	no
Mercury	8.00E-02	5.10E+02	2.30E+01	no
Nickel	2.41E+02	3.40E+04	1.50E+03	no
Silver	8.00E-01	8.50E+03	3.80E+02	no
Thallium	1.80E-01	1.40E+02	6.10E+00	no
Vanadium	3.43E+01	1.20E+04	5.40E+02	no
Zinc	9.02E+02	1.00E+05	2.30E+04	no
Petroleum hydrocarbons				
TPH-Diesel	2.60E+02	na	na	na
TPH-Gasoline	1.00E+00	na	na	na
Journal box oil	6.20E+03	na	na	na
Oil & Grease	9.42E+03	na	na	na

na - not applicable; no PRG was available for comparison

5.0E-3 is read 0.005

*The cancer-based residential (0.38 mg/kg) and industrial PRGs (2.4 mg/kg) for arsenic are at or below background arsenic concentrations for Bay area locations (see Table 19 of the RI report). For this reason, cancer-based PRGs were considered inappropriate for screening arsenic concentrations in soil. Instead, the average arsenic concentration in soil was compared to Bay area background concentrations. Arsenic was eliminated as a chemical of concern on the basis of similarity to Bay area background concentrations (see Section 2.2.4 of this report).

**The cancer-based residential PRG for beryllium (0.14 mg/kg) is below average background soil concentrations for the Bay area (see Table 19 of the RI report). For this reason, cancer-based PRGs were considered inappropriate for screening beryllium concentrations in soil. Instead, the average beryllium concentration in soil was compared to Bay area background concentrations. Beryllium was eliminated as a chemical of concern on the basis of similarity to Bay area background concentrations. (see Section 2.2.4 of this report).

Table 2-8 Data Summary
Elevated Sections Groundwater

		Detected Concentrations (mg/L)			Range of Detection Limits (mg/L)		
Chemical	Number of times detected/ *Number of times analyzed*	Average	Minimum	Maximum	Median	Minimum	Maximum
Volatile organic chemicals							
Butylbenzene (sec)	1 / 96	na	na	1.8E-02	1E-03	5E-04	5E-03
Butylbenzene (tert)	1 / 96	na	na	2.6E-02	1E-03	5E-04	5E-03
1,2-Dibromo-3-chloropropane (DBCP)	2 / 96	5.9E-03	5.9E-03	5.9E-03	1E-03	3.9E-04	5E-03
1,2-Dibromoethane (EDB)	2 / 96	5.8E-02	5.7E-02	5.9E-02	1E-03	3.3E-04	5E-03
1,2-Dichlorobenzene	2 / 96	9E-02	1.9E-02	1.6E-01	1E-03	5E-04	5E-03
1,4-Dichlorobenzene	1 / 96	na	na	2.8E-02	1E-03	5E-04	5E-03
1,2-Dichloroethane	2 / 96	2E-02	1.9E-02	2E-02	1E-03	5E-04	5E-03
Ethylbenzene	3 / 97	1.3E-02	8E-04	2.8E-02	1E-03	5E-04	5E-03
Isopropylbenzene	11 / 96	3.1E-01	3.0E-02	2.8E+00	1E-03	5E-04	5E-03
n-Propyl benzene	1 / 96	na	na	1.8E-02	1E-03	5E-04	5E-03
Styrene	1 / 96	na	na	2.5E-02	1E-03	5E-04	5E-03
Toluene	5 / 97	2.8E-02	3.4E-03	7.3E-02	1E-03	5E-04	5E-03
1,2,4-Trichlorobenzene	1 / 96	na	na	8.6E-02	1E-03	5E-04	5E-03
1,2,4-Trimethylbenzene	1 / 96	na	na	6.5E-02	1E-03	5E-04	5E-03
1,3,5-Trimethylbenzene	2 / 96	3.4E-02	1E-02	5.8E-02	1E-03	5E-04	5E-03
Xylene (m & p)	2 / 96	1.1E-02	3.1E-03	1.9E-02	1E-03	5E-04	5E-03
Xylene (o)	1 / 94	na	na	1.8E-02	1E-03	5E-05	5E-03
Polynuclear aromatic hydrocarbons							
Acenaphthene	1 / 2	na	na	3E-03	5E-03	2E-06	5E-03
Benzidine	1 / 16	na	na	1.7E-02	1E-03	5E-04	5E-03
2-Methylnaphthalene	1 / 16	na	na	9E-03	5E-03	2E-04	5E-03
Naphthalene	3 / 96	2.2E-01	1E-02	5.8E-01	1E-03	2E-06	5E-03
Phenanthrene	1 / 18	na	na	6E-03	2E-03	2E-06	5E-03
Pesticides/PCBs							
Aroclor 1260	1 / 17	na	na	7E-04	1E-04	1E-04	5E-04
Metals							
Arsenic	2 / 21	1.2E-02	6E-03	1.8E-02	3E-02	3E-02	3E-01
Cadmium	2 / 21	1.1E-02	1E-03	2E-02	1E-02	1E-03	1E-02
Chromium, Total	4 / 21	3.8E-02	2E-02	8E-02	2E-02	1E-02	2E-01
Mercury	2 / 21	1E-03	1E-03	1E-03	2E-03	2E-03	2E-03
Nickel	2 / 21	3E-02	3E-02	3E-02	3E-02	3E-02	3E-01
Zinc	6 / 21	4E-02	2E-02	6E-02	2E-02	2E-02	2E-01
Petroleum hydrocarbons							
Diesel Fuel	6 / 56	1.7E+00	7E-02	4.9E+00	5E-01	5E-02	1.3E+01
Gasoline	1 / 35	na	na	7.6E-02	5E+01	5E-02	5E+01

na - not applicable
5.0E-3 is read 0.005

Table 2-9 Data Summary
At-Grade Sections Groundwater

		Detected Concentrations (mg/L)			Range of Detection Limits (mg/L)		
Chemical	**Number of times detected/ Number of times analyzed**	**Average**	**Minimum**	**Maximum**	**Median**	**Minimum**	**Maximum**
Volatile organic chemicals							
Acetone	1 / 1	na	na	4.2E-02	na	na	na
Benzene	2 / 26	1.3E-03	5.5E-04	2E-03	5E-04	5E-04	5E-03
1,1-Dichloroethane	5 / 33	1.0E-02	1.4E-03	3.2E-02	1E-03	1E-03	1E-02
1,1-Dichloroethene	1 / 33	2.1E-03	2.1E-03	2.1E-03	1E-03	1E-03	1E-02
cis-1,2-Dichloroethene	5 / 32	4.6E-02	2.3E-03	2.1E-01	1E-03	1E-03	1E-02
Ethylbenzene	2 / 26	8.1E-04	6.2E-04	1E-03	5E-04	5E-04	5E-03
Tetrachloroethylene	6 / 33	4.2E-02	1.2E-03	7.3E-02	1E-03	1E-03	5E-03
Toluene	4 / 26	7.1E-04	6.0E-04	8.4E-04	5E-04	5E-04	5E-03
1,1,1-Trichloroethane	1 / 33	na	na	3.8E-03	1E-03	1E-03	1E-02
Trichloroethylene	7 / 33	8.7E-02	3.5E-03	1.6E-01	1E-03	1E-03	5E-03
Vinyl Chloride	3 / 33	1.6E-02	9.5E-04	4.5E-02	5E-04	5E-04	1E-02
Xylenes (total)	2 / 26	2.5E-03	1.8E-03	3.2E-03	5E-04	5E-04	5E-03
Semivolatile organic chemical							
Bis(2-ethylhexyl) phthalate	1 / 5	na	na	6E-03	2E-04	2E-04	1E-02
Polynuclear aromatic hydrocarbons							
Acenaphthylene	1 / 15	na	na	1.2E-02	2.4E-03	2E-03	1E-02
Benzo(a)pyrene	1 / 15	na	na	3.3E-04	2E-04	2E-04	1E-02
Indeno(1,2,3-cd)pyrene	1 / 15	na	na	3.1E-04	2E-04	2E-04	1E-02
Naphthalene	2 / 47	5.1E-01	4.3E-01	5.8E-01	1E-03	1E-03	1E-02
Phenanthrene	1 / 15	na	na	2.2E-03	2E-03	2E-03	1E-02
Metals							
Arsenic	2 / 16	1.1E-02	5.3E-03	1.6E-02	5E-03	5E-03	5E-03
Nickel	1 / 16	na	na	8.9E-02	4E-02	4E-02	4E-02
Zinc	4 / 16	0.032	0.022	0.056	0.02	0.02	0.02
Petroleum hydrocarbons							
Diesel fuel	7 / 11	1.0E-01	5.1E-02	1.7E-01	5E-02	5E-02	5E-02

na - not applicable
5.0E-3 is read 0.005

3.0 EXPOSURE ASSESSMENT

The objectives of the exposure assessment are to evaluate potential pathways of human exposure to the chemicals of concern detected in soil and groundwater at I-880 Corridor site. Once complete exposure pathways are identified, chemical intakes associated with each pathway and each potentially exposed population are calculated. This section analyzes exposure conditions associated with future use of the Elevated Sections and the At Grade Section as portions of the future I-880 freeway in Oakland. This risk assessment does not address possible exposures to vehicle emissions or road dust arising from future use as a freeway.

Human exposure to the chemicals present in the environmental media of concern may occur via three routes; these are ingestion, inhalation, and skin contact. Exposures via these pathways were assumed to occur without installation of institutional controls, remedial measures, or the wearing of personal protection equipment such as respirators or special clothing. As mentioned in Section 1, Caltrans has a contractual responsibility to protect workers and nearby residents from potential exposure to chemicals during freeway construction activities; therefore, exposure (and risk) were not assessed for construction phases of the I-880 freeway realignment.

This exposure assessment calculates chemical intakes for potentially exposed populations which could be considered representative of "reasonable maximum exposure" (RME). The USEPA defines the RME as "the highest exposure that is reasonably expected to occur at a site" and states that "The intent of the RME is to estimate a conservative exposure case (i.e., well above the average case) that is still within the range of possible exposures" (USEPA 1989a).

3.1 Exposure Pathway Analysis

As stated by the USEPA, an exposure pathway "describes the course a chemical or physical agent takes from the source to the exposed individual. An exposure pathway analysis links the sources, locations, and types of environmental releases with population locations and activity patterns to determine the significant pathways of human exposure" (USEPA 1989a).

An exposure pathway is made up of four elements. These are:

- A source and mechanism of chemical release,
- A retention or transport medium,
- A point of potential human contact with the contaminated medium, and;
- An exposure route at the contact point.

In the following discussion, exposure pathways to site chemicals in soil and groundwater are identified. These exposure pathways are based on the planned future use of the I-880 Corridor for both Elevated Sections and At-Grade Section of the freeway. Designation of an exposure pathway as "complete" indicates that human exposure is possible, but does not necessarily mean that exposure will actually occur in the future. Table 3-1 summarizes possible exposure pathways to the chemicals of concern which were identified for chemicals in soil and ground water for the I-880 Corridor site. Possible pathways of exposure are discussed in the following sections.

3.1.1 Surface Soils

According to current freeway construction plans, two sections of the I-880 Corridor will have an elevated portion of the new freeway passing over it. These two sections, designated as the north and south Elevated Sections, will be separated by an At-Grade Section of the freeway. For Elevated Sections of the freeway, it is possible that individuals may come into direct contact with surface soil through play or other activities.

Following construction of the freeway, children living near the Elevated Sections of the freeway and transients could be exposed to surface soils underneath the elevated freeway. For the purpose of this risk assessment, a child was conservatively selected as the most likely receptor for surface soil contact in the Elevated Sections of the I-880 Corridor. While transients may also be exposed to chemicals in soil in these areas, they are unlikely to experience frequent, long-term exposure to these areas because of their mobility. In addition, a child is likely to have greater exposure to chemicals in soil when exposure is considered on the basis of body weight.

Surface soil in the At Grade Section will be covered by pavement (active freeway) and unavailable for contact. Surface soil exposure in the At Grade Section was considered to be an incomplete pathway.

3.1.2 Subsurface Soils

As defined in Section 2.0 of this report, subsurface soils are considered deeper than one foot. It is unlikely that children at play or transient individuals would be exposed to chemicals present in subsurface soils below the Elevated Sections or At-Grade Section of the freeway. For example, in the Elevated Sections where soils are accessible, activities of children at play or transients would be unlikely to result in exposure to soils deeper than one foot. Because soils in the At-Grade Section of the freeway will be covered by pavement, regular human contact will not occur.

It is possible that utility workers could be exposed to surface and subsurface soils during trenching for utility lines or pipelines or during road repair in either the Elevated Section or At-Grade Section of the freeway. For this reason, ingestion of soil, dermal contact with soil, and inhalation of chemicals in surface and subsurface soils were considered to be complete exposure pathways for a utility worker in both the Elevated Sections and At Grade Section of the freeway.

3.2 Ground Water

Shallow ground water is present at a depth of four to five feet below the surface in the Elevated Sections and the At Grade Section of the I-880 Corridor. While this shallow ground water is not a source of drinking water, it is possible that volatile chemicals (chemicals with Henry's Law constants 1×10^{-5} or higher and a vapor pressure of 0.001 mm Hg and greater (DTSC, 1994a) may volatilize from shallow groundwater through the soil and be released at the soil surface and be inhaled. Thus, inhalation of organic chemicals volatilizing from shallow ground water through soil is assessed for a child at play in the Elevated Sections of the I-880 Corridor.

In addition, VOC affected shallow ground water may collect in trenches excavated for utility lines and release VOCs directly to the air. For this reason, inhalation of organic chemicals volatilizing directly from pooled water in trenches is assessed for a utility worker for both the Elevated Sections and the At Grade Section. Ingestion and dermal absorption of chemicals in ground water were considered to be incomplete exposure pathways in that the trench was assumed to be dewatered prior to entry. See Attachment C for further explanation.

Chemicals detected in shallow groundwater that were considered sufficiently volatile (Henry's Law constant greater than 1 x 10^{-5} and a vapor pressure greater than or equal to 0.001 mm Hg) are listed below.

Volatile Chemicals in Elevated Sections Shallow Ground Water

sec-Butylbenzene
tert-Butylbenzene
1,2-Dibromo-3-chloropropane (DBCP)
1,2-Dibromoethane (EDB)
1,2-Dichlorobenzene
1,4-Dichlorobenzene
1,2-Dichloroethane
Ethylbenzene
Isopropylbenzene (1-Methylethylbenzene)
n-Propyl benzene
Styrene
Toluene
1,2,4-Trichlorobenzene
1,2,4-Trimethylbenzene
1,3,5-Trimethylbenzene
Xylenes
Acenaphthene
Naphthalene

Volatile Chemicals in At Grade Section Shallow Ground Water

Acetone
Benzene
1,1-Dichloroethane
1,1-Dichloroethene
cis-1,2-Dichloroethene
Ethylbenzene
Tetrachloroethene
1,1,1-Trichloroethane
Trichloroethene
Toluene
Vinyl chloride
Xylenes (total)
Acenaphthylene
Naphthalene

3.3 Summary of Potential Exposure Pathways

Exposure pathways considered to be complete for persons potentially exposed to chemicals in soil and shallow groundwater are summarized in Table 3-1.

3.4 Quantification of Exposure

3.4.1 *Estimation of Chemical Intakes*

Chemical intakes may be calculated for human receptors for each complete exposure pathway once the concentration of the chemical in a medium is known and the factors associated with human exposure to the medium of concern have been assessed. DTSC (DTSC, 1992) and USEPA (USEPA, 1992a) direct that the 95 percent upper confidence limit (UCL) on the arithmetic mean concentration of chemicals detected in an environmental medium be used to assess exposure. When the 95% UCL on the arithmetic mean exceeds the maximum detected concentration, the maximum detected value is often conservatively used to estimate chemical intake (USEPA, 1992a).

The 95% UCLs for chemicals detected in soils were calculated according to the formula:

$$95\%\ \text{UCL} = e^{\left(\bar{y} + 0.5\, s^2 + \frac{sH_{1-a}}{\sqrt{n-1}}\right)}$$

where:

e = the exponential function
$\bar{y}$ = arithmetic mean of n log-transformed data measurements
s^2 = variance of n log transformed data measurements
H_{1-a} = value looked up in a statistical table. This table was further modified using LaGrangian four-point interpolation to provide additional H values in accordance with the method suggested by Gilbert (1987)
n = the number of samples

Calculated 95% UCLs for the chemicals of concern in Elevated and At Grade Section soils are presented in Table 3-2. As noted in Section 3.1.1, the Elevated Sections of the freeway will be divided by the At Grade Section of the freeway into two sections described as the "North" and "South" Sections. As presented in Figure 2 of the RI report, the North Elevated Section is located to the west of Wood Street. The South Elevated Section of the freeway will pass over portions of Kirkham, Cypress, and Third Streets. Conservatively, the higher of the 95% UCLs calculated for the North and South Elevated Sections was used in calculating exposure and risks due to chemicals in Elevated Sections soils.

For calculating risks posed by inhalation of chemicals from ground water, the maximum detected concentration for each volatile chemical detected in Elevated and At Grade Section are used.

Emission rates for volatile organic chemicals from shallow groundwater through soil are calculated using methods described by Johnson and Ettinger, 1991. These calculations are described in Attachment B of this report. Emission rates for VOCs from ground water pooled in excavated trenches is described in Attachment C of this report.

Air concentrations of vapor phase chemicals volatilizing from soil and ground water were calculated according to methods described in the DTSC's Preliminary Endangerment Assessment Guidance Manual (DTSC, 1994).

Equations used to calculate chemical intakes from soil and groundwater are presented in Table 3-3. Exposure variables used to calculate chemical intakes from soil via ingestion, inhalation, and dermal contact are presented in Tables 3-4 for a child and a utility worker. The source of each exposure variable is identified in Table 3-4.

3.5 Exposure Estimates for Populations Potentially Exposed to the Chemicals of Concern Under Planned Future Land Use Conditions

Estimated chemical intakes resulting from soil exposure for the child at play and the utility worker in the Elevated Sections of the I-880 Corridor are presented in Tables 3-5 and 3-6, respectively. Estimated chemical intakes resulting from soil exposure for the utility worker in the At Grade Section is presented in Table 3-7. Calculated inhalation intakes of volatile chemicals in shallow ground water are presented in Table 3-8 and 3-9 for the child and the utility worker in the Elevated Sections of the I-880 Corridor, respectively, while the calculated inhalation intakes of volatile chemicals in shallow ground water are presented in Table 3-10 for the utility worker in the At Grade Section of the I-880 Corridor.

Estimates of daily chemical intake are expressed as average daily intakes (noncarcinogens) or lifetime average daily intakes (carcinogens). Average daily intakes are calculated over the assumed period of exposure whereas lifetime average daily intakes are calculated over a lifetime (70 years).

Average daily intakes and lifetime average daily intakes for ingested and inhaled chemicals of concern are expressed as intakes rather than absorbed doses. Dermal average daily intakes are calculated as absorbed doses.

Daily intakes were not calculated for lead. The California DTSC currently recommends the use of its own lead exposure model to assess lead exposure and the resulting blood lead concentration associated with exposure to lead in dust, soil, food, drinking water, and air (DTSC, 1992). The lead exposure model conservatively assumes that for days when a child or utility worker is at the site, all soil and dust exposure comes from site sources. Exposure assumptions used in calculating lead exposure are presented in Attachment D of this risk assessment. Risk associated with intake of lead in soil is addressed in Section 5.1.1.

Table 3-1
Summary of Potentially Complete Exposure Pathways

Potentially Exposed Population	Exposure Medium, Route, and Exposure Point	Pathway Selected for Examination?	Reason for Selection or Exclusion
Child at play	**Air** Inhalation of chemicals volatilizing from soil and chemicals released from soil as fugitive dusts	Yes	Chemicals may volatilize or be released from surface soil as dusts in the Elevated Sections of the freeway.
	Inhalation of volatile organic chemicals released at the soil surface due to volatilization from shallow groundwater	Yes	Volatile organic chemical vapors may be released from shallow groundwater, migrate through soils in the Elevated Sections of the freeway, and be inhaled.
	Soil Incidental ingestion of site soils	Yes	Children may be exposed to chemicals in surface soils underneath the Elevated Sections of the freeway.
	Dermal contact with site soils	Yes	Children may be exposed to chemicals in surface soils underneath the Elevated Sections of the freeway.
Utility Workers	**Air** Inhalation of chemicals volatilizing from soil and chemicals released from soil as fugitive dusts	Yes	Chemicals may volatilize or be released from soil as dusts during soil excavation.
	Inhalation of volatile organic chemicals released from shallow groundwater	Yes	Volatile organic chemicals may volatilize from shallow ground water that has pooled in trenches
	Soil Incidental ingestion of site soils	Yes	Workers may be exposed to site soils during soil excavation.
	Dermal contact with site soils	Yes	Workers may be exposed to site soils during soil excavation.

Table 3-2
Elevated and At-Grade Section Soils
Soil Exposure Concentrations

	ELEVATED SECTIONS				AT-GRADE SECTION
	Surface Soils		Surface and Subsurface Soils		Surface and Subsurface Soils
Chemical	95% UCL Concentrations (mg/kg)	Elevated Section with Highest 95% UCL	95% UCL Concentrations (mg/kg)	Elevated Section with Highest 95% UCL	95% UCL Concentrations (mg/kg)
Volatile organic chemicals					
1,2-Dibromoethane (EDB)	not detected	not detected	0.0029	South	not detected
Polynuclear aromatic hydrocarbons					
Benzo(a)anthracene	* 0.16	North	* 0.16	North	0.373
Benzo(a)pyrene	* 0.54	South	* 0.54	South	0.399
Benzo(b)fluoranthene	* 0.78	South	* 0.78	South	0.201
Benzo(g,h,i)perylene	* 2.5	South	* 2.5	South	0.761
Benzo(k)fluoranthene	* 0.14	North	* 0.14	North	0.128
Chrysene	* 0.3	North	* 0.3	North	0.991
Dibenz(a,h)anthracene	not detected	not detected	not detected	not detected	0.83
Indeno(1,2,3-cd)pyrene	* 1.9	South	* 1.9	South	0.328
Naphthalene	not detected	not detected	* 4.9	North	not detected
Metals					
Lead	605	South	312	South	361
Petroleum hydrocarbons					
TPH-Diesel	10.00	South	110	North	55.3
TPH-Gasoline	0.533	North	200	South	not detected
TPH-Motor oil	680	South	1613	South	not detected
Journal Box oil	not detected	not detected	not detected	not detected	811

*Maximum detected concentration

Table 3-3
Calculation of Intakes of the Chemicals of Concern in Soil

Exposure Pathway	Exposure Equation	Exposure variables
Air		
Inhalation of particulate phase chemicals	$\frac{C x PC x IR x EF x ED x CF}{BW x AT}$	C = Concentration of chemical in particulate (mg/kg) PC = Particulate concentration in air (mg/m^3); for the child at play, PC was assumed to be 0.05 mg/m^3 in accordance with the California Preliminary Endangerment Assessment Manual (DTSC, 1994a). For the construction worker, PC was assumed to be 1 mg/m^3 due to soil disturbance. IR = Inhalation rate (m^3/day or event) EF = *Exposure frequency (days or events/year)* ED = Exposure duration (years) CF = Conversion factor (10^{-6} kg/mg) BW = Body weight (kg) AT =Averaging time (period over which exposure is averaged (for non-carcinogens: ED x 365 days/year; for carcinogens: 70 years x 365 days/year)
Inhalation of vapor *phase chemicals*	$\frac{CA x IR x EF x ED}{BW x AT}$	CA = Concentration of chemical in air (mg/m^3) IR = Inhalation rate (m^3/day or event) EF = Exposure frequency (days or events/year) ED = Exposure duration (years) BW = Body weight (kg) AT =Averaging Time (period over which exposure is averaged (for non-carcinogens: ED x 365 days/year; for carcinogens: 70 years x 365 days/year)
Soil		
Ingestion of soil	$\frac{CS x IR x EF x ED x CF}{BW x AT}$	CS = Chemical concentration in soil (mg/kg) IR = Ingestion rate (mg soil/day) EF = Exposure frequency (days/year) ED = Exposure duration (years) CF= Conversion factor (1 x 10^{-6} kg/mg) BW = Body weight (kg) AT =Averaging time (period over which exposure is averaged (for non-carcinogens: ED x 365 days/year; for carcinogens: 70 years x 365 days/year)

Table 3-3
(contd)

Exposure Pathway	Exposure Equation	Exposure variables
Dermal absorption of chemicals in soil	$\frac{CS \times SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$	CS = Chemical concentration in soil (mg/kg) SA = Skin surface area available for contact (cm^2) AF = Adherence of soil to skin (mg/cm^2) ABS = Fraction of chemical absorbed through the skin (unitless); dermal absorption fractions for the chemicals of concern were as follows: volatiles, 0.10; PNAs, 0.15 in accordance with the California Preliminary Endangerment Assessment Manual (DTSC, 1994a). EF = Exposure frequency (days/year) ED = Exposure Duration (years) CF= Conversion factor (1×10^{-6} kg/mg) BW = Body Weight (kg) AT =Averaging Time (period over which exposure is averaged (for non-carcinogens: ED x 365 days/year; for carcinogens: 70 years x 365 days/year)

Table 3-4
Summary of Exposure Assumptions

Ingestion of Chemicals in Soil

Population	Receptor	Body Weight (BW) (kg)	Ingestion Rate (IR) (mg /day)	Exposure Frequency (EF)	Exposure Duration (ED) (years)
Child at play	Child	*44 (3)	100 (1)	36 events per year (2)	7
Utility Worker	Adult	70 (1)	480 (1)	60 days per year	1

Dermal Absorption of Chemicals in Soil

Population	Receptor	Body Weight (BW) (kg)	Exposed Skin Surface Area (SA) (cm^2)	Soil Adherence to Skin (AF) (mg/cm^2)	Exposure Frequency (EF) (days)	Exposure Duration (ED) (years)
Soil						
Child at play	Child	*44 (3)	3300**	1 (2)	36 events per year (2)	7
Utility Worker	Adult	70 (1)	5800 (2	1 (2)	60 days per year	1

Inhalation of Particulate Phase- and Vapor Phase- Chemicals (Emission from Soil And Groundwater)

Population	Receptor	Body Weight (BW) (kg)	Inhalation Rate (IR)	Exposure Frequency (EF) (days)	Exposure Duration (ED) (years)
Child at play	Child	*44 (3)	5 m^3 per event (4) ***	36 events per year (2)	7
Utility Worker	Adult	70 (1)	20 m^3 per day (1)	60 days per year	1

References for exposure parameters: (1) USEPA, 1991; (2) DTSC, 1992; (3) USEPA, 1989b (Exposure Factors Handbook) (4) CARB, 1993a

*Average body weight for a 9 to 15 year old child

**Assumes 25% of the body surface is exposed to soil

***A child at play breathes approximately 20 L of air/min (1.2 m^3/hr; CARB, 1993)

Table 3-5
Child at Play-Elevated Sections
Exposure to Chemicals in Surface Soils
Average Daily Intakes

Chemical	Average Daily Intake			Lifetime Average Daily Intake		
	Ingestion mg/kg/day	Dermal mg/kg/day	Inhalation mg/kg/day	Ingestion mg/kg/day	Dermal mg/kg/day	Inhalation mg/kg/day
Polynuclear aromatic hydrocarbons						
Benzo(a)anthracene	3.59E-08	1.78E-07	8.97E-11	3.59E-09	1.78E-08	8.97E-12
Benzo[a]pyrene	1.21E-07	5.99E-07	3.03E-10	1.21E-08	5.99E-08	3.03E-11
Benzo[b]fluoranthene	1.75E-07	8.65E-07	4.37E-10	1.75E-08	8.65E-08	4.37E-11
Benzo[g,h,i]perylene	5.60E-07	2.77E-06	1.40E-09	na	na	na
Benzo[k]fluoranthene	3.14E-08	1.55E-07	7.85E-11	3.14E-09	1.55E-08	7.85E-12
Chrysene	6.72E-08	3.33E-07	1.68E-10	6.72E-09	3.33E-08	1.68E-11
Indeno[1,2,3-cd]pyrene	4.26E-07	2.11E-06	1.06E-09	4.26E-08	2.11E-07	1.06E-10
Petroleum hydrocarbons						
TPH-Diesel	8.11E-07	2.68E-06	2.03E-09	na	na	na
TPH-Gasoline	1.19E-07	3.94E-07	2.99E-10	na	na	na
TPH-Motor oil	1.52E-04	5.03E-04	3.81E-07	na	na	na
Metals						
Lead	see Attachment D			see Attachment D		

na - not applicable; chemical is not a potential carcinogen

Table 3-6
Utility Worker-Elevated Sections
Exposure to Chemicals in Surface and Subsurface Soils
Average Daily Intakes

Chemical	Average Daily Intake			Lifetime Average Daily Intake		
	Ingestion mg/kg/day	Dermal mg/kg/day	Inhalation mg/kg/day	Ingestion mg/kg/day	Dermal mg/kg/day	Inhalation mg/kg/day
Volatile organic chemicals						
Ethylene dibromide	3.27E-09	3.95E-09	1.64E-06	4.67E-11	5.64E-11	2.35E-08
Polynuclear aromatic hydrocarbons						
Benzo(a)anthracene	1.80E-07	3.27E-07	7.51E-09	2.58E-09	4.67E-09	1.07E-10
Benzo[a]pyrene	6.09E-07	1.10E-06	2.54E-08	8.70E-09	1.58E-08	3.62E-10
Benzo[b]fluoranthene	8.79E-07	1.59E-06	3.66E-08	1.26E-08	2.28E-08	5.23E-10
Benzo[g,h,i]perylene	2.82E-06	5.11E-06	1.17E-07	na	na	na
Benzo[k]fluoranthene	1.58E-07	2.86E-07	6.58E-09	2.25E-09	4.09E-09	9.39E-11
Chrysene	3.38E-07	6.13E-07	1.41E-08	4.83E-09	8.76E-09	2.01E-10
Indeno[1,2,3-cd]pyrene	2.14E-06	3.88E-06	8.92E-08	3.06E-08	5.55E-08	1.27E-09
Naphthalene	5.52E-06	1.00E-05	2.30E-07	na	na	na
Petroleum hydrocarbons						
TPH-Diesel	8.92E-06	1.08E-05	3.72E-07	na	na	na
TPH-Gasoline	1.20E-06	1.45E-06	5.00E-08	na	na	na
TPH-Motor oil	1.82E-03	2.20E-03	7.57E-05	na	na	na
Metals						
Lead	see Attachment D			see Attachment D		

na-not applicable; chemical is not considered to be a potential carcinogen

Table 3-7
Utility Worker-At-Grade Section
Exposure to Chemicals in Surface and Subsurface Soils
Average Daily Intakes

Chemical	Average Daily Intake			Lifetime Average Daily Intake		
	Ingestion mg/kg/day	Dermal mg/kg/day	Inhalation mg/kg/day	Ingestion mg/kg/day	Dermal mg/kg/day	Inhalation mg/kg/day
Polynuclear *aromatic* hydrocarbons						
Benzo(a)anthracene	4.20E-07	7.62E-07	1.75E-08	6.00E-09	1.09E-08	2.50E-10
Benzo[a]pyrene	4.50E-07	8.16E-07	1.88E-08	6.43E-09	1.17E-08	2.68E-10
Benzo[b]fluoranthene	2.26E-07	4.10E-07	9.42E-09	3.23E-09	5.85E-09	1.35E-10
Benzo[g,h,i]perylene	8.58E-07	1.55E-06	3.57E-08	na	na	na
Benzo[k]fluoranthene	1.45E-07	2.62E-07	6.02E-09	2.06E-09	3.74E-09	8.60E-11
Chrysene	1.12E-06	2.02E-06	4.65E-08	1.60E-08	2.89E-08	6.65E-10
Dibenz[a,h]anthracene	9.36E-07	1.70E-06	3.90E-08	1.34E-08	2.42E-08	5.57E-10
Indeno[1,2,3-cd]pyrene	3.69E-07	6.70E-07	1.54E-08	5.28E-09	9.57E-09	2.20E-10
Petroleum hydrocarbons						
TPH-Diesel	6.23E-05	7.53E-05	2.60E-06	na	na	na
Journal box oil	9.14E-04	1.10E-03	3.81E-05	na	na	na
Metals						
Lead	see Attachment D			see Attachment D		

na-not applicable; chemical is not considered to be a potential carcinogen

Table 3-8
Child at Play
Inhalation of Chemicals Volatilizing from Shallow Groundwater through Soil
Elevated Sections

Chemical	Average Daily Inhalation Intake (mg/kg/day)	Lifetime Average Daily Inhalation Intake (mg/kg/day)
Volatile organic chemicals		
Butylbenzene (sec)	1.34E-07	na
Butylbenzene (tert)	3.47E-08	na
1,2-Dibromo-3-chloropropane (DBCP)	1.51E-09	1.51E-10
1,2-Dibromoethane (EDB)	2.23E-08	2.23E-09
1,2-Dichlorobenzene	8.57E-08	na
1,4-Dichlorobenzene	1.65E-08	1.65E-09
1,2-Dichloroethane	1.00E-08	1.00E-09
Ethylbenzene	3.26E-08	na
Isopropylbenzene	4.52E-06	na
n-Propyl benzene	2.16E-08	na
Styrene	4.45E-08	na
Toluene	7.20E-08	na
1,2,4-Trichlorobenzene	4.20E-08	na
1,2,4-Trimethylbenzene	5.45E-08	na
1,3,5-Trimethylbenzene	5.81E-08	na
Xylene (m & p)	2.15E-08	na
Xylene (o)	1.62E-08	na
Polynuclear aromatic hydrocarbons		
Acenaphthene	1.93E-09	na
Naphthalene	5.39E-07	na
Phenanthrene	4.42E-09	na

na- not applicable; chemical is not considered to be a potential carcinogen

Table 3-9
Utility Worker
Inhalation of Chemicals Volatilizing from Shallow Groundwater in Trenches- Elevated Sections

Chemical	Average Daily Inhalation Intake (mg/kg/day)	Lifetime Average Daily Inhalation Intake (mg/kg/day)
Volatile organic chemicals		
Butylbenzene (sec)	2.65E-06	na
Butylbenzene (tert)	3.83E-06	na
1,2-Dibromo-3-chloropropane (DBCP)	8.70E-07	1.24E-08
1,2-Dibromoethane (EDB)	8.70E-06	1.24E-07
1,2-Dichlorobenzene	2.36E-05	na
1,4-Dichlorobenzene	4.13E-06	5.90E-08
1,2-Dichloroethane	2.95E-06	4.21E-08
Ethylbenzene	4.13E-06	na
Isopropylbenzene	4.13E-04	na
n-Propyl benzene	2.65E-06	na
Styrene	3.69E-06	na
Toluene	1.08E-05	na
1,2,4-Trichlorobenzene	1.27E-05	na
1,2,4-Trimethylbenzene	9.58E-06	na
1,3,5-Trimethylbenzene	8.55E-06	na
Xylene (m & p)	2.80E-06	na
Xylene (o)	2.65E-06	na
Polynuclear aromatic hydrocarbons		
Acenaphthene	4.42E-07	na
Naphthalene	8.49E-05	na
Phenanthrene	8.85E-07	na

na- not applicable; chemical is not considered to be a potential carcinogen

Table 3-10
Utility Worker
Inhalation of Chemicals Volatilizing from Shallow Groundwater in Trenches
At-Grade Section

Chemical	Average Daily Inhalation Intake (mg/kg/day)	Lifetime Average Daily Inhalation Intake (mg/kg/day)
Volatile organic chemicals		
Acetone	6.19E-06	na
Benzene	2.95E-07	4.21E-09
1,1-Dichloroethane	4.72E-06	6.74E-08
1,1-Dichloroethene	3.10E-07	na
cis-1,2-Dichloroethene	3.10E-05	na
Ethylbenzene	1.47E-07	na
Tetrachloroethylene	1.08E-05	1.54E-07
Toluene	1.24E-07	na
1,1,1-Trichloroethane	5.60E-07	na
Trichloroethene	2.36E-05	3.37E-07
Vinyl chloride	6.64E-06	9.48E-08
Xylenes	4.72E-07	na
Polynuclear aromatic hydrocarbons		
Acenaphthylene	1.77E-06	na
Naphthalene	8.55E-05	na
Phenanthrene	3.24E-07	na

na- not applicable; chemical is not considered to be a potential carcinogen

4.0 TOXICITY ASSESSMENT

4.1 Noncarcinogenic Risks

The noncarcinogenic effects of the chemicals of concern were assessed by comparing chemical intakes calculated in Section 3.5 with USEPA reference doses (RfDs). The USEPA definition of the RfD is presented below.

> "The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of the daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a portion of the lifetime, in the case of a subchronic RfD, or during a lifetime, in the case of a chronic RfD." (USEPA, 1989c)

The USEPA derives RfDs for inhalation and oral exposure for subchronic exposures (2 weeks to 7 years) and chronic exposures (7 years and longer) for many chemicals. Inhalation and oral reference doses for the chemicals of concern in soil and ground water are presented in Tables 4-1 and 4-2. As discussed in Sections 2.1 and 2.2, only one volatile organic chemical (1,2-dibromoethane) and five PNAs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene) were retained as chemicals of concern in soils of the I-880 Corridor. However, since the ASTM and API risk assessment methods discussed in Section 4.4 of this report consider other volatile organic chemicals and PNAs to be important indicator chemicals for petroleum hydrocarbons, the reference doses and slope factors for these additional volatile organic chemicals and PNAs are also added to Table 4-1 and 4-2 for completeness. Chronic RfDs were used to assess risks to a child and subchronic RfDs were used to assess risks to construction workers. For instances where only a chronic reference dose exists, the chronic reference dose was also used as the subchronic reference dose.

In several cases, RfDs were not available for chemicals of concern. The uncertainty associated with a lack of RfDs for certain chemicals is discussed in Section 5.3 of this report.

In particular, Integrated Risk Information System (IRIS) reference doses have not been developed to assess the noncarcinogenic effects of petroleum hydrocarbon mixtures.

Instead, as recommended by the DTSC (DTSC, 1995), the potential noncarcinogenic and carcinogenic effects associated with exposure to petroleum hydrocarbons in soil is evaluated according to methods developed by the American Society for Testing and Materials (ASTM, 1994), Massachusetts Department of Environmental Protection (MDEP, 1994), and the American Petroleum Institute (API, 1994). These methods are discussed further in Section 4.3 of this report.

The RfDs used in this assessment are generally derived from animal studies. Results from these studies are extrapolated to humans using appropriate factors to adjust for uncertainties resulting from:

- Extrapolation from the results of animal studies to humans,
- Variation within individuals of the same species,
- Extrapolation from the results of short-term animal studies and,
- Extrapolation from exposure levels in animal studies that demonstrate an effect rather than a no-effect level.

For any particular chemical, an intake that exceeds the RfD for that chemical indicates that an adverse health effect may be observed. The chemical intake divided by the reference dose is defined by the USEPA to be the hazard quotient (HQ) for a chemical. As a general rule, when the HQ < 1, it is unlikely that an adverse health effect will occur. The chance of observing an effect increases as the HQ increasingly exceeds unity. The USEPA directs that the HQ for each chemical and each route of exposure be summed to calculate a hazard index (HI). This process conservatively assumes that simultaneous exposure to multiple chemicals at intakes below the RfD may produce an adverse health effect if the HI exceeds one. When calculated according to USEPA methods, the HI assumes that the effects of each chemical are additive. The HI is used as a screen to determine whether or not the effects of intake of multiple chemicals may be of concern. If the HI is less than one, there is little reason to expect that any adverse effect will result from concurrent exposure to all of the chemicals of concern.

The USEPA does not derive dermal RfDs for chemicals. However, since dermal exposure may add to the overall intake of a chemical and possibly cause an adverse effect, the oral RfD is used as the dermal RfD (when an oral RfD is available).

4.2 Carcinogenic Risks

The chemicals of concern that are considered by the USEPA and the DTSC to be potentially carcinogenic in humans are presented in Tables 4-1 and 4-2. As discussed above, most PNAs detected at the site were eliminated as chemicals of concern based on comparison to residential PRGs. However, the slope factors for PNAs presented in Tables 4-1 and 4-2 were used with the ASTM and API risk assessment methods; methods for petroleum hydrocarbons are discussed in Section 4.4. With the exception of benzene and vinyl chloride, the potential carcinogenicity of the other chemicals of concern has been extrapolated from animal studies. This is reflected in the "B" USEPA Group classification of these chemicals.

Slope factors for the potentially carcinogenic chemicals of concern were determined by the DTSC and USEPA by applying the linearized multistage model to data from animal carcinogenicity studies or human epidemiological studies. In the absence of data concerning the carcinogenic potential of very low doses of a chemical, linearized multistage modeling is used to generate estimates of carcinogenic potency. Inherent in the linearized multistage model is the provision that there is no dose, no matter how small, that is not associated with some carcinogenic risk. The USEPA defaults to this conservative position in the absence of firm scientific data to support the application of the linearized multistage model. The uncertainties associated with weight-of-evidence classifications and use of the linearized multistage model are addressed in a later section of this report. Multiplication of the lifetime average daily intake by the slope factor [in $(\text{mg/kg/day})^{-1}$] produces a unitless estimate of theoretical lifetime cancer risk. Increased theoretical lifetime cancer risk calculated by this method is often expressed in terms of 1 in ten thousand (1E-04), 1 in one hundred thousand (1E-05), or 1 in one million (1E-06).

In cases where both the USEPA and DTSC have derived different slope factors for the same chemical, the DTSC slope factor was used.

The USEPA has recently proposed draft guidance for carcinogenic risk assessment that is different from the guidance currently used by USEPA. The draft guidance includes a new weight of evidence scheme for classifying chemical carcinogens and proposes new mathematical models for calculating the potency of chemical carcinogens. If this draft guidance is implemented, slope factors (which reflect the carcinogenic potency of a chemical) for certain carcinogenic chemicals may change. In particular, implementation of the draft guidance may result in slope factors for non-genotoxic carcinogens (carcinogens that do not directly alter DNA) that are lower than the slope factors currently used by USEPA.

4.3 Toxicological Effects of Lead

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

The USEPA and others have developed lead exposure models for evaluating blood lead concentrations associated with intake of lead from food, water, air, and soil. The USEPA lead model (integrated exposure uptake biokinetic model) is calibrated for use only for children ages 7 and younger (USEPA, 1994). The State of California has developed its own lead exposure model to calculate lead exposure in children and adults (DTSC, 1992). The DTSC child and adult lead exposure models are used for calculating blood lead concentrations for a child at play and construction workers potentially exposed to lead in surface and subsurface soil at the I-880 Corridor site.

While lead has been shown to affect numerous organ systems in humans including the nervous system, kidneys, the blood, and reproductive system, medical and scientific attention has recently focused on the neurobehavioral effects of lead in children and the cardiovascular effects of lead in adults. A summary of the lowest observed effect levels of lead for key lead-induced effects in adults and children is presented in Tables 4-3a and 4-3b, respectively.

The calculated blood lead concentration for a child at play and a construction worker resulting from exposure to lead in soil is evaluated in Section 5.1.1 of this report. The results are also discussed in terms of applicable California laws designed to protect construction workers from overexposure to lead.

4.4 Toxicological Effects of Petroleum Hydrocarbon Mixtures

There is currently no single, universally accepted method for addressing risks posed by petroleum hydrocarbon mixtures in soil or water. The problems associated with the evaluation of risks associated petroleum mixtures in the environment have been outlined by Michelsen and Boyce (1993). These problems relate to the analytical characterization of petroleum mixtures, the uncertainties associated with a relative lack of toxicological information concerning the toxicity of whole petroleum mixtures, the use of "indicator chemicals" to evaluate the toxicity of a whole petroleum mixture, and the effect of weathering on petroleum mixtures in the environment. Despite their technical deficiencies, risk assessments of petroleum mixtures in the environment typically use one of two approaches-- a "whole-product" approach or an "indicator chemical" approach. These approaches are briefly described below.

The *whole-product* approach uses toxicological information regarding the whole petroleum mixture to evaluate health risks. The USEPA indicates that when adequate information is available, it is preferable to use mixture-specific toxicity tests to evaluate the toxicity of a complex mixture (USEPA, 1986). One advantage of a whole-product approach over the indicator chemical approach is that it avoids the necessity of selecting "toxicologically representative" indicator chemicals and the uncertainty associated with a toxicological evaluation of only a few components of a complex mixture.

The USEPA has examined the toxicity of several petroleum mixtures and has derived "provisional" reference doses for unleaded gasoline, jet fuels (JP-4 and JP-5), and marine diesel fuel (USEPA, 1992b). These RfDs could be used in a mixture-specific toxicological evaluation of these mixtures. However, due to data gaps and other uncertainties, USEPA confidence in these provisional reference doses is "low." As a result of these uncertainties, the USEPA apparently does not encourage their widespread use in risk assessments and has recently withdrawn this document (Personal communication, Joan Dollarhide, 2/22/96).

In addition to the uncertainty introduced by the relative lack of toxicological information for some petroleum mixtures, petroleum mixtures also undergo "weathering" in the environment, resulting in the loss of the more water-soluble, volatile, and degradable components of the mixture. Thus, after some period of time in the environment, a petroleum mixture may not be chemically or toxicologically similar to the unweathered mixture. For the purpose of evaluating human health risk, weathered petroleum hydrocarbons were evaluated according to the standard by which the petroleum hydrocarbon was quantified. Typically, similarities between the chromatograms for the weathered petroleum hydrocarbon in soil and the fresh standard were observed. For this reason, the weathered petroleum mixture was then evaluated as being toxicologically similar to the petroleum standard against which it was quantified.

The most commonly used alternative to the whole-product approach to the toxicological evaluation of petroleum mixtures is the use of indicator chemicals for a petroleum mixture. In particular, the American Society for Testing and Materials (ASTM) has action levels for soil and water for selected indicator chemicals. According to ASTM (ASTM, 1994), "It is inherently assumed that a significant fraction of the total potential impact from all chemicals is due to the indicator compounds. The selection of indicator compounds is based on the consideration of exposure routes, concentrations, mobilities, toxicological properties and aesthetic characteristics." This has lead ASTM to identify benzene, ethylbenzene, toluene, xylenes, and PNAs as potential indicator chemicals. ASTM has also developed health-based action levels for benzene, ethylbenzene, toluene, xylenes, naphthalene, and benzo(a)pyrene for air, soil, and ground water. As stated above, the most important and unavoidable uncertainty associated with the indicator chemical approach is that it purports to represent the toxicity of a complex mixture containing hundreds of constituents by a limited number of chemicals. The degree to which the indicator chemical approach represents the toxicity of a whole petroleum mixture has not been systematically examined.

Available indicator chemical approaches include the ASTM method (ASTM, 1994) and the API's Risk/Exposure Assessment Decision Support System (DSS) (API, 1994). As recommended by the DTSC (DTSC, 1995), these methods are used to assess risks posed by petroleum hydrocarbons present in soils at the I-880 Corridor site in Section 5.3 of this report.

The Massachusetts Department of Environmental Protection (MDEP) has developed a system for evaluating the toxicity of petroleum hydrocarbon mixtures that incorporates elements of both the "whole mixture" and "indicator chemical" approaches (MDEP, 1994). In their approach, rather than treating the entire range of petroleum hydrocarbons as one mass, the MDEP divides the broad chemical classes of petroleum hydrocarbons (alkanes, cycloalkanes, alkenes and aromatics) into subgroups of compounds based on the carbon number of the petroleum hydrocarbon in each subgroup and assigns discrete estimates of health risk for each specific subgroup based on a "reference compound" for that subgroup.

The MDEP has derived a reference dose for each subgroup based on identification of a "reference compound" for each subgroup. In the case of PNAs, the lowest RfD for a noncarcinogenic PNA (pyrene) was selected. MDEP RfDs for these subgroups are shown in the following table. In a sample calculation, MDEP suggests that benzene, ethylbenzene, toluene, xylenes, and PNAs compounds are to be evaluated separately using their specific RfDs or slope factors.

Compound	**Reference compound**	**Toxic effect**	**Proposed Alternate RfD (mg/kg/day)**
ALKANES/CYCLOALKANES			
C5-C8	*n-hexane*	*neurotoxicity*	0.06
C9-C18	n-nonane	neurotoxicity	0.6
C19-C32	eicosane	irritation/functional changes	6.0
AROMATICS/ALKENES			
C9-C32	pyrene	nephrotoxic	0.03

The MDEP approach requires that the amount of petroleum hydrocarbons in each subgroup be quantified using chromatographic methods specified by the MDEP. The type of analysis necessary to use the MDEP risk assessment methods is not available for petroleum mixtures detected at the I-880 Corridor site. However, the lack of MDEP-type analyses for petroleum hydrocarbons does not preclude the application of the MDEP method to petroleum hydrocarbon mixtures detected at the I-880 Corridor site.

Using a "worst-case" analysis, the MDEP method can be used to estimate health risks associated with petroleum hydrocarbons detected in soils if it is assumed that measured petroleum hydrocarbon mixtures are composed of C9-C32 aromatic/alkene compounds, the most toxic fraction identified by the MDEP. According to MDEP methods, these compounds are considered to have the highest non-carcinogenic health risks. RfDs for the other subgroups are 2-200 times higher. Noncarcinogenic health risks can then be estimated by applying the most conservative RfD of 0.03 mg/kg/day to the petroleum hydrocarbons detected in soils at the I-880 Corridor site. However, such an assumption is overly conservative when used for less toxic petroleum hydrocarbon mixtures such as motor oil. For example, mineral oil comprises 75% or more of motor oils and poses little toxic hazard (MDEP, 1994). The application of the MDEP method in assessing the risks posed by TPH-gasoline, TPH-diesel, TPH-motor oil, and journal box oil exposure is presented in Section 5.3.3.

Table 4-1
Inhalation Reference Doses and Slope Factors for the Chemicals of Concern

	Noncarcinogenic effects *Inhalation*	Subchronic RfD (RfC) Inhalation mg/kg/day (mg/m^3)	Safety Factor Inhalation	Chronic RfD (RfC) Inhalation mg/kg/day (mg/m^3)	Safety Factor Inhalation	Carcinogenic Effects Inhalation	Slope Factor Inhalation mg/kg/day^{-1} (mg/m^3)c	EPA Group Inhalation
Volatile organic chemicals								
Acetone	-	-	-	-	-	-	-	-
Benzene	-	-	-	-	-	Leukemia	1.00E-01b (2.90E-05)	A
sec-Butylbenzene	-	-	-	-	-	-	-	-
tert-Butylbenzene	-	-	-	-	-	-	-	-
1,2-Dibromo-3-chloropropane	-	-	-	-	-	Stomach, liver, and kidney tumors	7.00E+00	B2
1,2-Dibromoethane	Sperm effects	5.71E-04 (2.00E-03)	100	5.71E-05 (2.00E-04)	1000	Nasal cavity tumors	2.50E-01b (7.10E-05)	B2
1,2-Dichlorobenzene	Decreased weight gain	5.71E-01 (2.00E+00)	100	5.71E-02 (2.00E-01)	1000	-	-	-
1,4-Dichlorobenzene	Increased liver weight	7.14E-01 (2.50E+00)	30	2.29E-01 (8.00E-01)	100	Liver tumors	4.00E-02b (1.10E-05)	C
1,1-Dichloroethane	Kidney toxicity	1.43E+00 (5.00E+00)	100	1.43E-01 (5.00E-01)	1000	Mammary gland; adenocarcinoma	5.70E-03b (1.60E-06)	-
1,2-Dichloroethane	-	-	-	-	-	Circulatory system sarcoma	7.00E-02b (2.20E-05)	B2
1,1-Dichloroethene	-	-	-	-	-	Adenocarcinoma	1.20E+00	C
cis-1,2-Dichloroethene	-	-	-	-	-	-	-	-
Ethylbenzene	Developmental toxicity	-	-	2.83E-01 (1.00E+00)	300	-	-	-
Isopropylbenzene (cumene)	CNS, nose irritation	2.57E-02 (9.00E-02)	1000	2.57E-03 (9.00E-03)	10000	-	-	-
n-Propylbenzene	-	-	-	-	-	-	-	-
Toluene	CNS neurological effects, eye and nose irritation	-	-	1.14E-01 (4.00E-01)	300	-	-	-
1,2,4-Trichlorobenzene	Liver weight change	5.71E-01 (2.00E+00)	100	5.71E-02 (2.00E-01)	1000	-	-	-
1,1,1-Trichloroethane	-	2.90E-01		2.90E-01		-	-	-
Trichloroethene	-	-	-	-	-	Liver; hepatocellular carcinoma	1.00E-02b (2.00E-06)	B2-C§
1,2,4-Trimethylbenzene	-	-	-	-	-	-	-	-
1,3,5-Trimethylbenzene	-	-	-	-	-	-	-	-
Vinyl chloride	-	-	-	-	-	Liver & lung; angiosarcomas	2.70E-01b (7.80E-05)	A
Xylenes	-	-	-	-	-	-	-	-

Table 4-1
Inhalation Reference Doses and Slope Factors for the Chemicals of Concern

	Noncarcinogenic effects Inhalation	Subchronic RfD (RfC) Inhalation mg/kg/day (mg/m^3)	Safety Factor Inhalation	Chronic RfD (RfC) Inhalation mg/kg/day (mg/m^3)	Safety Factor Inhalation	Carcinogenic Effects Inhalation	Slope Factor Inhalation mg/kg/day^{-1} (mg/m^3)c	EPA Group Inhalation
Semivolatile organic chemicals								
Acenaphthene	-	-	-	-	-	-	-	-
Acenaphthylene	-	-	-	-	-	-	-	-
Benz[a]anthracene	-	-	-	-	-	PEF	3.90E-01c	B2
Benzo[a]pyrene	-	-	-	-	-	Respiratory tract tumors	3.90E+00b (1.10E-03)	B2
Benzo[b]fluoranthene	-	-	-	-	-	PEF	3.90E-01c	B2
Benzo(k)fluoranthene	-	-	-	-	-	PEF	3.90E-01c	B2
Benzo[g,h,i]perylene	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-					Lung; alveolar cell carcinoma	4.10E+00b (1.20E-03)	B2
Indeno(1,2,3-cd)pyrene	-	-	-	-	-	PEF	3.90E-01c	B2
2-Methylnaphthalene	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	-	-	-	-	-
Phenanthrene	-	-	-	-	-	-	-	-
Pyrene	-	-	-	-	-	-	-	-
Metals								
Lead	-	-	-	-	-	-	-	B2

a RfD calculated from RfC (mg/m^3) using the formula: RfC x 20 m^3 per day/70 kg= RfD (mg/kg/day)

b Value taken from Cal EPA 1994 Cancer Potency Factors: Update

c Converted to (mg/kg/day)$^{-1}$ from the unit risk (µg/m^3) using the formula: Unit risk x 70 kg x 1000 µg/mg x 1/20 m^3 per day = Slope factor

- Not available

Table 4-2
Oral Reference Doses and Slope Factors for the Chemicals of Concern

	Noncarcinogenic effects Oral	Subchronic RfD Oral mg/kg/day	Safety Factor Oral	Chronic RfD Oral mg/kg/day	Safety Factor Oral	Carcinogenic Effects Oral	Slope Factor Oral mg/kg/day^{-1}	EPA Group Oral
Volatile organic chemicals								
Acetone	Increased liver and kidney weight	1.00E+00	100	1.00E-01	1000	-	-	-
Benzene	-	-	-	-	-	Leukemia	1.00E-01a	A
sec-Butylbenzene	-	-	-	-	-	-	-	-
tert-Butylbenzene	-	-	-	-	-	-	-	-
1,2-Dibromo-3-chloropropane	-	-	-	-	-	Stomach, liver, and kidney tumors	7.00E+00a	B2
1,2-Dibromoethane	-	-	-	-	-	Nasal cavity tumors	3.60E+00a	B2
1,2-Dichlorobenzene	-	-	-	-	-	-	-	-
1,4-Dichlorobenzene	-	-	-	-	-	Liver tumors	4.00E-02a	C
1,1-Dichloroethane	None observed	1.00E+00	100	1.00E-01	1000	Mammary gland; adenocarcinoma	5.70E-03a	C
1,2-Dichloroethane	-	-	-	-	-	Circulatory system sarcoma	7.00E-02a	B2
1,1-Dichloroethene	Liver lesions	9.00E-03	1000	9.00E-03	1000	Adrenal pheochromocytomas	6.00E-01	C
cis-1,2-Dichloroethene	Decreased hematocrit and hemoglobin	1.00E-01	300	1.00E-02	3000	-	-	
Ethylbenzene	Liver and kidney toxicity	-	-	1.00E+00	100	-	-	-
Isopropylbenzene (cumene)	Increased kidney weight	4.00E-01	300	4.00E-02	3000	-	-	-
n-Propylbenzene	-	-	-	-	-	-	-	-
Toluene	Liver and kidney altered weight	2.00E+00	100	2.00E-01	1000	-	-	-
1,2,4-Trichlorobenzene	Increased adrenal weight	1.00E-02	1000	1.00E-02	1000	-	-	-
1,1,1-Trichloroethane	-	9.00E-02		9.00E-02				
Trichloroethene	-	-	-	-	-	Liver; hepatocellular adenoma, carcinomas	1.50E-02a	B2-C
1,2,4-Trimethylbenzene	-	-	-	-	-	-	-	-
1,3,5-Trimethylbenzene	-	-	-	-	-	-	-	-
Vinyl chloride	-	-	-	-	-	Lung and liver tumors	2.70E-01a	A
Xylenes	Decreased weight and hyperactivity	-	-	2.00E+00	100	-	-	-

Table 4-2
Oral Reference Doses and Slope Factors for the Chemicals of Concern

	Noncarcinogenic effects Oral	Subchronic RfD Oral mg/kg/day	Safety Factor Oral	Chronic RfD Oral mg/kg/day	Safety Factor Oral	Carcinogenic Effects Oral	Slope Factor Oral mg/kg/day^{-1}	EPA Group Oral
Semivolatile organic chemicals								
Acenaphthene	Liver toxicity	6.00E-01	300	6.00E-02	3000			
Acenaphthylene	-	-	-	-	-	-	-	-
Benz[a]anthracene	-	-	-	-	-	PEF	1.20E+00a	B2
Benzo[a]pyrene	-	-	-	-	-	Forestomach tumors	1.20E+01a	B2
Benzo[b]fluoranthene	-	-	-	-	-	PEF	1.20E+00a	B2
Benzo(k)fluoranthene	-	-	-	-	-	PEF	1.20E+00a	B2
Benzo[g,h,i]perylene	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	Lung; alveolar cell carcinoma	4.10E+00a	B2
Indeno(1,2,3-cd)pyrene	-	-	-	-	-	PEF	1.20E+00a	B2
2-Methylnaphthalene	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	-	-	-	-	-
Phenanthrene	-	-	-	-	-	-	-	-
Pyrene	Kidney effects	3.00E-01	300	3.00E-02	3000	-	-	-
Metals								
Lead	-	-	-	-	-	-	-	B2

a Value taken from Cal EPA 1994 Cancer Potency Factors: Update

- Not available

Table 4-3a Summary of Lowest-Observed-Effect Levels for Key Lead-Induced Health Effects in Children

Lowest observed effect level (blood lead conc. in µg/dL)	Heme synthesis and hematological effects	Neurological effects	Effects on the kidney	Gastrointestinal effects
80-100		Encephalopathic signs and symptoms	Chronic nephropathy	Colic and other overt gastrointestinal symptoms ↓
70	Frank anemia			↓
60		Peripheral neuropathies ↓		
50		↓ ?		
40	Reduced hemoglobin production	Slowed peripheral nerve conduction		
	Elevated coproporphyrin	CNS cognitive effects (IQ deficits, etc.)		
	Increased urinary ALA	?		
30			Interference with Vitamin D metabolism ↓	
15	EP elevation	Altered CNS electrophysiological responses	↓ ↓	
10	ALA-deydrase inhibition Py-5-N activity inhibition ↓ ?	Mental development index deficits, reduced gestational age and birth weight (prenatal exposure) ↓ ?	?	

CNS- Central nervous system; ALA - Aminolevulinic acid; EP - Erythrocyte protoporphyrin; Py-5-N - Pyrimidine -5'-nucleotidase

Table 4-3b Summary of Lowest-Observed-Effect Levels for Key Lead-Induced Health Effects in Adults

Lowest observed effect level (blood lead conc. in µg/dL)	Heme synthesis and hematological effects	Neurological effects	Effects on the kidney	Reproductive function effects	Cardiovascular effects
100-120		Encephalopathic signs and symptoms	Chronic nephropathy ↓		
80	Frank anemia		↓		
60		↑ ↑	↓	Female reproductive effects	
50	Reduced hemoglobin production	Overt subencephalopathic neurological symptoms ↓	↓ ↓	Altered testicular function ↓	
40	Increased urinary ALA and elevated coprophyrins	Slowed peripheral nerve conduction ↓ ↓ ↓			
30					Elevated blood pressure (white males aged 40-59) ↓
25-30	EP elevation in males				↓
15-20	EP elevation in females				↓ ↓
<10	ALA dehydrase inhibition				↓ ?

ALA - Aminolevulinic acid; EP - Erythrocyte protoporphyrin

5.0 RISK CHARACTERIZATION

Hazard quotients and theoretical lifetime cancer risks calculated for a child at play and utility worker exposed to chemicals in soil and shallow ground water are presented in Tables 5-1 through 5-6. Lead risk calculations for the child at play and the utility worker exposed to lead in soil are discussed in Section 5.1.1. The results of risk calculations for petroleum hydrocarbons performed using the ASTM, API, and MDEP methods are discussed in Section 5.3.

5.1 Noncarcinogenic Risks

Hazard quotients calculated for the child at play exposed to the chemicals of concern in Elevated Sections surface soils and shallow ground water were less than 1 for all chemicals (Tables 5-1 and 5-4, respectively). Hazard indices (the total of the hazard quotients) for each exposure pathway were likewise less than 1. Even after combining hazard indices across exposure pathways, the total hazard indices for exposure to surface soils (0.022) and shallow ground water (0.0022) were less than 1, indicating that noncarcinogenic health effects would be unlikely to result from exposure to the chemicals of concern in these media.

For the utility worker, hazard quotients calculated for all chemicals of concern in Elevated Sections soils and At Grade Section soils and Elevated Sections ground water and At Grade Section ground water were less than one (Tables 5-2, 5-3, 5-5 and 5-6, respectively). Hazard indices for all exposure pathways were also less than one. When summed across exposure pathways, the total hazard indices for the utility worker exposed to the chemicals of concern in Elevated Sections and At Grade soils was 0.021 (Table 5-2) and 0.0073 (Table 5-3), respectively, indicating that noncarcinogenic health effects would be unlikely to result from exposure to the chemicals of concern. The inhalation hazard indices from exposure to chemicals volatilizing from shallow ground water in the Elevated Sections (Table 5-5) and At Grade Section (Table 5-6) were also less than 1 (0.33 and 0.000049, respectively), indicating that inhalation of volatile chemicals present in either Elevated Sections or At Grade Section shallow ground water is unlikely to be associated with noncarcinogenic adverse health risks.

5.1.1 Characterization of Risks from Lead in Soil

Blood lead concentrations calculated for a child at play exposed to lead in surface soils and a utility worker exposed to lead in surface and subsurface soils can be calculated using methods outlined in DTSC guidance (DTSC, 1992) and a recent DTSC memorandum (DTSC, 1994b). The calculations presented below assume that no protective measures are taken to prevent exposure to lead-affected soils. The assumptions used to calculate blood lead concentrations for a child at play and a utility worker exposed to lead in soil are presented in Attachment D.

5.1.1.1 Child at play

A child at play may be exposed to lead in surface soil at the Elevated Sections of the I-880 Corridor site. The exposure parameters used to calculate lead exposure for the child at play are presented in Attachment D. For reasons of conservatism, the higher of the 95% upper confidence limit concentrations for lead in Elevated Sections surface soils was used to assess lead exposure (South Elevated Section, 605 mg/kg). The calculated blood lead concentrations associated with a child's exposure to 605 mg/kg lead in soil for 3 days per week were 3.4, 5.3, 6.0, 6.9, and 7.6 µg/dL for the 50th, 90th, 95th, 98th, and 99th percentile values, respectively. These concentrations are all below the DTSC's blood lead concentration of concern for a child of 10 µg/dL, indicating that a child's exposure to surface soil in the Elevated Sections of the I-880 Corridor is unlikely to result in overexposure to lead.

As a point of comparison, lead exposure modeling performed by O'Flaherty (O'Flaherty, 1995) predicts that a child resident's exposure to average soil lead concentrations of 500 mg/kg and lower would result in blood lead concentrations less than 10 µg/dL. It should be noted that the average lead concentration in Elevated Sections surface soil from the I-880 Corridor site is 318 mg/kg, lower than the soil lead concentration evaluated by O'Flaherty (500 mg/kg). Further, the child at play would not be exposed to lead in site soils on a daily basis as would O'Flaherty's child resident. For these reasons, lead exposure modeling performed by O'Flaherty provides further support that a child's exposure to surface soil at the I-880 Corridor is unlikely to result in a blood lead concentration over 10 µg/dL.

5.1.1.2 Utility worker

During excavation of soils for utilities or below-grade structures at the I-880 Corridor site, utility workers could be exposed to higher concentrations of lead present in subsurface soils. The exposure parameters used to calculate lead exposure for the utility worker are presented in Attachment D. According to California Code of Regulations (CCR) Title 8 § 1532.1, Lead in Construction standard, workers engaged in "New construction, alteration, repair, or renovation of structures, substrates, or portions thereof, that contain lead, or materials containing lead" would be covered under this regulation. Thus, Title 8 § 1532.1 appears to be applicable to workers that could lay utility lines or sewer lines in soils at the I-880 Corridor site after the freeway is constructed.

Using the DTSC leadspread model, the calculated 50th, 90th, 95th, 98th, and 99th percentile blood lead concentrations for a utility worker exposed to surface and subsurface soils containing an average of 361 mg/kg lead (higher 95% UCL value for surface and subsurface soils from Elevated vs. At Grade Sections) were 2.6, 4.0, 4.5, 5.2 and 5.8 μg/dL, respectively. Based on these calculations, utility worker exposure to lead in surface and subsurface soils is unlikely to result in a blood lead concentration that would exceed 10 μg/dL.

Based on exposure calculations using the DTSC lead exposure model, a utility worker's exposure to soil lead concentrations detected at I-880 Corridor site is unlikely to result in blood lead concentrations that exceed any recommended blood lead standard (40 μg/dL) or health protection goal (30 μg/dL) in CCR Title 8 § 1532.1, the California Lead in Construction standard.

5.2 Theoretical Lifetime Cancer Risks

For the child at play at the Elevated Sections of the I-880 Corridor site, calculated theoretical lifetime cancer risks resulting from exposure to the chemicals of concern in Elevated Sections surface soils and shallow groundwater were 1 E-06 and 2 E-09, respectively (Tables 5-1 and 5-4, respectively). Benzo(a)pyrene accounts for nearly all of the calculated lifetime cancer risk for surface soils.

Theoretical lifetime cancer risks calculated for the utility worker exposed to the chemicals of concern in Elevated Sections and At Grade Section surface and subsurface soils were 5 E-07 and 4 E-07 (Tables 5-2 and 5-3, respectively). Theoretical lifetime cancer risks calculated for the utility worker exposed to volatile organic chemicals released from shallow ground water in the Elevated Sections and At Grade Section were 1 E-07 and 3 E-08, respectively (Tables 5-5 and 5-6). Benzo(a)pyrene accounts for most of the calculated theoretical lifetime cancer risk for the utility worker exposed to surface and subsurface soils in both the Elevated Sections and the At Grade Section of the I-880 Corridor.

5.3 Risks Posed by Petroleum Hydrocarbons

As recommended by DTSC (DTSC, 1995), this risk assessment considers human health risks posed by petroleum hydrocarbons using three risk assessment methods. These methods, termed the ASTM, API, and MDEP methods, are briefly explained in Section 4.4 of this report. Risks calculated for chemicals associated with petroleum hydrocarbons are discussed below by the method used to calculate risks.

As discussed in Sections 2.1 and 2.2 of this report, volatile organic chemicals other than 1,2-dibromoethane, PNAs other than benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene were eliminated as chemicals of concern for I-880 Corridor site based on comparison to residential PRGs. However, several volatile chemicals and PNAs are used as indicator chemicals for petroleum hydrocarbons for both the ASTM and API methods. For this reason, in order to use the indicator chemical approaches used in the ASTM and API risk assessment methods, it is necessary to consider detected concentrations of PNAs at the I-880 Corridor site. For the sake of completeness, this report evaluates detected PNAs using both the ASTM and API methods below.

5.3.1 ASTM Risk Method

As described in Section 4.4 of this report, ASTM has developed an "indicator" chemical approach to deriving risk-based screening level concentrations for selected chemicals in soil and ground water. In particular, the ASTM has developed risk-based screening levels for benzene, ethylbenzene, toluene, xylene, naphthalene, and benzo(a)pyrene in soil and ground water for residential and industrial exposure scenarios. The risk-based screening levels for these chemicals in soil and ground water are presented in Table 4 of the "Emergency Standard Guide for Risk-Based Corrective Action at Petroleum Release

Sites" (ASTM, 1994). Comparisons of detected chemical concentrations to risk-based screening level concentrations listed in Table 4 of the ASTM guidance are discussed for soils and ground water below. It should be noted that this comparison is quite conservative since it compares the most stringent risk-based screening level (residential) to maximum detected concentrations of indicator chemicals in soil and ground water. Further, it compares screening levels developed for residential exposure scenarios to exposure conditions (child at play and the utility worker) that would be associated with less soil or inhalation exposure.

5.3.1.1 Elevated Sections Soil

As discussed in Section 2 of this report, benzene, ethylbenzene, toluene, xylenes, naphthalene, and several other PNAs in soil were eliminated from the risk assessment based on comparison to USEPA Region IX residential PRGs. However, in the interest of completeness, maximum detected concentrations of these chemicals in Elevated Sections soils are compared to Tier 1 ASTM risk-based screening levels in Table 5-7. As calculated by ASTM, the Tier 1 risk-based soil screening levels take into account ingestion, skin contact, and inhalation of the indicator chemicals under residential exposure conditions.

Tier 1 ASTM screening levels are calculated using default exposure parameters and USEPA slope factors for carcinogenic chemicals and USEPA reference doses for non-carcinogenic chemicals. DTSC slope factors for benzene and the potentially carcinogenic PNAs are different from those developed by the USEPA and used by ASTM. For this reason, the ASTM Tier 1 risk-based screening level is also presented as an adjusted value based on the DTSC slope factor. While the ASTM has not calculated risk-based screening levels for benzo(a) anthracene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-c,d)pyrene, values were calculated using a relative potency factor of 0.1 and 0.01 and DTSC slope factors for benzo(a)pyrene (DTSC, 1994). Dibenz(a,h)anthracene has no ASTM screening level. In order to calculate a value for dibenz(a,h)anthracene, the California EPA slope factor for dibenz(a,h) anthracene was divided by the USEPA slope factor for benzo(a) pyrene and then multiplied by the ASTM screening level for benzo(a) pyrene. This resulted in an adjusted screening level for dibenz(a,h)anthracene nearly equivalent to the adjusted ASTM value for benzo(a)pyrene.

The volatile organic hydrocarbons, benzene, ethylbenzene, toluene, and xylenes were detected in Elevated Section soil at concentrations below both ASTM Tier 1 screening levels for residential soil and adjusted ASTM levels (Table 5-7). The maximum detected concentration of benzo(a)pyrene in Elevated Section soil exceeded the ASTM Tier 1 risk-based residential soil screening level and the adjusted ASTM value calculated using DTSC slope factors. The maximum detected concentration of indeno(1,2,3-cd)pyrene also exceeded the adjusted ASTM value calculated using the DTSC slope factor.

Maximum detected concentrations of benzo(b)fluoranthene, benzo(k)fluoranthene, and chrysene were below adjusted ASTM values. The maximum concentrations of naphthalene in Elevated Sections soil were below the ASTM screening level. No ASTM Tier 1 screening levels were available for the PNA benzo(g,h,i)perylene, however, as discussed in Section 2, benzo(g,h,i)perylene was not considered to contribute to noncarcinogenic risk to any appreciable degree.

Although the maximum detected concentrations of benzo(a)pyrene and indeno(1,2,3-cd)pyrene in Elevated Sections soil exceeded their respective ASTM residential risk-based screening levels, these chemicals were not expected to pose significant risk under I-880 Corridor site exposure conditions.

5.3.1.2 At Grade Section Soil

As discussed in Section 2 of this report, toluene, naphthalene, and several other petroleum indicator chemicals in At Grade Section soil were eliminated from the risk assessment based on comparison to USEPA Region IX residential PRGs. However, in the interest of completeness, maximum detected concentrations of these chemicals in At Grade Section surface/subsurface soils are compared to Tier 1 ASTM risk-based screening levels in Tables 5-8.

The volatile organic hydrocarbon, toluene, was detected in At Grade Section surface/subsurface soil at a concentration below ASTM Tier 1 screening levels for residential soil (Table 5-8). The maximum detected concentration of benzo(a)pyrene in At Grade Section surface/subsurface soils exceeded the ASTM Tier 1 risk-based residential soil screening level and the adjusted ASTM value calculated using DTSC slope factors. The maximum detected concentrations of benzo(a)anthracene, benzo(b)fluoranthene, dibenz(a,h)anthracene and indeno(1,2,3-cd)pyrene also exceeded the adjusted ASTM values calculated using the DTSC slope factors.

Maximum detected concentrations of benzo(k)fluoranthene and chrysene were below adjusted ASTM values. No ASTM Tier 1 screening levels were available for the PNA benzo(g,h,i)perylene, however, as discussed in Section 2, benzo(g,h,i)perylene was not considered to contribute to noncarcinogenic risk to any appreciable degree.

In summary, the results of the comparison indicate that five PNAs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene and indeno(1,2,3-c,d)pyrene) exceeded either ASTM Tier 1 risk-based screening levels or risk-based ASTM screening levels adjusted for the DTSC slope factor in At Grade Section soil. Although the maximum detected concentrations of these PNAs in At Grade Section soil exceeded their respective ASTM residential risk-based screening levels, these chemicals do not pose significant risk to utility workers under I-880 Corridor site exposure conditions. As presented in Table 5-3, theoretical lifetime cancer risks due to a utility worker's exposure to these five PNAs are well below the target lifetime cancer risk of 1 x 10^{-6}.

5.3.1.2 Ground Water

ASTM has derived Tier 1 risk-based screening levels for chemicals detected in ground water for three different exposure scenarios for both residential and industrial exposure conditions. These scenarios are: inhalation of chemicals volatilizing from ground water through soils to the outdoor air; ingestion of chemicals in ground water and; inhalation of vapor-phase chemicals released from shallow ground water that have migrated into a building. Of these exposure scenarios, only inhalation of chemicals volatilizing from ground water to outdoor air was applicable to the I-880 Corridor site. The Tier 1 risk-based residential exposure scenario values for the scenario are compared to maximum detected concentrations of petroleum hydrocarbon indicator chemicals of Elevated Sections shallow ground water in Table 5-9 and in At Grade Section shallow ground water in Table 5-10.

Maximum detected concentrations of petroleum hydrocarbon indicator chemicals detected in shallow ground water in the Elevated Sections (benzene, ethylbenzene, toluene, xylenes, and naphthalene) did not exceed ASTM Tier 1 risk-based screening levels. Maximum detected concentrations of benzene, ethylbenzene, toluene, xylenes, benzo(a)pyrene, indeno(1,2,3-cd)pyrene and naphthalene in At Grade Section also did not exceed ASTM Tier 1 risk-based screening levels.

This comparison indicates that these chemicals would be unlikely to pose unacceptable health risk even under residential exposure conditions. Thus, these chemicals would not pose unacceptable health risks for a child at play in the Elevated Sections of the I-880 Corridor since the child would have less exposure than under residential exposure conditions.

5.3.2 API DSS Risk Model

As reviewed in Section 4.4, the API DSS risk assessment model may be used to calculate risks posed by chemicals that are considered to be common indicator chemicals for petroleum mixtures. Along with the model, the API supplies physical, chemical, and toxicological data concerning 25 chemicals considered to be indicators of petroleum contamination in the environment. The API model includes fate and transport models for ground water, soil, and air so that the user can calculate exposure point concentrations for the indicator chemicals in these media. While it includes emission of volatile components of fuels from soil to air, the API DSS model does not consider exposure to volatiles released from ground water (as in an excavation) into outdoor air; this pathway was considered in Sections 5.1 and 5.2 of this assessment.

API DSS fate and transport modeling was required only for calculating air concentrations of the indicator chemicals. The Thibodeaux-Hwang vapor emissions model was used for this purpose. This model is presented in a modified form in the Superfund Exposure Assessment Manual (USEPA, 1988b). Other applicable fate and transport models available in the API DSS model for calculating emissions of volatiles from soil include Farmer's model, the Jury model, and SESOIL. The Thibodeaux-Hwang model was selected to calculate emissions of volatiles from soil because it requires relatively little site-specific data, is less complicated than the Jury or SESOIL models, and does not require the user to assume that the affected soil is covered by a clean soil cover (as in Farmer's model).

The API DSS model also allows the user to input site-specific exposure assumptions into the model. The same exposure assumptions listed in Table 3-3 were used to calculate exposure to API indicator chemicals in soil. Maximum detected concentrations of the indicator chemicals in soil were used as exposure point concentrations. Default USEPA slope factors and reference doses available in the API DSS model were used to calculate risks. All exposure assumptions, calculated volatile concentrations in air, and API DSS risk model inputs are summarized in Attachments E and F for the child at play and the utility worker, respectively.

Tables 5-11, 5-12, and 5-13 summarize noncarcinogenic and carcinogenic risk calculations for the API indicator chemicals detected at the I-880 Corridor site. Note that the API has not included benzo(k)fluoranthene, and indeno(1,2,3-c,d) pyrene as indicator chemicals for petroleum hydrocarbon mixtures, however, benzo(k)fluoranthene did not exceed Region IX residential PRGs and indeno(1,2,3-cd)pyrene only slightly exceeded its residential PRG. Given the difference in exposure between a residential scenario and the exposure conditions at the I-880 Corridor site (i.e., recreational/industrial scenario), the lack of inclusion of these two PNAs as indicator chemicals in the API DSS model should not underestimate risk.

Using the API DSS model, the total hazard index for the child at play exposed to the API indicator chemicals in Elevated Sections surface soil was 0.000022 (Table 5-11). This value is well below one, indicating that exposure to these chemicals in surface soil is unlikely to be associated with noncarcinogenic adverse health effects. The theoretical lifetime cancer risks calculated for the child at play in Elevated Sections surface soil were 1 E-06 (Table 5-11).

For the utility worker exposed to the API indicator chemicals in surface/subsurface soils in the Elevated Sections, the total hazard index (0.028) is less than 1, indicating that it is unlikely that exposure to these chemicals would be associated with noncarcinogenic adverse health effects (Table 5-12). Calculated theoretical lifetime cancer risk resulting from exposure to these chemicals in soil was 2 E-07 (Table 5-12).

For the utility worker exposed to the API indicator chemicals in soils in the At Grade Section, the total hazard index (0.027) is less than 1, indicating that it is unlikely that exposure to these chemicals would be associated with noncarcinogenic adverse health effects (Table 5-13). Calculated theoretical lifetime cancer risk resulting from exposure to these chemicals in soil was 1 E-06 (Table 5-13).

In summary, for the child at play and the utility worker, the API DSS risk model indicates that exposure to petroleum indicator chemicals in soils at the I-880 Corridor site would not be associated with noncarcinogenic adverse health effects or theoretical lifetime cancer risks higher than 1 E-06.

5.3.3 MDEP Risk Method

The MDEP risk method is a health-based alternative to the use of the TPH (total petroleum hydrocarbon) parameter in the evaluation of human health risks posed by petroleum hydrocarbons in water and soil. As discussed in Section 4.4 of this report, the MDEP scheme requires analysis of petroleum hydrocarbons to detect the quantity of C5 to C8, C9 to C18, and C19 to C32 alkanes/cycloalkanes and C9 to C32 aromatics/alkenes in soil or water. These hydrocarbon-specific data are unavailable for the I-880 Corridor site.

While GC and GC/MS analyses of soil samples at the I-880 Corridor site indicate that the majority of detected hydrocarbons are in the high-boiling (motor oil) range of petroleum hydrocarbons, these data do not supply the characterization necessary to identify whether detected hydrocarbons are alkanes, alkenes, or aromatic compounds. Thus, the MDEP method cannot be fully implemented at the I-880 Corridor site.

Despite the above-described shortcomings in the chemical characterization of petroleum hydrocarbons detected at the site, the MDEP method may be applied to perform a "worst case" analysis if it is conservatively assumed that the detected petroleum hydrocarbons are the most toxic MDEP petroleum hydrocarbon fraction. For example, if it is assumed that all TPH-diesel and TPH-gasoline detected at the I-880 Corridor site are comprised of the most toxic petroleum fraction (C9 to C32 aromatic/alkenes), the lowest reference dose applied by the MDEP (i.e., 0.03 mg/kg/day) can be used to evaluate the noncarcinogenic risk associated with these petroleum hydrocarbons in soil at the site.

It should be noted that the MDEP method discusses only the use of chronic reference doses in assessing risks posed by petroleum hydrocarbons in soil or water. However, pyrene, the reference chemical used by the MDEP to represent the most toxic hydrocarbon fraction, also has a USEPA-derived subchronic reference dose of 0.3 mg/kg/day. A subchronic reference dose is more appropriately applied to the subchronic exposure (less than 7 years) calculated for a utility worker. Thus, in calculating the risks posed by a child's chronic exposure to petroleum hydrocarbons in soil, a chronic reference dose of 0.03 mg/kg/day is used. For the subchronic soil exposure experienced by a utility worker, a subchronic reference dose of 0.3 mg/kg/day is used.

Noncarcinogenic risks posed by petroleum hydrocarbons in soil may be calculated by using the average daily intakes of petroleum hydrocarbons for the child at play in the Elevated Sections and the utility worker in the Elevated Sections and the At Grade Section presented in Tables 3-5, 3-6, and 3-7, respectively. The average daily intakes were calculated using the maximum detected concentration of the petroleum hydrocarbons in soil.

The hazard quotients associated with ingestion, skin contact, and inhalation of the petroleum hydrocarbon mixtures are presented in Tables 5-14, 5-15, and 5-16 for the child at play and the construction worker, respectively. The overall hazard indices for the child at play (Elevated Sections) and the utility worker (Elevated Sections and At Grade Section) are 0.022, 0.016 and 0.0073, respectively. These calculations indicate that the child at play and the utility worker are unlikely to experience noncarcinogenic health effects as a result of exposure to petroleum hydrocarbons in soil at the I-880 Corridor site.

The risk calculations discussed above may be considered overly conservative for TPH-motor oil if the typical composition of motor oil is considered. For example, gasoline and diesel fuel consist primarily of C4 - C12 and C9 - C20 range hydrocarbons, respectively, whereas motor oil consists primarily of C15 to C50 range hydrocarbons (MDEP, 1994). Gosselin (1984) indicates that motor oils are 75% to 100% composed of mineral oil. Mineral oil is widely recognized as having low toxicity (ATSDR, 1994; MDEP, 1994). Ellenhorn and Barceloux (1988) classify a child's consumption of 5 ml and less of lubricating oils, mineral oil, and motor oils as a “nontoxic ingestion”. At a concentration of 4800 mg/kg of motor oil in soil (the maximum detected concentration in Elevated Sections surface soil at the I-880 site), a child would have to ingest 1 kg (2.2 pounds) of soil to equal a 5 ml ingestion of motor oil.

5.4 Evaluation of Risk Assessment Uncertainties

Several areas of uncertainty were associated with the estimation of chemical intakes from exposure to soil and air and the characterization of risk. For ease of discussion, uncertainties are discussed as they relate to either the estimation of exposure or the evaluation of chemical toxicity.

5.4.1 Uncertainties Related to Estimation of Exposure

Uncertainties associated with estimation of exposure to the chemicals of concern in soil or shallow ground water primarily relate to:

- chemical analysis of volatile organic chemicals in soil;
- chemical analysis of petroleum hydrocarbons as "total petroleum hydrocarbons";
- the selected frequencies of human contact with chemicals in soil and shallow ground water;
- the selection of exposure variables to estimate oral, dermal, and inhalation intakes of the chemicals of concern in soil and ground water and;
- estimation of chemical release from soil and ground water and the resulting air concentrations at receptor locations.

These areas of uncertainty are discussed below.

Analysis of Volatile Organic Chemicals in Soil

Several chemicals detected in the Elevated Section and At-Grade Section soils are considered volatile. USEPA indicates that analysis of volatile chemicals is a source of considerable uncertainty that may affect confidence in sampling results (USEPA, 1992c). In particular, concentrations of volatile chemicals such as acetone, benzene, 1,2-dibromoethane, 1,2-dichloroethane, ethylbenzene, methylene chloride, methyl ethyl ketone, tetrachloroethene, toluene, trichloroethene, and xylenes may be underestimated if precautions are not taken to minimize loss of chemicals from soil during sample handling. However, because this risk assessment assumes that exposure to volatile chemicals in soil may be as long as months to years, the loss of volatile chemicals that may occur during sample handling is probably offset by the assumed duration of exposure to volatile chemicals in soil. For example, if loss of volatile organic chemicals from soil occurs during sample handling, similar losses of volatile chemicals from soil would also be expected to occur as a result of trenching or excavation of affected soils.

Chemical Analysis of Petroleum Hydrocarbons

Recent publications have questioned the usefulness of gravimetric ("oil and grease") and USEPA Method 418.1 ("total recoverable petroleum hydrocarbons") methods for analyzing petroleum hydrocarbons in soil and water and in particular, their usefulness for risk assessment purposes (Block et al., 1991; Douglas et al., 1992; MDEP, 1994). Principal concerns regarding the "oil and grease" analysis include the fact that: the method of extraction leads to removal of petroleum hydrocarbons with the extraction solvent; the method has high detection limits and; the method cannot discriminate between simple classes of petroleum hydrocarbons. As stated by MDEP, the gravimetric procedure "represents the most basic level of analysis and is not recommended for health risk assessment purposes." Due to these obvious shortcomings, "oil and grease" analyses of soils from the I-880 Corridor site were not used in this risk assessment. Rather than provide worthwhile data, use of the "oil and grease" analysis for soils at the I-880 Corridor site would introduce even greater uncertainty to the risk assessment.

Similarly, the results of USEPA Method 418.1 analyses are not useful for risk assessments. For example, Method 418.1 has been criticized because it leads to the loss of volatile organic chemicals from the soil sample during the extraction, it has a poor extraction efficiency for high molecular weight hydrocarbons, it may remove 5- and 6-ring alkylated aromatics during the silica cleanup procedure, and it measures naturally occurring hydrocarbons. Technical problems such as these have lead the MDEP to conclude that "[Method 418.1] does not provide product identification if it is performed as outlined in the EPA method" and that it is "not recommended for generating data used in health risk assessments" (MDEP, 1994). Thus, "total recoverable petroleum hydrocarbon" (Method 418.1) analyses were not used in the risk assessment for the I-880 Corridor site.

The gas chromatography (GC) and GC/mass spectrometry techniques used to detect TPH-gasoline, TPH-diesel, and TPH-motor oil provide little information to characterize the classes of petroleum hydrocarbons present in soils at the I-880 Corridor site. However, given the conservative MDEP assumptions used in evaluating the toxicity of these detected petroleum hydrocarbons (Sections 5.3.3), it is unlikely that the use of these data has resulted in underestimation of human health risks posed by petroleum hydrocarbons in soil at the I-880 Corridor site.

Frequencies of Human Contact with Chemicals

Determining the frequency of a child's contact with the I-880 Corridor site is clearly dependent on site-specific factors, several of which remain uncertain. These factors include whether or not the areas under the freeway will be fenced or paved, the availability of recreation areas near the raised portion of the freeway, and others. The conservatism of the exposure assumptions used to calculate exposure to chemicals for the child at play is discussed below.

It was assumed that a child at play would be exposed to surface soils underneath the freeway 36 days per year for 7 years. This frequency of exposure was derived from guidance provided in the "Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities (DTSC, 1992). In that guidance document, the DTSC calculated that a six year old child would spend time equivalent to 43.7 days of exposure (a soil "exposure day" was considered to be equivalent of 13 waking hours) at a community park. In addition, the DTSC calculated that a 7 to 17 year old child would spend time equivalent of 390.5 days of exposure (an "exposure day" for the 7 to 17 year old child was considered to be 16 waking hours) at a community park over an 11 year period. If these days of exposure are summed and divided by the 12 year exposure period, an average of 36 days per year is calculated for the amount of exposure days that a child may spend at a community park.

From the results of a recent study by Silvers et al. (1994), the assumption of 36 days of exposure to chemicals in soil can be considered conservative. Silvers et al. surveyed 1000 households in six states (including California) to determine the activity patterns of children between the ages of 5 to 12 years. A total of 182 households were surveyed in California. The time children participated in various activities (sleeping, attending school, eating meals, etc.) was recorded. In addition, the amount of time spent in outdoor and indoor play at home and away from home was also recorded. The results of the California survey are presented below.

Activities of California Children 5- to 12-Years of Age

Location by site and activity	Mean (hours per day)	Standard Deviation
Indoors at home	16.70	3.32
Indoors away from home	4.91	3.47
Indoors, unknown site	0.05	0.28
Outdoors at home	1.06	1.74
Outdoors away from home	0.96	1.73
Outdoors, unknown site	0.01	0.13
At home, unknown location	0.02	0.20
Away from home, unknown location	0.06	0.32
Unknown location and site	0.23	0.96
Total over location by site	24.00	-
Total hours indoors	21.66	2.61
Total hours outdoors	2.03	2.41

From Silvers et al. (1994)

From these data, California children spend over 90% of their day indoors. The statistic most applicable to an estimate of a child's exposure to soil away from home ("outdoors away from home") indicates that very little time is spent outside away from the home (mean = 0.96 hours per day; standard deviation, 1.73). The calculated 95% upper confidence limit on the arithmetic mean of time spent outside away from home is calculated to be 1.17 hours per day. Given that the mean number of waking hours in a 5- to 12-year old child's day is 13.5 (Silvers et al., 1994), approximately 8.7% of a California child's waking hours are spent outside away from home. It should be noted that the Silvers et al. study did not differentiate time spent outside while away at school or while on vacation from the time recorded as being spent "outdoors away from home". Thus, the mean amount of time spent in outdoor activities away from home determined by Silvers et al. (1994) would tend to overestimate the time spent outdoors away from home in areas in a child's neighborhood. Based on the results of their study, Silvers et al. concluded that:

> "Children between 5 and 12 years of age spend much more time indoors than outdoors. The average time spent indoors by children in New York, New Jersey, Pennsylvania, Washington, and Oregon during Fall and Winter is almost 22.8 h per day. The children in California are not far behind, at about 22.7 h per day spent inside. The California Air

> Resources Board obtained nearly identical results for California children: 22.0 h inside. Children also spend a great deal of time at home. These results alone have great import for exposure and risk assessments of children; they indicate that attention should be focused on indoor, *on-site hazards*."

Thus, the estimated frequency of exposure to soils underneath the freeway (36 days per year for 7 years) is likely to overestimate any actual soil exposure that a child may experience.

The assumption of 60 days of exposure for a utility worker may be evaluated in terms of time required to excavate a trench across the sections of the I-880 Corridor site. For example, calculations performed using data in Means Building Construction Cost Data, 53rd Annual Edition (Means, 1995), indicate that it would require approximately 9 person-days to dig a trench 68 meters long by 1.75 meters deep by 1.25 meters wide and haul the excavated soil away from the site. This estimate was based on use of a one-half cubic yard backhoe to excavate soils, the time required to install steel sheet piling into the trench, perform daily dewatering of the trench, and load and haul away the excavated soils. From these calculations, the assumed 60 days of exposure for a utility worker can be considered quite conservative.

Selection of Exposure Variables

In addition to the frequencies of exposure assumed for soil at the site, the degree of exposure to these media is also somewhat uncertain. Estimates of exposure to these media depend on the assumed amount of air inhaled, the amount of soil ingested, the amount of skin surface soiled, and the amount of a chemical absorbed through the skin from soil and ground water.

In keeping with the USEPA default assumption, utility workers were assumed to ingest 480 mg of soil per day. A review of the USEPA source for this assumption leads to the speculation of Hawley (1985). Hawley calculated that with an assumed soil adherence of 3.5 mg/cm^2 to the surface of the hands, an adult would ingest (presumably by licking or mouthing) half of the soil present on the inside of the surfaces of the thumb and fingers of both hands twice daily. However, it is noteworthy that if the EPA recommended upper bound soil adherence value is used (1 mg/cm^2; as cited in USEPA, 1992c) is substituted into Hawley's equation, a soil ingestion rate of 137 mg/day is calculated. Thus, the 480 mg/day soil ingestion rate that the USEPA states "may be used" is unsupported by any empirical observation or study and is likely to overestimate soil ingestion in a utility worker.

Uncertainties associated with dermal exposure estimates for chemicals in soil are primarily associated with the lack of chemical-specific data concerning the rate or amount of chemical which is absorbed through the skin. The fractions of dermal absorption of chemicals from soil were 0.10 for 1,2-dibromoethane, 0.15 for PNAs, and 0.10 for petroleum hydrocarbons as presented in the California Preliminary Endangerment Assessment Manual (DTSC, 1994).

In addition, the amount of soil adhering to the skin is an important but somewhat uncertain factor in estimating the amount of a chemical that will be absorbed through the skin. This report uses the USEPA recommended upper bound value of 1 mg/ cm^2 as a soil adherence value for a child at play and a utility worker. It should be noted that these values are derived from studies that examined the adherence of soil to the hands and for this reason, the selected soil adherence values probably overestimate adherence of soil to skin for other areas of the body. For example, EPA states that:

> "However, these studies [Que Hee et al. (1989) and Driver et al. (1989)] were conducted under laboratory conditions and examined adherence to hands only after intimate contact with soil. <u>Such contact may not be representative of normal behavior. Parts of the body that have less intimate contact with the soil will likely have lower values.</u>" [Emphasis added]
>
> and
>
> "Thus, the lower end of this range (0.2) may be the best value to represent an average over all exposed skin and 1 mg may be a reasonable upper value."
> (pages 8-16 and 8-17, USEPA, 1992d)

It is also noteworthy that the DTSC has used a soil adherence factor of 0.5 mg/cm^2 when assessing exposure to DDT in soil (DTSC, 1992). Thus, the soil adherence values selected are reasonably conservative estimates of soil exposure for the child at play and the utility worker.

Estimation Of Chemical Release From Soil And Ground Water

Chemicals of concern with low volatility (PNAs and petroleum hydrocarbons) were assessed by assuming that the dust concentration in air was 0.05 mg/m^3 for the child at play and 1 mg/m^3 for the utility worker. The 0.05 mg/m^3 level is the same value assumed for use in the California Preliminary Endangerment Assessment Guidance Manual. The 1 mg/m^3 dust concentration assumed for the utility worker is intended to account for increased dust concentrations associated with excavation of soil. These values are reasonably conservative given previous observations of dust concentrations around construction areas.

For example, dust concentrations measured in a general construction area ranged from 0.094 mg/m^3 to 0.593 mg/ m^3 with a median concentration of 0.280 mg/ m^3 (Cowherd et al., 1974). Thus, a 1 mg/m^3 airborne dust concentration is likely to represent the upper bound of conditions likely to exist at a construction site.

Additionally, all dust particles present in air were assumed to be respirable and that all dust in air was assumed to be made up of site soil. It was also assumed that the wind blows in the direction of the receptors 100% of the time. These assumptions would also tend to result in overestimation of chemical exposure from inhalation of particulates.

The risk assessment for the I-880 Corridor site also conservatively assumes that chemical concentrations in soil and shallow ground water will remain constant over the exposure periods considered. Further, soils and shallow ground water were assumed to be affected by the maximum concentrations or 95% UCL concentrations of the chemicals of concern. The use of these assumptions leads to the overestimation of exposures to chemicals detected in soil and shallow ground water.

5.4.2 Uncertainties Related to Estimation of Risk

Uncertainties associated with characterization of risks associated with the chemicals of concern primarily relate to the characterization of carcinogenic risk. While assessment of risk from petroleum hydrocarbons may also be considered somewhat uncertain, these uncertainties are conservatively addressed using the ASTM, API, and MDEP methods described in Section 4.4 of this report.

Perhaps the greatest uncertainty associated with the risk assessment process is the evaluation of carcinogenic risk due to chemical exposure. The fundamental principles underlying risk assessment for carcinogenic chemicals remain arguable, including the tenet that every potential carcinogen is associated with some degree of carcinogenic risk, no matter how small the dose. The belief that chemically induced cancer is a non-threshold process is a conservative default policy which the EPA assumes to ensure the protection of human health. However, there is little biological basis to support the widespread application of this policy to all potential carcinogens.

The EPA default policy for potential chemical carcinogens mandates that results from high-dose animal studies be extrapolated to exposures in humans which are thousands of times lower. The EPA uses a mathematical model known as the linearized multistage model to extrapolate from high doses to very low doses. As applied by the EPA, the linearized multistage model leads to quantitative estimates of cancer risk which are conservative, upper bound approximations of lifetime cancer risk. The EPA expressed the following uncertainty in using the linearized multistage model to determine carcinogenic risks in humans:

> *"It should be emphasized that the linearized multistage procedure leads to a plausible upper limit to the risk that is consistent with some proposed mechanisms of carcinogenesis. Such an estimate, however, does not necessarily give a realistic prediction of the risk. The true value of risk is unknown, and may be as low as zero. The range of risks, defined by the upper limit given by the chosen model and the lower limit which may be stated as low as zero, should be explicitly stated." (51 Federal Register 33998)*

Thus, according to the EPA commentary cited above, carcinogenic risks estimated using the linearized multistage procedure lead to conservative but not necessarily realistic estimates of risk. The National Research Council has also commented concerning use of the linearized multistage model, stating:

> *"The linearized multistage model is widely used to estimate cancer risks associated with environmental exposures (EPA, 1987) and is said to provide an upper-limit estimate of low-dose response. To some degree, the model's wide use reflects its mathematical flexibility.* ***However, biologic support for the assumption of linearity at low doses remains largely inferential and probably wrong in a high proportion of cases*** *(emphasis added) (Bailar et al., 1988). (NRC, 1989)*

For these reasons, it is likely that the risks calculated in this report will substantially overestimate the actual risks which may be associated with exposure to the chemicals of concern in soil and shallow ground water. As discussed in Section 4.2 of this report, proposed USEPA carcinogenic risk assessment guidance indicates that carcinogenic potencies for non-genotoxic carcinogens may be considerably overestimated by current cancer risk assessment methods.

Table 5-1
Child at Play-Elevated Sections
Noncarcinogenic and Carcinogenic Risks Associated with Exposure to Chemicals in Surface Soils

Chemical	Chronic Hazard Quotient			Lifetime Cancer Risks		
	Ingestion	Dermal	Inhalation	Ingestion	Dermal	Inhalation
Polynuclear aromatic hydrocarbons						
Benzo(a)anthracene	-	-	-	4.30E-09	2.13E-08	3.50E-12
Benzo[a]pyrene	-	-	-	1.45E-07	7.19E-07	1.18E-10
Benzo[b]fluoranthene	-	-	-	2.10E-08	1.04E-07	1.70E-11
Benzo[g,h,i]perylene	-	-	-	na	na	na
Benzo[k]fluoranthene	-	-	-	3.77E-09	1.86E-08	3.06E-12
Chrysene	-	-	-	8.07E-10	3.99E-09	6.56E-13
Indeno[1,2,3-cd]pyrene	-	-	-	5.11E-08	2.53E-07	4.15E-11
Petroleum hydrocarbons						
TPH-Diesel*	2.70E-05	8.92E-05	6.76E-08	na	na	na
TPH-Gasoline*	3.98E-06	1.31E-05	9.96E-09	na	na	na
TPH-Motor oil/Journal box oil*	5.08E-03	1.68E-02	1.27E-05	na	na	na
Metals						
Lead		see Attachment D			see Attachment D	
Pathway Risk	5.1 E-03	1.7 E-02	1.3 E-05	2.3 E-07	1.1 E-06	1.8 E-10
Risk for All Pathways		2.2 E-02			1 E-06	

(-) Hazard quotient could not be calculated due to lack of a reference dose

*There is no USEPA reference dose for petroleum hydrocarbons. The reference dose used is from Massachussetts Dept. of Environmental Protection

na - not applicable; chemical is not a potential carcinogen

Table 5-2
Utility Worker-Elevated Sections
Noncarcinogenic and Carcinogenic Risks Associated with Exposure to Chemicals in Surface and Subsurface Soils

Chemical	Subchronic Hazard Quotient			Lifetime Cancer Risks		
	Ingestion	Dermal	Inhalation	Ingestion	Dermal	Inhalation
Volatile organic chemicals						
Ethylene dibromide	-	-	7.17E-03	1.68E-10	2.03E-10	5.86E-09
Polynuclear aromatic hydrocarbons						
Benzo(a)anthracene	-	-	-	3.09E-09	5.60E-09	4.19E-11
Benzo[a]pyrene	-	-	-	1.04E-07	1.89E-07	1.41E-09
Benzo[b]fluoranthene	-	-	-	1.51E-08	2.73E-08	2.04E-10
Benzo[g,h,i]perylene	-	-	-	na	na	na
Benzo[k]fluoranthene	-	-	-	2.71E-09	4.90E-09	3.66E-11
Chrysene	-	-	-	5.80E-10	1.05E-09	7.85E-12
Indeno[1,2,3-cd]pyrene	-	-	-	3.67E-08	6.65E-08	4.97E-10
Naphthalene	1.38E-04	2.50E-04	-	na	na	na
Petroleum hydrocarbons						
TPH-Diesel*	2.97E-05	3.59E-05	1.24E-06	na	na	na
TPH-Gasoline*	4.00E-06	4.84E-06	1.67E-07	na	na	na
TPH-Motor oil/Journal box oil*	6.06E-03	7.32E-03	2.52E-04	na	na	na
Metals						
Lead	see Attachment D			see Attachment D		
Pathway Risk	6.2 E-03	7.6 E-03	7.4 E-03	1.6 E-07	2.9 E-07	8.1 E-09
Risk for All Pathways	2.1 E-02			5 E-07		

(-) Hazard quotient could not be calculated due to lack of a reference dose

*There is no USEPA reference dose for petroleum hydrocarbons. The reference dose used is from Massachussetts Dept. of Environmental Protection

na - not applicable; chemical is not a potential carcinogen

Table 5-3
Utility Worker-At-Grade Section
Noncarcinogenic and Carcinogenic Risks Associated with Exposure to Chemicals in Surface and Subsurface Soils

Chemical	Subchronic Hazard Quotient			Lifetime Cancer Risks		
	Ingestion	Dermal	Inhalation	Ingestion	Dermal	Inhalation
Polynuclear aromatic hydrocarbons						
Benzo(a)anthracene	-	-	-	7.21E-09	1.31E-08	9.76E-11
Benzo[a]pyrene	-	-	-	7.72E-08	1.40E-07	1.05E-09
Benzo[b]fluoranthene	-	-	-	3.88E-09	7.02E-09	5.25E-11
Benzo[g,h,i]perylene	-	-	-	na	na	na
Benzo[k]fluoranthene	-	-	-	2.48E-09	4.49E-09	3.35E-11
Chrysene	-	-	-	1.92E-09	3.47E-09	2.59E-11
Dibenz[a,h]anthracene	-	-	-	5.48E-08	9.93E-08	2.28E-09
Indeno[1,2,3-cd]pyrene	-	-	-	6.33E-09	1.15E-08	8.58E-11
Petroleum hydrocarbons						
TPH-Diesel*	2.08E-04	2.51E-04	8.66E-06	na	na	na
Journal box oil*	3.05E-03	3.68E-03	1.27E-04	na	na	na
Metals						
Lead	see Attachment D			see Attachment D		
Pathway Risk	3.3 E-03	3.9 E-03	1.4 E-04	1.5 E-07	2.8 E-07	3.6 E-09
Risk for All Pathways	7.3 E-03			4 E-07		

(-) Hazard quotient could not be calculated due to lack of a reference dose

*There is no USEPA reference dose for petroleum hydrocarbons. The reference dose used is from Massachussetts Dept. of Environmental Protection

na - not applicable; chemical is not a potential carcinogen

Table 5-4
Child at Play
Noncarcinogenic and Carcinogenic Risks Associated with Inhalation of Chemicals Volatilizing from Shallow Groundwater through Soil
Elevated Sections

Chemical	Inhalation Hazard Quotient	Lifetime Cancer Risk
Volatile organic chemicals		
Butylbenzene (sec)	-	na
Butylbenzene (tert)	-	na
1,2-Dibromo-3-chloropropane (DBCP)	2.6E-05	1.06E-09
1,2-Dibromoethane (EDB)	3.9E-04	5.57E-10
1,2-Dichlorobenzene	2.1E-06	na
1,4-Dichlorobenzene	8.3E-08	6.61E-11
1,2-Dichloroethane	-	7.02E-11
Ethylbenzene	1.1E-07	na
Isopropylbenzene	1.8E-03	na
n-Propyl benzene	-	na
Styrene	1.6E-07	na
Toluene	6.3E-07	na
1,2,4-Trichlorobenzene	7.4E-07	na
1,2,4-Trimethylbenzene	-	na
1,3,5-Trimethylbenzene	-	na
Xylene (m & p)	-	na
Xylene (o)	-	na
Polynuclear aromatic hydrocarbons		
Acenaphthene	-	na
Naphthalene	-	na
Phenanthrene	-	na
Total Inhalation Risk	**2.2E-03**	**2E-09**

(-) Hazard quotient could not be calculated due to lack of a reference dose

na- not applicable; chemical is not considered to be a potential carcinogen

Table 5-5
Utility Worker
Noncarcinogenic and Carcinogenic Risks Associated with Inhalation
Inhalation of Chemicals Volatilizing from Shallow Groundwater in Trenches- Elevated Sections

Chemical	Inhalation Hazard Quotient	Lifetime Cancer Risk
Volatile organic chemicals		
Butylbenzene (sec)	-	na
Butylbenzene (tert)	-	na
1,2-Dibromo-3-chloropropane (DBCP)	1.5E-02	8.70E-08
1,2-Dibromoethane (EDB)	1.5E-01	3.11E-08
1,2-Dichlorobenzene	5.9E-04	na
1,4-Dichlorobenzene	2.1E-05	2.36E-09
1,2-Dichloroethane	-	2.95E-09
Ethylbenzene	1.4E-05	na
Isopropylbenzene	1.6E-01	na
n-Propyl benzene	-	na
Styrene	1.3E-05	na
Toluene	9.4E-05	na
1,2,4-Trichlorobenzene	2.2E-04	na
1,2,4-Trimethylbenzene	-	na
1,3,5-Trimethylbenzene	-	na
Xylene (m & p)	-	na
Xylene (o)	-	na
Polynuclear aromatic hydrocarbons		
Acenaphthene	-	na
Naphthalene	-	na
Phenanthrene	-	na
Total Inhalation Risk	**3.3E-01**	**1E-07**

(-) Hazard quotient could not be calculated due to lack of a reference dose

na - not applicable; chemical is not considered to be a potential carcinogen

Table 5-6
Utility Worker
Noncarcinogenic and Carcinogenic Risks Associated with Inhalation of Chemicals Volatilizing from Shallow Groundwater in Trenches
At-Grade

Chemical	Inhalation Hazard Quotient	Lifetime Cancer Risk
Volatile organic chemicals		
Acetone	-	na
Benzene	-	4.21E-10
1,1-Dichloroethane	4.7E-05	3.84E-10
1,1-Dichloroethene	-	na
cis-1,2-Dichloroethene	-	na
Ethylbenzene	5.2E-07	na
Tetrachloroethylene	-	3.23E-09
Toluene	1.1E-06	na
1,1,1-Trichloroethane	-	na
Trichloroethene	-	3.37E-09
Vinyl chloride	-	2.56E-08
Xylenes	-	na
Polynuclear aromatic hydrocarbons		
Acenaphthylene	-	-
Naphthalene	na	na
Phenanthrene	-	na
Total Inhalation Risk	**4.9E-05**	**3E-08**

(-) Hazard quotient could not be calculated due to lack of a reference dose

na - not applicable; chemical is not considered to be a potential carcinogen

Table 5-7 Comparison to ASTM Risk Based Screening Levels-
Elevated Sections Surface and Subsurface Soils

Chemical	Maximum Detected Soil Concentration (mg/kg)	ASTM Surficial Soil (0-3') Concentration Residential Ingestion/Dermal/ Inhalation mg/kg	*ASTM Adjusted Values mg/kg	Does the Maximum Detected Soil Concentration Exceed the ASTM Residential RBSL?
Volatile organic chemicals				
Benzene	1.80E-02	5.81E+00	1.69E+00	no
Ethylbenzene	3.30E-02	7.83E+03	-	no
Toluene	3.70E-01	1.33E+04	-	no
Xylenes (total)	2.80E-02	1.45E+05	-	no
Polynuclear aromatic hydrocarbons				
Benzo(a)anthracene	1.60E-01	-	7.91E-01	no
Benzo(a)pyrene	5.40E-01	1.30E-01	7.91E-02	••Yes••
Benzo(b)fluoranthene	7.80E-01	-	7.91E-01	no
Benzo(g,h,i)perylene	2.50E+00	-	-	na
Benzo(k)fluoranthene	1.40E-01	-	7.91E-01	no
Chrysene	3.00E-01	-	7.91E+00	no
Indeno(1,2,3-cd)pyrene	1.90E+00	-	7.91E-01	••Yes••
Naphthalene	4.90E+00	9.77E+02	-	no

Table 5-8 *Comparison to ASTM Risk Based* Screening Levels-
At Grade Section Surface and Subsurface Soils

Chemical	Maximum Detected Soil Concentration (mg/kg)	ASTM Surficial Soil (0-3') Concentration Residential Ingestion/Dermal/ Inhalation mg/kg	*ASTM Adjusted Values mg/kg	Does the Maximum Detected Soil Concentration Exceed the ASTM Residential RBSL?
Volatile organic chemicals				
Toluene	3.00E-03	1.33E+04	-	no
Polynuclear aromatic hydrocarbons				
Benzo(a)anthracene	1.10E+00	-	7.91E-01	••Yes••
Benzo(a)pyrene	2.00E+00	1.30E-01	7.91E-02	••Yes••
Benzo(b)fluoranthene	1.30E+00	-	7.91E-01	••Yes••
Benzo(g,h,i)perylene	1.00E+00	-	-	no
Benzo(k)fluoranthene	7.40E-01	-	7.91E-01	no
Chrysene	4.40E+00	-	7.91E+00	no
Dibenz(a,h)anthracene	8.30E-01		7.30E-02	••Yes••
Indeno(1,2,3-cd)pyrene	1.40E+00	-	7.91E-01	••Yes••

*ASTM risk-based screening levels were calculated using DTSC slope factors

(-) no risk based screening level available

Table 5-9
Comparison of ASTM Tier 1 Risk-Based Screening Levels to Maximum Detected Concentrations of Petroleum Hydrocarbon Indicator Chemicals in Elevated Sections Shallow Ground Water

Chemical	Maximum Detected Concentration In Ground Water mg/L	ASTM Ground water Volatilization to Outdoor Air mg/L	*ASTM Adjusted Values mg/L
Volatile organic chemicals			
Benzene	6.00E-02	1.10E+01	3.19E+00
Ethylbenzene	1.80E-01	**1.52E+02	-
Toluene	8.90E+00	**5.35E+02	-
Xylenes	1.10E+00	**1.98E+02	-
Polynuclear aromatic hydrocarbons			
Naphthalene	1.70E-01	**3.10E+02	-

Table 5-10
Comparison of ASTM Tier 1 Risk-Based Screening Levels to Maximum Detected Concentrations of Petroleum Hydrocarbon Indicator Chemicals in At-Grade Section Shallow Ground Water

Chemical	Maximum Detected Concentration In Ground Water mg/L	ASTM Ground water Volatilization to Outdoor Air mg/L	*ASTM Adjusted Values mg/L
Volatile organic chemicals			
Benzene	2.00E-03	1.10E+01	3.19E+00
Ethylbenzene	1.00E-03	**1.52E+02	-
Toluene	8.00E-04	**5.35E+02	-
Xylenes	3.20E-03	**1.98E+02	-
Polynuclear aromatic hydrocarbons			
Benzo(a)pyrene	3.30E-04	**6.1E+00	-
Indeno(1,2,3-cd)pyrene	3.10E-04	**6.2E-02	-
Naphthalene	2.20E-03	**3.10E+02	-

*ASTM risk-based screening levels were calculated using DTSC slope factors

(-) no risk-based screening level available

**Calculated screening level exceeds solubility limit in water; water solubility limit is listed.

Table 5-11
API DSS Model Risk Calculations
Child at Play--Elevated Sections
Noncarcinogenic and Carcinogenic Risks Associated with Exposure to Chemicals in Surface Soils

	Hazard Quotient			Lifetime Cancer Risks		
Chemical	Ingestion	Dermal	Inhalation	Ingestion	Dermal	Inhalation
Volatile organic chemicals						
Benzene	-	-	-	2.91E-11	9.62E-11	3.53E-10
Toluene	4.15E-07	1.37E-06	1.98E-05	na	na	na
Xylene	2.47E-09	8.14E-09	2.99E-07	na	na	na
Polynuclear aromatic hydrocarbons						
Benz(a)anthracene				4.30E-09	2.13E-08	1.06E-11
Benzo(a)pyrene	-	-	-	1.45E-07	7.19E-07	5.36E-11
Benzo(b)fluoranthene	-	-	-	2.10E-08	1.04E-07	1.07E-10
Benzo(g,h,i)perylene	-	-	-	3.98E-09	1.97E-08	3.39E-13
Chrysene	-	-	-	8.07E-10	3.99E-09	4.68E-12
Pathway Risk	**4.2 E-07**	**1.4 E-06**	**2.0 E-05**	**1.75E-07**	**8.68E-07**	**5.29E-10**
Risk for All Pathways		**2.2 E-05**			**1 E-06**	

(-) Hazard quotient could not be calculated due to lack of a reference dose

na - not applicable; chemical is not a potential carcinogen

Table 5-12
API DSS Model Risk Calculations
Utility Worker-Elevated Sections
Noncarcinogenic and Carcinogenic Risks Associated with Exposure to Chemicals in Surface and Subsurface Soils

	Hazard Quotient			Lifetime Cancer Risks		
Chemical	Ingestion	Dermal	Inhalation	Ingestion	Dermal	Inhalation
Volatile organic chemicals						
Benzene	-	-	-	6.07E-11	7.34E-11	3.23E-10
Ethylbenzene	1.01E-04	1.23E-04	1.57E-04	na	na	na
1,2-Dibromoethane	-	-	-	1.62E-09	1.96E-09	1.14E-09
1,2-Dichloroethene	-	-	-	2.25E-10	2.72E-10	2.27E-09
Toluene	2.20E-03	2.66E-03	2.05E-02	na	na	na
Xylenes	6.20E-05	3.75E-05	1.65E-03	na	na	na
Polynuclear aromatic hydrocarbons						
Benzo(a)pyrene	-	-	-	1.19E-08	2.16E-08	8.37E-13
Benzo(b)fluoranthene	-	-	-	2.18E-09	3.95E-09	2.10E-12
Benzo(g,h,i)perylene	-	-	-	1.37E-09	2.49E-09	5.13E-14
Benzo(k)fluoranthene	nc	nc	nc	nc	nc	nc
Dibenz(a,h)anthracene	-	-	-	5.75E-08	1.04E-07	1.75E-12
Fluoranthene	nc	nc	nc	na	na	na
Indeno(1,2,3-c,d)pyrene	nc	nc	nc	nc	nc	nc
Naphthalene	1.41E-04	2.55E-04	-	na	na	na
Phenanthrene	-	-	-	na	na	na
Pathway Risk	**2.5 E-03**	**3.1 E-03**	**2.2 E-02**	**7.49E-08**	**1.34E-07**	**3.74E-09**
Risk for All Pathways		**2.8 E-02**			**2 E-07**	

(-) Hazard quotient could not be calculated due to lack of a reference dose

na - not applicable; chemical is not a potential carcinogen

nc - not calculated; the API DSS Model does not include the chemical as an indicator chemical

Table 5-13
API DSS Model Risk Calculations
Utility Worker-At-Grade Section
Noncarcinogenic and Carcinogenic Risks Associated with Exposure to Chemicals in Surface and Subsurface Soils

	Hazard Quotient			Lifetime Cancer Risks		
Chemical	Ingestion	Dermal	Inhalation	Ingestion	Dermal	Inhalation
Volatile organic chemicals						
Benzene	-	-	-	6.07E-11	7.34E-11	3.23E-10
Ethylbenzene	1.01E-04	1.23E-04	1.57E-04	na	na	na
Toluene	2.20E-03	2.66E-03	2.05E-02	na	na	na
Xylenes	6.20E-05	3.75E-05	1.65E-03	na	na	na
Polynuclear aromatic hydrocarbons						
Benzo(a)anthracene	-	-	-	2.13E-08	3.85E-08	6.30E-11
Benzo(a)pyrene	-	-	-	3.86E-07	7.00E-07	3.86E-10
Benzo(b)fluoranthene	-	-	-	2.51E-08	4.55E-08	3.47E-10
Benzo(g,h,i)perylene	-	-	-	1.14E-09	2.07E-09	2.63E-13
Benzo(k)fluoranthene	-	-	-	nc	nc	nc
Chrysene	-	-	-	8.50E-09	1.54E-08	5.00E-11
Dibenz(a,h)anthracene	nc	nc	nc	5.48E-08	9.93E-08	7.29E-11
Indeno(1,2,3-cd)pyrene				nc	nc	nc
Pathway Risk	**2.4 E-03**	**2.8 E-03**	**2.2 E-02**	**4.97E-07**	**9.01E-07**	**1.24E-09**
Risk for All Pathways		**2.7 E-02**			**1 E-06**	

(-) Hazard quotient could not be calculated due to lack of a reference dose

na - not applicable; chemical is not a potential carcinogen

nc - not calculated; the API DSS Model does not include the chemical as an indicator chemical

Table 5-14
Child at Play-Elevated Sections
MDEP Noncarcinogenic Risks Associated with Exposure to Petroleum Hydrocarbons in Surface Soil

Petroleum hydrocarbons	Chronic Hazard Quotient		
	Ingestion	Dermal	Inhalation
TPH-Diesel*	7.47E-05	2.47E-04	1.87E-07
TPH-Gasoline*	3.98E-06	1.31E-05	9.96E-09
TPH-Motor oil/Journal box oil*	5.08E-03	1.68E-02	1.27E-05
Pathway Risk	**5.2 E-03**	**1.7 E-02**	**1.3 E-05**
Risk for All Pathways	**2.2 E-02**		

Table 5-15
Utility Worker-Elevated Sections
MDEP Noncarcinogenic Risks Associated with Exposure to Petroleum Hydrocarbons in Surface and Subsurface Soils

Petroleum hydrocarbons	Subchronic Hazard Quotient		
	Ingestion	Dermal	Inhalation
TPH-Diesel*	4.13E-04	4.99E-04	1.72E-05
TPH-Gasoline*	7.51E-04	9.08E-04	3.13E-05
TPH-Motor oil*	6.06E-03	7.32E-03	2.53E-04
Pathway Risk	**7.2 E-03**	**8.7 E-03**	**3.0 E-04**
Risk for All Pathways	**1.6 E-02**		

Table 5-16
Utility Worker-At-Grade Sections
MDEP Noncarcinogenic Risks Associated with Exposure to Petroleum Hydrocarbons in Surface and Subsurface Soils

Petroleum hydrocarbons	Subchronic Hazard Quotient		
	Ingestion	Dermal	Inhalation
TPH-Diesel*	2.08E-04	2.51E-04	8.66E-06
TPH-Motor oil*	3.05E-03	3.68E-03	1.27E-04
Pathway Risk	**3.3 E-03**	**3.9 E-03**	**1.4 E-04**
Risk for All Pathways	**7.3 E-03**		

*There is no USEPA reference dose for petroleum hydrocarbons. The reference dose used is from Massachussetts Dept. of Environmental Protection

6.0 SUMMARY AND CONCLUSIONS

The objectives of the risk assessment for the I-880 Corridor site were to evaluate possible human health risks that may be associated with chemicals detected in soil and shallow ground water after the new I-880 freeway is constructed. Soil and ground water in elevated areas of the future I-880 Corridor ("Elevated Sections") were given separate consideration from the at grade section ("At Grade Section") because of the different potential for human exposures to chemicals in soil and ground water in these areas. The Elevated Sections of the freeway (North and South Elevated Sections) are separated by an At Grade Section of the freeway.

Chemicals of concern in soils of the Elevated and At Grade Sections of the I-880 Corridor site were conservatively selected by comparison of the maximum detected concentration of each chemical to USEPA Region IX residential PRGs. Surface soil (0 to 1 foot depths) and surface/subsurface soils (0 to 5 feet depths) were given separate consideration due to differences in the potential for human contact with surface and subsurface soils. Maximum detected soil concentrations of the following chemicals in I-880 Corridor soils exceeded their respective residential PRG concentrations:

Chemicals of Concern-Elevated Section Soils

Volatile organic chemicals	**Polynuclear aromatic hydrocarbons**	**Metals**
1,2-Dibromoethane (subsurface soils only)	Benzo(a)pyrene	Lead
	Benzo(b)fluoranthene	
	Indeno(1,2,3-cd)pyrene	

Chemicals of Concern-At Grade Section Soils

Polynuclear aromatic hydrocarbons	**Metals**
Benzo(a)anthracene	Lead
Benzo(a)pyrene	
Benzo(b)fluoranthene	
Dibenz(a,h)anthracene	
Indeno(1,2,3-cd)pyrene	

In addition to the above chemicals that exceeded residential PRGs, TPH detected in soil and characterized as gasoline (low boiling hydrocarbon fraction similar to gasoline; TPH-gasoline), diesel fuel (mid-boiling hydrocarbon fraction similar to diesel; TPH-diesel), and motor oil or journal box oil (high-boiling hydrocarbon fraction similar to motor oil or journal box oil; TPH-motor oil or journal box oil) were identified for further evaluation in the risk assessment.

Shallow ground water at the I-880 Corridor site is not likely potable. Thus, ingestion of chemicals detected in ground water was not evaluated. However, volatilization of chemicals from shallow ground water was considered to be a possible route of exposure. Thus, all volatile chemicals (chemicals with Henry's Law constants of 1×10^{-5} or greater and a vapor pressure of 0.001 mm Hg or greater) were considered for further evaluation in the risk assessment.

Possible pathways of the human exposure to the chemicals of concern in soil and shallow ground water in the future I-880 Corridor were evaluated under conditions that will exist after the freeway is built. The Elevated Sections of the freeway were considered separately from the At Grade Section of the freeway since possible human exposure could occur to surface soils in the Elevated Sections. Casual human exposure to surface soil in the At Grade Section of the freeway will be prevented by pavement.

For Elevated Sections of the freeway, two possible receptors were identified that may be exposed to chemicals present in soil and shallow ground water. A child at play was considered to be potentially exposed to the chemicals of concern in Elevated Section surface soil (0-1' depth) via ingestion, skin contact, and inhalation of affected dusts and vapors. In addition, inhalation of the chemicals of concern volatilizing from shallow ground water through vadose zone soils was also assessed for a child at play in the Elevated Sections of the I-880 Corridor site. The child at play was assumed to be exposed to the chemicals of concern in surface soil and shallow ground water for 36 days per year for 7 years. In addition, a utility worker was also assumed to be exposed to the chemicals of concern in surface/subsurface soils (0-5') by the ingestion, skin contact, and inhalation routes of exposure in the Elevated Sections of the freeway. Due to the possibility that shallow ground water may pool in excavated trenches, utility worker inhalation of chemicals volatilizing from shallow ground water in the Elevated Sections was also assessed. The utility worker was assumed to be exposed to the chemicals of concern in soil and shallow ground water for 60 days (5 days per week for 12 weeks).

Secondly, utility worker exposure to the chemicals of concern in surface/subsurface soils in the At Grade Section of the I-880 Corridor site by the ingestion, skin contact, and inhalation routes of exposure were also assessed. Utility workers were assumed to have contact with surface/subsurface soils in the At Grade Section as a result of road repair, excavation of utility trenches, or from other ground intrusive activities. Like the utility worker in the Elevated Sections of the freeway, the utility worker in the At Grade Section was assumed to inhale chemicals volatilizing from shallow ground water. Like the utility worker in the Elevated Section exposure scenario, the utility worker in the At Grade Section was assumed to be exposed to soil and shallow ground water for 60 days.

The child at play and the utility worker were assumed to be exposed to the chemicals of concern in soils and shallow ground water in the absence of any measures designed to protect against exposure (such as paving to prevent contact with soil or the use of respirators or protective clothing by utility workers).

Conservative DTSC and USEPA exposure assumptions were used to assess a child's and utility worker's exposure to the chemicals of concern in soil and shallow ground water. The 95% upper confidence limit (UCL) on the arithmetic mean concentration was used as the exposure point concentration for chemicals in soil in the Elevated and At Grade Sections. Because the Elevated Sections are separated into North and South Sections, the higher of the 95% UCLs calculated for the North and South Sections was used as the exposure point concentration for Elevated Section soils. Maximum detected concentrations of the volatile chemicals of concern in shallow ground water were used to assess exposure and risk for the child at play and the utility worker.

USEPA reference doses and DTSC and USEPA slope factors were used to assess potential noncarcinogenic and carcinogenic effects associated with chemical exposure.

Calculated noncancer and theoretical lifetime cancer risks associated with exposure to the chemicals of concern in soil and shallow ground water at the I-880 Corridor site are summarized in Table 6-1. As determined by calculating hazard indices and theoretical lifetime cancer risks, a child at play and a utility worker are unlikely to experience noncarcinogenic adverse health effects or theoretical lifetime cancer risks greater than one in one million (1E-06) from inhalation, ingestion, or dermal contact with Elevated Section or At Grade Section soils or inhalation of chemicals volatilizing from shallow ground water in Elevated or At Grade Sections.

Elevated Section Soil

Even when hazard indices for the ingestion, skin contact, and inhalation pathways are combined, the overall hazard indices for the child (0.022) and utility worker (0.021) assumed to be exposed to Elevated Section soils were less than or equal to 1, indicating that soil exposure is unlikely to be associated with noncarcinogenic adverse health effects.

Calculated carcinogenic risks for the child at play and the utility worker exposed to Elevated Section soils were at or below 1 E-06 (one in one million). The 1E-06 theoretical lifetime cancer risk is the most conservative of the 1E-04 (one in ten thousand) to 1E-06 range of risks considered by the USEPA to be safe and protective of public health. The overall theoretical lifetime cancer risk calculated for the child at play exposed to the chemicals of concern in surface soil was 1 E-06 for the ingestion, skin contact, and inhalation routes of exposure. Ingestion, skin contact, and inhalation of soils containing the maximum detected concentration of benzo(a)pyrene (0.54 mg/kg) accounted for 85% of theoretical lifetime cancer risk for the child at play.

Calculated theoretical lifetime cancer risks for the utility worker exposed to Elevated Sections soils was 5E-07. This risk is below even the most conservative of theoretical lifetime cancer risks considered by the USEPA to be safe and protective of public health.

At Grade Section Soil

Noncancer risk and theoretical lifetime cancer risk calculated for the utility worker exposed to At Grade Section soils were also acceptably low. The hazard index for ingestion, skin contact, and inhalation of At Grade soils was 0.0073. This value is well below the value of 1, indicating that a utility worker's exposure to the chemicals of concern in At Grade soils is unlikely to be associated with noncarcinogenic adverse health effects.

Calculated theoretical lifetime cancer risks for the utility worker exposed to At Grade Section soils was 4E-07. Like the theoretical lifetime cancer risk calculated for the utility worker exposed to Elevated Section soils, this risk is below the range of theoretical lifetime cancer risks considered by the USEPA to be safe and protective of public health (1E-04 to 1E-06).

Ground Water

Risks posed by volatile chemicals in shallow ground water in Elevated and At Grade Sections are also summarized in Table 6-1. Hazard indices calculated for the child at play in the Elevated Sections (0.0022) and utility worker in the Elevated Sections and At Grade Section (0.331 and 0.000049, respectively) were much lower than 1, indicating that adverse noncancer health effects would not result from exposure to these chemicals in shallow ground water. Theoretical lifetime cancer risks calculated for the child at play in the Elevated Sections (2E-09) and the utility worker in Elevated and At Grade Sections (1E-07 and 3E-08, respectively) were also below the most conservative of the range of theoretical lifetime cancer risks considered by the USEPA to be safe and protective of public health (1E-04 to 1E-06).

Lead in Soil

Risk posed by exposure to lead in soil was evaluated using the DTSC's lead exposure model. For the child at play, the higher of the 95% UCL on the arithmetic mean of the soil lead concentration of the North and South Elevated Sections (605 mg/kg; South Elevated Section) was used to perform the lead exposure calculation. Using the higher of the 95% UCL of the two sections was considered to be a more conservative approach to assessing risk to a child. The calculated blood lead concentrations associated with a child's exposure to 605 mg/kg lead in soil for 3 days per week were 3.4, 5.3, 6.0, 6.9, and 7.6 µg/dL for the 50th, 90th, 95th, 98th, and 99th percentile values, respectively. These concentrations are all below the DTSC's blood lead concentration of concern of 10 µg/dL, indicating that a child's exposure to surface soil in the Elevated Sections of the I-880 Corridor is unlikely to result in overexposure to lead.

Using the DTSC leadspread model, the calculated 50th, 90th, 95th, 98th, and 99th percentile blood lead concentrations for a utility worker exposed to surface and subsurface soils containing an average of 361 mg/kg lead (higher 95% UCL value for surface and subsurface soils from Elevated vs. At Grade Sections) were 2.6, 4.0, 4.5, 5.2 and 5.8 µg/dL, respectively. Based on these calculations, utility worker exposure to lead in surface and subsurface soils is unlikely to result in a blood lead concentration that would exceed 10 µg/dLor a blood lead standard (40 µg/dL) or health protection goal (30 µg/dL) in CCR Title 8 § 1532.1, the State of California Lead in Construction standard.

ASTM, API, and MDEP Methods for Evaluating Risk from Petroleum Hydrocarbons in Soil

There are no universally accepted procedures established for assessing the risks posed by petroleum hydrocarbons in soil or ground water. As recommended by DTSC, risks posed by petroleum hydrocarbon mixtures and indicator chemicals of petroleum hydrocarbons (such as benzene, ethylbenzene, toluene, xylenes, and PNAs) were assessed using three different methods. These methods are the American Society for Testing and Materials method (ASTM method), the American Petroleum Institute Risk/Exposure Assessment Decision Support System method (API DSS method), and the Massachusetts Department of Environmental Protection Development of a Health-Based Alternative to the Total Petroleum Hydrocarbon (TPH) Parameter method (MDEP method). The ASTM and API DSS method deal specifically with selected indicator chemicals of petroleum hydrocarbons. The MDEP method evaluates the risks posed by petroleum hydrocarbons by identifying a chemical surrogate for the different subfractions of petroleum hydrocarbons present in gasoline, diesel fuel, and oil (motor oil and journal box oil).

The ASTM has calculated risk-based soil screening levels for benzene, ethylbenzene, toluene, xylenes, and the PNAs benzo(a)pyrene and naphthalene in soil and ground water for residential exposure conditions. Because residential exposure conditions are generally recognized as providing the lowest risk-based soil and ground water concentrations for these indicator chemicals, comparison of maximum detected concentrations of these chemicals in soil and ground water at the I-880 site to the ASTM risk-based levels is highly conservative. The ASTM risk-based soil screening levels for benzene and benzo(a)pyrene were also recalculated to reflect DTSC slope factors. Further, risk-based values were also calculated for potentially carcinogenic PNAs other than benzo(a)pyrene.

The results of the comparison of maximum detected soil concentrations of indicator chemicals to ASTM residential screening level concentrations indicated that in Elevated Section soils, benzo(a)pyrene and indeno(1,2,3-cd) pyrene exceeded their respective residential soil screening levels. In At Grade Section soils, benzo(a)anthracene, benzo(a)pyrene benzo(b)fluoranthene, dibenz(a,h)anthracene and indeno(1,2,3-cd)pyrene exceeded their respective residential screening level concentration. No chemical detected in shallow ground water in either the Elevated or At Grade Sections exceeded the applicable ASTM residential risk-based screening level for indicator chemicals. As discussed in Section 5.3.1, although the maximum detected concentrations of some petroleum indicator chemicals in Elevated Sections soil and At Grade Section soil exceeded their respective ASTM residential risk-based screening levels, these chemicals were not expected to pose significant risk under I-880 Corridor site exposure conditions (i.e., recreational/industrial).

The API DSS model was used to assess the risks of chemicals in soil detected at the I-880 Corridor site that are considered indicator chemicals for petroleum hydrocarbon mixtures. Calculated overall hazard indices for exposure to these indicator chemicals in soils for the ingestion, skin contact, and inhalation routes of exposure were 0.000022 and 0.028 for the child and utility worker, respectively, in the Elevated Sections and 0.027 and for the utility worker in the At Grade Section. These hazard indices are well below 1, indicating that exposure to API DSS indicator chemicals at the I-880 Corridor site is unlikely to be associated with noncarcinogenic adverse health effects.

Theoretical lifetime cancer risks calculated for API DSS indicator chemicals were 1 E-06 and 2 E-07 for the child at play and the utility worker, respectively, in the Elevated Sections and 1E-06 for the utility worker in the At Grade Section. These risks are at or below the lower end of theoretical lifetime cancer risk range considered by the USEPA to be safe and protective of public health (1E-04 to 1E-06).

The MDEP method was used to evaluate possible health risks associated with exposure to TPH-gasoline, TPH-diesel, and TPH-motor oil concentrations detected in surface and subsurface soils for the child at play and the utility worker. In the absence of hydrocarbon analyses specified by the MDEP, certain assumptions must be made with regard to the types of hydrocarbons present in soils at the site in order to apply the MDEP method. For example, the reference dose established for the most toxic hydrocarbon fraction (0.03 mg/kg/day for the C9 to C32 aromatic/alkene fraction) was used to assess the risks posed by chronic exposure to TPH-gasoline, TPH-diesel, and TPH-motor oil in soil for the child at play.

Because exposure was assumed to occur over a subchronic period of time (less than 7 years), a subchronic reference dose of 0.3 mg/kg/day was used to assess the noncarcinogenic risks posed by petroleum hydrocarbons in soil for the utility worker.

Overall hazard indices calculated for the child at play and the utility worker in the Elevated Sections were 0.022 and 0.016, respectively, and for the utility worker in the At Grade Section was 0.0073. These hazard indices indicate that exposure to TPH-gasoline, TPH-diesel, TPH-motor oil, and journal box oil in soils is unlikely to be associated with noncarcinogenic adverse health effects, particularly since the maximum detected concentrations of these petroleum hydrocarbons were used in calculating exposures.

Summary

In summary, assessment of potential health risks resulting from exposure to chemicals in soil and shallow ground water at the I-880 Corridor site indicates that:

- A child at play and a utility worker exposed to chemicals in soil or shallow ground water is unlikely to experience noncarcinogenic adverse health effects as a result of calculated levels of exposure.

- Overall theoretical lifetime cancer risks associated with soil exposure at the I-880 site were 1 E-06 for the child at play and 5 E-07 for the utility worker in the Elevated Sections and 4 E-07 for the utility worker in the At Grade Section. These theoretical lifetime cancer risks are at or below the risk range considered by the USEPA to be safe and protective of public health (1E-04 to 1E-06). Theoretical lifetime cancer risks posed by calculated levels of exposure to chemicals detected in soils at the I-880 site are primarily associated with PNAs.

- Calculated blood lead concentrations for the child at play exposed to lead in surface soil are below the 10 µg/dL level of concern for children. For the unprotected utility worker exposed to lead in surface and subsurface soil, blood lead concentrations are unlikely to exceed the 10 µg/dL. This blood lead concentration is much less than the 30 µg/dL recommended limit and the blood lead concentrations of 40 to 49 µg/dL that trigger medical monitoring and employee notification in the California Title 8, § 1532 Lead in Construction standard.

- Exposure to petroleum hydrocarbons or indicator chemicals of petroleum hydrocarbons is unlikely to result in noncarcinogenic health effects or theoretical lifetime cancer risks above 1 E-06 for the child at play or the utility worker.

Table 6-1
Risk Summary Table

Potentially Exposed Population	Source and Route of Exposure	Risk Posed by Chemicals of Concern	
		Hazard Index	Theoretical lifetime Cancer Risk
Child at Play			
	Surface Soil-Elevated Sections		
	Incidental ingestion of surface soils	0.0051	2 E-07
	Dermal contact with surface soils	0.017	1 E-06
	Inhalation of chemicals volatilizing from soil and chemicals released from surface soil as fugitive dusts	0.000013	2 E-10
	Shallow Ground Water-Elevated Sections		
	Inhalation of chemicals volatilizing from shallow ground water through vadose zone soils	0.0022	2 E-09
Utility Worker	**Surface/Subsurface soil - Elevated Sections**		
	Incidental ingestion of site soils	0.0062	2 E-07
	Dermal contact with site soils	0.0076	3 E-07
	Inhalation of chemicals volatilizing from soil and chemicals released from soil as fugitive dusts	0.0074	8 E-09
	Soil - At Grade Section		
	Incidental ingestion of site soils	0.0033	2 E-07
	Dermal contact with site soils	0.0039	3 E-07
	Inhalation of chemicals volatilizing from soil and chemicals released from soil as fugitive dusts	0.00014	4 E-09
	Shallow Ground Water - Elevated Sections		
	Inhalation of chemicals volatilizing from shallow ground water through vadose zone soils	0.33	1 E-07
	Shallow Ground Water - At Grade Section		
	Inhalation of chemicals volatilizing from shallow ground water through vadose zone soils	4.9 E-05	4 E-08

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ATTACHMENT A
Clarification of Risk Assessment Responsibilities In Response to DTSC Comments

Southern Pacific Lines

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October 30, 1995

Ms. Lynn Nakashima
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Berkeley, CA. 94710

SUBJECT: Clarification of Risk Assessment Responsibilities In Response To DTSC Comments, Draft Remedial Investigation And Baseline Risk Assessment Report, Former Bobo's Junkyard Operable Unit, 1401 Third St, West Oakland, CA.

Dear Ms. Nakashima:

Please refer to the California Department of Toxic Substances Control (DTSC) letter dated September 28, 1995 containing comments to the Draft Remedial Investigation and Risk Assessment Report for the Former Bobo's Junkyard site. The first comment of the DTSC's letter requests clear documentation and supporting evidence demonstrating the division of responsibility between Caltrans and Southern Pacific regarding risk assessment functions. In particular, the DTSC requests clarification as to responsibility for any risk assessments required for the subject property before, during and after the freeway is constructed.

The purpose of this letter is to provide the requested documentation and associated explanation of the division of responsibility. It should be understood that there is no single document that addresses the specific subject of risk assessment responsibilities, however the attached Right of Possession and Use Agreement does contain language that delineates certain responsibilities concerning soils and groundwater contamination that may exist at the site. It should be further understood that SPTCo through the performance of an RI/FS has already assumed the responsibility of assessing risk posed by this site in its current state and for its future use as a freeway. Therefore, the only question to be answered is who is responsible for assessing the risk posed by actual construction of the freeway.

The key question that needs to be answered to determine who has the responsibility for assessing risks associated with freeway construction is who is responsible for actual <u>excavation</u> (emphasis added) of materials that may be contaminated. Review of the attached Right of Possession and Use Agreement defines this responsibility as Caltrans in Sections 1, 3 and 11.

In light of the above, and with respect to risk assessment responsibilities at Bobo's Junkyard, SPTCo has the responsibility for performing a risk assessment based on the RI data and establishing appropriate long term cleanup standards for the site for freeway use. If the risk assessment establishes that a cleanup at the site is required for freeway use, then SPTCo is required to remediate the site. The RI and risk assessment at Bobo's indicate that the site does not pose a risk in its current state or its future use as a freeway. The only risk that may exist would be associated with excavation activities for which Caltrans is responsible. Caltrans has accepted this responsibility and is currently performing the appropriate risk assessment.

Sincerely,

Greg Shepherd

paragraph 11 below) to be held in escrow pursuant to the Escrow Agreement (as defined below). Neither State, its contractors, agents, nor any other party shall take possession until and unless said sums are paid to Owner and Escrow Agent, and Owner shall retain the right of possession of the New Corridor until said sum is paid.

(b) In connection with the excavation work to be performed by State on the New Corridor, State will incur an additional out-of-pocket cost (which the parties have agree is $4.00 per cubic yard of soil excavated and refer to herein as "Additional Excavation Cost") for the excavation of certain portions of the New Corridor containing hazardous wastes and/or contaminated materials in excess of Legal Standards (as described more fully in subparagraph 11(a) below). The parties agree that $89,079.00 shall be retained by State from the amount of State's estimate of probable just compensation to reimburse State for its actual Additional Excavation Cost. The parties acknowledge that this retention amount is an estimate based on the anticipated volume of contaminated soil to be excavated of 22,270 cubic yards ("Estimated Volume"). The parties agree that (i) if the Estimated Volume exceeds the actual total volume of such contaminated excavated soil, upon completion of its excavation on the New Corridor, State will tender to Owner an amount equal to $4.00 times the amount of such excess volume, and (ii) if the actual total volume of contaminated excavated soil exceeds the Estimated Volume, Owner shall reimburse State in an amount equal to $4.00 times the amount of such excess volume upon delivery to Owner by State of its request for reimbursement and reasonable evidence of the actual volume of contaminated soil excavated.

In addition, the State will incur additional out-of-pocket costs for air monitoring equipment and a mobile laboratory used for environmental testing during its excavation and construction on the New Corridor. The parties agree that $221,110 shall be further retained by State from the amount of State's estimate of probable just compensation to pay for such equipment and laboratory. Owner shall not be obligated to reimburse State for any additional expenses related to air monitoring or laboratory expenses.

date hereof. Simultaneously with State's payments to Owner and Escrow Agent under paragraph 1 above, Owner will convey to State a deed of trust (the "State Deed of Trust") on the New Corridor, securing Owner's obligations to convey title to the New Corridor as described herein. The State Deed of Trust will create a first mortgage lien on the New Corridor subject only to real property taxes, assessments or liens, building and zoning regulations and those items listed in paragraph 13 below. Upon settlement or entry of a final order of condemnation as described in paragraph 6 below, the State Deed of Trust will be cancelled.

As a condition precedent to the State's obligation to make the payment under paragraph 1 hereof, Owner shall provide State with evidence reasonably satisfactory to State that Fidelity National Title Insurance Company has received from Bank of America duly executed partial reconveyances conveying title to the New Corridor to Owner ("Partial Reconveyances"), and that upon payment of $4,789,204.00 to Owner's account at Bank of America, Fidelity National Title Insurance Company will (a) record in the real property records of Alameda County, California the Partial Reconveyances, and a copy of this Agreement and, (b) issue a binder of title insurance to State in the amount of $26,368,616.00, which binder will show the lien of the State Deed of Trust and additionally any and all ownership interest eventually obtained by the State in the New Corridor subject to real property taxes, assessments or liens, building and zoning regulations and those items listed in paragraph 13 below, saving and excepting, however, the deeds of trust in favor of Bank of America National Trust and Savings Association and the Bankers Trust Mortgage. The State shall receive a credit against its estimate of probable just compensation paid hereunder to Owner equal to the cost of any endorsement to the title insurance policy necessary to insure over the Bankers Trust Mortgage.

5. Owner agrees to pay when due all taxes, including prorated taxes for the current year, and special assessments due on the date State takes possession of the New Corridor as provided for by §5086 of the California Revenue and Taxation Code. After such date, State shall be responsible for paying all taxes and assessments for the periods thereafter.

hereby waives its right to appear and be heard on the matters referred to in Section 1240.030 of the Code of Civil Procedure, as quoted above with respect to the New Corridor. Owner agrees that State can establish the truth of the above-quoted matters, and Owner will not contest the adoption of a resolution of necessity by the California Transportation Commission. Therefore, because Section 1245.250 of the Code of Civil Procedure states that the adoption of a resolution of necessity by the California Transportation Commission conclusively establishes the matters quoted above, it is understood that the issues which will be determined in any subsequent eminent domain proceeding will be limited to those of just compensation as they relate to the property covered by this Agreement and no issues will be raised therein or in preliminary proceedings thereto challenging the public use or necessity of the project, or the utilization therefor of the property covered by this Right of Entry.

8. Owner agrees that in the event the ultimate amount of any settlement, award, or verdict is less than the total of the sums paid by State to Owner under this Agreement, the Owner shall refund the difference including interest at the rate set forth in paragraph 10 to the State.

9. In the event State files an action in eminent domain it is understood and agreed that the payment by State of the above sum of $26,368,616.00, based on State's estimate of probable just compensation, shall be deemed to be a deposit, notice of deposit, and withdrawal of probable just compensation pursuant to Code of Civil Procedure §§1255.010, 1255.020, and 1255.260 for all purposes under eminent domain law.

10. In addition to the amount of compensation to be paid Owner as set forth in paragraph 1 above, whether it be determined by negotiation or court award, State shall pay to Owner interest on any additional amount of compensation for each Section over that received by Owner for such Section (as allocated to such Section under the State's estimate of probable just compensation) pursuant to paragraph 1 above, commencing upon the date Owner has delivered exclusive possession of such Section to State and terminating sixty (60) days after receipt by Owner of a mutually satisfactory right of way contract, or terminating on the date judgment is entered and the

parties hereto but does not create duties and obligations with respect to non-party governmental agencies over and above duties and obligations created under Federal, State and local laws.

The parties hereto acknowledge and agree that the process of pretesting, excavation, hauling and delivery to Owner for remediation of excavated hazardous wastes and/or contaminated materials will require the cooperation of both parties. Owner agrees to prepare and submit to State, for State's reasonable concurrence, within 45 days after the execution of this Agreement a proposed plan which will include among other things specific procedures and guidelines for pretesting, stock-piling, excavation, hauling and delivery (including allowances for Owner to seek appropriate governmental exemptions) of such wastes and materials. State shall have 30 days after receipt of such plan to review, comment on, request reasonable modifications to and concur with such plan. Such finalized plan shall govern the process of pretesting, excavation, hauling and delivery of such wastes and materials.

In connection with Owner's obligations hereunder, the sum of $2,112,407 shall be deducted from the amount due to Owner under paragraph 1 hereof and deposited with Fidelity National Title Insurance Company ("Escrow Agent") to be held in escrow pursuant to an Escrow Agreement in the form of Exhibit E (the "Escrow Agreement"). As Owner removes and/or remediates hazardous wastes and/or contaminated materials from the New Corridor hereunder, Owner may withdraw funds from such escrow to pay for or reimburse Owner for its out-of-pocket expenses incurred in removing and/or remediating such wastes and/or materials. In no event shall State be obligated to deposit any additional funds in escrow hereunder or reimburse Owner for any additional out-of-pocket expenses in connection with such remediation.

Except as set forth in subparagraph 11(b) hereof: (i) with respect to the portions of the New Corridor to be obtained by State in fee title, any and all liability, expenses and costs for remediating or removing hazardous wastes and/or contaminated materials in excess of the Legal Standards (in effect as of the date of excavation by State on the New Corridor and the date of remediation of such

State's obligation to remediate such contaminated groundwater is based upon the understanding that the New Corridor will be used for construction and operation of a transportation corridor and for no other purpose and State shall not be required to remediate such contaminated groundwater to levels below Legal Standards which are required for such use. Without limiting the generality of the foregoing, State shall not be required to remediate any contaminated groundwater under the New Corridor to Legal Standards required for its use by the public as a park or other recreation area or for use for residential or commercial purposes.

(c) Owner's obligation to remove and/or remediate hazardous wastes and/or contaminated materials from the New Corridor is based upon the understanding that the New Corridor will be used for the construction and operation of a transportation corridor and for no other purpose, and except as set forth below, Owner shall not be required to remove or remediate hazardous wastes and/or contaminated materials to levels below Legal Standards (in effect as of the applicable dates described in subparagraph 11(a) above) which are required for such use. Without limiting the generality of the foregoing and except as set forth in next sentence, Owner shall not be required to remediate any portion of the New Corridor to Legal Standards required for use by the public as a park or other recreation area or for use for residential or commercial purposes. Notwithstanding the foregoing, Owner shall be required to clean the sites listed on Exhibit D as required by the governmental agencies having jurisdiction over such sites (provided Owner shall have the right to contest such agencies' requirements and seek excemptions therefrom) as set forth in paragraph 11(a) above.

(d) Except for amounts to be retained by State as described in paragraph 1(b) above, Owner shall not be liable for (i) any environmental investigation or testing performed by State, or (ii) any delay charges or similar charges which may be incurred by State due to any contractor or subcontractor of State encountering any hazardous wastes and/or contaminated materials other than delays caused directly by Owner's default of, breach or failure to perform its obligations hereunder.

to vacate the applicable property, but only upon the express written request of State. The State hereby agrees to indemnify, defend and hold Owner harmless from any liability, costs, expenses and damages whatsoever that Owner may incur or be subject to as a result of any and all actions taken or omissions by State under the power of attorney or as a result of Owner taking the actions requested by State hereunder. Owner hereby indemnifies, defends and holds State harmless from any liability, costs, expenses or damages imputed or attempted to be imputed to State arising from Owner's status as a landlord or licensor of any such tenant and/or licensee except for liability, costs, expenses or damages caused or resulting from any action or omission by State under the power of attorney or from any action taken by Owner hereunder as requested by State.

14. In order to complete the relocation of its facilities, Owner must obtain the right of possession and thereafter title to the three parcels of property listed on Exhibit C attached hereto. State hereby agrees to acquire and provide full and exclusive rights of possession to such parcels to Owner on or before the Availability Date set forth on Exhibit C. State hereby agrees to acquire fee title and convey to Owner such parcels as soon as practicable thereafter (Owner hereby acknowledges that State may find it necessary to obtain such title by eminent domain procedures, the timing and length of which may not be under its control). Upon conveyance of fee title to Owner, State shall be entitled to a credit against the purchase price of the New Corridor based upon the fair market value of such parcels (however, any credit for the fair market value of any improvements located thereon will take into account the provisions and rationale of the Construction and Maintenance Agreement). The fair market value of such parcels shall be determined assuming that they are delivered to Owner free and clear of hazardous wastes and/or contaminated materials. It is recognized that such parcels may not be free of such waste and/or materials at this time and State has the obligation to take all action to remove or remediate all hazardous wastes and/or contaminated materials in excess of Legal Standards (as of the date of delivery of possession to Owner and based on those parcels being used for the same purposes as the Owner's facilities to be relocated thereon are currently

determining the time during which such work shall be completed.

18. This Agreement shall also extend to and bind the heirs, devisees, executors, administrators, legal representatives, successors and assigns of the parties.

19. State shall record a memorandum of this Agreement.

IN WITNESS WHEREOF, the parties have executed this Agreement the day and year first above written.

SOUTHERN PACIFIC TRANSPORTATION
COMPANY

By: ____________________
Robert F. Starzel
Vice-Chairman

Attachment

ACCEPTED THIS ____ DAY OF OCTOBER, 1992, ON BEHALF OF THE STATE OF CALIFORNIA, ACTING BY AND THROUGH ITS DEPARTMENT OF TRANSPORTATION.

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

By: ____________________________
as ____________________________

Exhibit "A"

Parcel 50036-1

COMMENCING at a point on the northwesterly line of that parcel of land described in the Deed from Crocker Estate Company to Western Pacific Railway Company, dated September 26, 1905, recorded October 3, 1905, in Book 1083, Page 339, Alameda County Records, distant thereon S. 33°26'14" W., 95.66 feet from the southerly line of 5th Street, as said street is shown on the "Map No. 2 of the Briggs Tract", filed January 7, 1876, in Book 2 of Maps, Page 19, in the office of the County Recorder of Alameda County; thence along said northwesterly line S. 33°26'14" W., 412.92 feet to the northerly line of 3rd Street, as said street is shown on said map; thence continuing along the southwesterly prolongation of said northwesterly line S. 33°26'14" W., 116.69 feet; thence from a tangent that bears S. 78°46'57" W., along a curve to the right with a radius of 948.75 feet, through an angle of 04°41'35", an arc length of 77.71 feet; thence S. 83°28'32" W., 196.70 feet; thence along a tangent curve to the right with a radius of 2535.00 feet, through an angle of 13°10'37", on arc length of 583.00 feet; thence S. 88°47'25" W., 138.66 feet; thence from a tangent that bears N. 86°58'16.7" W., along a curve to the right with a radius of 2541.00 feet, through an angle of 20°33'53", an arc length of 912.02 feet to a point of compound curvature, said point being distant S. 26°06'19" W., 119.70 feet from CENTERLINE Station 212+68.15 shown on the Department of Transportation survey for the State freeway in Alameda County, Road 4-Ala-880; thence along a tangent curve to the right with a radius of 711.00 feet, through an angle of 08°59'22", an arc length of 111.55 feet; thence N. 57°25'02" W., 118.04 feet; thence N. 56°55'03" W., 336.53 feet; thence N. 56°24'55" W., 120.01 feet; thence from a tangent that bears N. 55°24'28" W., along a curve to the right with a radius of 2271.87 feet, through an angle of 25°51'25", an arc length of 1025.27 feet; thence N. 29°33'03" W., 153.23 feet; thence along a tangent curve to the right with a radius of 2035.52 feet, through an angle of 3°46'39", an arc length of 134.20 feet to the southerly line of Atlantic Street; thence along last said southerly line S. 73°21'33" E., 84.99 feet to the westerly line of Pine Street; thence along last said westerly line S. 16°39'54" W., 66.46 feet to the northerly property line of the Central Pacific Railway Company, as said northerly property line is shown on "Record of Survey", portion of the northerly property line of the Central Pacific Railway Company, located in the City of Oakland, Alameda County, California, filed February 7, 1952 in Record of Survey Book 3, Page 25, in the office of the County Recorder of the County of Alameda, State of California, under Recorder's Series No. AG-10973 of Official Records of said County of Alameda; thence along said northerly property line S. 56°34'41" E., 1489.13 feet to the easterly line of Peralta Street; as said Atlantic Street, Pine Street and Peralta Street are shown on said "Record of Survey"; thence along said easterly line of Peralta Street N. 33°27'02" E., 8.97 feet to the southerly line of 3rd Street; thence along last said southerly line S. 72°53'28" E., 272.00 feet to the westerly line of Lewis Street; thence along last said westerly line S. 17°06'32" W., 88.95 feet; thence S. 56°34'41" E., 62.51 feet to the easterly line of Lewis Street; thence along last said easterly line N. 17°06'32" E., 6.51 feet to the southerly line of Lot 1, in Block J of Bay View Homestead, according to the map thereof, filed April 15, 1869, in Map Book 4, at Page 5, in the office of the County Recorder of Alameda County; thence along last said southerly line and the southerly line of Lots 2 through 10 in said Block J, S. 72°53'28" E., 250.04 feet to the westerly line of Henry Street; thence along last said westerly line S. 17°06'32" W., 79.69 feet; thence S. 56°34'41" E., 62.51 feet to the easterly line of Henry Street; thence along last said easterly line N. 17°06'32" E., 97.25 feet to the southerly

Parcel 50038-1

COMMENCING at the intersection of the easterly line of Bay Street with the northerly line of 7th Street (Oakland Avenue), as said streets are shown on the "Map of Land on Oakland Point, (Railroad Ferry Landing), City of Oakland, Tract 406", filed May 24, 1864, Map Book 5, Page 33, Alameda County Records; thence along the prolongation of said easterly line of Bay Street, S. 16°39'54" W., 30.00 feet; thence parallel with the northerly line of said 7th Street, N. 73°20'06" W., 106.80 feet to the Point of Beginning; thence continuing parallel with last said northerly line N. 73°20'06" W., 178.18 feet; thence S. 16°39'54" W., 54.09 feet; thence S. 81°57'06" E., 106.71 feet; thence S. 87°19'29" E., 74.89 feet to the Point of Beginning.

Parcel 50034-7

AN AERIAL EASEMENT upon, over and across the following described parcel:

COMMENCING at a point on the northerly line of 7th Street, distant thereon along said northerly line N. 73°19'53" W., 40.52 feet from the intersection of the westerly line of Cedar Street with the northerly line of 7th Street (Oakland Avenue) as said streets are shown on the "Map of Land on Oakland Point (Railroad Ferry Landing), City of Oakland, Tract 406, filed May 24, 1864, Map Book 5, Page 33, Alameda County Records; thence along said northerly line of 7th Street N. 73°19'55" W., 117.19 feet; thence N. 03°13'59" W., 121.16 feet; thence S. 87°19'06" E., 24.05 feet; thence along a tangent curve to the right with a radius of 789.00 feet, through an angle of 06°15'17", an arc length of 86.13 feet to a point distant S. 87°,33'07" W., 200.50 feet from Engineer's Station 238+58.10 on the "A" Line of the Department of Transportation's survey for the State Freeway in Alameda County, Road 04-Ala-880-30.1; thence S. 03°43'24" E., 145.05 feet to the point of commencement.

Parcel 50034-6

COMMENCING at a point on the northerly line of 7th Street, distant thereon along said northerly line N. 73°19'53" W., 117.19 feet from the northwesterly terminus of the course described in PARCEL (50034-1) below as "N. 73°19'53" W., 40.52 feet"; thence along said northerly line of 7th Street N. 73°19'53" W., 143.59 feet and N. 73°20'06" W., 425.40 feet; thence S. 79°06'27" E., 86.51 feet; thence from a tangent that bears S. 80°58'11" E., along a curve to the left with a radius of 761.00 feet, through an angle of 06°21'18", an arc length of 84.41 feet; thence S. 87°19'29" E., 170.60 feet; thence N. 49°05'51" E., 85.59 feet; thence N. 02°40'31" E., 43.78 feet; thence N. 00°45'30" W., 100.18 feet; thence N. 02°40'31" E., 6.45 feet; thence along a tangent curve to the left with a feet; thence (7) S. 01°53'44" E., 53.26 feet; thence (8) S. 56°25'46" E., 64.68 feet; thence (9) S. 33°26'33" W., 25.82 feet to the centerline of 10th Street; thence along last said line (10) N. 56°33'27" W., 77.99 feet to the point of commencement.

Parcel 50031-2

AN AERIAL EASEMENT upon, over and across the following described parcel:

COMMENCING at a point on the common property line, now or formerly, of Southern Pacific Transportation Company, a Delaware Corporation, and of the United States of America, distant thereon S. 44°38'35" W., 167.14 feet from the intersection of said common property line, with the southwesterly line of West Grand Avenue, formerly 22nd Street, as said street is shown on the map entitled "Map of the Hougham Tract", filed June 10, 1875, in Book 4 of Maps, Page 8, Alameda County Records; thence from a tangent that bears S. 08°23'18" E., along a curve to the right with a radius of 1236.00 feet, through an angle of 12°48'56", an arc length of 276.46 feet; thence S. 59°39'16" W., 123.75 feet; thence from a tangent that bears S. 44°31'49" W., along a curve to the right with a radius of 3839.76 feet, through an angle of 04°11'15", an arc length of 280.64 feet; thence S. 48°43'04" W., 199.97 feet; thence along a tangent curve to the left with a radius of 3799.67 feet, through an angle of 04°11'16", an arc length of 277.72 feet; thence S. 44°31'48" W., 467.93 feet; thence N. 40°36'04" E., 100.26 feet, N. 43°37'22" E., 638.78 feet; thence along a tangent curve to the left with a radius of 926.00 feet, through an angle of 09°30'51", an arc length of 153.77 feet; thence N. 57°54'10" W., 45.43 feet; thence N. 32°05'49" E., 65.00 feet; thence S. 57°54'10" E., 45.43 feet; thence from a tangent that bears N. 30°05'09" E., along a curve to the left with a radius of 926.00 feet, through an angle of 14°38'01", an arc length of 236.50 feet to above said common property line; thence along last said line N. 44°38'35" E., 360.46 feet to the point of commencement.

Parcel 50031-1

COMMENCING at a point on the southwesterly line of West Grand Avenue, 80.00 feet wide (formerly 22nd Street) distant thereon N. 56°29'58" W., 173.13 feet from the point of intersection thereof with the northwesterly line of Wood Street, as said streets are shown on the map of Hougham Tract, filed July 10, 1875, Map Book 4, Page 8, Alameda County Records; thence continuing along said southwesterly line N. 56°29'58" W., 316.49 feet; thence from a tangent that bears S. 43°00'52" W., along a curve to the right with a radius of 4963.00 feet, through an angle of 02°49'04", an arc length of 244.07 feet; thence S. 45°49'56" W., 152.54 feet to a point distant N. 44°10'04" W., 37.00 feet from the Station 86+21.12 on the "C" Line of the State Department of Transportation's Survey in Alameda County; 04-Ala-880-34.1; thence S. 59°39'16" W., 123.75 feet; thence from a tangent that bears S. 44°31'49" W., along a curve to the right with a radius of 3839.76 feet, through an angle of 04°11'15", an arc length of 280.64 feet; thence S. 48°43'04" W., 199.97 feet; thence along a tangent curve to the left with a radius of 3799.67 feet, through an angle of 04°11'16", an arc length of 277.72 feet; thence S. 44°31'48" W., 1172.26 feet; thence S. 40°03'24" W., 34.48 feet to the northerly line of 14th Street; thence along last said line S.

feet, through an angle of 0°55'36", an arc length of 64.45 feet to a point of compound curvature, along a tangent curve to the right with a radius of 4595.36 feet, through an angle of 0°17'23", an arc length of 23.24 feet, S. 5°48'31" E., 45.22 feet, S. 25°12'55" W., 15.00 feet, from a tangent that bears S. 35°00'21" W., along a curve to the left with a radius of 655.70 feet, through an angle of 11°26,46", an arc length of 131.00 feet to a point of reverse curvature, along a tangent curve to the right with a radius of 4600.36 feet, through an angle of 1°52'06", an arc length of 150.02 feet, S. 25°25'41" W., 326.23 feet, S. 18°54'56" W., 58.50 feet and S. 22°13'56" W., 199.17 feet to the point of commencement.

Parcel 50026-2

AN AERIAL EASEMENT upon, over and across the following described parcel:

Beginning for reference at the intersection of the northeasterly line of West Grand Street, formerly 22nd Street, with the northwesterly line of Wood Street; as said streets are shown on the map entitled "Map of the Hougham Tract", filed June 10, 1875, in Book 4 of Maps, Page 8, Alameda County Records; thence along said northeasterly line of West Grand Avenue, N. 56°29'58" W., 476.80 feet; thence from a tangent that bears N. 42°04'45.8" E., along a curve to the left with a radius of 4963 feet, through an angle of 7°18'25.2", an arc length of 632.94 feet to the TRUE POINT OF COMMENCEMENT, said true point being measured radially N. 55°13'39" W., 37.00 feet from Highway Engineer's Station 97+38.82 of the "C" line of the Department of Transportation's Survey for the State Freeway in Alameda County, Road 04-Ala-880; thence N. 12°13'11" E., 382.58 feet; thence along a tangent curve to the right with a radius of 899.00 feet, through an angle of 29°56'19", an arc length of 469.75 feet; thence N. 42°09'31" E., 164.97 feet; thence along a tangent curve to the right with a radius of 319.00 feet, through an angle of 6°43'21", an arc length of 37.43 feet to a point of reverse curvature; thence along a tangent curve to the left with a radius of 289.00 feet, through an angle of 12°52'34", an arc length of 64.95 feet to a point of compound curvature; thence along a tangent curve to the left with a radius of 953.00 feet, through an angle of 3°32'47", an arc length of 58.99 feet to the line common to the properties, now or formerly, of Southern Pacific Transportation Company, a Delaware Corporation, and of the Atchison, Topeka and Santa Fe Railway Company, a corporation; thence along said common property line from a tangent that bears S. 14°49'08" W., along a curve to the right with a radius of 8758.53 feet, through an angle of 1°23'06", an arc length of 211.74 feet and S. 31°10'50" W., 19.53 feet; thence N. 65°21'32" W., 36.00 feet; thence S. 42°09'31" W., 107.22 feet; thence along a tangent curve to the left with a radius of 837.00 feet, through an angle of 29°56'19", an arc length of 437.36 feet; thence S. 12°13'11" W., 225.82 feet; thence from a tangent that bears S. 32°49'34" W., along a curve to the right with a radius of 4963.00 feet, through an angle of 01°56'46", an arc length of 168.58 feet to the true point of commencement.

EXHIBIT B

AVAILABILITY DATES

Stage	Available for Construction
Section D	August 31, 1993
Section A	January 31, 1994
Section B	January 31, 1994
Section C	November 30, 1993
Section F	November 30, 1993
Section G	November 30, 1993

[See map attached hereto for Section references]

EXHIBIT C

PARCELS TO BE CONVEYED BY STATE

State's Parcel*	Possession Date
50111 Atkins Propeller Co.	July 1, 1993
50112 R.J. Bugatto, et al.	December 31, 1992
50113 Macor, Inc.	December 31, 1992

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* As shown on the State's Appraisal Map No. A-1095.7.

EXHIBIT E

ESCROW AGREEMENT

THIS ESCROW AGREEMENT (the "Agreement"), dated October 28, 1992 is by and among SOUTHERN PACIFIC TRANSPORTATION COMPANY, a Delaware corporation ("Owner"), STATE OF CALIFORNIA, DEPARTMENT OF TRANSPORTATION ("State") and FIDELITY NATIONAL TITLE INSURANCE COMPANY, as escrow agent ("Escrow Agent").

RECITALS

A. Owner and State have entered into the State of California Department of Transportation Agreement for Possession and Use (the "Use Agreement"), dated October 28, 1992 relating to certain real property more particularly described therein and located in Alameda County, California (the "New Corridor").

B. Pursuant to Section 11 of the Use Agreement, Owner and State have agreed to escrow certain funds for the purpose of paying for or reimbursing Owner for its out-of-pocket costs and expenses incurred in connection with Owner's obligations to remove and remediate hazardous wastes and/or contaminated materials existing at the New Corridor, as more particularly described in Section 11 therein (the "Cleanup Costs").

C. Owner and State desire to set forth the terms and conditions of such escrow below.

AGREEMENT

NOW THEREFORE FOR GOOD AND VALUABLE CONSIDERATION, the receipt and sufficiency of which are hereby acknowledged, Owner, State and Escrow Agent hereby agree as follows:

1. Simultaneously with the execution of this Agreement by State, State shall deposit with Escrow Agent the sum of $2,112,407.00 (which sum together with all interest or income earned thereon is herein referred to as the "Holdback Amount"), which shall be deposited by Escrow Agent in an interest-bearing escrow account (the "Account") with Bank of America National Trust and Savings Association, San Francisco branch, to be disbursed in accordance with the terms and conditions hereof.

(a) Written evidence by State that Owner has failed to cure a default, failure to perform or breach of its obligations under Section 11 of the Use Agreement and State has performed such obligations; and

(b) Written invoices, bills or statements evidencing the Cleanup Costs to be reimbursed or paid for from the Account.

4. This Agreement shall terminate on the earlier of: (a) fifteen business days after Owner's delivery to Escrow Agent and State of reasonably satisfactory evidence that Owner's remediation obligations under Section 11 of the Use Agreement have been completed (unless within such fifteen day period State reasonably objects to such termination in writing delivered to Escrow Agent and Owner describing such objection, in which event such dispute shall be resolved by arbitration pursuant to Section 9 hereof), (b) the date on which no undisbursed Holdback Amount remains in the Account, or (c) the sixth anniversary of the date of this Agreement. If any undisbursed Holdback Amount remains in the Account upon termination of this Agreement pursuant to this Section 4, such amounts shall be tendered by Escrow Agent to Owner immediately. State shall in no event be obligated to deposit any additional funds in the Account if the Cleanup Costs exceed the Holdback Amount.

5. This Agreement shall not alter or otherwise modify the respective liabilities and obligations of Owner and State with respect to the ownership or remediation of hazardous wastes and/or contaminants as set forth in the Use Agreement.

6. Owner and State shall each pay one-half of the reasonable fees and expenses of Escrow Agent for administering the Account.

7. Owner and State acknowledge that Escrow Agent is acting solely as a stakeholder at their request and for their convenience. Escrow Agent shall not be deemed to be the agent of either party and both Owner and State waive any conflict arising from this situation.

8. The duties and obligations of Escrow Agent with respect to the matters set forth herein shall only be as specifically provided hereunder and Escrow Agent shall incur no liability for any act it may do or fail to do hereunder while acting in good faith and in the exercise of its own best judgement.

If to State:

State of California, Department of Transportation
111 Grand Avenue
Oakland , California 94623
Attn: Richard Murphy
Deputy District Director

If to Escrow Agent:

Fidelity National Title Insurance Company
5925 Stoneridge Drive
Pleasanton, California 94588
Attn: R. Jonathan Pena, Assistant V.P.

11. This Agreement may be amended or modified only by written agreement signed by all the parties hereto.

12. This Agreement shall be binding on and shall inure to the benefit of each party hereto and its respective successors and assigns.

13. Time is of the essence hereof with respect to the dates, times, terms and conditions of this Agreement.

14. This Agreement may be executed in counterparts, each of which when combined shall constitute an original.

IN WITNESS WHEREOF, Owner, State and Escrow Agent have executed this Agreement on the day and year first above written.

OWNER:

SOUTHERN PACIFIC
TRANSPORTATION CORPORATION,
a Delaware corporation

By: ______________________
Robert F. Starzel
Vice Chairman

LMT

ESCROW AGREEMENT

THIS ESCROW AGREEMENT (the "Agreement"), dated October 28, 1992 is by and among SOUTHERN PACIFIC TRANSPORTATION COMPANY, a Delaware corporation ("Owner"), STATE OF CALIFORNIA, DEPARTMENT OF TRANSPORTATION ("State") and FIDELITY NATIONAL TITLE INSURANCE COMPANY, as escrow agent ("Escrow Agent").

RECITALS

A. Owner and State have entered into the State of California Department of Transportation Agreement for Possession and Use (the "Use Agreement"), dated October 28, 1992 relating to certain real property more particularly described therein and located in Alameda County, California (the "New Corridor").

B. Pursuant to Section 11 of the Use Agreement, Owner and State have agreed to escrow certain funds for the purpose of paying for or reimbursing Owner for its out-of-pocket costs and expenses incurred in connection with Owner's obligations to remove and remediate hazardous wastes and/or contaminated materials existing at the New Corridor, as more particularly described in Section 11 therein (the "Cleanup Costs").

C. Owner and State desire to set forth the terms and conditions of such escrow below.

AGREEMENT

NOW THEREFORE FOR GOOD AND VALUABLE CONSIDERATION, the receipt and sufficiency of which are hereby acknowledged, Owner, State and Escrow Agent hereby agree as follows:

1. Simultaneously with the execution of this Agreement by State, State shall deposit with Escrow Agent the sum of $2,112,407.00 (which sum together with all interest or income earned thereon is herein referred to as the "Holdback Amount"), which shall be deposited by Escrow Agent in an interest-bearing escrow account (the "Account") with Bank of America National Trust and Savings Association, San Francisco branch, to be disbursed in accordance with the terms and conditions hereof.

(a) Written evidence by State that Owner has failed to cure a default, failure to perform or breach of its obligations under Section 11 of the Use Agreement and State has performed such obligations; and

(b) Written invoices, bills or statements evidencing the Cleanup Costs to be reimbursed or paid for from the Account.

4. This Agreement shall terminate on the earlier of: (a) fifteen business days after Owner's delivery to Escrow Agent and State of reasonably satisfactory evidence that Owner's remediation obligations under Section 11 of the Use Agreement have been completed (unless within such fifteen day period State reasonably objects to such termination in writing delivered to Escrow Agent and Owner describing such objection, in which event such dispute shall be resolved by arbitration pursuant to Section 9 hereof), (b) the date on which no undisbursed Holdback Amount remains in the Account, or (c) the sixth anniversary of the date of this Agreement. If any undisbursed Holdback Amount remains in the Account upon termination of this Agreement pursuant to this Section 4, such amounts shall be tendered by Escrow Agent to Owner immediately. State shall in no event be obligated to deposit any additional funds in the Account if the Cleanup Costs exceed the Holdback Amount.

5. This Agreement shall not alter or otherwise modify the respective liabilities and obligations of Owner and State with respect to the ownership or remediation of hazardous wastes and/or contaminants as set forth in the Use Agreement.

6. Owner and State shall each pay one-half of the reasonable fees and expenses of Escrow Agent for administering the Account.

7. Owner and State acknowledge that Escrow Agent is acting solely as a stakeholder at their request and for their convenience. Escrow Agent shall not be deemed to be the agent of either party and both Owner and State waive any conflict arising from this situation.

8. The duties and obligations of Escrow Agent with respect to the matters set forth herein shall only be as specifically provided hereunder and Escrow Agent shall incur no liability for any act it may do or fail to do hereunder while acting in good faith and in the exercise of its own best judgement.

If to State:

State of California, Department of Transportation
111 Grand Avenue
Oakland , California 94623
Attn: Richard Murphy
Deputy District Director

If to Escrow Agent:

Fidelity National Title Insurance Company
5925 Stoneridge Drive
Pleasanton, California 94588
Attn: R. Jonathan Pena, Assistant V.P.

11. This Agreement may be amended or modified only by written agreement signed by all the parties hereto.

12. This Agreement shall be binding on and shall inure to the benefit of each party hereto and its respective successors and assigns.

13. Time is of the essence hereof with respect to the dates, times, terms and conditions of this Agreement.

14. This Agreement may be executed in counterparts, each of which when combined shall constitute an original.

IN WITNESS WHEREOF, Owner, State and Escrow Agent have executed this Agreement on the day and year first above written.

OWNER:

SOUTHERN PACIFIC
TRANSPORTATION CORPORATION,
a Delaware corporation

By: ______________________
Robert F. Starzel
Vice Chairman

ATTACHMENT B
Calculation of Volatile Chemical Emissions from Shallow Ground Water into Air

The conceptual model for the transport of chemicals from ground water to ambient air is depicted in ASTM, 1994. In the ASTM model, volatile organic chemicals are assumed to volatilize from ground water, diffuse through capillary fringe soils and vadose zone soils, and be released to the air.

The volatilization of chemicals from ground water to outdoor ambient air involves the following assumptions.

- A constant dissolved chemical concentration in ground water
- Linear equilibrium partitioning between dissolved chemicals in ground water and chemical vapors at the ground water table
- Steady-state vapor-phase diffusion through the capillary fringe and vadose zones to ground surface
- No loss of chemical as it diffuses towards ground surface (i.e. no biodegradation), and
- Steady well-mixed atmospheric dispersion of the emanating vapors within the breathing zone

The volatilization of chemicals from shallow ground water to ambient outdoor air can be calculated using the following series of equations. The results of these calculations are presented at the end of this attachment.

$$VF_{amb}\left[\frac{(mg/m^3-air)}{(mg/L-H_2O)}\right]=\frac{H}{1+\left[\frac{U_{air}\delta_{air}L_{GW}}{WD_{ws}^{eff}}\right]}\times 10^3\frac{L}{m^3}$$

where:

VF_{wamb} = the volatilization factor for chemicals volatilizing from groundwater to air

H = Henry's law constant, cm^3-H_20/ cm^3-air

U_{air} = Wind speed, cm/s

$_{air}$= Mixing zone height, cm

D_{ws}^{eff} = the effective diffusion coefficient between ground water and soil surface

where:

$$D_{ws}^{eff}\left[\frac{cm^2}{s}\right]=(h_{cap}+h_v)\left[\frac{h_{cap}}{D_{cap}^{eff}}+\frac{h_v}{D_s^{eff}}\right]^{-1}$$

h_{cap} = thickness of capillary fringe

h_v = thickness of vadose zone

D_s^{eff} = the effective diffusion coefficient in soil based on vapor-phase concentration

$$D_s^{eff}\left[\frac{cm^2}{s}\right]=D^{air}\frac{\theta_{as}^{3.33}}{\theta_T^2}+D^{wat}\frac{1}{H}\frac{\theta_{ws}^{3.33}}{\theta_T^2}$$

D_{cap}^{eff} = the effective diffusion through capillary fringe

$$D_{cap}^{eff}\left[\frac{cm^2}{s}\right]=D^{air}\frac{\theta_{acap}^{3.33}}{\theta_T^2}+D^{wat}\frac{1}{H}\frac{\theta_{wcap}^{3.33}}{\theta_T^2}$$

D^{air} = diffusion coefficient in air

D^{wat} = diffusion coefficient in water

θ_{as} = air content in vadose zone

θ_{ws} = water content in vadose zone

θ_T = total soil porosity

θ_{acap} = air content in capillary fringe

θ_{wcap} = water content in capillary fringe

ATTACHMENT C
Calculation of Volatile Chemical Emissions from Pooled Ground Water in Trenches

Exposure Scenario

Ground water in the I-880 Corridor is present at a depth of about 4.5 to 5 feet below ground surface (bgs). As a result, shallow ground water may collect in trenches excavated for utility lines or other purposes. Utility workers in the area may be exposed to chemicals volatilizing from ground water in these trenches. The following assumptions were used to estimate volatile emissions from ground water in trenches excavated for utility lines.

Assumptions

Dimensions of the trench

The trench was assumed to be 68 meters long by 1.22 meters wide by 2.3 meters deep. The 68 meter length is the square root of an area approximately one acre in size. The width and depth of the trench were based on best professional judgment.

Amount of water in the trench

Water was assumed to pool in the trench over the entire length of the trench to a depth of 1 meter. Thus, the volume of water in the trench is equal to 68 m x 1.22 m x 1 m = 83 m^3.

Chemicals of concern in pooled ground water

All volatile chemicals (Volatile chemicals were defined as having a Henry's law constant of 1 x 10^{-5} and greater and a vapor pressure greater than 0.001 mm Hg) detected in the trench were considered chemicals of concern. The maximum detected concentrations of VOCs in shallow ground water were conservatively assumed to be present over the entire length of the trench.

Rate of volatilization of the chemicals of concern in pooled ground water

The rate of emission of a volatile organic chemical (VOC) from water is determined by the solubility, molecular weight, the vapor pressure of the chemical and the air-water interface though which the chemical must pass (Lyman, 1990). As a simplifying assumption, it was conservatively assumed that all the VOCs present in pooled ground water would be emitted over a 24 hour period. One of the most volatile of the chemicals detected in shallow ground water, vinyl chloride, has estimated volatilization half lives of 43, 8.7 and 35 hours for a typical pond, river, or lake, respectively (ATSDR, 1993c). If the most rapid volatilization emission rate (8.7 hours) is considered, approximately 85% of vinyl chloride in a river will volatilize over a 24 hour period. Thus, this assumption would tend to overestimate the emission rate of the less volatile chemicals in shallow ground water.

Calculations

Using vinyl chloride as an example, the rate of volatilization of the VOCs from shallow ground water in the trench would be calculated in the following manner:

Maximum concentration of vinyl chloride in At-Grade section ground water = 0.045 mg/L

Amount of vinyl chloride in water = 83 m^3 x 0.045 mg/L x 1000 L/m^3 = 3735 mg

Emission rate in mg/s over 1 day (24 hours) = 3735 mg ÷ 86,400 s/day = 0.0.043 mg/s

The air concentration of vinyl chloride resulting from emission from ground water in the trench is calculated using the box model formula presented below (DTSC, 1994):

C_{air} = E/L x W x H

where:

C_{air} = Concentration in air, mg/m^3

E = Emission rate, mg/s

L = Length of side of box, meters

W = Wind speed, meters/s

H = Height of box, meters

C_{air} = (0.043 mg per s)/(68 m x 2.25 m per s x 2 m) = 0.00014 mg/m^3

Further, it was conservatively assumed that ground water would pool in the trench to the same depth each day and that the concentration of VOCs (the maximum detected concentration) in ground water would remain constant over the 12 week exposure period (60 exposure days; 5 days per week for 12 weeks). To approximate this scenario, it is necessary to assume that ground water depleted of VOCs from the previous day would be pumped out of the trench at the beginning of each work day and that ground water would recharge the ditch to a depth of 1 m over the period of a day. From conversations with

Geomatrix personnel, it is possible that ground water could recharge to a depth of 1 m over a 24 hour period.

All utility worker exposure assumptions are listed in Table 3-4 of the report. Note that the utility worker was assumed to inhale 20 m^3 of air containing the VOCs per work day.

ATTACHMENT D

Lead Exposure Calculations

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

The State of California DTSC, United States Environmental Protection Agency (EPA), and others have developed lead exposure models for evaluating blood lead concentrations associated with intake of lead from food, water, air, and soil. The California DTSC lead exposure model (DTSC, 1992) was used in this Risk Assessment to evaluate lead exposures for the child at play and a utility worker assumed to be exposed to lead in soil. The model was used to predict blood lead increases associated with exposure to lead in Elevated and At Grade soils as well as lead from background sources including air, food, and water. The lead exposure model inherently assumes that all soil exposure on that day comes from the freeway source on days when the child at play or the utility worker is exposed to freeway corridor soil.

The DTSC uses a 10 µg/dL blood lead concentration as its "concentration of concern" in both children and adults. This level is consistent with USEPAís guidance regarding lead exposure in children. However, this level is not consistent with the State of Californiaís guidance with regard to utility workers. CCR (California Code of Regulations) Title 8 § 1532.1 requires that a utility worker be removed for medical reasons if any blood lead test on the worker yields a blood lead concentration that is at or above 50 µg/dL. A blood lead concentration of 40 µg/dL to 49 µg/dL triggers several employee notification requirements. Appendix A to § 1532.1 indicates that maintaining a blood lead concentration below 30 µg/dL is a "health protection goal".

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

Child at Play

The site-specific exposure inputs used in the DTSC lead exposure model are presented in Table D-1. All other exposure inputs used in the DTSC lead exposure model were DTSC default values (DTSC, 1992). Calculated blood lead concentrations for the child at play exposed to 605 mg/kg lead in Elevated Section soils are presented in the attached table.

As calculated using the DTSC lead exposure model, blood lead concentrations for the child at play are below the 99th percentile (Table D-2).

Utility Worker

With the exception of the parameters listed in Table D-1, DTSC default exposure assumptions were used to calculate a utility workerís blood lead concentration (DTSC, 1992). At the reasonable maximum exposure soil lead concentration of 361 mg/kg, a utility workerís blood lead exposure did not exceed 10 µg/dL at the 99th percentile (Table D-3).

Table D-1
Exposure Parameters for Lead Exposure Model

Parameter	Input	Source/Comment
General Parameters		
Frequency of soil contact	3 days/week (child at play)	The child at play is assumed to be exposed to site soil 36 days per year. The majority of this exposure is expected to occur over 12 weeks of summer vacation. This averages 3 days of exposure per week.
	5 days/week (utility worker)	
Soil Lead Concentration	605 µg/g (child at play)	RME concentration of lead in 0 to 1' depth soils at the South Elevated Section
	361 µg/g (utility worker)	RME concentration of lead in surface and subsurface depth soils at the At-Grade Section
Drinking Water Lead Intake		
Drinking water lead concentration	5 µg/L	Concentration of lead in water exceeded by 6% of samples collected in California surface water and ground water supplies *California Air Resources Board, 1993*
Lead Intake Via Inhalation		
Background lead concentration in air	0.02 µg/m^3	January to June 1992 mean lead concentration in air for San Francisco and Richmond, California California Air Resources Board, 1993
Dust concentration in air	50 µg/m^3 (child at play)	Child at play- Default from Preliminary Endangerment Assessment Guidance Manual (DTSC, 1994a)
	500 µg/m^3 (utility worker)	Utility worker - DTSC default
Soil Ingestion	240 mg (utility worker)	DTSC default

TABLE D-2 CHILD AT PLAY

LEAD RISK ASSESSMENT SPREADSHEET
CALIFORNIA DEPARTMENT OF TOXIC SUBSTANCES CONTROL

INPUT		**OUTPUT**					
MEDIUM	LEVEL		percentiles				
			50th	90th	95th	98th	99th
LEAD IN AIR (ug/m^3)	0.02						
LEAD IN SOIL (ug/g)	605.0						
LEAD IN WATER (ug/l)	5	BLOOD Pb, CHILD AT PLAY (ug/	3.4	5.3	6.0	6.9	7.6
PLANT UPTAKE? 1=YES 0=NO	0						
RESPIRABLE DUST (ug/m^3)	50						

EXPOSURE PARAMETERS

	units	Child at Play			
General					
Days per week	days/wk		3		
Dermal Contact					
Skin area	cm^2		2800		
Soil adherence	mg/cm^2		0.5		
Route-specific constant	(ug/dl)/(ug/day)		0.00011		
Soil ingestion					
Soil ingestion	mg/day		55		
Route-specific constant	*(ug/dl)/(ug/day)*		0.0704		
Inhalation					
Breathing rate	m^3/day		10		
Route-specific constant	(ug/dl)/(ug/day)		0.192		
Water ingestion					
Water ingestion	l/day		0.4		
Route-specific constant	(ug/dl)/(ug/day)		0.16		
Food ingestion					
Food ingestion	kg/day		1.3		
Route-specific constant	(ug/dl)/(ug/day)		0.16		
Dietary concentration	ug/kg		9.5		
Lead in produce	ug/kg		10.0		

PRG-99 (ug/g)	PRG-95 (ug/g)
1134.4	1819.9

PATHWAYS, ADULTS

Pathway				
SOIL CONTACT:				
SOIL INGESTION:				
INHALATION:				
WATER INGESTION:				
FOOD INGESTION:				

PATHWAYS, CHILDREN

	Typical				
Pathway	Blood Pb *ug/dl*	percent *of total*			concentration *in medium*
SOIL CONTACT:	0.04	1%			605 ug/g
SOIL INGESTION:	1.00	30%			605 ug/g
INHALATION:	0.04	1%			0.05 ug/m^3
WATER INGESTION:	0.32	9%			5 ug/l
FOOD INGESTION:	1.97	58%			9.5 ug Pb/kg diet

TABLE D-3 UTILITY WORKER
LEAD RISK ASSESSMENT SPREADSHEET
CALIFORNIA DEPARTMENT OF TOXIC SUBSTANCES CONTROL

INPUT		OUTPUT					
MEDIUM	LEVEL		percentiles				
			50th	90th	95th	98th	99th
LEAD IN AIR (ug/m^3)	0.01						
LEAD IN SOIL (ug/g)	361.0						
LEAD IN WATER (ug/l)	5						
PLANT UPTAKE? 1=YES 0=NO	0						
RESPIRABLE DUST (ug/m^3)	500	BLOOD Pb, UTILITY (ug/dl)	2.6	4.0	4.5	5.2	5.8

EXPOSURE PARAMETERS

	units				Construction Worker
General					
Days per week	days/wk				5
Dermal Contact					
Skin area	cm^2				5800
Soil adherence	mg/cm^2				0.5
Route-specific constant	(ug/dl)/(ug/day)				0.00011
Soil ingestion					
Soil ingestion	mg/day				240
Route-specific constant	(ug/dl)/(ug/day)				0.0176
Inhalation					
Breathing rate	m^3/day				20
Route-specific constant	(ug/dl)/(ug/day)				0.082
Water ingestion					
Water ingestion	l/day				1.4
Route-specific constant	(ug/dl)/(ug/day)				0.04
Food ingestion					
Food ingestion	kg/day				2.2
Route-specific constant	(ug/dl)/(ug/day)				0.04
Dietary concentration	ug/kg				10.0
Lead in produce	ug/kg				

PRG-99 (ug/g)	PRG-95 (ug/g)
922.6	1239.0

PATHWAYS, ADULTS

			Construction Worker		
Pathway			Blood Pb ug/dl	percent of total	Concentration in medium
SOIL CONTACT:			0.08	3%	361 ug/g
SOIL INGESTION:			1.09	43%	361 ug/g
INHALATION:			0.22	9%	0.19 ug/m^3
WATER INGESTION:			0.28	11%	5 ug/l
FOOD INGESTION:			0.88	34%	0.0 ug Pb/kg diet

ATTACHMENT E
API DSS Exposure and Risk Calculations
Child at Play

Data Summary for Elevated Sections Surface Soil - Child Scenario

Chemical Intake Analysis

Carcinogenic Risk by Chemical for Each Route of Concern

Chemical	Inhalation of Soil Emissions	Dermal Contact With Soil	Soil Ingestion	Total
Benz(a)anthracene	1.06E-11	2.13E-08	4.30E-09	2.56E-08
Benzo(a)pyrene	5.36E-11	7.19E-07	1.45E-07	8.64E-07
Benzo(b)fluoranthene	1.07E-10	1.04E-07	2.10E-08	1.25E-07
Benzo(g,h,i)perylene	3.39E-13	1.97E-08	3.98E-09	2.37E-08
Chrysene	4.68E-12	3.99E-09	8.07E-10	4.80E-09
Total	1.76E-10	8.68E-07	1.75E-07	1.04E-06

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

Data Summary for Elevated Sections Surface Soil - Child Scenario

Chemical Intake Analysis
Dose by Chemical for Each Route of Concern (mg/kg-day)

Inhalation of Soil Emissions

	Intake	Value
Benz(a)anthracene	DI	2.76E-09
	CDI	2.72E-10
	LADD	2.72E-11
Benzo(a)pyrene	DI	1.39E-09
	CDI	1.37E-10
	LADD	1.37E-11
Benzo(b)fluoranthene	DI	2.78E-08
	CDI	2.74E-09
	LADD	2.74E-10
Benzo(g,h,i)perylene	DI	3.43E-09
	CDI	3.39E-10
	LADD	3.39E-11
Chrysene	DI	1.22E-08
	CDI	1.20E-09
	LADD	1.20E-10

Dermal Contact With Soil

	Intake	Value
Benz(a)anthracene	DI	1.80E-06
	CDI	1.78E-07
	LADD	1.78E-08
Benzo(a)pyrene	DI	6.08E-06
	CDI	5.99E-07
	LADD	5.99E-08
Benzo(b)fluoranthene	DI	8.78E-06
	CDI	8.65E-07
	LADD	8.65E-08
Benzo(g,h,i)perylene	DI	2.81E-05
	CDI	2.77E-06
	LADD	2.77E-07
Chrysene	DI	3.38E-06
	CDI	3.33E-07
	LADD	3.33E-08

Soil Ingestion

	Intake	Value
Benz(a)anthracene	DI	3.64E-07
	CDI	3.59E-08
	LADD	3.59E-09
Benzo(a)pyrene	DI	1.23E-06
	CDI	1.21E-07
	LADD	1.21E-08
Benzo(b)fluoranthene	DI	1.77E-06
	CDI	1.75E-07
	LADD	1.75E-08
Benzo(g,h,i)perylene	DI	5.68E-06
	CDI	5.60E-07
	LADD	5.60E-08
Chrysene	DI	6.82E-07
	CDI	6.72E-08
	LADD	6.72E-09

Deterministic Run

NA = Not Applicable

Data Summary for Elevated Sections Surface Soil - Child Scenario

Analysis for Receptor Point Concentration in Air

Averaging Time* [Years]	Benz(a)anthracene $[mg/m^3]$	Benzo(a)pyrene $[mg/m^3]$	Benzo(b)fluoranthene $[mg/m^3]$	Benzo(g,h,i)perylene $[mg/m^3]$	Chrysene $[mg/m^3]$
5	2.43E-08	1.23E-08	2.45E-07	3.02E-08	1.07E-07
10	1.72E-08	8.67E-09	1.73E-07	2.14E-08	7.57E-08
15	1.40E-08	7.08E-09	1.41E-07	1.75E-08	6.18E-08
20	1.21E-08	6.13E-09	1.22E-07	1.51E-08	5.35E-08
25	1.08E-08	5.48E-09	1.10E-07	1.35E-08	4.79E-08
30	9.90E-09	5.01E-09	9.99E-08	1.23E-08	4.37E-08
35	9.17E-09	4.63E-09	9.25E-08	1.14E-08	4.05E-08
40	8.57E-09	4.34E-09	8.65E-08	1.07E-08	3.79E-08
45	8.08E-09	4.09E-09	8.16E-08	1.01E-08	3.57E-08
50	7.67E-09	3.88E-09	7.74E-08	9.56E-09	3.39E-08
55	7.31E-09	3.70E-09	7.38E-08	9.11E-09	3.23E-08
60	7.00E-09	3.54E-09	7.07E-08	8.73E-09	3.09E-08
65	6.73E-09	3.40E-09	6.79E-08	8.38E-09	2.97E-08
70	6.48E-09	3.28E-09	6.54E-08	8.08E-09	2.86E-08
75	6.26E-09	3.17E-09	6.32E-08	7.80E-09	2.77E-08

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

Data Summary for Elevated Sections Surface Soil - Child Scenario

Analysis for
Volatile Emissions

Averaging Time* [Years]	Benz(a)anthracene [kg/year]	Benzo(a)pyrene [kg/year]	Benzo(b)fluoranthene [kg/year]	Benzo(g,h,i)perylene [kg/year]	Chrysene [kg/year]
5	1.73E-03	3.85E-04	7.69E-03	9.49E-04	7.62E-03
10	1.22E-03	2.72E-04	5.44E-03	6.71E-04	5.39E-03
15	9.96E-04	2.22E-04	4.44E-03	5.48E-04	4.40E-03
20	8.63E-04	1.93E-04	3.84E-03	4.75E-04	3.81E-03
25	7.72E-04	1.72E-04	3.44E-03	4.25E-04	3.41E-03
30	7.04E-04	1.57E-04	3.14E-03	3.88E-04	3.11E-03
35	6.52E-04	1.46E-04	2.91E-03	3.59E-04	2.88E-03
40	6.10E-04	1.36E-04	2.72E-03	3.36E-04	2.69E-03
45	5.75E-04	1.28E-04	2.56E-03	3.16E-04	2.54E-03
50	5.46E-04	1.22E-04	2.43E-03	3.00E-04	2.41E-03
55	5.20E-04	1.16E-04	2.32E-03	2.86E-04	2.30E-03
60	4.98E-04	1.11E-04	2.22E-03	2.74E-04	2.20E-03
65	4.79E-04	1.07E-04	2.13E-03	2.63E-04	2.11E-03
70	4.61E-04	1.03E-04	2.05E-03	2.54E-04	2.04E-03
75	4.46E-04	9.94E-05	1.99E-03	2.45E-04	1.97E-03

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

Data Summary for Elevated Sections Surface Soil - Child Scenario

Chemical Intake Analysis
Dose by Chemical for Each Route of Concern (mg/kg-day)

Inhalation of Soil Emissions

	Intake	Value
Benzene	DI	3.58E-07
	CDI	3.53E-08
	LADD	3.53E-09
Toluene	DI	2.29E-05
	CDI	2.26E-06
	LADD	2.26E-07
Xylene	DI	6.05E-07
	CDI	5.97E-08
	LADD	5.97E-09

Dermal Contact With Soil

	Intake	Value
Benzene	DI	9.75E-08
	CDI	9.62E-09
	LADD	9.62E-10
Toluene	DI	2.77E-06
	CDI	2.74E-07
	LADD	2.74E-08
Xylene	DI	1.65E-07
	CDI	1.63E-08
	LADD	1.63E-09

Soil Ingestion

	Intake	Value
Benzene	DI	2.95E-08
	CDI	2.91E-09
	LADD	2.91E-10
Toluene	DI	8.41E-07
	CDI	8.29E-08
	LADD	8.29E-09
Xylene	DI	5.00E-08
	CDI	4.93E-09
	LADD	4.93E-10

Deterministic Run
NA = Not Applicable

Data Summary for Elevated Sections Surface Soil - Child Scenario

Analysis for
Receptor Point Concentration in Air

Averaging Time* [Years]	Benzene [mg/m^3]	Toluene [mg/m^3]	Xylene [mg/m^3]
5	3.15E-06	2.01E-04	5.33E-06
10	1.57E-06	1.01E-04	2.66E-06
15	1.05E-06	6.71E-05	1.78E-06
20	7.87E-07	5.03E-05	1.33E-06
25	6.30E-07	4.03E-05	1.07E-06
30	5.25E-07	3.36E-05	8.88E-07
35	4.50E-07	2.88E-05	7.61E-07
40	3.94E-07	2.52E-05	6.66E-07
45	3.50E-07	2.24E-05	5.92E-07
50	3.15E-07	2.01E-05	5.33E-07
55	2.86E-07	1.83E-05	4.84E-07
60	2.62E-07	1.68E-05	4.44E-07
65	2.42E-07	1.55E-05	4.10E-07
70	2.25E-07	1.44E-05	3.81E-07
75	2.10E-07	1.34E-05	3.55E-07

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

Data Summary for Elevated Sections Surface Soil - Child Scenario

Analysis for Volatile Emissions

Averaging Time* [Years]	Benzene [kg/year]	Toluene [kg/year]	Xylene [kg/year]
5	9.89E-02	1.43E+01	1.67E-01
10	4.94E-02	7.16E+00	8.37E-02
15	3.30E-02	4.77E+00	5.58E-02
20	2.47E-02	3.58E+00	4.18E-02
25	1.98E-02	2.87E+00	3.35E-02
30	1.65E-02	2.39E+00	2.79E-02
35	1.41E-02	2.05E+00	2.39E-02
40	1.24E-02	1.79E+00	2.09E-02
45	1.10E-02	1.59E+00	1.86E-02
50	9.89E-03	1.43E+00	1.67E-02
55	8.99E-03	1.30E+00	1.52E-02
60	8.24E-03	1.19E+00	1.39E-02
65	7.60E-03	1.10E+00	1.29E-02
70	7.06E-03	1.02E+00	1.20E-02
75	6.59E-03	9.55E-01	1.12E-02

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

The following chemicals were selected:
Toluene

a for Fate and Transport Models

Thibideaux-Hwang Model - Deterministic

Define Media Specific Parameters

Area of contaminated soil [m^2]	84000
Depth to top of cont. soil [m]	0
Depth to bottom of cont. soil [m]	1.52
Unsaturated zone porosity [-]	0.3
Water content [-]	0.1
Dry Wt. Soil bulk density [g/cm^3]	1.8
Fraction Organic Carbon [-]	0.01
Temperature [C]	25

Thibideaux-Hwang Chemical Specific Parameters

Toluene	
Henrys Constant [(mg/L)/(mg/L)	2.84E-01
Koc [ug/gOC/ug/ml]	300
Diffusion in Air [cm^2/sec]	0.078
Vapor Pressure [mmHg]	28.1
Total Concentration in Soil [mg/kg]	0.37

Box Dispersion Model - Deterministic

Wind Speed [m/s]	3.89
Height of Box [m]	2
Width of Box [m]	2

ata for Risk Assessment

Body Weight and Lifetime - Deterministic

Average Weight (kg)	44
Lifetime (yrs)	70

Inhalation of Soil Emissions

Exposure Frequency [days/yr]	36
Exposure Duration [years]	7
Inhalation Rate [m^3/hr]	2.5
Time Outdoors [hours/day]	2

Inhalation of Soil Emissions Chemical Specific Parameters

Toluene	
Bioavailability [fraction]	1

Dermal Contact with Soil

Exposure Frequency [days/yr]	36
Exposure Duration [years]	7
Skin Surface Area [cm^2]	3300
Adherence Factor [mg/cm^2]	1

Dermal Contact Chemical Specific Parameters

Toluene	
Dermal Absorption Factors [fraction]	0.1

Ingestion of Soil

Exposure Frequency [days/yr]	36
Exposure Duration [years]	7
Ingestion Rate [mg/day]	100
Fraction Soil Contaminated [-]	1

Ingestion of Soil Chemical Specific Parameters

Toluene

Bioavailability [fraction]	1

Oral Dose

uene

lope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	0.2

Dermal Dose

Toluene

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

Inhalation Dose

Toluene

Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	1.14E-1

Receptor Point Concentration Distributions

Soil Concentrations

Toluene

Soil [mg/kg]	0.37

```
 Emissions/Dispersion Model Output

Analysis for ....

 Analyses Performed:
   -----------------
 Thibodeaux-Hwang volatile emissions
 Box Model used for dispersion


 *** PARAMETERS ***

 Deterministic Run

PARAMETER NAME                      UNITS    VALUE
----------------------------------------------


Area                                  m^2   .840E+05
Depth to Top of Cont. Zone              m   .000E+00
Depth to Bottom of Cont. Zone           m   .152E+01
Porosity                        cm^3/cm^3   .300E+00
Water Content                   cm^3/cm^3   .100E+00
Soil Bulk Density                  g/cm^3   .180E+01
Fractional Organic Carbon             g/g   .100E-01
Temperature                             C   .250E+02
Wind Speed                            m/s   .389E+01
Box Height                              m   .200E+01
Box Width                               m   .290E+03

 Toluene
   -----------
PARAMETER NAME                      UNITS    VALUE
----------------------------------------------


Henrys const               (mg/L)/(mg/L)   .284E+00
Organic Carbon Part Coeff         cm^3/g   .300E+03
Molecular Weight                   g/mol   .920E+02
Diffusion Coefficient in Air    cm^2/s   .780E-01
Vapor Pressure                      mmHg   .281E+02
Total Soil Concentration           mg/kg   .370E+00

 OUTPUTS

Time to depletion (yr) for Toluene                     =   .172E+01

                        Volatile          Particulate        Air
                        Emissions         Emissions          Concentration
                        (kg/yr)           (kg/yr)            (mg/m^3)
 -----------------------------------------------------------------------


 Averaging Time, yr =             5
Toluene                  .143E+02          .000E+00           .201E-03

 Averaging Time, yr =            10
Toluene                  .716E+01          .000E+00           .101E-03

 Averaging Time, yr =            15
Toluene                  .477E+01          .000E+00           .671E-04

 Averaging Time, yr =            20
Toluene                  .358E+01          .000E+00           .503E-04
```

```
 Averaging Time, yr =           25
Toluene                .286E+01             .000E+00              .403E-04

 Averaging Time, yr =           30
Toluene                .239E+01             .000E+00              .336E-04

 Averaging Time, yr =           35
Toluene                .205E+01             .000E+00              .288E-04

 Averaging Time, yr =           40
Toluene                .179E+01             .000E+00              .252E-04

 Averaging Time, yr =           45
Toluene                .159E+01             .000E+00              .224E-04

 Averaging Time, yr =           50
Toluene                .143E+01             .000E+00              .201E-04

 Averaging Time, yr =           55
Toluene                .130E+01             .000E+00              .183E-04

 Averaging Time, yr =           60
Toluene                .119E+01             .000E+00              .168E-04

 Averaging Time, yr =           65
Toluene                .110E+01             .000E+00              .155E-04

 Averaging Time, yr =           70
Toluene                .102E+01             .000E+00              .144E-04

 Averaging Time, yr =           75
  luene                .955E+00             .000E+00              .134E-04
```

The following chemicals were selected:
Benzene
Xylene

ta for Fate and Transport Models

Thibideaux-Hwang Model - Deterministic

Define Media Specific Parameters

Area of contaminated soil [m^2]	16500
Depth to top of cont. soil [m]	0
Depth to bottom of cont. soil [m]	1.52
Unsaturated zone porosity [-]	0.3
Water content [-]	0.1
Dry Wt. Soil bulk density [g/cm^3]	1.8
Fraction Organic Carbon [-]	0.01
Temperature [C]	25

Thibideaux-Hwang Chemical Specific Parameters

Benzene	
Henrys Constant [(mg/L)/(mg/L)	2.49E-01
Koc [ug/gOC/ug/ml]	83
Diffusion in Air [cm^2/sec]	0.087
Vapor Pressure [mmHg]	95.2
Total Concentration in Soil [mg/kg]	0.013
Xylene	
Henrys Constant [(mg/L)/(mg/L)	3.15E-01
Koc [ug/gOC/ug/ml]	240
Diffusion in Air [cm^2/sec]	0.072
Vapor Pressure [mmHg]	10
Total Concentration in Soil [mg/kg]	0.022

Box Dispersion Model - Deterministic

Wind Speed [m/s]	3.89
Height of Box [m]	2
Width of Box [m]	2

Data for Risk Assessment

Body Weight and Lifetime - Deterministic

Average Weight (kg)	44
Lifetime (yrs)	70

Inhalation of Soil Emissions

Exposure Frequency [days/yr]	36
Exposure Duration [years]	7
Inhalation Rate [m^3/hr]	2.5
Time Outdoors [hours/day]	2

Inhalation of Soil Emissions Chemical Specific Parameters

Benzene	
Bioavailability [fraction]	1
Xylene	
Bioavailability [fraction]	1

ermal Contact with Soil

xposure Frequency [days/yr]	36
Exposure Duration [years]	7
Skin Surface Area [cm^2]	3300
Adherence Factor [mg/cm^2]	1

Dermal Contact Chemical Specific Parameters

Benzene	
Dermal Absorption Factors [fraction]	0.1
Xylene	
Dermal Absorption Factors [fraction]	0.1

Ingestion of Soil

Exposure Frequency [days/yr]	36
Exposure Duration [years]	7
Ingestion Rate [mg/day]	100
Fraction Soil Contaminated [-]	1

Ingestion of Soil Chemical Specific Parameters

Benzene	
Bioavailability [fraction]	1
Xylene	
Bioavailability [fraction]	1

Oral Dose

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

Dermal Dose

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

Inhalation Dose

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

Receptor Point Concentration Distributions

Soil Concentrations

Benzene	
Soil [mg/kg]	0.013
Xylene	
Soil [mg/kg]	0.022

```
 Emissions/Dispersion Model Output

Analysis for ...

 Analyses Performed:
  -----------------
 Thibodeaux-Hwang volatile emissions
 Box Model used for dispersion


 *** PARAMETERS ***

 Deterministic Run

PARAMETER NAME                 UNITS    VALUE
-------------------------------------------

Area                             m^2   .165E+05
Depth to Top of Cont. Zone         m   .000E+00
Depth to Bottom of Cont. Zone      m   .152E+01
Porosity                   cm^3/cm^3   .300E+00
Water Content              cm^3/cm^3   .100E+00
Soil Bulk Density             g/cm^3   .180E+01
Fractional Organic Carbon        g/g   .100E-01
Temperature                        C   .250E+02
Wind Speed                       m/s   .389E+01
Box Height                         m   .200E+01
Box Width                          m   .128E+03

 Benzene
-------------
PARAMETER NAME                 UNITS    VALUE
-------------------------------------------

Henrys const             (mg/L)/(mg/L)  .249E+00
Organic Carbon Part Coeff     cm^3/g   .830E+02
Molecular Weight               g/mol   .780E+02
Diffusion Coefficient in Air cm^2/s   .870E-01
Vapor Pressure                  mmHg   .952E+02
Total Soil Concentration       mg/kg   .130E-01

 Xylene
-------------
PARAMETER NAME                 UNITS    VALUE
-------------------------------------------

Henrys const             (mg/L)/(mg/L)  .315E+00
Organic Carbon Part Coeff     cm^3/g   .240E+03
Molecular Weight               g/mol   .106E+03
Diffusion Coefficient in Air cm^2/s   .720E-01
Vapor Pressure                  mmHg   .100E+02
Total Soil Concentration       mg/kg   .220E-01

 OUTPUTS

Time to depletion (yr) for Benzene              =  .519E+00
Time to depletion (yr) for Xylene               =  .135E+01

                    Volatile         Particulate       Air
                    Emissions        Emissions         Concentration
                    (kg/yr)          (kg/yr)           (mg/m^3)
 ------------------------------------------------------------------
```

```
 Averaging Time, yr =          5
Benzene              .989E-01          .000E+00          .315E-05
Xylene               .167E+00          .000E+00          .533E-05

  veraging Time, yr =         10
  nzene              .494E-01          .000E+00          .157E-05
Xylene               .836E-01          .000E+00          .266E-05

 Averaging Time, yr =         15
Benzene              .330E-01          .000E+00          .105E-05
Xylene               .558E-01          .000E+00          .178E-05

 Averaging Time, yr =         20
Benzene              .247E-01          .000E+00          .787E-06
Xylene               .418E-01          .000E+00          .133E-05

 Averaging Time, yr =         25
Benzene              .198E-01          .000E+00          .630E-06
Xylene               .335E-01          .000E+00          .107E-05

 Averaging Time, yr =         30
Benzene              .165E-01          .000E+00          .525E-06
Xylene               .279E-01          .000E+00          .888E-06

 Averaging Time, yr =         35
Benzene              .141E-01          .000E+00          .450E-06
Xylene               .239E-01          .000E+00          .761E-06

 Averaging Time, yr =         40
Benzene              .124E-01          .000E+00          .393E-06
  lene               .209E-01          .000E+00          .666E-06

 Averaging Time, yr =         45
Benzene              .110E-01          .000E+00          .350E-06
Xylene               .186E-01          .000E+00          .592E-06

 Averaging Time, yr =         50
Benzene              .989E-02          .000E+00          .315E-06
Xylene               .167E-01          .000E+00          .533E-06

 Averaging Time, yr =         55
Benzene              .899E-02          .000E+00          .286E-06
Xylene               .152E-01          .000E+00          .484E-06

 Averaging Time, yr =         60
Benzene              .824E-02          .000E+00          .262E-06
Xylene               .139E-01          .000E+00          .444E-06

 Averaging Time, yr =         65
Benzene              .760E-02          .000E+00          .242E-06
Xylene               .129E-01          .000E+00          .410E-06

 Averaging Time, yr =         70
Benzene              .706E-02          .000E+00          .225E-06
Xylene               .119E-01          .000E+00          .380E-06

  veraging Time, yr =         75
Benzene              .659E-02          .000E+00          .210E-06
Xylene               .112E-01          .000E+00          .355E-06
```

The following *chemicals* were selected:

Benz(a)anthracene
Chrysene

Data for Fate and Transport Models

Thibideaux-Hwang Model - Deterministic

Define Media Specific Parameters

Area of contaminated soil [m^2]	84000
Depth to top of cont. soil [m]	0
Depth to bottom of cont. soil [m]	1.52
Unsaturated zone porosity [-]	0.3
Water content [-]	0.1
Dry Wt. Soil bulk density [g/cm^3]	1.8
Fraction Organic Carbon [-]	0.01
Temperature [C]	25

Thibideaux-Hwang Chemical Specific Parameters

Benz(a)anthracene	
Henrys Constant [(mg/L)/(mg/L)	5.17E-05
Koc [ug/gOC/ug/ml]	1380000
Diffusion in Air [cm^2/sec]	0.051
Vapor Pressure [mmHg]	2.20E-08
Total Concentration in Soil [mg/kg]	0.16
Chrysene	
Henrys Constant [(mg/L)/(mg/L)	4.69E-05
Koc [ug/gOC/ug/ml]	200000
Diffusion in Air [cm^2/sec]	0.0452
Vapor Pressure [mmHg]	6.3E-09
Total Concentration in Soil [mg/kg]	0.3

Box Dispersion Model - Deterministic

Wind Speed [m/s]	3.89
Height of Box [m]	2
Width of Box [m]	2

Data for Risk Assessment

Body Weight and Lifetime - *Deterministic*

Average Weight (kg)	44
Lifetime (yrs)	70

Inhalation of Soil Emissions

Exposure Frequency [days/yr]	36
Exposure Duration [years]	7
Inhalation Rate [m^3/hr]	2.5
Time Outdoors [hours/day]	2

Inhalation of Soil Emissions Chemical Specific Parameters

Benz(a)anthracene	
Bioavailability [fraction]	1
Chrysene	
Bioavailability [fraction]	1

Dermal Contact with Soil

Exposure Frequency [days/yr]	36
Exposure Duration [years]	7
Skin Surface Area [cm^2]	3300
Adherence Factor [mg/cm^2]	1

Dermal Contact Chemical Specific Parameters

Benz(a)anthracene	
Dermal Absorption Factors [fraction]	0.15
rysene	
Dermal Absorption Factors [fraction]	0.15

Ingestion of Soil

Exposure Frequency [days/yr]	36
Exposure Duration [years]	7
Ingestion Rate [mg/day]	100
Fraction Soil Contaminated [-]	1

Ingestion of Soil Chemical Specific Parameters

Benz(a)anthracene	
Bioavailability [fraction]	1
Chrysene	
Bioavailability [fraction]	1

Oral Dose

Benz(a)anthracene	
Slope Factor [1/(mg/kg-day)]	1.2
Reference Dose [mg/kg-day]	ND
Chrysene	
Slope Factor [1/(mg/kg-day)]	0.12
Reference Dose [mg/kg-day]	ND

Dermal Dose

Benz(a)anthracene	
Slope Factor [1/(mg/kg-day)]	1.2
Reference Dose [mg/kg-day]	ND
Chrysene	
Slope Factor [1/(mg/kg-day)]	0.12
Reference Dose [mg/kg-day]	ND

Inhalation Dose

Benz(a)anthracene	
Slope Factor [1/(mg/kg-day)]	0.39
Reference Dose [mg/kg-day]	ND
Chrysene	
Slope Factor [1/(mg/kg-day)]	0.039
Reference Dose [mg/kg-day]	ND

Receptor Point Concentration Distributions

Soil Concentrations

Benz(a)anthracene	
Soil [mg/kg]	0.16
Chrysene	
Soil [mg/kg]	0.3

```
 Emissions/Dispersion Model Output

Analysis for ....

 Analyses Performed:
   -----------------
 Thibodeaux-Hwang volatile emissions
 Box Model used for dispersion


 *** PARAMETERS ***

 Deterministic Run

PARAMETER NAME                 UNITS    VALUE
--------------------------------------------


Area                             m^2   .840E+05
Depth to Top of Cont. Zone         m   .000E+00
Depth to Bottom of Cont. Zone      m   .152E+01
Porosity                   cm^3/cm^3   .300E+00
Water Content              cm^3/cm^3   .100E+00
Soil Bulk Density             g/cm^3   .180E+01
Fractional Organic Carbon        g/g   .100E-01
Temperature                        C   .250E+02
Wind Speed                       m/s   .389E+01
Box Height                         m   .200E+01
Box Width                          m   .290E+03

 Benz(a)anthracene
-------------
   AMETER NAME                 UNITS    VALUE
--------------------------------------------


Henrys const           (mg/L)/(mg/L)   .517E-04
Organic Carbon Part Coeff     cm^3/g   .138E+07
Molecular Weight               g/mol   .228E+03
Diffusion Coefficient in Air cm^2/s    .510E-01
Vapor Pressure                  mmHg   .220E-07
Total Soil Concentration       mg/kg   .160E+00

 Chrysene
-------------
PARAMETER NAME                 UNITS    VALUE
--------------------------------------------


Henrys const           (mg/L)/(mg/L)   .469E-04
Organic Carbon Part Coeff     cm^3/g   .200E+06
Molecular Weight               g/mol   .228E+03
Diffusion Coefficient in Air cm^2/s    .452E-01
Vapor Pressure                  mmHg   .630E-08
Total Soil Concentration       mg/kg   .300E+00

 OUTPUTS

Time to depletion (yr) for Benz(a)anthracene     =   .644E+08
Time to depletion (yr) for Chrysene              =   .116E+08

                    Volatile         Particulate      Air
                    Emissions        Emissions        Concentration
                    (kg/yr)          (kg/yr)          (mg/m^3)
 ------------------------------------------------------------------
```

```
 Averaging Time, yr =            5
Benz(a)anthr           .173E-02          .000E+00            .242E-07
  rysene               .762E-02          .000E+00            .107E-06

 Averaging Time, yr =           10
Benz(a)anthr           .122E-02          .000E+00            .171E-07
Chrysene               .539E-02          .000E+00            .757E-07

 Averaging Time, yr =           15
Benz(a)anthr           .996E-03          .000E+00            .140E-07
Chrysene               .440E-02          .000E+00            .618E-07

 Averaging Time, yr =           20
Benz(a)anthr           .863E-03          .000E+00            .121E-07
Chrysene               .381E-02          .000E+00            .535E-07

 Averaging Time, yr =           25
Benz(a)anthr           .772E-03          .000E+00            .108E-07
Chrysene               .341E-02          .000E+00            .479E-07

 Averaging Time, yr =           30
Benz(a)anthr           .704E-03          .000E+00            .990E-08
Chrysene               .311E-02          .000E+00            .437E-07

 Averaging Time, yr =           35
Benz(a)anthr           .652E-03          .000E+00            .916E-08
Chrysene               .288E-02          .000E+00            .405E-07

 Averaging Time, yr =           40
Benz(a)anthr           .610E-03          .000E+00            .857E-08
Chrysene               .269E-02          .000E+00            .379E-07

 Averaging Time, yr =           45
Benz(a)anthr           .575E-03          .000E+00            .808E-08
Chrysene               .254E-02          .000E+00            .357E-07

 Averaging Time, yr =           50
Benz(a)anthr           .546E-03          .000E+00            .767E-08
Chrysene               .241E-02          .000E+00            .339E-07

 Averaging Time, yr =           55
Benz(a)anthr           .520E-03          .000E+00            .731E-08
Chrysene               .230E-02          .000E+00            .323E-07

 Averaging Time, yr =           60
Benz(a)anthr           .498E-03          .000E+00            .700E-08
Chrysene               .220E-02          .000E+00            .309E-07

 Averaging Time, yr =           65
Benz(a)anthr           .478E-03          .000E+00            .673E-08
Chrysene               .211E-02          .000E+00            .297E-07

 Averaging Time, yr =           70
Benz(a)anthr           .461E-03          .000E+00            .648E-08
Chrysene               .204E-02          .000E+00            .286E-07

 Averaging Time, yr =           75
Benz(a)anthr           .445E-03          .000E+00            .626E-08
Chrysene               .197E-02          .000E+00            .276E-07
```

The following chemicals were selected:
Benzo(a)pyrene
Benzo(b)fluoranthene
nzo(g,h,i)perylene

Data for Fate and Transport Models

Thibideaux-Hwang Model - Deterministic

Define Media Specific Parameters

Area of contaminated soil [m^2]	16500
Depth to top of cont. soil [m]	0
Depth to bottom of cont. soil [m]	1.52
Unsaturated zone porosity [-]	0.3
Water content [-]	0.1
Dry Wt. Soil bulk density [g/cm^3]	1.8
Fraction Organic Carbon [-]	0.01
Temperature [C]	25

Thibideaux-Hwang Chemical Specific Parameters

Benzo(a)pyrene	
Henrys Constant [(mg/L)/(mg/L)	2.77E-05
Koc [ug/gOC/ug/ml]	5500000
Diffusion in Air [cm^2/sec]	0.043
Vapor Pressure [mmHg]	5.6E-09
Total Concentration in Soil [mg/kg]	0.54
Benzo(b)fluoranthene	
Henrys Constant [(mg/L)/(mg/L)	5.29E-04
Koc [ug/gOC/ug/ml]	550000
Diffusion in Air [cm^2/sec]	0.043
Vapor Pressure [mmHg]	5.00E-07
Total Concentration in Soil [mg/kg]	0.78
Benzo(g,h,i)perylene	
Henrys Constant [(mg/L)/(mg/L)	2.39E-06
Koc [ug/gOC/ug/ml]	1600000
Diffusion in Air [cm^2/sec]	0.0411
Vapor Pressure [mmHg]	1.03E-10
Total Concentration in Soil [mg/kg]	2.5

Box Dispersion Model - Deterministic

Wind Speed [m/s]	3.89
Height of Box [m]	2
Width of Box [m]	2

Data for Risk Assessment

Body Weight and Lifetime - Deterministic

Average Weight (kg)	44
Lifetime (yrs)	70

Inhalation of Soil Emissions

Exposure Frequency [days/yr]	36
Exposure Duration [years]	7
Inhalation Rate [m^3/hr]	2.5
Time Outdoors [hours/day]	2

Inhalation of Soil Emissions Chemical Specific Parameters

Benzo(a)pyrene	
Bioavailability [fraction]	1
Benzo(b)fluoranthene	
Bioavailability [fraction]	1

Benzo(g,h,i)perylene	
Bioavailability [fraction]	1

Dermal Contact with Soil

Exposure Frequency [days/yr]	36
Exposure Duration [years]	7
in Surface Area [cm^2]	3300
Adherence Factor [mg/cm^2]	1

Dermal Contact Chemical Specific Parameters

Benzo(a)pyrene	
Dermal Absorption Factors [fraction]	0.15
Benzo(b)fluoranthene	
Dermal Absorption Factors [fraction]	0.15
Benzo(g,h,i)perylene	
Dermal Absorption Factors [fraction]	0.15

Ingestion of Soil

Exposure Frequency [days/yr]	36
Exposure Duration [years]	7
Ingestion Rate [mg/day]	100
Fraction Soil Contaminated [-]	1

Ingestion of Soil Chemical Specific Parameters

Benzo(a)pyrene	
Bioavailability [fraction]	1
Benzo(b)fluoranthene	
Bioavailability [fraction]	1
Benzo(g,h,i)perylene	
Bioavailability [fraction]	1

Oral Dose

Benzo(a)pyrene	
Slope Factor [1/(mg/kg-day)]	12
Reference Dose [mg/kg-day]	ND
Benzo(b)fluoranthene	
Slope Factor [1/(mg/kg-day)]	1.2
Reference Dose [mg/kg-day]	ND
Benzo(g,h,i)perylene	
Slope Factor [1/(mg/kg-day)]	0.071
Reference Dose [mg/kg-day]	ND

Dermal Dose

Benzo(a)pyrene	
Slope Factor [1/(mg/kg-day)]	12
Reference Dose [mg/kg-day]	ND
Benzo(b)fluoranthene	
Slope Factor [1/(mg/kg-day)]	1.2
Reference Dose [mg/kg-day]	ND
Benzo(g,h,i)perylene	
Slope Factor [1/(mg/kg-day)]	0.071
Reference Dose [mg/kg-day]	ND

Inhalation Dose

Benzo(a)pyrene	
Slope Factor [1/(mg/kg-day)]	3.9
Reference Dose [mg/kg-day]	ND
Benzo(b)fluoranthene	
Slope Factor [1/(mg/kg-day)]	0.39
Reference Dose [mg/kg-day]	ND
enzo(g,h,i)perylene	
Slope Factor [1/(mg/kg-day)]	0.010
Reference Dose [mg/kg-day]	ND

Receptor Point Concentration Distributions

Soil Concentrations

Benzo(a)pyrene	
Soil [mg/kg]	0.54
Benzo(b)fluoranthene	
Soil [mg/kg]	0.78
Benzo(g,h,i)perylene	
Soil [mg/kg]	2.5

```
 Emissions/Dispersion Model Output

Analysis for ...

 Analyses Performed:
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   ıibodeaux-Hwang volatile emissions
 Box Model used for dispersion


 *** PARAMETERS ***

 Deterministic Run

PARAMETER NAME                     UNITS    VALUE
-------------------------------------------------

Area                                 m^2  .165E+05
Depth to Top of Cont. Zone             m  .000E+00
Depth to Bottom of Cont. Zone          m  .152E+01
Porosity                     cm^3/cm^3  .300E+00
Water Content                cm^3/cm^3  .100E+00
Soil Bulk Density                 g/cm^3  .180E+01
Fractional Organic Carbon            g/g  .100E-01
Temperature                            C  .250E+02
Wind Speed                           m/s  .389E+01
Box Height                             m  .200E+01
Box Width                              m  .128E+03

 Benzo(a)pyrene
 -------------
PARAMETER NAME                     UNITS    VALUE
  -----------------------------------------------

Henrys const           (mg/L)/(mg/L)  .277E-04
Organic Carbon Part Coeff     cm^3/g  .550E+07
Molecular Weight               g/mol  .252E+03
Diffusion Coefficient in Air cm^2/s  .430E-01
Vapor Pressure                  mmHg  .560E-08
Total Soil Concentration       mg/kg  .540E+00

 Benzo(b)fluoranthene
 -------------
PARAMETER NAME                     UNITS    VALUE
-------------------------------------------------

Henrys const           (mg/L)/(mg/L)  .529E-03
Organic Carbon Part Coeff     cm^3/g  .550E+06
Molecular Weight               g/mol  .252E+03
Diffusion Coefficient in Air cm^2/s  .430E-01
Vapor Pressure                  mmHg  .500E-06
Total Soil Concentration       mg/kg  .780E+00

 Benzo(g,h,i)perylene
 -------------
PARAMETER NAME                     UNITS    VALUE
-------------------------------------------------

  nrys const           (mg/L)/(mg/L)  .239E-05
Organic Carbon Part Coeff     cm^3/g  .160E+07
Molecular Weight               g/mol  .276E+03
Diffusion Coefficient in Air cm^2/s  .411E-01
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Vapor Pressure                         mmHg    .103E-09
Total Soil Concentration              mg/kg    .250E+01

 OUTPUTS

   e to depletion (yr) for Benzo(a)pyrene        =   .569E+09
   me to depletion (yr) for Benzo(b)fluoranthene =   .298E+07
Time to depletion (yr) for Benzo(g,h,i)perylene =   .201E+10

                       Volatile          Particulate       Air
                       Emissions         Emissions         Concentration
                       (kg/yr)           (kg/yr)           (mg/m^3)
 ------------------------------------------------------------------

 Averaging Time, yr =            5
Benzo(a)pyre            .385E-03          .000E+00          .123E-07
Benzo(b)fluo            .769E-02          .000E+00          .245E-06
Benzo(g,h,i)            .949E-03          .000E+00          .302E-07

 Averaging Time, yr =           10
Benzo(a)pyre            .272E-03          .000E+00          .867E-08
Benzo(b)fluo            .544E-02          .000E+00          .173E-06
Benzo(g,h,i)            .671E-03          .000E+00          .214E-07

 Averaging Time, yr =           15
Benzo(a)pyre            .222E-03          .000E+00          .708E-08
Benzo(b)fluo            .444E-02          .000E+00          .141E-06
Benzo(g,h,i)            .548E-03          .000E+00          .174E-07

 Averaging Time, yr =           20
Benzo(a)pyre            .193E-03          .000E+00          .613E-08
  nzo(b)fluo            .384E-02          .000E+00          .122E-06
 enzo(g,h,i)            .475E-03          .000E+00          .151E-07

 Averaging Time, yr =           25
Benzo(a)pyre            .172E-03          .000E+00          .548E-08
Benzo(b)fluo            .344E-02          .000E+00          .109E-06
Benzo(g,h,i)            .424E-03          .000E+00          .135E-07

 Averaging Time, yr =           30
Benzo(a)pyre            .157E-03          .000E+00          .501E-08
Benzo(b)fluo            .314E-02          .000E+00          .999E-07
Benzo(g,h,i)            .387E-03          .000E+00          .123E-07

 Averaging Time, yr =           35
Benzo(a)pyre            .146E-03          .000E+00          .463E-08
Benzo(b)fluo            .291E-02          .000E+00          .925E-07
Benzo(g,h,i)            .359E-03          .000E+00          .114E-07

 Averaging Time, yr =           40
Benzo(a)pyre            .136E-03          .000E+00          .434E-08
Benzo(b)fluo            .272E-02          .000E+00          .865E-07
Benzo(g,h,i)            .336E-03          .000E+00          .107E-07

 Averaging Time, yr =           45
Benzo(a)pyre            .128E-03          .000E+00          .409E-08
Benzo(b)fluo            .256E-02          .000E+00          .816E-07
 enzo(g,h,i)            .316E-03          .000E+00          .101E-07

 Averaging Time, yr =           50
Benzo(a)pyre            .122E-03          .000E+00          .388E-08
Benzo(b)fluo            .243E-02          .000E+00          .774E-07
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Benzo(g,h,i)          .300E-03              .000E+00              .956E-08

 Averaging Time, yr =           55
Benzo(a)pyre          .116E-03              .000E+00              .370E-08
Benzo(b)fluo          .232E-02              .000E+00              .738E-07
Benzo(g,h,i)          .286E-03              .000E+00              .911E-08

 Averaging Time, yr =           60
Benzo(a)pyre          .111E-03              .000E+00              .354E-08
Benzo(b)fluo          .222E-02              .000E+00              .707E-07
Benzo(g,h,i)          .274E-03              .000E+00              .872E-08

 Averaging Time, yr =           65
Benzo(a)pyre          .107E-03              .000E+00              .340E-08
Benzo(b)fluo          .213E-02              .000E+00              .679E-07
Benzo(g,h,i)          .263E-03              .000E+00              .838E-08

 Averaging Time, yr =           70
Benzo(a)pyre          .103E-03              .000E+00              .328E-08
Benzo(b)fluo          .205E-02              .000E+00              .654E-07
Benzo(g,h,i)          .254E-03              .000E+00              .808E-08

 Averaging Time, yr =           75
Benzo(a)pyre          .994E-04              .000E+00              .317E-08
Benzo(b)fluo          .198E-02              .000E+00              .632E-07
Benzo(g,h,i)          .245E-03              .000E+00              .780E-08
```

ATTACHMENT F
API DSS Exposure and Risk Calculations
Utility Worker

Data Summary for Elevated Sections Surface and Subsurface Soil - Worker Scenario

Chemical Intake Analysis

Carcinogenic Risk by Chemical for Each Route of Concern

Chemical	Inhalation of Soil Emissions	Dermal Contact With Soil	Soil Ingestion	Total
Benz(a)anthracene	6.35E-12	5.60E-09	3.09E-09	8.70E-09
Benzo(a)pyrene	3.21E-11	1.89E-07	1.04E-07	2.93E-07
Benzo(b)fluoranthene	6.40E-11	2.73E-08	1.51E-08	4.25E-08
Benzo(g,h,i)perylene	2.03E-13	5.18E-09	2.86E-09	8.04E-09
Chrysene	2.80E-12	1.05E-09	5.80E-10	1.63E-09
Naphthalene	ND	ND	ND	0.00E+00
Total	1.05E-10	2.28E-07	1.26E-07	3.54E-07

Hazard Index by Chemical for Each Route of Concern

Chemical	Inhalation of Soil Emissions	Dermal Contact With Soil	Soil Ingestion	Total
Benz(a)anthracene	ND	ND	ND	0.00E+00
Benzo(a)pyrene	ND	ND	ND	0.00E+00
Benzo(b)fluoranthene	ND	ND	ND	0.00E+00
Benzo(g,h,i)perylene	ND	ND	ND	0.00E+00
Chrysene	ND	ND	ND	0.00E+00
Naphthalene	ND	2.50E-04	1.38E-04	3.88E-04
Total	0.00E+00	2.50E-04	1.38E-04	3.88E-04

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

Data Summary for Elevated Sections Surface and Subsurface Soil - Worker Scenario

Chemical Intake Analysis
Dose by Chemical for Each Route of Concern (mg/kg-day)

Inhalation of Soil Emissions

	Intake	Value
Benz(a)anthracene	DI	6.93E-09
	CDI	1.14E-09
	LADD	1.63E-11
Benzo(a)pyrene	DI	3.50E-09
	CDI	5.76E-10
	LADD	8.23E-12
Benzo(b)fluoranthene	DI	6.99E-08
	CDI	1.15E-08
	LADD	1.64E-10
Benzo(g,h,i)perylene	DI	8.63E-09
	CDI	1.42E-09
	LADD	2.03E-11
Chrysene	DI	3.06E-08
	CDI	5.03E-09
	LADD	7.19E-11
Naphthalene	DI	4.37E-04
	CDI	7.18E-05
	LADD	1.03E-06

Dermal Contact With Soil

	Intake	Value
Benz(a)anthracene	DI	1.99E-06
	CDI	3.27E-07
	LADD	4.67E-09
Benzo(a)pyrene	DI	6.71E-06
	CDI	1.10E-06
	LADD	1.58E-08
Benzo(b)fluoranthene	DI	9.69E-06
	CDI	1.59E-06
	LADD	2.28E-08
Benzo(g,h,i)perylene	DI	3.11E-05
	CDI	5.11E-06
	LADD	7.30E-08
Chrysene	DI	3.73E-06
	CDI	6.13E-07
	LADD	8.76E-09
Naphthalene	DI	6.09E-05
	CDI	1.00E-05
	LADD	1.43E-07

Soil Ingestion

	Intake	Value
Benz(a)anthracene	DI	1.10E-06
	CDI	1.80E-07
	LADD	2.58E-09
Benzo(a)pyrene	DI	3.70E-06
	CDI	6.09E-07
	LADD	8.70E-09
Benzo(b)fluoranthene	DI	5.35E-06
	CDI	8.79E-07
	LADD	1.26E-08
Benzo(g,h,i)perylene	DI	1.71E-05
	CDI	2.82E-06
	LADD	4.03E-08
Chrysene	DI	2.06E-06
	CDI	3.38E-07
	LADD	4.83E-09
Naphthalene	DI	3.36E-05
	CDI	5.52E-06
	LADD	7.89E-08

Deterministic Run
NA = Not Applicable

Data Summary for Elevated Sections Surface and Subsurface Soil - Worker Scenario

Chemical Intake Analysis

Carcinogenic Risk by Chemical for Each Route of Concern

Chemical	Inhalation of Soil Emissions	Dermal Contact With Soil	Soil Ingestion	Total
Benzene	2.92E-10	3.50E-11	2.90E-11	3.56E-10
Ethylbenzene	ND	ND	ND	0.00E+00
Ethylene Dibromide	1.14E-09	1.96E-09	1.62E-09	4.72E-09
Ethylene Dichloride	2.27E-09	2.72E-10	2.25E-10	2.77E-09
Toluene	ND	ND	ND	0.00E+00
Xylene	ND	ND	ND	0.00E+00
Total	3.70E-09	2.27E-09	1.87E-09	7.84E-09

Hazard Index by Chemical for Each Route of Concern

Chemical	Inhalation of Soil Emissions	Dermal Contact With Soil	Soil Ingestion	Total
Benzene	ND	ND	ND	0.00E+00
Ethylbenzene	2.46E-06	4.49E-07	3.72E-07	3.28E-06
Ethylene Dibromide	ND	ND	ND	0.00E+00
Ethylene Dichloride	ND	ND	ND	0.00E+00
Toluene	8.29E-05	2.52E-06	2.09E-06	8.75E-05
Xylene	4.04E-06	4.84E-08	4.00E-08	4.13E-06
Total	8.94E-05	3.02E-06	2.50E-06	9.49E-05

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

Data Summary for Elevated Sections Surface and Subsurface Soil - Worker Scenario

Chemical Intake Analysis
Dose by Chemical for Each Route of Concern (mg/kg-day)

Inhalation of Soil Emissions

	Intake	Value
Benzene	DI	1.25E-06
	CDI	2.05E-07
	LADD	2.92E-09
Ethylbenzene	DI	4.27E-06
	CDI	7.02E-07
	LADD	1.00E-08
Ethylene Dibromide	DI	1.94E-06
	CDI	3.18E-07
	LADD	4.55E-09
Ethylene Dichloride	DI	1.38E-05
	CDI	2.27E-06
	LADD	3.25E-08
Toluene	DI	5.75E-05
	CDI	9.45E-06
	LADD	1.35E-07
Xylene	DI	4.91E-06
	CDI	8.07E-07
	LADD	1.15E-08

Dermal Contact With Soil

	Intake	Value
Benzene	DI	1.49E-07
	CDI	2.45E-08
	LADD	3.50E-10
Ethylbenzene	DI	2.73E-07
	CDI	4.49E-08
	LADD	6.42E-10
Ethylene Dibromide	DI	2.32E-07
	CDI	3.81E-08
	LADD	5.45E-10
Ethylene Dichloride	DI	1.66E-06
	CDI	2.72E-07
	LADD	3.89E-09
Toluene	DI	3.07E-06
	CDI	5.04E-07
	LADD	7.20E-09
Xylene	DI	5.88E-07
	CDI	9.67E-08
	LADD	1.38E-09

Soil Ingestion

	Intake	Value
Benzene	DI	1.23E-07
	CDI	2.03E-08
	LADD	2.90E-10
Ethylbenzene	DI	2.26E-07
	CDI	3.72E-08
	LADD	5.31E-10
Ethylene Dibromide	DI	1.92E-07
	CDI	3.16E-08
	LADD	4.51E-10
Ethylene Dichloride	DI	1.37E-06
	CDI	2.25E-07
	LADD	3.22E-09
Toluene	DI	2.54E-06
	CDI	4.17E-07
	LADD	5.96E-09
Xylene	DI	4.87E-07
	CDI	8.00E-08
	LADD	1.14E-09

Deterministic Run
NA = Not Applicable

Data Summary for Elevated Sections Surf[illegible] and Subsurface Soil - Worker Scenario

Analysis for Volatile Emissions

Averaging Time* [Years]	Benzene [kg/year]	Ethylbenzene [kg/year]	Ethylene Dibromide [kg/year]	Ethylene Dichloride [kg/year]	Toluene [kg/year]	Xylene [kg/year]
5	1.37E-01	1.06E+00	2.13E-01	1.52E+00	1.43E+01	5.40E-01
10	6.84E-02	6.39E-01	1.07E-01	7.60E-01	7.16E+00	2.70E-01
15	4.56E-02	4.26E-01	7.10E-02	5.07E-01	4.77E+00	1.80E-01
20	3.42E-02	3.19E-01	5.32E-02	3.80E-01	3.58E+00	1.35E-01
25	2.74E-02	2.56E-01	4.26E-02	3.04E-01	2.87E+00	1.08E-01
30	2.28E-02	2.13E-01	3.55E-02	2.54E-01	2.39E+00	9.00E-02
35	1.96E-02	1.83E-01	3.04E-02	2.17E-01	2.05E+00	7.71E-02
40	1.71E-02	1.60E-01	2.66E-02	1.90E-01	1.79E+00	6.75E-02
45	1.52E-02	1.42E-01	2.37E-02	1.69E-01	1.59E+00	6.00E-02
50	1.37E-02	1.28E-01	2.13E-02	1.52E-01	1.43E+00	5.40E-02
55	1.24E-02	1.16E-01	1.94E-02	1.38E-01	1.30E+00	4.91E-02
60	1.14E-02	1.07E-01	1.77E-02	1.27E-01	1.19E+00	4.50E-02
65	1.05E-02	9.83E-02	1.64E-02	1.17E-01	1.10E+00	4.15E-02
70	9.78E-03	9.13E-02	1.52E-02	1.09E-01	1.02E+00	3.86E-02
75	9.13E-03	8.52E-02	1.42E-02	1.01E-01	9.55E-01	3.60E-02

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

Data Summary for Elevated Sections Surf and Subsurface Soil - Worker Scenario

Analysis for
Volatile Emissions

Averaging Time* [Years]	Benz(a)anthracene [kg/year]	Benzo(a)pyrene [kg/year]	Benzo(b)fluoranthene [kg/year]	Benzo(g,h,i)perylene [kg/year]	Chrysene [kg/year]	Naphthalene [kg/year]
5	1.73E-03	3.85E-04	7.69E-03	9.49E-04	7.62E-03	1.09E+02
10	1.22E-03	2.72E-04	5.44E-03	6.71E-04	5.39E-03	5.44E+01
15	9.96E-04	2.22E-04	4.44E-03	5.48E-04	4.40E-03	3.62E+01
20	8.63E-04	1.93E-04	3.84E-03	4.75E-04	3.81E-03	2.72E+01
25	7.72E-04	1.72E-04	3.44E-03	4.25E-04	3.41E-03	2.17E+01
30	7.04E-04	1.57E-04	3.14E-03	3.88E-04	3.11E-03	1.81E+01
35	6.52E-04	1.46E-04	2.91E-03	3.59E-04	2.88E-03	1.55E+01
40	6.10E-04	1.36E-04	2.72E-03	3.36E-04	2.69E-03	1.36E+01
45	5.75E-04	1.28E-04	2.56E-03	3.16E-04	2.54E-03	1.21E+01
50	5.46E-04	1.22E-04	2.43E-03	3.00E-04	2.41E-03	1.09E+01
55	5.20E-04	1.16E-04	2.32E-03	2.86E-04	2.30E-03	9.88E+00
60	4.98E-04	1.11E-04	2.22E-03	2.74E-04	2.20E-03	9.06E+00
65	4.79E-04	1.07E-04	2.13E-03	2.63E-04	2.11E-03	8.36E+00
70	4.61E-04	1.03E-04	2.05E-03	2.54E-04	2.04E-03	7.77E+00
75	4.46E-04	9.94E-05	1.99E-03	2.45E-04	1.97E-03	7.25E+00

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

Data Summary for Elevated Sections Surface and Subsurface Soil - Worker Scenario

Analysis for
Receptor Point Concentration in Air

Averaging Time* [Years]	Benz(a)anthracene [mg/m³]	Benzo(a)pyrene [mg/m³]	Benzo(b)fluoranthene [mg/m³]	Benzo(g,h,i)perylene [mg/m³]	Chrysene [mg/m³]	Naphthalene [mg/m³]
5	2.43E-08	1.23E-08	2.45E-07	3.02E-08	1.07E-07	1.53E-03
10	1.72E-08	8.67E-09	1.73E-07	2.14E-08	7.57E-08	7.64E-04
15	1.40E-08	7.08E-09	1.41E-07	1.75E-08	6.18E-08	5.09E-04
20	1.21E-08	6.13E-09	1.22E-07	1.51E-08	5.35E-08	3.82E-04
25	1.08E-08	5.48E-09	1.10E-07	1.35E-08	4.79E-08	3.06E-04
30	9.90E-09	5.01E-09	9.99E-08	1.23E-08	4.37E-08	2.55E-04
35	9.17E-09	4.63E-09	9.25E-08	1.14E-08	4.05E-08	2.18E-04
40	8.57E-09	4.34E-09	8.65E-08	1.07E-08	3.79E-08	1.91E-04
45	8.08E-09	4.09E-09	8.16E-08	1.01E-08	3.57E-08	1.70E-04
50	7.67E-09	3.88E-09	7.74E-08	9.56E-09	3.39E-08	1.53E-04
55	7.31E-09	3.70E-09	7.38E-08	9.11E-09	3.23E-08	1.39E-04
60	7.00E-09	3.54E-09	7.07E-08	8.73E-09	3.09E-08	1.27E-04
65	6.73E-09	3.40E-09	6.79E-08	8.38E-09	2.97E-08	1.18E-04
70	6.48E-09	3.28E-09	6.54E-08	8.08E-09	2.86E-08	1.09E-04
75	6.26E-09	3.17E-09	6.32E-08	7.80E-09	2.77E-08	1.02E-04

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

Data Summary for Elevated Sections Surface and Subsurface Soil - Worker Scenario

Analysis for Receptor Point Concentration in Air

Averaging Time* [Years]	Benzene [mg/m^3]	Ethylbenzene [mg/m^3]	Ethylene Dibromide [mg/m^3]	Ethylene Dichloride [mg/m^3]	Toluene [mg/m^3]	Xylene [mg/m^3]
5	4.36E-06	1.50E-05	6.78E-06	4.84E-05	2.01E-04	1.72E-05
10	2.18E-06	8.98E-06	3.39E-06	2.42E-05	1.01E-04	8.60E-06
15	1.45E-06	5.99E-06	2.26E-06	1.61E-05	6.71E-05	5.73E-06
20	1.09E-06	4.49E-06	1.70E-06	1.21E-05	5.03E-05	4.30E-06
25	8.72E-07	3.59E-06	1.36E-06	9.69E-06	4.03E-05	3.44E-06
30	7.26E-07	2.99E-06	1.13E-06	8.07E-06	3.36E-05	2.87E-06
35	6.23E-07	2.57E-06	9.69E-07	6.92E-06	2.88E-05	2.46E-06
40	5.45E-07	2.24E-06	8.48E-07	6.05E-06	2.52E-05	2.15E-06
45	4.84E-07	2.00E-06	7.53E-07	5.38E-06	2.24E-05	1.91E-06
50	4.36E-07	1.80E-06	6.78E-07	4.84E-06	2.01E-05	1.72E-06
55	3.96E-07	1.63E-06	6.16E-07	4.40E-06	1.83E-05	1.56E-06
60	3.63E-07	1.50E-06	5.65E-07	4.04E-06	1.68E-05	1.43E-06
65	3.35E-07	1.38E-06	5.22E-07	3.73E-06	1.55E-05	1.32E-06
70	3.11E-07	1.28E-06	4.84E-07	3.46E-06	1.44E-05	1.23E-06
75	2.91E-07	1.20E-06	4.52E-07	3.23E-06	1.34E-05	1.15E-06

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

Data Summary for At Grade Sections Surface and Subsurface Soil - Worker Scenario

Chemical Intake Analysis
Dose by Chemical for Each *Route of Concern* (mg/kg-day)

Inhalation of Soil Emissions

	Intake	Value
Benz(a)anthracene	DI	6.88E-08
	CDI	1.13E-08
	LADD	1.62E-10
Benzo(a)pyrene	DI	4.21E-08
	CDI	6.93E-09
	LADD	9.90E-11
Benzo(b)fluoranthene	DI	3.79E-07
	CDI	6.22E-08
	LADD	8.89E-10
Benzo(g,h,i)perylene	DI	1.12E-08
	CDI	1.84E-09
	LADD	2.63E-11
Chrysene	DI	5.46E-07
	CDI	8.98E-08
	LADD	1.28E-09
Dibenz(a,h)anthracene	DI	7.57E-09
	CDI	1.25E-09
	LADD	1.78E-11

Dermal Contact With Soil

	Intake	Value
Benz(a)anthracene	DI	1.37E-05
	CDI	2.25E-06
	LADD	3.21E-08
Benzo(a)pyrene	DI	2.49E-05
	CDI	4.09E-06
	LADD	5.84E-08
Benzo(b)fluoranthene	DI	1.62E-05
	CDI	2.66E-06
	LADD	3.79E-08
Benzo(g,h,i)perylene	DI	1.24E-05
	CDI	2.04E-06
	LADD	2.92E-08
Chrysene	DI	5.47E-05
	CDI	8.99E-06
	LADD	1.28E-07
Dibenz(a,h)anthracene	DI	1.03E-05
	CDI	1.70E-06
	LADD	2.42E-08

Soil Ingestion

	Intake	Value
Benz(a)anthracene	DI	7.54E-06
	CDI	1.24E-06
	LADD	1.77E-08
Benzo(a)pyrene	DI	1.37E-05
	CDI	2.25E-06
	LADD	3.22E-08
Benzo(b)fluoranthene	DI	8.91E-06
	CDI	1.47E-06
	LADD	2.09E-08
Benzo(g,h,i)perylene	DI	6.86E-06
	CDI	1.13E-06
	LADD	1.61E-08
Chrysene	DI	3.02E-05
	CDI	4.96E-06
	LADD	7.09E-08
Dibenz(a,h)anthracene	DI	5.69E-06
	CDI	9.36E-07
	LADD	1.34E-08

Deterministic Run
NA = Not Applicable

Data Summary for At Grade Sections Surface and Subsurface Soil - Worker Scenario

Analysis for
Volatile Emissions

Averaging Time* [Years]	Toluene [kg/year]	Benz(a)anthracene [kg/year]	Benzo(a)pyrene [kg/year]	Benzo(b)fluoranthene [kg/year]	Benzo(g,h,i)perylene [kg/year]	Chrysene [kg/year]	Dibenz(a,h)anthracene [kg/year]
5	2.42E-01	2.47E-02	1.51E-02	1.36E-01	4.03E-03	1.96E-01	2.72E-03
10	1.21E-01	1.75E-02	1.07E-02	9.61E-02	2.85E-03	1.39E-01	1.92E-03
15	8.07E-02	1.43E-02	8.73E-03	7.84E-02	2.33E-03	1.13E-01	1.57E-03
20	6.05E-02	1.24E-02	7.56E-03	6.79E-02	2.01E-03	9.81E-02	1.36E-03
25	4.84E-02	1.11E-02	6.77E-03	6.08E-02	1.80E-03	8.77E-02	1.22E-03
30	4.03E-02	1.01E-02	6.18E-03	5.55E-02	1.64E-03	8.01E-02	1.11E-03
35	3.46E-02	9.34E-03	5.72E-03	5.14E-02	1.52E-03	7.41E-02	1.03E-03
40	3.02E-02	8.74E-03	5.35E-03	4.80E-02	1.42E-03	6.93E-02	9.61E-04
45	2.69E-02	8.24E-03	5.04E-03	4.53E-02	1.34E-03	6.54E-02	9.06E-04
50	2.42E-02	7.81E-03	4.78E-03	4.30E-02	1.27E-03	6.20E-02	8.60E-04
55	2.20E-02	7.45E-03	4.56E-03	4.10E-02	1.21E-03	5.91E-02	8.20E-04
60	2.02E-02	7.13E-03	4.37E-03	3.92E-02	1.16E-03	5.66E-02	7.85E-04
65	1.86E-02	6.85E-03	4.20E-03	3.77E-02	1.12E-03	5.44E-02	7.54E-04
70	1.73E-02	6.60E-03	4.04E-03	3.63E-02	1.08E-03	5.24E-02	7.27E-04
75	1.61E-02	6.38E-03	3.91E-03	3.51E-02	1.04E-03	5.06E-02	7.02E-04

*The maximum RUNNING average concentration is shown for these averaging times.

For example, the maximum 5-year average concentration may not occur in the first five years.

To find out when the maximum RUNNING concentrations occured, view the charts.

Simulation Time = 75 Years

Data Summary for At Grade Sections Surface and Subsurface Soil - Worker Scenario

Analysis for
Receptor Point Concentration in Air

Averaging Time* [Years]	Toluene [mg/m^3]	Benz(a)anthracene [mg/m^3]	Benzo(a)pyrene [mg/m^3]	Benzo(b)fluoranthene [mg/m^3]	Benzo(g,h,i)perylene [mg/m^3]	Chrysene [mg/m^3]	Dibenz(a,h)anthracene [mg/m^3]
5	2.36E-06	2.41E-07	1.48E-07	1.33E-06	3.93E-08	1.91E-06	2.65E-08
10	1.18E-06	1.70E-07	1.04E-07	9.37E-07	2.78E-08	1.35E-06	1.88E-08
15	7.86E-07	1.39E-07	8.52E-08	7.65E-07	2.27E-08	1.10E-06	1.53E-08
20	5.90E-07	1.21E-07	7.37E-08	6.62E-07	1.96E-08	9.56E-07	1.33E-08
25	4.72E-07	1.08E-07	6.60E-08	5.93E-07	1.76E-08	8.55E-07	1.19E-08
30	3.93E-07	9.84E-08	6.02E-08	5.41E-07	1.60E-08	7.81E-07	1.08E-08
35	3.37E-07	9.11E-08	5.58E-08	5.01E-07	1.48E-08	7.23E-07	1.00E-08
40	2.95E-07	8.52E-08	5.22E-08	4.68E-07	1.39E-08	6.76E-07	9.37E-09
45	2.62E-07	8.03E-08	4.92E-08	4.42E-07	1.31E-08	6.37E-07	8.84E-09
50	2.36E-07	7.62E-08	4.66E-08	4.19E-07	1.24E-08	6.05E-07	8.38E-09
55	2.15E-07	7.27E-08	4.45E-08	3.99E-07	1.18E-08	5.77E-07	7.99E-09
60	1.97E-07	6.96E-08	4.26E-08	3.82E-07	1.13E-08	5.52E-07	7.65E-09
65	1.82E-07	6.68E-08	4.09E-08	3.67E-07	1.09E-08	5.30E-07	7.35E-09
70	1.69E-07	6.44E-08	3.94E-08	3.54E-07	1.05E-08	5.11E-07	7.09E-09
75	1.57E-07	6.22E-08	3.81E-08	3.42E-07	1.01E-08	4.94E-07	6.85E-09

*The maximum RUNNING average concentration is shown for these averaging times.

For example, the maximum 5-year average concentration may not occur in the first five years.

To find out when the maximum RUNNING concentrations occured, view the charts.

Simulation Time = 75 Years

Data Summary for At Grade Sections Surface and Subsurface Soil - Worker Scenario

Chemical Intake Analysis
Dose by Chemical for Each Route of Concern (mg/kg-day)

Inhalation of Soil Emissions

	Intake	Value
Toluene	DI	6.74E-07
	CDI	1.11E-07
	LADD	1.58E-09

Dermal Contact With Soil

	Intake	Value
Toluene	DI	2.49E-08
	CDI	4.09E-09
	LADD	5.84E-11

Soil Ingestion

	Intake	Value
Toluene	DI	2.06E-08
	CDI	3.38E-09
	LADD	4.83E-11

Deterministic Run
NA = Not Applicable

The following chemicals were selected:
Toluene

ta for Fate and Transport Models

Thibideaux-Hwang Model - Deterministic

Define Media Specific Parameters

Area of contaminated soil [m^2]	175000
Depth to top of cont. soil [m]	0
Depth to bottom of cont. soil [m]	1.52
Unsaturated zone porosity [-]	0.3
Water content [-]	0.1
Dry Wt. Soil bulk density [g/cm^3]	1.8
Fraction Organic Carbon [-]	0.01
Temperature [C]	25

Thibideaux-Hwang Chemical Specific Parameters

Toluene	
Henrys Constant [(mg/L)/(mg/L)	2.84E-01
Koc [ug/gOC/ug/ml]	300
Diffusion in Air [cm^2/sec]	0.078
Vapor Pressure [mmHg]	28.1
Total Concentration in Soil [mg/kg]	0.003

Box Dispersion Model - Deterministic

Wind Speed [m/s]	3.89
Height of Box [m]	2
Width of Box [m]	2

Data for Risk Assessment

Body Weight and Lifetime - Deterministic

Average Weight (kg)	70
Lifetime (yrs)	70

Inhalation of Soil Emissions

Exposure Frequency [days/yr]	60
Exposure Duration [years]	1
Inhalation Rate [m^3/hr]	2.5
Time Outdoors [hours/day]	8

Inhalation of Soil Emissions Chemical Specific Parameters

Toluene	
Bioavailability [fraction]	1

Dermal Contact with Soil

Exposure Frequency [days/yr]	*60*
Exposure Duration [years]	1
Skin Surface Area [cm^2]	5800
Adherence Factor [mg/cm^2]	1

Dermal Contact Chemical Specific Parameters

Toluene	
Dermal Absorption Factors [fraction]	0.1

Ingestion of Soil

Exposure Frequency [days/yr]	60
Exposure Duration [years]	1
Ingestion Rate [mg/day]	480
Fraction Soil Contaminated [-]	1

Ingestion of Soil Chemical Specific Parameters

Toluene	
Bioavailability [fraction]	1

Oral Dose

ıene	
Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	0.2

Dermal Dose

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

Inhalation Dose

Toluene	
Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	1.14E-1

Receptor Point Concentration Distributions

Soil Concentrations

Toluene	
Soil [mg/kg]	0.003

```
 Emissions/Dispersion Model Output

Analysis for ...

 Analyses Performed:
   -----------------
 Thibodeaux-Hwang volatile emissions
 Box Model used for dispersion


 *** PARAMETERS ***

 Deterministic Run

PARAMETER NAME                     UNITS    VALUE
-------------------------------------------------------

Area                                 m^2   .175E+06
Depth to Top of Cont. Zone             m   .000E+00
Depth to Bottom of Cont. Zone          m   .152E+01
Porosity                       cm^3/cm^3   .300E+00
Water Content                  cm^3/cm^3   .100E+00
Soil Bulk Density                 g/cm^3   .180E+01
Fractional Organic Carbon            g/g   .100E-01
Temperature                            C   .250E+02
Wind Speed                           m/s   .389E+01
Box Height                             m   .200E+01
Box Width                              m   .418E+03

 Toluene
 -----------
   AMETER NAME                     UNITS    VALUE
-------------------------------------------------------

Henrys const            (mg/L)/(mg/L)   .284E+00
Organic Carbon Part Coeff      cm^3/g   .300E+03
Molecular Weight                g/mol   .920E+02
Diffusion Coefficient in Air cm^2/s   .780E-01
Vapor Pressure                   mmHg   .281E+02
Total Soil Concentration        mg/kg   .300E-02

 OUTPUTS

Time to depletion (yr) for Toluene              =   .172E+01

                     Volatile          Particulate       Air
                     Emissions         Emissions         Concentration
                     (kg/yr)           (kg/yr)           (mg/m^3)
 -------------------------------------------------------------------

 Averaging Time, yr =          5
Toluene               .242E+00           .000E+00           .236E-05

 Averaging Time, yr =         10
Toluene               .121E+00           .000E+00           .118E-05

   veraging Time, yr =         15
  luene               .807E-01           .000E+00           .786E-06

 Averaging Time, yr =         20
Toluene               .605E-01           .000E+00           .590E-06
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 Averaging Time, yr =            25
Toluene                 .484E-01            .000E+00            .472E-06

 Averaging Time, yr =            30
Toluene                 .403E-01            .000E+00            .393E-06

 Averaging Time, yr =            35
Toluene                 .346E-01            .000E+00            .337E-06

 Averaging Time, yr =            40
Toluene                 .302E-01            .000E+00            .295E-06

 Averaging Time, yr =            45
Toluene                 .269E-01            .000E+00            .262E-06

 Averaging Time, yr =            50
Toluene                 .242E-01            .000E+00            .236E-06

 Averaging Time, yr =            55
Toluene                 .220E-01            .000E+00            .214E-06

 Averaging Time, yr =            60
Toluene                 .202E-01            .000E+00            .197E-06

 Averaging Time, yr =            65
Toluene                 .186E-01            .000E+00            .181E-06

 Averaging Time, yr =            70
Toluene                 .173E-01            .000E+00            .169E-06

 Averaging Time, yr =            75
   uene                 .161E-01            .000E+00            .157E-06
```

The following chemicals were selected:

Benz(a)anthracene
Benzo(a)pyrene
zo(b)fluoranthene
rysene
Dibenz(a,h)anthracene

Data for Fate and Transport Models

Thibideaux-Hwang Model - Deterministic

Define Media Specific Parameters

Area of contaminated soil [m^2]	175000
Depth to top of cont. soil [m]	0
Depth to bottom of cont. soil [m]	1.52
Unsaturated zone porosity [-]	0.3
Water content [-]	0.1
Dry Wt. Soil bulk density [g/cm^3]	1.8
Fraction Organic Carbon [-]	0.01
Temperature [C]	25

Thibideaux-Hwang Chemical Specific Parameters

Benz(a)anthracene	
Henrys Constant [(mg/L)/(mg/L)	5.17E-05
Koc [ug/gOC/ug/ml]	1380000
Diffusion in Air [cm^2/sec]	0.051
Vapor Pressure [mmHg]	2.20E-08
Total Concentration in Soil [mg/kg]	1.1
Benzo(a)pyrene	
Henrys Constant [(mg/L)/(mg/L)	2.77E-05
Koc [ug/gOC/ug/ml]	5500000
Diffusion in Air [cm^2/sec]	0.043
Vapor Pressure [mmHg]	5.6E-09
Total Concentration in Soil [mg/kg]	2
Benzo(b)fluoranthene	
Henrys Constant [(mg/L)/(mg/L)	5.29E-04
Koc [ug/gOC/ug/ml]	550000
Diffusion in Air [cm^2/sec]	0.043
Vapor Pressure [mmHg]	5.00E-07
Total Concentration in Soil [mg/kg]	1.3
Chrysene	
Henrys Constant [(mg/L)/(mg/L)	4.69E-05
Koc [ug/gOC/ug/ml]	200000
Diffusion in Air [cm^2/sec]	0.0452
Vapor Pressure [mmHg]	6.3E-09
Total Concentration in Soil [mg/kg]	4.4
Dibenz(a,h)anthracene	
Henrys Constant [(mg/L)/(mg/L)	3.27E-06
Koc [ug/gOC/ug/ml]	3300000
Diffusion in Air [cm^2/sec]	0.041
Vapor Pressure [mmHg]	1E-10
Total Concentration in Soil [mg/kg]	0.83

Box Dispersion Model - Deterministic

Wind Speed [m/s]	3.89
Height of Box [m]	2
Width of Box [m]	2

Data for Risk Assessment

Body Weight and Lifetime - Deterministic

Average Weight (kg)	70

Lifetime (yrs)	70
Inhalation of Soil Emissions	
Exposure Frequency [days/yr]	60
osure Duration [years]	1
lation Rate [m^3/hr]	2.5
Time Outdoors [hours/day]	8
Inhalation of Soil Emissions Chemical Specific Parameters	
Benz(a)anthracene	
Bioavailability [fraction]	1
Benzo(a)pyrene	
Bioavailability [fraction]	1
Benzo(b)fluoranthene	
Bioavailability [fraction]	1
Chrysene	
Bioavailability [fraction]	1
Dibenz(a,h)anthracene	
Bioavailability [fraction]	1
Dermal Contact with Soil	
Exposure Frequency [days/yr]	60
Exposure Duration [years]	1
Skin Surface Area [cm^2]	5800
Adherence Factor [mg/cm^2]	1
Dermal Contact Chemical Specific Parameters	
Benz(a)anthracene	
Dermal Absorption Factors [fraction]	0.15
Benzo(a)pyrene	
Dermal Absorption Factors [fraction]	0.15
zo(b)fluoranthene	
Dermal Absorption Factors [fraction]	0.15
Chrysene	
Dermal Absorption Factors [fraction]	0.15
Dibenz(a,h)anthracene	
Dermal Absorption Factors [fraction]	0.15
Ingestion of Soil	
Exposure Frequency [days/yr]	60
Exposure Duration [years]	1
Ingestion Rate [mg/day]	480
Fraction Soil Contaminated [-]	1
Ingestion of Soil Chemical Specific Parameters	
Benz(a)anthracene	
Bioavailability [fraction]	1
Benzo(a)pyrene	
Bioavailability [fraction]	1
Benzo(b)fluoranthene	
Bioavailability [fraction]	1
Chrysene	
Bioavailability [fraction]	1
Dibenz(a,h)anthracene	
Bioavailability [fraction]	1
Oral Dose	
Benz(a)anthracene	
Slope Factor [1/(mg/kg-day)]	1.2
Reference Dose [mg/kg-day]	ND
Benzo(a)pyrene	
Slope Factor [1/(mg/kg-day)]	12
Reference Dose [mg/kg-day]	ND
Benzo(b)fluoranthene	

Slope Factor [1/(mg/kg-day)]	1.2
Reference Dose [mg/kg-day]	ND
Chrysene	
Slope Factor [1/(mg/kg-day)]	0.12
Reference Dose [mg/kg-day]	ND
benz(a,h)anthracene	
Slope Factor [1/(mg/kg-day)]	4.1
Reference Dose [mg/kg-day]	ND

Dermal Dose

Benz(a)anthracene	
Slope Factor [1/(mg/kg-day)]	1.2
Reference Dose [mg/kg-day]	ND
Benzo(a)pyrene	
Slope Factor [1/(mg/kg-day)]	12
Reference Dose [mg/kg-day]	ND
Benzo(b)fluoranthene	
Slope Factor [1/(mg/kg-day)]	1.2
Reference Dose [mg/kg-day]	ND
Chrysene	
Slope Factor [1/(mg/kg-day)]	0.12
Reference Dose [mg/kg-day]	ND
Dibenz(a,h)anthracene	
Slope Factor [1/(mg/kg-day)]	4.1
Reference Dose [mg/kg-day]	ND

Inhalation Dose

Benz(a)anthracene	
Slope Factor [1/(mg/kg-day)]	0.39
Reference Dose [mg/kg-day]	ND
Benzo(a)pyrene	
Slope Factor [1/(mg/kg-day)]	3.9
Reference Dose [mg/kg-day]	ND
enzo(b)fluoranthene	
Slope Factor [1/(mg/kg-day)]	0.39
Reference Dose [mg/kg-day]	ND
Chrysene	
Slope Factor [1/(mg/kg-day)]	0.039
Reference Dose [mg/kg-day]	ND
Dibenz(a,h)anthracene	
Slope Factor [1/(mg/kg-day)]	4.1
Reference Dose [mg/kg-day]	ND

Receptor Point Concentration Distributions

Soil Concentrations

Benz(a)anthracene	
Soil [mg/kg]	1.1
Benzo(a)pyrene	
Soil [mg/kg]	2
Benzo(b)fluoranthene	
Soil [mg/kg]	1.3
Chrysene	
Soil [mg/kg]	4.4
Dibenz(a,h)anthracene	
Soil [mg/kg]	0.83

```
 Emissions/Dispersion Model Output

Analysis for ...

 Analyses Performed:
  -----------------
  Thibodeaux-Hwang volatile emissions
 Box Model used for dispersion


 *** PARAMETERS ***

 Deterministic Run

PARAMETER NAME                   UNITS    VALUE
-------------------------------------------


Area                              m^2   .175E+06
Depth to Top of Cont. Zone          m   .000E+00
Depth to Bottom of Cont. Zone       m   .152E+01
Porosity                    cm^3/cm^3   .300E+00
Water Content               cm^3/cm^3   .100E+00
Soil Bulk Density              g/cm^3   .180E+01
Fractional Organic Carbon         g/g   .100E-01
Temperature                         C   .250E+02
Wind Speed                        m/s   .389E+01
Box Height                          m   .200E+01
Box Width                           m   .418E+03

 Benz(a)anthracene
-------------
  RAMETER NAME                   UNITS    VALUE
  -----------------------------------------


Henrys const          (mg/L)/(mg/L)   .517E-04
Organic Carbon Part Coeff    cm^3/g   .138E+07
Molecular Weight              g/mol   .228E+03
Diffusion Coefficient in Air cm^2/s   .510E-01
Vapor Pressure                 mmHg   .220E-07
Total Soil Concentration      mg/kg   .110E+01

 Benzo(a)pyrene
-------------
PARAMETER NAME                   UNITS    VALUE
-------------------------------------------


Henrys const          (mg/L)/(mg/L)   .277E-04
Organic Carbon Part Coeff    cm^3/g   .550E+07
Molecular Weight              g/mol   .252E+03
Diffusion Coefficient in Air cm^2/s   .430E-01
Vapor Pressure                 mmHg   .560E-08
Total Soil Concentration      mg/kg   .200E+01

 Benzo(b)fluoranthene
-------------
PARAMETER NAME                   UNITS    VALUE
-------------------------------------------


Henrys const          (mg/L)/(mg/L)   .529E-03
Organic Carbon Part Coeff    cm^3/g   .550E+06
Molecular Weight              g/mol   .252E+03
Diffusion Coefficient in Air cm^2/s   .430E-01
```

```
Vapor Pressure                    mmHg   .500E-06
Total Soil Concentration          mg/kg  .130E+01

 Chrysene
------------
  AMETER NAME                     UNITS    VALUE
   ------------------------------------------

Henrys const            (mg/L)/(mg/L)   .469E-04
Organic Carbon Part Coeff      cm^3/g   .200E+06
Molecular Weight                g/mol   .228E+03
Diffusion Coefficient in Air   cm^2/s   .452E-01
Vapor Pressure                   mmHg   .630E-08
Total Soil Concentration        mg/kg   .440E+01

 Dibenz(a,h)anthracen
------------
PARAMETER NAME                    UNITS    VALUE
-------------------------------------------

Henrys const            (mg/L)/(mg/L)   .327E-05
Organic Carbon Part Coeff      cm^3/g   .330E+07
Molecular Weight                g/mol   .278E+03
Diffusion Coefficient in Air   cm^2/s   .410E-01
Vapor Pressure                   mmHg   .100E-09
Total Soil Concentration        mg/kg   .830E+00

 OUTPUTS

Time to depletion (yr) for Benz(a)anthracene    =  .644E+08
Time to depletion (yr) for Benzo(a)pyrene       =  .569E+09
   me to depletion (yr) for Benzo(b)fluoranthene =  .298E+07
  me to depletion (yr) for Chrysene             =  .116E+08
Time to depletion (yr) for Dibenz(a,h)anthracen =  .303E+10

                    Volatile          Particulate      Air
                    Emissions         Emissions        Concentration
                    (kg/yr)           (kg/yr)          (mg/m^3)
 ------------------------------------------------------------------

 Averaging Time, yr =          5
Benz(a)anthr          .247E-01         .000E+00          .241E-06
Benzo(a)pyre          .151E-01         .000E+00          .147E-06
Benzo(b)fluo          .136E+00         .000E+00          .132E-05
Chrysene              .196E+00         .000E+00          .191E-05
Dibenz(a,h)a          .272E-02         .000E+00          .265E-07

 Averaging Time, yr =         10
Benz(a)anthr          .175E-01         .000E+00          .170E-06
Benzo(a)pyre          .107E-01         .000E+00          .104E-06
Benzo(b)fluo          .961E-01         .000E+00          .937E-06
Chrysene              .139E+00         .000E+00          .135E-05
Dibenz(a,h)a          .192E-02         .000E+00          .187E-07

 Averaging Time, yr =         15
Benz(a)anthr          .143E-01         .000E+00          .139E-06
Benzo(a)pyre          .873E-02         .000E+00          .852E-07
  nzo(b)fluo          .784E-01         .000E+00          .765E-06
Chrysene              .113E+00         .000E+00          .110E-05
Dibenz(a,h)a          .157E-02         .000E+00          .153E-07

 Averaging Time, yr =         20
```

```
Benz(a)anthr          .124E-01          .000E+00          .120E-06
Benzo(a)pyre          .756E-02          .000E+00          .737E-07
Benzo(b)fluo          .679E-01          .000E+00          .662E-06
Chrysene              .981E-01          .000E+00          .956E-06
Dibenz(a,h)a          .136E-02          .000E+00          .133E-07

 Averaging Time, yr =           25
Benz(a)anthr          .111E-01          .000E+00          .108E-06
Benzo(a)pyre          .676E-02          .000E+00          .660E-07
Benzo(b)fluo          .608E-01          .000E+00          .592E-06
Chrysene              .877E-01          .000E+00          .855E-06
Dibenz(a,h)a          .122E-02          .000E+00          .119E-07

 Averaging Time, yr =           30
Benz(a)anthr          .101E-01          .000E+00          .984E-07
Benzo(a)pyre          .618E-02          .000E+00          .602E-07
Benzo(b)fluo          .555E-01          .000E+00          .541E-06
Chrysene              .801E-01          .000E+00          .781E-06
Dibenz(a,h)a          .111E-02          .000E+00          .108E-07

 Averaging Time, yr =           35
Benz(a)anthr          .934E-02          .000E+00          .911E-07
Benzo(a)pyre          .572E-02          .000E+00          .557E-07
Benzo(b)fluo          .514E-01          .000E+00          .501E-06
Chrysene              .741E-01          .000E+00          .723E-06
Dibenz(a,h)a          .103E-02          .000E+00          .100E-07

 Averaging Time, yr =           40
Benz(a)anthr          .874E-02          .000E+00          .852E-07
Benzo(a)pyre          .535E-02          .000E+00          .521E-07
Benzo(b)fluo          .480E-01          .000E+00          .468E-06
   ysene              .693E-01          .000E+00          .676E-06
Dibenz(a,h)a          .961E-03          .000E+00          .937E-08

 Averaging Time, yr =           45
Benz(a)anthr          .824E-02          .000E+00          .803E-07
Benzo(a)pyre          .504E-02          .000E+00          .492E-07
Benzo(b)fluo          .453E-01          .000E+00          .442E-06
Chrysene              .654E-01          .000E+00          .637E-06
Dibenz(a,h)a          .906E-03          .000E+00          .884E-08

 Averaging Time, yr =           50
Benz(a)anthr          .781E-02          .000E+00          .762E-07
Benzo(a)pyre          .478E-02          .000E+00          .466E-07
Benzo(b)fluo          .430E-01          .000E+00          .419E-06
Chrysene              .620E-01          .000E+00          .605E-06
Dibenz(a,h)a          .860E-03          .000E+00          .838E-08

 Averaging Time, yr =           55
Benz(a)anthr          .745E-02          .000E+00          .726E-07
Benzo(a)pyre          .456E-02          .000E+00          .445E-07
Benzo(b)fluo          .410E-01          .000E+00          .399E-06
Chrysene              .591E-01          .000E+00          .577E-06
Dibenz(a,h)a          .820E-03          .000E+00          .799E-08

 Averaging Time, yr =           60
Benz(a)anthr          .713E-02          .000E+00          .696E-07
  nzo(a)pyre          .437E-02          .000E+00          .426E-07
Benzo(b)fluo          .392E-01          .000E+00          .382E-06
Chrysene              .566E-01          .000E+00          .552E-06
Dibenz(a,h)a          .785E-03          .000E+00          .765E-08
```

```
 Averaging Time, yr =          65
Benz(a)anthr          .685E-02          .000E+00          .668E-07
Benzo(a)pyre          .420E-02          .000E+00          .409E-07
Benzo(b)fluo          .377E-01          .000E+00          .367E-06
Chrysene              .544E-01          .000E+00          .530E-06
   benz(a,h)a         .754E-03          .000E+00          .735E-08

 Averaging Time, yr =          70
Benz(a)anthr          .660E-02          .000E+00          .644E-07
Benzo(a)pyre          .404E-02          .000E+00          .394E-07
Benzo(b)fluo          .363E-01          .000E+00          .354E-06
Chrysene              .524E-01          .000E+00          .511E-06
Dibenz(a,h)a          .727E-03          .000E+00          .709E-08

 Averaging Time, yr =          75
Benz(a)anthr          .638E-02          .000E+00          .622E-07
Benzo(a)pyre          .391E-02          .000E+00          .381E-07
Benzo(b)fluo          .351E-01          .000E+00          .342E-06
Chrysene              .506E-01          .000E+00          .494E-06
Dibenz(a,h)a          .702E-03          .000E+00          .685E-08
```

The following chemicals were selected:
Benzo(g,h,i)perylene

a for Fate and Transport Models

Thibideaux-Hwang Model - Deterministic

Define Media Specific Parameters

Area of contaminated soil [m^2]	175000
Depth to top of cont. soil [m]	0
Depth to bottom of cont. soil [m]	1.52
Unsaturated zone porosity [-]	0.3
Water content [-]	0.1
Dry Wt. Soil bulk density [g/cm^3]	1.8
Fraction Organic Carbon [-]	0.01
Temperature [C]	25

Thibideaux-Hwang Chemical Specific Parameters

Benzo(g,h,i)perylene	
Henrys Constant [(mg/L)/(mg/L)	2.39E-06
Koc [ug/gOC/ug/ml]	1600000
Diffusion in Air [cm^2/sec]	0.0411
Vapor Pressure [mmHg]	1.03E-10
Total Concentration in Soil [mg/kg]	1

Box Dispersion Model - Deterministic

Wind Speed [m/s]	3.89
Height of Box [m]	2
Width of Box [m]	2

ta for Risk Assessment

Body Weight and Lifetime - Deterministic

Average Weight (kg)	70
Lifetime (yrs)	70

Inhalation of Soil Emissions

Exposure Frequency [days/yr]	60
Exposure Duration [years]	1
Inhalation Rate [m^3/hr]	2.5
Time Outdoors [hours/day]	8

Inhalation of Soil Emissions Chemical Specific Parameters

Benzo(g,h,i)perylene	
Bioavailability [fraction]	1

Dermal Contact with Soil

Exposure Frequency [days/yr]	60
Exposure Duration [years]	1
Skin Surface Area [cm^2]	5800
Adherence Factor [mg/cm^2]	1

Dermal Contact Chemical Specific Parameters

Benzo(g,h,i)perylene	
Dermal Absorption Factors [fraction]	0.15

gestion of Soil

Exposure Frequency [days/yr]	60
Exposure Duration [years]	1
Ingestion Rate [mg/day]	480
Fraction Soil Contaminated [-]	1

Ingestion of Soil Chemical Specific Parameters

Benzo(g,h,i)perylene

Bioavailability [fraction]	1

Oral Dose

zo(g,h,i)perylene

lope Factor [1/(mg/kg-day)]	0.071
Reference Dose [mg/kg-day]	ND

Dermal Dose

Benzo(g,h,i)perylene

Slope Factor [1/(mg/kg-day)]	0.071
Reference Dose [mg/kg-day]	ND

Inhalation Dose

Benzo(g,h,i)perylene

Slope Factor [1/(mg/kg-day)]	0.010
Reference Dose [mg/kg-day]	ND

Receptor Point Concentration Distributions

Soil Concentrations

Benzo(g,h,i)perylene

Soil [mg/kg]	1

```
 Emissions/Dispersion Model Output

Analysis for ...

 Analyses Performed:
  ------------------
   ibodeaux-Hwang volatile emissions
 Box Model used for dispersion


 *** PARAMETERS ***

 Deterministic Run

PARAMETER NAME                  UNITS    VALUE
--------------------------------------------


Area                              m^2   .175E+06
Depth to Top of Cont. Zone          m   .000E+00
Depth to Bottom of Cont. Zone       m   .152E+01
Porosity                  cm^3/cm^3   .300E+00
Water Content             cm^3/cm^3   .100E+00
Soil Bulk Density            g/cm^3   .180E+01
Fractional Organic Carbon       g/g   .100E-01
Temperature                       C   .250E+02
Wind Speed                      m/s   .389E+01
Box Height                        m   .200E+01
Box Width                         m   .418E+03

 Benzo(g,h,i)perylene
-------------
  RAMETER NAME                  UNITS    VALUE
  ------------------------------------------

Henrys const           (mg/L)/(mg/L)  .239E-05
Organic Carbon Part Coeff    cm^3/g   .160E+07
Molecular Weight              g/mol   .276E+03
Diffusion Coefficient in Air cm^2/s   .411E-01
Vapor Pressure                 mmHg   .103E-09
Total Soil Concentration      mg/kg   .100E+01

 OUTPUTS

Time to depletion (yr) for Benzo(g,h,i)perylene =  .201E+10

                     Volatile         Particulate      Air
                     Emissions        Emissions        Concentration
                     (kg/yr)          (kg/yr)          (mg/m^3)
-----------------------------------------------------------------


 Averaging Time, yr =          5
Benzo(g,h,i)          .403E-02         .000E+00          .393E-07

 Averaging Time, yr =         10
Benzo(g,h,i)          .285E-02         .000E+00          .278E-07

 Averaging Time, yr =         15
  zo(g,h,i)           .232E-02         .000E+00          .227E-07

 Averaging Time, yr =         20
Benzo(g,h,i)          .201E-02         .000E+00          .196E-07
```

The following chemicals were selected:
Ethylbenzene
Toluene

Data for Fate and Transport Models

Thibideaux-Hwang Model - Deterministic

Define Media Specific Parameters

Area of contaminated soil [m^2]	84000
Depth to top of cont. soil [m]	0
Depth to bottom of cont. soil [m]	1.52
Unsaturated zone porosity [-]	0.3
Water content [-]	0.1
Dry Wt. Soil bulk density [g/cm^3]	1.8
Fraction Organic Carbon [-]	0.01
Temperature [C]	25

Thibideaux-Hwang Chemical Specific Parameters

Ethylbenzene	
Henrys Constant [(mg/L)/(mg/L)	2.87E-01
Koc [ug/gOC/ug/ml]	1100
Diffusion in Air [cm^2/sec]	0.066
Vapor Pressure [mmHg]	7
Total Concentration in Soil [mg/kg]	0.033
Toluene	
Henrys Constant [(mg/L)/(mg/L)	2.84E-01
Koc [ug/gOC/ug/ml]	300
Diffusion in Air [cm^2/sec]	0.078
Vapor Pressure [mmHg]	28.1
Total Concentration in Soil [mg/kg]	0.37

Box Dispersion Model - Deterministic

Wind Speed [m/s]	3.89
Height of Box [m]	2
Width of Box [m]	2

Data for Risk Assessment

Body Weight and Lifetime - Deterministic

Average Weight (kg)	70
Lifetime (yrs)	70

Inhalation of Soil Emissions

Exposure Frequency [days/yr]	60
Exposure Duration [years]	1
Inhalation Rate [m^3/hr]	2.5
Time Outdoors [hours/day]	8

Inhalation of Soil Emissions Chemical Specific Parameters

Ethylbenzene	
Bioavailability [fraction]	1
Toluene	
Bioavailability [fraction]	1

Dermal Contact with Soil

Exposure Frequency [days/yr]	60
Exposure Duration [years]	1
Skin Surface Area [cm^2]	5800
Adherence Factor [mg/cm^2]	1

```
 Averaging Time, yr =           25
Benzo(g,h,i)           .180E-02          .000E+00          .176E-07

 Averaging Time, yr =           30
Benzo(g,h,i)           .164E-02          .000E+00          .160E-07

 Averaging Time, yr =           35
Benzo(g,h,i)           .152E-02          .000E+00          .148E-07

 Averaging Time, yr =           40
Benzo(g,h,i)           .142E-02          .000E+00          .139E-07

 Averaging Time, yr =           45
Benzo(g,h,i)           .134E-02          .000E+00          .131E-07

 Averaging Time, yr =           50
Benzo(g,h,i)           .127E-02          .000E+00          .124E-07

 Averaging Time, yr =           55
Benzo(g,h,i)           .121E-02          .000E+00          .118E-07

 Averaging Time, yr =           60
Benzo(g,h,i)           .116E-02          .000E+00          .113E-07

 Averaging Time, yr =           65
Benzo(g,h,i)           .112E-02          .000E+00          .109E-07

 Averaging Time, yr =           70
Benzo(g,h,i)           .108E-02          .000E+00          .105E-07

 Averaging Time, yr =           75
   nzo(g,h,i)           .104E-02          .000E+00          .101E-07
```

```
API DSS Data Requirements          D:\APIDSS\I880\WORKNS3.SAV      01/24/96   11:16

 The following chemicals were selected:
 Benz(a)anthracene
 Chrysene
    hthalene

 Data for Fate and Transport Models

 Thibideaux-Hwang Model -  Deterministic

 Define Media Specific Parameters
 Area of contaminated soil [m^2]              84000
 Depth to top of cont. soil [m]               0
 Depth to bottom of cont. soil [m]            1.52
 Unsaturated zone porosity [-]                0.3
 Water content [-]                            0.1
 Dry Wt. Soil bulk density [g/cm^3]           1.8
 Fraction Organic Carbon [-]                  0.01
 Temperature [C]                              25

 Thibideaux-Hwang Chemical Specific Parameters
 Benz(a)anthracene
   Henrys Constant [(mg/L)/(mg/L)             5.17E-05
   Koc [ug/gOC/ug/ml]                         1380000
   Diffusion in Air [cm^2/sec]                0.051
   Vapor Pressure [mmHg]                      2.20E-08
   Total Concentration in Soil [mg/kg]        0.16
 Chrysene
   Henrys Constant [(mg/L)/(mg/L)             4.69E-05
   Koc [ug/gOC/ug/ml]                         200000
   Diffusion in Air [cm^2/sec]                0.0452
   Vapor Pressure [mmHg]                      6.3E-09
   Total Concentration in Soil [mg/kg]        0.3
 Naphthalene
   Henrys Constant [(mg/L)/(mg/L)             5.78E-02
   Koc [ug/gOC/ug/ml]                         0
   Diffusion in Air [cm^2/sec]                0.059
   Vapor Pressure [mmHg]                      0.23
   Total Concentration in Soil [mg/kg]        4.9

 Box Dispersion Model -  Deterministic
 Wind Speed [m/s]                             3.89
 Height of Box [m]                            2
 Width of Box [m]                             2


 Data for Risk Assessment

 Body Weight and Lifetime -  Deterministic
Average Weight (kg)                           70
 Lifetime (yrs)                               70


 Inhalation of Soil Emissions
 Exposure Frequency [days/yr]                 60
 Exposure Duration [years]                    1
 Inhalation Rate [m^3/hr]                     2.5
 Time Outdoors [hours/day]                    8

Inhalation of Soil Emissions Chemical Specific Parameters
 Benz(a)anthracene
   Bioavailability [fraction]                 1
 Chrysene
   Bioavailability [fraction]                 1
```

Naphthalene	
Bioavailability [fraction]	1

Dermal Contact with Soil

Exposure Frequency [days/yr]	60
osure Duration [years]	1
n Surface Area [cm^2]	5800
Adherence Factor [mg/cm^2]	1

Dermal Contact Chemical Specific Parameters

Benz(a)anthracene	
Dermal Absorption Factors [fraction]	0.15
Chrysene	
Dermal Absorption Factors [fraction]	0.15
Naphthalene	
Dermal Absorption Factors [fraction]	0.15

Ingestion of Soil

Exposure Frequency [days/yr]	60
Exposure Duration [years]	1
Ingestion Rate [mg/day]	480
Fraction Soil Contaminated [-]	1

Ingestion of Soil Chemical Specific Parameters

Benz(a)anthracene	
Bioavailability [fraction]	1
Chrysene	
Bioavailability [fraction]	1
Naphthalene	
Bioavailability [fraction]	1

Oral Dose

z(a)anthracene	
Slope Factor [1/(mg/kg-day)]	1.2
Reference Dose [mg/kg-day]	ND
Chrysene	
Slope Factor [1/(mg/kg-day)]	0.12
Reference Dose [mg/kg-day]	ND
Naphthalene	
Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	0.04

Dermal Dose

Benz(a)anthracene	
Slope Factor [1/(mg/kg-day)]	1.2
Reference Dose [mg/kg-day]	ND
Chrysene	
Slope Factor [1/(mg/kg-day)]	0.12
Reference Dose [mg/kg-day]	ND
Naphthalene	
Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	0.04

Inhalation Dose

Benz(a)anthracene	
Slope Factor [1/(mg/kg-day)]	0.39
Reference Dose [mg/kg-day]	ND
Chrysene	
Slope Factor [1/(mg/kg-day)]	0.039
Reference Dose [mg/kg-day]	ND
Naphthalene	
Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	ND

Receptor Point Concentration Distributions

Soil Concentrations

Benz(a)anthracene	
Soil [mg/kg]	0.16
Chrysene	
Soil [mg/kg]	0.3
hthalene	
oil [mg/kg]	4.9

```
 Emissions/Dispersion Model Output

Analysis for ...

 Analyses Performed:
   -----------------
 Thibodeaux-Hwang volatile emissions
 Box Model used for dispersion


 *** PARAMETERS ***

 Deterministic Run

PARAMETER NAME                      UNITS    VALUE
-------------------------------------------------


Area                                  m^2   .840E+05
Depth to Top of Cont. Zone              m   .000E+00
Depth to Bottom of Cont. Zone           m   .152E+01
Porosity                      cm^3/cm^3   .300E+00
Water Content                 cm^3/cm^3   .100E+00
Soil Bulk Density                  g/cm^3   .180E+01
Fractional Organic Carbon             g/g   .100E-01
Temperature                             C   .250E+02
Wind Speed                            m/s   .389E+01
Box Height                              m   .200E+01
Box Width                               m   .290E+03

 Benz(a)anthracene
  -----------
  RAMETER NAME                      UNITS    VALUE
-------------------------------------------------


Henrys const           (mg/L)/(mg/L)   .517E-04
Organic Carbon Part Coeff      cm^3/g   .138E+07
Molecular Weight                g/mol   .228E+03
Diffusion Coefficient in Air cm^2/s   .510E-01
Vapor Pressure                   mmHg   .220E-07
Total Soil Concentration        mg/kg   .160E+00

 Chrysene
-------------
PARAMETER NAME                      UNITS    VALUE
-------------------------------------------------


Henrys const           (mg/L)/(mg/L)   .469E-04
Organic Carbon Part Coeff      cm^3/g   .200E+06
Molecular Weight                g/mol   .228E+03
Diffusion Coefficient in Air cm^2/s   .452E-01
Vapor Pressure                   mmHg   .630E-08
Total Soil Concentration        mg/kg   .300E+00

 Naphthalene
-------------
PARAMETER NAME                      UNITS    VALUE
  -----------------------------------------------


Henrys const           (mg/L)/(mg/L)   .578E-01
Organic Carbon Part Coeff      cm^3/g   .000E+00
Molecular Weight                g/mol   .128E+03
Diffusion Coefficient in Air cm^2/s   .590E-01
```

```
Vapor Pressure                    mmHg   .230E+00
Total Soil Concentration         mg/kg   .490E+01

 OUTPUTS

  e to depletion (yr) for Benz(a)anthracene     =  .644E+08
Time to depletion (yr) for Chrysene             =  .116E+08
Time to depletion (yr) for Naphthalene          =  .224E+00

                      Volatile          Particulate       Air
                      Emissions         Emissions         Concentration
                      (kg/yr)           (kg/yr)           (mg/m^3)
 ------------------------------------------------------------------


 Averaging Time, yr =              5
Benz(a)anthr           .173E-02          .000E+00          .242E-07
Chrysene               .762E-02          .000E+00          .107E-06
Naphthalene            .109E+03          .000E+00          .153E-02

 Averaging Time, yr =             10
Benz(a)anthr           .122E-02          .000E+00          .171E-07
Chrysene               .539E-02          .000E+00          .757E-07
Naphthalene            .544E+02          .000E+00          .764E-03

 Averaging Time, yr =             15
Benz(a)anthr           .996E-03          .000E+00          .140E-07
Chrysene               .440E-02          .000E+00          .618E-07
Naphthalene            .362E+02          .000E+00          .509E-03

 Averaging Time, yr =             20
Benz(a)anthr           .863E-03          .000E+00          .121E-07
   ysene               .381E-02          .000E+00          .535E-07
Naphthalene            .272E+02          .000E+00          .382E-03

 Averaging Time, yr =             25
Benz(a)anthr           .772E-03          .000E+00          .108E-07
Chrysene               .341E-02          .000E+00          .479E-07
Naphthalene            .217E+02          .000E+00          .306E-03

 Averaging Time, yr =             30
Benz(a)anthr           .704E-03          .000E+00          .990E-08
Chrysene               .311E-02          .000E+00          .437E-07
Naphthalene            .181E+02          .000E+00          .255E-03

 Averaging Time, yr =             35
Benz(a)anthr           .652E-03          .000E+00          .916E-08
Chrysene               .288E-02          .000E+00          .405E-07
Naphthalene            .155E+02          .000E+00          .218E-03

 Averaging Time, yr =             40
Benz(a)anthr           .610E-03          .000E+00          .857E-08
Chrysene               .269E-02          .000E+00          .379E-07
Naphthalene            .136E+02          .000E+00          .191E-03

 Averaging Time, yr =             45
Benz(a)anthr           .575E-03          .000E+00          .808E-08
  rysene               .254E-02          .000E+00          .357E-07
  phthalene            .121E+02          .000E+00          .170E-03

 Averaging Time, yr =             50
Benz(a)anthr           .546E-03          .000E+00          .767E-08
Chrysene               .241E-02          .000E+00          .339E-07
```

```
Naphthalene           .109E+02         .000E+00         .153E-03

 Averaging Time, yr =           55
Benz(a)anthr          .520E-03         .000E+00         .731E-08
Chrysene              .230E-02         .000E+00         .323E-07
   hthalene           .988E+01         .000E+00         .139E-03

 Averaging Time, yr =           60
Benz(a)anthr          .498E-03         .000E+00         .700E-08
Chrysene              .220E-02         .000E+00         .309E-07
Naphthalene           .906E+01         .000E+00         .127E-03

 Averaging Time, yr =           65
Benz(a)anthr          .478E-03         .000E+00         .673E-08
Chrysene              .211E-02         .000E+00         .297E-07
Naphthalene           .836E+01         .000E+00         .118E-03

 Averaging Time, yr =           70
Benz(a)anthr          .461E-03         .000E+00         .648E-08
Chrysene              .204E-02         .000E+00         .286E-07
Naphthalene           .776E+01         .000E+00         .109E-03

 Averaging Time, yr =           75
Benz(a)anthr          .445E-03         .000E+00         .626E-08
Chrysene              .197E-02         .000E+00         .276E-07
Naphthalene           .725E+01         .000E+00         .102E-03
```

The following chemicals were selected:

Benzene
Ethylene Dibromide
ylene Dichloride
ene

Data for Fate and Transport Models

Thibideaux-Hwang Model - Deterministic

Define Media Specific Parameters

Area of contaminated soil [m^2]	16500
Depth to top of cont. soil [m]	0
Depth to bottom of cont. soil [m]	1.52
Unsaturated zone porosity [-]	0.3
Water content [-]	0.1
Dry Wt. Soil bulk density [g/cm^3]	1.8
Fraction Organic Carbon [-]	0.01
Temperature [C]	25

Thibideaux-Hwang Chemical Specific Parameters

Benzene	
Henrys Constant [(mg/L)/(mg/L)	2.49E-01
Koc [ug/gOC/ug/ml]	83
Diffusion in Air [cm^2/sec]	0.087
Vapor Pressure [mmHg]	95.2
Total Concentration in Soil [mg/kg]	0.018
Ethylene Dibromide	
Henrys Constant [(mg/L)/(mg/L)	3.01E-02
Koc [ug/gOC/ug/ml]	44
Diffusion in Air [cm^2/sec]	0.0498
Vapor Pressure [mmHg]	11.7
Total Concentration in Soil [mg/kg]	0.028
Ethylene Dichloride	
Henrys Constant [(mg/L)/(mg/L)	4.08E-02
Koc [ug/gOC/ug/ml]	0
Diffusion in Air [cm^2/sec]	0.104
Vapor Pressure [mmHg]	61
Total Concentration in Soil [mg/kg]	0.2
Xylene	
Henrys Constant [(mg/L)/(mg/L)	3.15E-01
Koc [ug/gOC/ug/ml]	240
Diffusion in Air [cm^2/sec]	0.072
Vapor Pressure [mmHg]	10
Total Concentration in Soil [mg/kg]	0.071

Box Dispersion Model - Deterministic

Wind Speed [m/s]	3.89
Height of Box [m]	2
Width of Box [m]	2

Data for Risk Assessment

Body Weight and Lifetime - Deterministic

Average Weight (kg)	70
Lifetime (yrs)	70

Inhalation of Soil Emissions

Exposure Frequency [days/yr]	60
Exposure Duration [years]	1
Inhalation Rate [m^3/hr]	2.5

Time Outdoors [hours/day]	8

Inhalation of Soil Emissions Chemical Specific Parameters

Benzene	
Bioavailability [fraction]	1
hylene Dibromide	
Bioavailability [fraction]	1
Ethylene Dichloride	
Bioavailability [fraction]	1
Xylene	
Bioavailability [fraction]	1

Dermal Contact with Soil

Exposure Frequency [days/yr]	60
Exposure Duration [years]	1
Skin Surface Area [cm^2]	5800
Adherence Factor [mg/cm^2]	1

Dermal Contact Chemical Specific Parameters

Benzene	
Dermal Absorption Factors [fraction]	0.1
Ethylene Dibromide	
Dermal Absorption Factors [fraction]	0.1
Ethylene Dichloride	
Dermal Absorption Factors [fraction]	0.1
Xylene	
Dermal Absorption Factors [fraction]	0.1

Ingestion of Soil

Exposure Frequency [days/yr]	60
Exposure Duration [years]	1
Ingestion Rate [mg/day]	480
action Soil Contaminated [-]	1

Ingestion of Soil Chemical Specific Parameters

Benzene	
Bioavailability [fraction]	1
Ethylene Dibromide	
Bioavailability [fraction]	1
Ethylene Dichloride	
Bioavailability [fraction]	1
Xylene	
Bioavailability [fraction]	1

Oral Dose

Benzene	
Slope Factor [1/(mg/kg-day)]	0.1
Reference Dose [mg/kg-day]	ND
Ethylene Dibromide	
Slope Factor [1/(mg/kg-day)]	3.6
Reference Dose [mg/kg-day]	ND
Ethylene Dichloride	
Slope Factor [1/(mg/kg-day)]	0.07
Reference Dose [mg/kg-day]	ND
Xylene	
Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	2

Dermal Dose

enzene	
Slope Factor [1/(mg/kg-day)]	0.1
Reference Dose [mg/kg-day]	ND
Ethylene Dibromide	
Slope Factor [1/(mg/kg-day)]	3.6
Reference Dose [mg/kg-day]	ND

Ethylene Dichloride	
Slope Factor [1/(mg/kg-day)]	0.07
Reference Dose [mg/kg-day]	ND
Xylene	
Slope Factor [1/(mg/kg-day)]	NA
ference Dose [mg/kg-day]	2

Inhalation Dose

Benzene	
Slope Factor [1/(mg/kg-day)]	0.1
Reference Dose [mg/kg-day]	ND
Ethylene Dibromide	
Slope Factor [1/(mg/kg-day)]	0.25
Reference Dose [mg/kg-day]	ND
Ethylene Dichloride	
Slope Factor [1/(mg/kg-day)]	0.07
Reference Dose [mg/kg-day]	ND
Xylene	
Slope Factor [1/(mg/kg-day)]	NA
Reference Dose [mg/kg-day]	0.2

Receptor Point Concentration Distributions

Soil Concentrations

Benzene	
Soil [mg/kg]	0.018
Ethylene Dibromide	
Soil [mg/kg]	0.028
Ethylene Dichloride	
Soil [mg/kg]	0.2
Xylene	
Soil [mg/kg]	0.071

```
 Emissions/Dispersion Model Output

Analysis for ...

 Analyses Performed:
   -----------------
 Thibodeaux-Hwang volatile emissions
 Box Model used for dispersion


 *** PARAMETERS ***

 Deterministic Run

PARAMETER NAME                    UNITS    VALUE
--------------------------------------------


Area                               m^2  .165E+05
Depth to Top of Cont. Zone           m  .000E+00
Depth to Bottom of Cont. Zone        m  .152E+01
Porosity                   cm^3/cm^3  .300E+00
Water Content              cm^3/cm^3  .100E+00
Soil Bulk Density             g/cm^3  .180E+01
Fractional Organic Carbon          g/g  .100E-01
Temperature                          C  .250E+02
Wind Speed                         m/s  .389E+01
Box Height                           m  .200E+01
Box Width                            m  .128E+03

 Benzene
-------------
   AMETER NAME                    UNITS    VALUE
--------------------------------------------


Henrys const           (mg/L)/(mg/L)  .249E+00
Organic Carbon Part Coeff     cm^3/g  .830E+02
Molecular Weight               g/mol  .780E+02
Diffusion Coefficient in Air cm^2/s  .870E-01
Vapor Pressure                  mmHg  .952E+02
Total Soil Concentration       mg/kg  .180E-01

 Ethylene Dibromide
-------------
PARAMETER NAME                    UNITS    VALUE
--------------------------------------------


Henrys const           (mg/L)/(mg/L)  .301E-01
Organic Carbon Part Coeff     cm^3/g  .440E+02
Molecular Weight               g/mol  .188E+03
Diffusion Coefficient in Air cm^2/s  .498E-01
Vapor Pressure                  mmHg  .117E+02
Total Soil Concentration       mg/kg  .280E-01

 Ethylene Dichloride
-------------
PARAMETER NAME                    UNITS    VALUE
  ------------------------------------------


Henrys const           (mg/L)/(mg/L)  .408E-01
Organic Carbon Part Coeff     cm^3/g  .000E+00
Molecular Weight               g/mol  .990E+02
Diffusion Coefficient in Air cm^2/s  .104E+00
```

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Vapor Pressure                    mmHg   .610E+02
Total Soil Concentration         mg/kg   .200E+00

 Xylene
-------------
   AMETER NAME                   UNITS    VALUE
- -------------------------------------------


Henrys const           (mg/L)/(mg/L)   .315E+00
Organic Carbon Part Coeff     cm^3/g   .240E+03
Molecular Weight               g/mol   .106E+03
Diffusion Coefficient in Air cm^2/s   .720E-01
Vapor Pressure                  mmHg   .100E+02
Total Soil Concentration       mg/kg   .710E-01

 OUTPUTS

Time to depletion (yr) for Benzene                 =  .519E+00
Time to depletion (yr) for Ethylene Dibromide      =  .410E+01
Time to depletion (yr) for Ethylene Dichloride     =  .174E+00
Time to depletion (yr) for Xylene                  =  .135E+01

                        Volatile         Particulate      Air
                        Emissions        Emissions        Concentration
                        (kg/yr)          (kg/yr)          (mg/m^3)
 ----------------------------------------------------------------------


 Averaging Time, yr =           5
Benzene                  .137E+00          .000E+00          .436E-05
Ethylene Dib             .213E+00          .000E+00          .678E-05
Ethylene Dic             .152E+01          .000E+00          .484E-04
   ene                   .540E+00          .000E+00          .172E-04

 Averaging Time, yr =          10
Benzene                  .684E-01          .000E+00          .218E-05
Ethylene Dib             .106E+00          .000E+00          .339E-05
Ethylene Dic             .760E+00          .000E+00          .242E-04
Xylene                   .270E+00          .000E+00          .860E-05

 Averaging Time, yr =          15
Benzene                  .456E-01          .000E+00          .145E-05
Ethylene Dib             .710E-01          .000E+00          .226E-05
Ethylene Dic             .507E+00          .000E+00          .161E-04
Xylene                   .180E+00          .000E+00          .573E-05

 Averaging Time, yr =          20
Benzene                  .342E-01          .000E+00          .109E-05
Ethylene Dib             .532E-01          .000E+00          .169E-05
Ethylene Dic             .380E+00          .000E+00          .121E-04
Xylene                   .135E+00          .000E+00          .430E-05

 Averaging Time, yr =          25
Benzene                  .274E-01          .000E+00          .872E-06
Ethylene Dib             .426E-01          .000E+00          .136E-05
Ethylene Dic             .304E+00          .000E+00          .969E-05
Xylene                   .108E+00          .000E+00          .344E-05

  veraging Time, yr =          30
Benzene                  .228E-01          .000E+00          .726E-06
Ethylene Dib             .355E-01          .000E+00          .113E-05
Ethylene Dic             .253E+00          .000E+00          .807E-05
Xylene                   .900E-01          .000E+00          .287E-05
```

```
 Averaging Time, yr =          35
Benzene               .196E-01          .000E+00          .623E-06
Ethylene Dib          .304E-01          .000E+00          .969E-06
Ethylene Dic          .217E+00          .000E+00          .692E-05
   ene                .771E-01          .000E+00          .246E-05

 Averaging Time, yr =          40
Benzene               .171E-01          .000E+00          .545E-06
Ethylene Dib          .266E-01          .000E+00          .847E-06
Ethylene Dic          .190E+00          .000E+00          .605E-05
Xylene                .675E-01          .000E+00          .215E-05

 Averaging Time, yr =          45
Benzene               .152E-01          .000E+00          .484E-06
Ethylene Dib          .237E-01          .000E+00          .753E-06
Ethylene Dic          .169E+00          .000E+00          .538E-05
Xylene                .600E-01          .000E+00          .191E-05

 Averaging Time, yr =          50
Benzene               .137E-01          .000E+00          .436E-06
Ethylene Dib          .213E-01          .000E+00          .678E-06
Ethylene Dic          .152E+00          .000E+00          .484E-05
Xylene                .540E-01          .000E+00          .172E-05

 Averaging Time, yr =          55
Benzene               .124E-01          .000E+00          .396E-06
Ethylene Dib          .194E-01          .000E+00          .616E-06
Ethylene Dic          .138E+00          .000E+00          .440E-05
Xylene                .491E-01          .000E+00          .156E-05

   eraging Time, yr =          60
Benzene               .114E-01          .000E+00          .363E-06
Ethylene Dib          .177E-01          .000E+00          .565E-06
Ethylene Dic          .127E+00          .000E+00          .404E-05
Xylene                .450E-01          .000E+00          .143E-05

 Averaging Time, yr =          65
Benzene               .105E-01          .000E+00          .335E-06
Ethylene Dib          .164E-01          .000E+00          .522E-06
Ethylene Dic          .117E+00          .000E+00          .373E-05
Xylene                .415E-01          .000E+00          .132E-05

 Averaging Time, yr =          70
Benzene               .978E-02          .000E+00          .311E-06
Ethylene Dib          .152E-01          .000E+00          .484E-06
Ethylene Dic          .109E+00          .000E+00          .346E-05
Xylene                .386E-01          .000E+00          .123E-05

 Averaging Time, yr =          75
Benzene               .912E-02          .000E+00          .291E-06
Ethylene Dib          .142E-01          .000E+00          .452E-06
Ethylene Dic          .101E+00          .000E+00          .323E-05
Xylene                .360E-01          .000E+00          .115E-05
```

The following chemicals were selected:

Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(g,h,i)perylene

Data for Fate and Transport Models

Thibideaux-Hwang Model - Deterministic

Define Media Specific Parameters

Area of contaminated soil [m^2]	16500
Depth to top of cont. soil [m]	0
Depth to bottom of cont. soil [m]	1.52
Unsaturated zone porosity [-]	0.3
Water content [-]	0.1
Dry Wt. Soil bulk density [g/cm^3]	1.8
Fraction Organic Carbon [-]	0.01
Temperature [C]	25

Thibideaux-Hwang Chemical Specific Parameters

Benzo(a)pyrene	
Henrys Constant [(mg/L)/(mg/L)	2.77E-05
Koc [ug/gOC/ug/ml]	5500000
Diffusion in Air [cm^2/sec]	0.043
Vapor Pressure [mmHg]	5.6E-09
Total Concentration in Soil [mg/kg]	0.54
Benzo(b)fluoranthene	
Henrys Constant [(mg/L)/(mg/L)	5.29E-04
Koc [ug/gOC/ug/ml]	550000
Diffusion in Air [cm^2/sec]	0.043
Vapor Pressure [mmHg]	5.00E-07
Total Concentration in Soil [mg/kg]	0.78
Benzo(g,h,i)perylene	
Henrys Constant [(mg/L)/(mg/L)	2.39E-06
Koc [ug/gOC/ug/ml]	1600000
Diffusion in Air [cm^2/sec]	0.0411
Vapor Pressure [mmHg]	1.03E-10
Total Concentration in Soil [mg/kg]	2.5

Box Dispersion Model - Deterministic

Wind Speed [m/s]	3.89
Height of Box [m]	2
Width of Box [m]	2

Data for Risk Assessment

Body Weight and Lifetime - Deterministic

Average Weight (kg)	70
Lifetime (yrs)	70

Inhalation of Soil Emissions

Exposure Frequency [days/yr]	60
Exposure Duration [years]	1
Inhalation Rate [m^3/hr]	2.5
Time Outdoors [hours/day]	8

Inhalation of Soil Emissions Chemical Specific Parameters

Benzo(a)pyrene	
Bioavailability [fraction]	1
Benzo(b)fluoranthene	
Bioavailability [fraction]	1

Benzo(g,h,i)perylene	
Bioavailability [fraction]	1

Dermal Contact with Soil

Exposure Frequency [days/yr]	60
osure Duration [years]	1
n Surface Area [cm^2]	5800
Adherence Factor [mg/cm^2]	1

Dermal Contact Chemical Specific Parameters

Benzo(a)pyrene	
Dermal Absorption Factors [fraction]	0.15
Benzo(b)fluoranthene	
Dermal Absorption Factors [fraction]	0.15
Benzo(g,h,i)perylene	
Dermal Absorption Factors [fraction]	0.15

Ingestion of Soil

Exposure Frequency [days/yr]	60
Exposure Duration [years]	1
Ingestion Rate [mg/day]	480
Fraction Soil Contaminated [-]	1

Ingestion of Soil Chemical Specific Parameters

Benzo(a)pyrene	
Bioavailability [fraction]	1
Benzo(b)fluoranthene	
Bioavailability [fraction]	1
Benzo(g,h,i)perylene	
Bioavailability [fraction]	1

Oral Dose

zo(a)pyrene	
Slope Factor [1/(mg/kg-day)]	12
Reference Dose [mg/kg-day]	ND
Benzo(b)fluoranthene	
Slope Factor [1/(mg/kg-day)]	1.2
Reference Dose [mg/kg-day]	ND
Benzo(g,h,i)perylene	
Slope Factor [1/(mg/kg-day)]	0.071
Reference Dose [mg/kg-day]	ND

Dermal Dose

Benzo(a)pyrene	
Slope Factor [1/(mg/kg-day)]	12
Reference Dose [mg/kg-day]	ND
Benzo(b)fluoranthene	
Slope Factor [1/(mg/kg-day)]	1.2
Reference Dose [mg/kg-day]	ND
Benzo(g,h,i)perylene	
Slope Factor [1/(mg/kg-day)]	0.071
Reference Dose [mg/kg-day]	ND

Inhalation Dose

Benzo(a)pyrene	
Slope Factor [1/(mg/kg-day)]	3.9
Reference Dose [mg/kg-day]	ND
Benzo(b)fluoranthene	
Slope Factor [1/(mg/kg-day)]	0.39
Reference Dose [mg/kg-day]	ND
Benzo(g,h,i)perylene	
Slope Factor [1/(mg/kg-day)]	0.010
Reference Dose [mg/kg-day]	ND

Receptor Point Concentration Distributions

Soil Concentrations

Benzo(a)pyrene	
Soil [mg/kg]	0.54
Benzo(b)fluoranthene	
Soil [mg/kg]	0.78
Benzo(g,h,i)perylene	
Soil [mg/kg]	2.5

```
 Emissions/Dispersion Model Output

Analysis for ...

 Analyses Performed:
   -----------------
   Thibodeaux-Hwang volatile emissions
 Box Model used for dispersion


 *** PARAMETERS ***

 Deterministic Run

PARAMETER NAME                      UNITS    VALUE
--------------------------------------------------


Area                                 m^2   .165E+05
Depth to Top of Cont. Zone             m   .000E+00
Depth to Bottom of Cont. Zone          m   .152E+01
Porosity                     cm^3/cm^3   .300E+00
Water Content                cm^3/cm^3   .100E+00
Soil Bulk Density                g/cm^3   .180E+01
Fractional Organic Carbon           g/g   .100E-01
Temperature                           C   .250E+02
Wind Speed                          m/s   .389E+01
Box Height                            m   .200E+01
Box Width                             m   .128E+03

 Benzo(a)pyrene
--------------
PARAMETER NAME                      UNITS    VALUE
--------------------------------------------------


Henrys const           (mg/L)/(mg/L)   .277E-04
Organic Carbon Part Coeff     cm^3/g   .550E+07
Molecular Weight               g/mol   .252E+03
Diffusion Coefficient in Air cm^2/s   .430E-01
Vapor Pressure                  mmHg   .560E-08
Total Soil Concentration       mg/kg   .540E+00

 Benzo(b)fluoranthene
--------------
PARAMETER NAME                      UNITS    VALUE
--------------------------------------------------


Henrys const           (mg/L)/(mg/L)   .529E-03
Organic Carbon Part Coeff     cm^3/g   .550E+06
Molecular Weight               g/mol   .252E+03
Diffusion Coefficient in Air cm^2/s   .430E-01
Vapor Pressure                  mmHg   .500E-06
Total Soil Concentration       mg/kg   .780E+00

 Benzo(g,h,i)perylene
--------------
PARAMETER NAME                      UNITS    VALUE
--------------------------------------------------


Henrys const           (mg/L)/(mg/L)   .239E-05
Organic Carbon Part Coeff     cm^3/g   .160E+07
Molecular Weight               g/mol   .276E+03
Diffusion Coefficient in Air cm^2/s   .411E-01
```

```
Vapor Pressure                  mmHg   .103E-09
Total Soil Concentration       mg/kg   .250E+01

 OUTPUTS

  ne to depletion  (yr)  for Benzo(a)pyrene        =   .569E+09
   e to depletion  (yr)  for Benzo(b)fluoranthene  =   .298E+07
Time to depletion  (yr)  for Benzo(g,h,i)perylene  =   .201E+10

                      Volatile          Particulate       Air
                      Emissions         Emissions         Concentration
                      (kg/yr)           (kg/yr)           (mg/m^3)
 ------------------------------------------------------------------

 Averaging Time, yr =            5
Benzo(a)pyre          .385E-03          .000E+00          .123E-07
Benzo(b)fluo          .769E-02          .000E+00          .245E-06
Benzo(g,h,i)          .949E-03          .000E+00          .302E-07

 Averaging Time, yr =           10
Benzo(a)pyre          .272E-03          .000E+00          .867E-08
Benzo(b)fluo          .544E-02          .000E+00          .173E-06
Benzo(g,h,i)          .671E-03          .000E+00          .214E-07

 Averaging Time, yr =           15
Benzo(a)pyre          .222E-03          .000E+00          .708E-08
Benzo(b)fluo          .444E-02          .000E+00          .141E-06
Benzo(g,h,i)          .548E-03          .000E+00          .174E-07

 Averaging Time, yr =           20
Benzo(a)pyre          .193E-03          .000E+00          .613E-08
   nzo(b)fluo         .384E-02          .000E+00          .122E-06
   nzo(g,h,i)         .475E-03          .000E+00          .151E-07

 Averaging Time, yr =           25
Benzo(a)pyre          .172E-03          .000E+00          .548E-08
Benzo(b)fluo          .344E-02          .000E+00          .109E-06
Benzo(g,h,i)          .424E-03          .000E+00          .135E-07

 Averaging Time, yr =           30
Benzo(a)pyre          .157E-03          .000E+00          .501E-08
Benzo(b)fluo          .314E-02          .000E+00          .999E-07
Benzo(g,h,i)          .387E-03          .000E+00          .123E-07

 Averaging Time, yr =           35
Benzo(a)pyre          .146E-03          .000E+00          .463E-08
Benzo(b)fluo          .291E-02          .000E+00          .925E-07
Benzo(g,h,i)          .359E-03          .000E+00          .114E-07

 Averaging Time, yr =           40
Benzo(a)pyre          .136E-03          .000E+00          .434E-08
Benzo(b)fluo          .272E-02          .000E+00          .865E-07
Benzo(g,h,i)          .336E-03          .000E+00          .107E-07

 Averaging Time, yr =           45
Benzo(a)pyre          .128E-03          .000E+00          .409E-08
 enzo(b)fluo          .256E-02          .000E+00          .816E-07
   nzo(g,h,i)         .316E-03          .000E+00          .101E-07

 Averaging Time, yr =           50
Benzo(a)pyre          .122E-03          .000E+00          .388E-08
Benzo(b)fluo          .243E-02          .000E+00          .774E-07
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Benzo(g,h,i)          .300E-03          .000E+00          .956E-08

 Averaging Time, yr =             55
Benzo(a)pyre          .116E-03          .000E+00          .370E-08
Benzo(b)fluo          .232E-02          .000E+00          .738E-07
Benzo(g,h,i)          .286E-03          .000E+00          .911E-08

 Averaging Time, yr =             60
Benzo(a)pyre          .111E-03          .000E+00          .354E-08
Benzo(b)fluo          .222E-02          .000E+00          .707E-07
Benzo(g,h,i)          .274E-03          .000E+00          .872E-08

 Averaging Time, yr =             65
Benzo(a)pyre          .107E-03          .000E+00          .340E-08
Benzo(b)fluo          .213E-02          .000E+00          .679E-07
Benzo(g,h,i)          .263E-03          .000E+00          .838E-08

 Averaging Time, yr =             70
Benzo(a)pyre          .103E-03          .000E+00          .328E-08
Benzo(b)fluo          .205E-02          .000E+00          .654E-07
Benzo(g,h,i)          .254E-03          .000E+00          .808E-08

 Averaging Time, yr =             75
Benzo(a)pyre          .994E-04          .000E+00          .317E-08
Benzo(b)fluo          .198E-02          .000E+00          .632E-07
Benzo(g,h,i)          .245E-03          .000E+00          .780E-08
```

Dermal Contact Chemical Specific Parameters

Ethylbenzene	
Dermal Absorption Factors [fraction]	0.1
Toluene	
Dermal Absorption Factors [fraction]	0.1

Ingestion of Soil

Exposure Frequency [days/yr]	60
Exposure Duration [years]	1
Ingestion Rate [mg/day]	480
Fraction Soil Contaminated [-]	1

Ingestion of Soil Chemical Specific Parameters

Ethylbenzene	
Bioavailability [fraction]	1
Toluene	
Bioavailability [fraction]	1

Oral Dose

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

Dermal Dose

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

Inhalation Dose

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

Receptor Point Concentration Distributions

Soil Concentrations

Ethylbenzene	
Soil [mg/kg]	0.033
Toluene	
Soil [mg/kg]	0.37

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 Emissions/Dispersion Model Output

Analysis for ...

 Analyses Performed:
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   ibodeaux-Hwang volatile emissions
 Box Model used for dispersion


 *** PARAMETERS ***

 Deterministic Run

PARAMETER NAME                 UNITS    VALUE
--------------------------------------------

Area                             m^2   .840E+05
Depth to Top of Cont. Zone         m   .000E+00
Depth to Bottom of Cont. Zone      m   .152E+01
Porosity                   cm^3/cm^3   .300E+00
Water Content              cm^3/cm^3   .100E+00
Soil Bulk Density             g/cm^3   .180E+01
Fractional Organic Carbon        g/g   .100E-01
Temperature                        C   .250E+02
Wind Speed                       m/s   .389E+01
Box Height                         m   .200E+01
Box Width                          m   .290E+03

 Ethylbenzene
-------------
PARAMETER NAME                 UNITS    VALUE
   -----------------------------------------

Henrys const          (mg/L)/(mg/L)   .287E+00
Organic Carbon Part Coeff    cm^3/g   .110E+04
Molecular Weight              g/mol   .106E+03
Diffusion Coefficient in Air cm^2/s   .660E-01
Vapor Pressure                 mmHg   .700E+01
Total Soil Concentration      mg/kg   .330E-01

 Toluene
-------------
PARAMETER NAME                 UNITS    VALUE
--------------------------------------------

Henrys const          (mg/L)/(mg/L)   .284E+00
Organic Carbon Part Coeff    cm^3/g   .300E+03
Molecular Weight              g/mol   .920E+02
Diffusion Coefficient in Air cm^2/s   .780E-01
Vapor Pressure                 mmHg   .281E+02
Total Soil Concentration      mg/kg   .370E+00

 OUTPUTS

Time to depletion (yr) for Ethylbenzene         =  .721E+01
Time to depletion (yr) for Toluene              =  .172E+01

                     Volatile         Particulate      Air
                     Emissions        Emissions        Concentration
                     (kg/yr)          (kg/yr)          (mg/m^3)
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 Averaging Time, yr =            5
Ethylbenzene          .106E+01          .000E+00          .150E-04
Toluene               .143E+02          .000E+00          .201E-03

  veraging Time, yr =           10
  ylbenzene           .639E+00          .000E+00          .898E-05
Toluene               .716E+01          .000E+00          .101E-03

 Averaging Time, yr =           15
Ethylbenzene          .426E+00          .000E+00          .598E-05
Toluene               .477E+01          .000E+00          .671E-04

 Averaging Time, yr =           20
Ethylbenzene          .319E+00          .000E+00          .449E-05
Toluene               .358E+01          .000E+00          .503E-04

 Averaging Time, yr =           25
Ethylbenzene          .255E+00          .000E+00          .359E-05
Toluene               .286E+01          .000E+00          .403E-04

 Averaging Time, yr =           30
Ethylbenzene          .213E+00          .000E+00          .299E-05
Toluene               .239E+01          .000E+00          .336E-04

 Averaging Time, yr =           35
Ethylbenzene          .182E+00          .000E+00          .256E-05
Toluene               .205E+01          .000E+00          .288E-04

 Averaging Time, yr =           40
Ethylbenzene          .160E+00          .000E+00          .224E-05
   luene              .179E+01          .000E+00          .252E-04

 Averaging Time, yr =           45
Ethylbenzene          .142E+00          .000E+00          .199E-05
Toluene               .159E+01          .000E+00          .224E-04

 Averaging Time, yr =           50
Ethylbenzene          .128E+00          .000E+00          .180E-05
Toluene               .143E+01          .000E+00          .201E-04

 Averaging Time, yr =           55
Ethylbenzene          .116E+00          .000E+00          .163E-05
Toluene               .130E+01          .000E+00          .183E-04

 Averaging Time, yr =           60
Ethylbenzene          .106E+00          .000E+00          .150E-05
Toluene               .119E+01          .000E+00          .168E-04

 Averaging Time, yr =           65
Ethylbenzene          .983E-01          .000E+00          .138E-05
Toluene               .110E+01          .000E+00          .155E-04

 Averaging Time, yr =           70
Ethylbenzene          .912E-01          .000E+00          .128E-05
Toluene               .102E+01          .000E+00          .144E-04

   eraging Time, yr =           75
  hylbenzene          .852E-01          .000E+00          .120E-05
Toluene               .955E+00          .000E+00          .134E-04
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