AGI
TECHNOLOGIES

Development of Risk-Based Cleanup Standards
Harbert Transportation Site
19984 Meekland Avenue
Hayward, California

August 16, 1995

Prepared For :

Harbert Transportation
c/o Reed, Elliott, Creech & Roth
99 Alameda Boulevard, Eighth Floor
San Jose, California 95113

AGI Project No. 15,833.001

95 AUG 18 PM 3:09

AGI
TECHNOLOGIES

A Report Prepared For :

Harbert Transportation
c/o Reed, Elliott, Creech & Roth
99 Alameda Boulevard, Eighth Floor
San Jose, California 95113

DEVELOPMENT OF RISK-BASED CLEANUP STANDARDS
HARBERT TRANSPORTATION SITE
19984 MEEKLAND AVENUE
HAYWARD, CALIFORNIA

August 16, 1995

Daniel T. Henninger
Senior Scientist

David W. Ashcom, P.E.
Associate Engineer

AGI Technologies
300 120th Avenue N.E.
Building 4
Bellevue, Washington 98005
206/453-8383

AGI Project No. 15,833.001

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLES

FIGURES

APPENDIX A: Example Calculations

LIST OF TABLES

LIST OF TABLES

LIST OF ILLUSTRATIONS

GLOSSARY

ACFCWCD	Alameda County Flood Control and Water Conservation District
ACHCS	Alameda County Health Care Services
AGI	AGI Technologies
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
BETX	benzene, ethylbenzene, toluene, and total xylenes
bgs	below ground surface
COC	chemicals of concern
CRWQCB	California Regional Water Quality Control Board
CSWQCB	California State Water Quality Control Board
DTSC	Department of Toxic Substances Control
EBMUD	East Bay Municipal Utility District
EPA	United States Environmental Protection Agency
g/min	gallon per minute
gpm	gallons per minute
HEAST	Health Effects Assessment Summary Tables
HQ	hazard quotient
IRIS	Integrated Risk Information System
IUBK	Integrated/Uptake Biokinetic
LUFT	Leaking Underground Fuel Tank
MDEP	Massachusetts Department of Environmental Protection
µg/dL	micrograms per deciliter
$\mu g/ft^2/hr$	micrograms per square foot per hour
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mL/g	milliliters per gram
MMWD	Moreland Mutual Water District
MSL	Mean Sea Level
OLM	Organic Leachate Model
PCE	tetrachloroethylene
RfD	chronic reference dose
RI	Remedial Investigation
RME	reasonable maximum exposure
TCE	trichloroethylene
TNRCC	Texas Natural Resource Conservation Commission
TPH	total petroleum hydrocarbons
TPH-D	total petroleum hydrocarbons quantified as diesel
TPH-G	total petroleum hydrocarbons quantified as gasoline
UST	underground storage tanks
VOC	volatile organic compounds
1,2-DCA	1,2-dichloroethane

EXECUTIVE SUMMARY

This report presents AGI Technologies' (AGI) development of site-specific risk-based soil and groundwater cleanup standards for the former Harbert Transportation site located at 19984 Meekland Avenue in Alameda County near Hayward, California. The development of cleanup standards used existing toxicological data of specific chemicals found at the site to determine the risk posed by these chemicals to human health and environmental resources. Based on the exposure assessment and calculated risks, soil and groundwater cleanup standards are established for the site.

In August 1989, three gasoline underground storage tanks (USTs) and one underground waste oil tank were removed. Subsequent investigations have indicated petroleum hydrocarbon and volatile organic compounds (VOCs) are present in soil and groundwater at the site.

Cleanup standards were developed for the Harbert Transportation site using existing toxicological data of specific chemicals found at the site to determine the risk posed by these chemicals to human health and environmental resources. Based on the exposure assessment and calculated risks, soil and potential groundwater cleanup standards were established for the site. Basic assumptions used in the risk assessment are presented below:

- On-site residential use is the scenario used and industrial and irrigation applications are the only designated beneficial uses of shallow groundwater at the site and in the surrounding area.
- Surface infiltration and the proximity to underground storage tanks, sewer systems, and drainage systems precludes shallow zone water from being used as drinking water.
- Domestic water needs are sufficiently met by three water districts in the area.

Total petroleum hydrocarbons (TPH) detected in subsurface soil samples were characterized as gasoline (TPH-G) and diesel (TPH-D). Benzene, ethylbenzene, toluene, and total xylenes (BETX); 1,2-dichloroethane (1,2-DCA); TPH-G; and TPH-D were consistently detected in wells near the former USTs. These same compounds were also consistently detected in three on-site downgradient wells at concentrations of one-half to an order of magnitude lower than in the source area wells.

Potential receptors were evaluated by screening chemical concentrations found at the site against promulgated standards and risk-based concentrations protective of human health. Chemicals whose maximum detected concentrations exceed one or more screening criteria were termed chemicals of concern (COC).

Based on AGI's evaluation, toluene is the only COC in surface soil (0 to 5.5 feet below ground surface). BETX, 1,2-DCA, TPH-G, and TPH-D are considered COCs in subsurface soil (5.5 to approximately 27 feet below ground surface). BETX, 1,2-DCA, TPH-G, TPH-D, and lead are considered COCs in groundwater.

Potential cleanup levels for the COCs in each medium were compiled from risk-based concentrations calculated according to the various exposure pathways and regulatory levels.

In surface soils (0 to 5.5 feet below ground surface), no cleanup concentration was determined because the maximum concentration of toluene detected in all samples was below the literature reported risk-based concentration selected as the cleanup level. In subsurface soils, a cleanup concentration of 0.675 milligrams per kilogram (mg/kg) was determined for benzene. No subsurface soil cleanup concentration was determined for ethylbenzene, toluene, xylenes, and 1,2-DCA given that the maximum concentrations detected were below the literature reported risk-based concentration selected as the cleanup level. A subsurface soil cleanup concentration of 1,000 mg/kg was selected for TPH-G and TPH-D using an interim regulatory approach for determining soil cleanup levels.

In groundwater, cleanup concentrations of 4 milligrams per liter (mg/L) for benzene, 12.5 mg/L for TPH-G, and 15 mg/L for TPH-D were determined. No cleanup concentration was determined for ethylbenzene, toluene, xylenes, and 1,2-DCA given the maximum concentrations detected were below the literature reported risk-based concentration selected as the cleanup level.

1.0 INTRODUCTION

This report presents AGI Technologies' (AGI) development of site-specific risk-based soil and groundwater cleanup standards for the former Harbert Transportation site located at 19984 Meekland Avenue in Alameda County near Hayward, California. This report is presented on behalf of Harbert Transportation, formerly of Hayward, California.

1.1 REGULATORY FRAMEWORK

Regulatory oversight for the Harbert Transportation site is provided by Alameda County Health Care Services (ACHCS). The technical basis for establishing cleanup standards using risk-based procedures is provided in the following documents:

- United States Environmental Protection Agency (EPA), *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part B: Development of Risk-Based Preliminary Remediation Goals* (EPA, 1991a).
- EPA, *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual, Part A, Interim Final,* (EPA, 1989a).
- EPA, *Soil Screening Level Guidance,* (EPA, 1994c).
- American Society for Testing and Materials (ASTM), *Emergency Standard Guide for Risk-Based Correction Action Applied at Petroleum Release Sites* (ASTM ES 38-94, 1994).
- California Regional Water Quality Control Board (CRWQCB), *LUFT Field Manual,* (CSWRCB 1989).
- CRWQCB, *Screening Levels for Petroleum-Impacted Sites* (CRWQCB, 1994).

1.2 TECHNICAL BASIS

The technical basis for development of risk-based cleanup standards includes work performed by AGI and others for Harbert Transportation. A formal Remedial Investigation (RI) has not been performed for the site, but several environmental assessments and site characterizations have been conducted. These are summarized in the following reports:

- Applied GeoSystems, Subsurface Environmental Investigation (July 1986).
- CTTS Inc., Phase II Report for Durham Transportation (November 1990).
- CTTS Inc., Well Abandonment and Groundwater Water Monitoring Well Installations (January 1990).
- CTTS Inc., Report for Additional Well Installation (April 1991).

- CTTS Inc., Work Plan for the Delineation, Containment and Remediation of Soil and Groundwater Contamination (November 1992).

- AGI Technologies Quarterly Groundwater Monitoring Report (September 1994 and February 1995).

While data gaps remain for full implementation of remedial action, data collected to date is, in our opinion, adequate to generally characterize the primary contaminants and their distribution, and to identify and evaluate the most likely remedial actions.

1.3 RATIONALE

The risk-based approach presented in the following sections uses existing toxicological data of specific chemicals found at the site to determine the risk posed by these chemicals to human health and environmental resources. Based on the exposure assessment and calculated risks, soil and groundwater cleanup standards are established for the site. Basic assumptions used in the risk assessment are presented below:

- On-site residential use is the scenario used and industrial and irrigation applications are the only designated beneficial uses of shallow groundwater at the site and in the surrounding area.

- Surface infiltration and the proximity to industrial contaminant sources, sewer systems, and drainage systems precludes shallow zone water from being used as drinking water.

- Domestic water needs are sufficiently met by three water districts in the area.

2.0 STUDY AREA DESCRIPTION

The site is located in an unincorporated area of Alameda County near the City of Hayward, at the northeast corner of Meekland Avenue and Blossom Way intersection, as shown on **Figures 1** and **2**. During the 1940s and 1950s, the subject site operated as a family-owned service station. Harbert Transportation purchased the site in the 1960s and operated it as a vehicle fueling and maintenance facility until 1986. In 1986, Durham Transportation of Austin, Texas purchased the property from Harbert Transportation and operated the site as a fueling and maintenance facility until 1989.

In August 1989, three gasoline underground storage tanks (USTs) with capacities of 4,000, 5,000, and 6,000 gallons and one 5,000-gallon waste oil UST were removed. The locations of these tanks are shown on **Figure 3**. Subsequent investigations have indicated petroleum hydrocarbon and volatile organic compounds (VOCs) are present in soil and groundwater at the site. Based on the results of site characterization activities, 10 groundwater monitoring wells were installed in 1989 and 1993 to monitor groundwater elevation and water quality. Groundwater monitoring, which began in 1989, is currently being conducted on a quarterly basis at the site. Historical analytical chemistry results from soil and groundwater samples are summarized in **Tables 1** and **2**, respectively.

The site is bounded by single-family homes to the north and east, Meekland Avenue to the west, and Blossom Way to the south (see **Figure 2**). An apartment complex is located west of the site across Meekland Avenue. Small businesses occupy three corners of the four-corner intersection formed by Meekland Avenue and Blossom Way. These businesses are located south, west, and southwest of the site and include a trading store, liquor store, and auto repair shop. Both the auto repair shop and liquor store locations were previously occupied by gas stations.

In March 1990, existing structures at the site were demolished and removed. Currently, the site is fenced on all sides and contains no structures. The ground surface is covered with concrete except where previous excavations were located to remove the USTs and associated piping.

Underground utilities at the site are likely to consist of water, sewer, and decommissioned electrical power lines. Underground piping associated with former USTs has been removed. Off-site underground utilities are likely to consist of water, sewer, storm, telephone, cable, and electrical lines.

2.1 REGIONAL AND LOCAL LAND USE

Regional land use in the area can be split into four categories:

- residential
- commercial
- industrial
- undeveloped open spaces

Predominant land use in the area is residential, with the majority of residences located east of Interstate 880. Commercial development consists of transportation facilities, shopping complexes, and service industries. Major industrial areas are generally located near Interstate 880 and the Southern Pacific Railroad, which runs north to south adjacent to the interstate.

Land use surrounding the site is mixed residential and commercial and has been zoned as a neighborhood business district since 1961. The area has been zoned to remain this way through the year 2000.

2.2 CLIMATE

The local area exhibits a Mediterranean climate, which features winter rains and summer dryness. Winter rains are from frontal storms generated in the northern Pacific Ocean. Most precipitation occurs during the months of November through March. Average annual rainfall for the City of Hayward is approximately 21 inches. The 100-year storm is capable of producing up to 5 inches of precipitation in a 24-hour period.

2.3 DOMESTIC WATER SUPPLY

Drinking water is supplied by East Bay Municipal Utility District (EBMUD), Hayward Water, and the Moreland Mutual Water District (MMWD). EBMUD water is imported from the Mokulume River system, with additional contributions from the EBMUD reservoir network located in the East Bay hills. Hayward Water is supplied by San Francisco Water Department, which imports water from Hetch Hetchy Reservoir. MMWD water is supplied by groundwater pumped from the Lower Zone Aquifer located near Chabot College in Hayward, approximately 5 miles southwest of the site.

2.4 SITE GEOLOGY

Soils in the area generally consist of a mixture of gravels, sands, and clays that were deposited on the San Leandro and San Lorenzo alluvial cones west of the Diablo Range. The soils are pliocene-pleistocene to late pleistocene in age and extend to depths ranging from 300 to 800 feet below ground surface (bgs). In general, the particle size and bed thickness of the alluvium decrease westward toward San Francisco Bay.

Three to four feet of fill overlies native soils at the site. The fill consists of clay, sand, and gravel, and extends from just below the asphalt surface to approximately 4 feet bgs. Underlying the fill are unconsolidated, fine-grained alluvial and floodplain deposits extending to 45 feet bgs, the maximum depth explored at the site. These deposits are derived from the Diablo Range located 2 miles east of the site and consist primarily of silty clays and clayey silts with interbedded lenses of silty sand and gravel 3 to 4 inches thick.

2.5 LOCAL HYDROGEOLOGY

Aquifers in the local area are divided into two zones, Upper and Lower. The Upper Zone is located from ground surface to approximately 400 feet bgs. The Lower Zone is located 400 to 800 feet bgs. The Upper Zone aquifer sequence contains four separate water-bearing deposits derived from the San Leandro and San Lorenzo Creeks. These deposits are known as the Shallow, Newark, Centerville, and Fremont Aquifers. The Newark, Centerville, and Freemont Aquifers consist of discontinuous beds of sand and gravel which extend westward under San Francisco Bay and are capped by confining layers of clay.

Shallow Aquifers typically occur at depths ranging from ground surface to 50 feet bgs. These aquifers have limited areal extent and generally occur under perched conditions, although some are confined by thin beds of clay. Groundwater recharge to these aquifers is by infiltration or rainfall, irrigation, and streamflow, with yields generally less than 35 gallons per minute (usually only sufficient for irrigation purposes).

Groundwater monitoring data collected from the site indicate groundwater elevations are highest in the spring and lowest in the fall. Since April 1991, groundwater elevations at the site have ranged from approximately 24 to 31 feet above Mean Sea Level (MSL). The highest groundwater elevations were encountered at the site in 1993. The lowest groundwater elevations were encountered in December 1991. Calculations using data collected from quarterly monitoring performed at the site have continually shown groundwater flow to be westward toward San Francisco Bay.

3.0 DEVELOPMENT OF SITE-SPECIFIC RISK-BASED CLEANUP STANDARDS

Cleanup standards were developed for the Harbert Transportation site using health risk as the primary focus. A concentration for each chemical that does not threaten human health or the environment, using conditions specific to the site, was estimated. The target risk level for individual cancer-causing chemicals (carcinogens) was estimated so as to not exceed one-in-a-million (1×10^{-6}) (a person's chance of developing cancer during a lifetime of consistent exposure to a hazardous chemical). EPA has stated that setting a 10^{-6} risk level for individual chemicals and pathways will generally ensure that the cumulative risks are within the 10^{-4} to 10^{-6} range for all chemical/pathway combinations (EPA, 1994a). Levels for noncarcinogens must be below that which could cause an adverse health effect in humans, nominally set at a hazard quotient (HQ) of 1. The potential for additive effects of noncarcinogenic chemicals that have the same toxic end-point or mechanism of action was accounted for.

The following documents formed the basis for development of risk-based concentrations:

- ASTM's *Emergency Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (ASTM, 1994)
- EPA's *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part B: Development of Risk-Based Preliminary Remediation Goals* (EPA, 1991b)

Risks were calculated following the equations and guidance of EPA's *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), Interim Final* (1989a) using standard default exposure parameters. The California Water Resources Control Board's *LUFT Field Manual* (CWRCB, 1989); and its interim approach during revision, *Screening Levels for Petroleum Impacted Sites* (CRWQCB, 1994); EPA's *Soil Screening Level Guidance* (EPA, 1994c); and other documents were consulted for readily available cleanup levels that matched conditions at the site.

3.1 SUMMARY OF ANALYTICAL DATA

Various investigations have taken place at the Harbert Transportation site over the last 6 years. Sampling and analytical methods as well as detection limits were generally consistent between investigations. Use of the historic data in conjunction with current data allows us to evaluate seasonal patterns as well as changes in concentration over time.

Tables 1 and 2 summarize historical soil and groundwater data for the Harbert Transportation site. These data are discussed below.

3.1.1 Surface Soil

Samples from the 0 to 5.5 foot depth are considered representative of surface conditions. Toluene is the only compound positively detected in samples from 0 to 5.5 feet in depth. It was detected in each of the four samples taken from this depth range.

3.1.2 *Subsurface Soil*

Table 3 shows the frequency of detection for chemicals in subsurface soil. Benzene, ethylbenzene, toluene, and xylenes (BETX) were detected at a frequency greater than 50 percent in soil at depths between 5.5 and 45 feet (termed subsurface). The majority (two-thirds) of the detections for benzene, ethylbenzene, and xylenes were at depths of 20 feet or greater. Half of the detections for toluene were at depths of 20 feet or greater. The additive 1,2-dichloroethane (1,2-DCA)) was detected in 23 percent of the subsurface samples analyzed for it, with 75 percent of those detections at a depth of 20 feet or greater. Trichloroethylene (TCE) was detected in one subsurface sample (34 total analyses), for a detection frequency of less than 3 percent. Tetrachloroethylene (PCE) was not detected in any of the 35 gasoline analyses of subsurface soil.

Total petroleum hydrocarbons (TPH) detected in subsurface soil samples was characterized as gasoline (TPH-G) and diesel (TPH-D). The laboratory reported that the diesel component resembled weathered gasoline as opposed to the heavier diesel components. Weathered gasoline is comprised mostly of hydrocarbons in the C7 to C12 range because the lighter hydrocarbons (C1 to C6 of gasoline) have evaporated. Weathered gasoline could be interpreted as diesel on a chromatogram because diesel fuel generally consists of hydrocarbons in the C10 to C20 range, which would overlap with the carbon range in weathered gasoline. There are no records of diesel storage on site; therefore, the laboratory's interpretation of the results appears valid. Weathered gasoline has significantly different properties than unweathered gasoline and is therefore considered separately when risk-based factors are calculated.

TPH-G was detected in 46 percent of the subsurface samples analyzed for this compound. Of those, 63 percent were at or below 20 feet in depth. TPH-D was detected in 26 percent of the subsurface samples analyzed, with 70 percent of the detections at or below 20 feet.

3.1.3 *Groundwater*

Table 4 presents the frequency of detections for each chemical in each well and the total for the site. BETX, 1,2-DCA, TPH-G, and TPH-D were consistently detected in wells in the source areas: MW1 and MW5 located near the former USTs, and MW7 located near the former waste oil tank. These same compounds were also consistently detected in the three on-site downgradient wells (MW3, MW6, and MW9) at concentrations of one-half to an order of magnitude lower than in the source area wells. Monitoring well MW11, located approximately 70 feet off site in a directly downgradient flow path, had concentrations of benzene, ethylbenzene, TPH-G and TPH-D at an order of magnitude lower than MW3, MW6, and MW9. Ethylbenzene and toluene were detected only once in MW11 and 1,2-DCA was not detected at all. Concentrations of BETX, 1,2-DCA, TPH-G, and TPH-D detected in monitoring well MW10, located approximately 90 feet off-site and slightly west of the presumed downgradient flow path.

Lead was not consistently analyzed for in groundwater; however, it has a 75 percent frequency of detection (six detections out of eight total analyses) in those samples analyzed for lead.

Trichloroethylene was detected in one analysis (from MW-4) out of 86 from the wells on-site. PCE was detected in three on-site wells, including upgradient well MW8. MW8 and MW7 display a consistent pattern of PCE detections and concentration (see **Table 2**). PCE was detected once in MW9 out of 10 analyses.

3.2 CHEMICALS OF CONCERN

The general methodology for development of risk-based cleanup standards involved compiling site- and chemical-specific information and evaluating possible adverse effects associated with potential receptor exposure to contaminated media. Evaluation of potential receptors comprises "screening" chemical concentrations against promulgated standards and risk-based concentrations protective of human health. Chemicals whose maximum detected concentrations exceed one or more screening criteria are termed contaminants of concern (COC). Other contaminants are not considered further.

TCE not included
in soil

Toluene was the only COC detected in surface soils and, as such, is the only COC for surface soils. BETX, 1,2-DCA, TPH-G, and TPH-D are considered COCs in subsurface soil. TCE is not included as a COC because it has a low frequency of detection (3 percent). PCE is not included as a COC because it was not detected in any soil samples taken, regardless of location or depth.

BETX, 1,2-DCA, TPH-G, TPH-D, and lead are considered COCs in groundwater. TCE is not included as a COC because it has a low frequency of detection (1 percent). Given the groundwater hydrology and the absence of PCE in soil, it appears that PCE is present in upgradient groundwater and has migrated on site. Therefore, PCE is not considered a COC in groundwater for this site.

3.3 BENEFICIAL USE SUMMARY

The site is designated by the City of Hayward as industrial property and has a history of continuous industrial use. The site was first developed for industrial use during the 1940s. Prior to that time, the property was undeveloped. The surrounding area consists of mixed industrial and limited residential use. According to the City of Hayward Planning Department, the land use and zoning are unlikely to change in the future.

EBMUD and Moreland Water provide all residents and businesses with potable water. The newest domestic groundwater supply well is located approximately 5 miles from the site. Alameda County Flood Control and Water Conservation District (ACFCWCD) indicated that there are three irrigation wells within a 5-mile radius of the site. ACFCWCD has stated that the shallow zone aquifer (approximately 27 to 50 feet bgs) should not be used for potable supply.

Groundwater is not used as a source of drinking water. The highest beneficial use is irrigation.

3.4 RECEPTOR SURVEY AND POTENTIAL EXPOSURE ROUTES

If a house were built on the site, residents could be exposed to toluene in surface soils through ingestion, inhalation of emissions, and dermal absorption. Dermal absorption is not considered a complete pathway for toluene because it is a volatile compound. Volatiles in soil are more likely to dissipate into the atmosphere than be absorbed through the skin (EPA, 1992a).

Residents are not expected to have direct exposure to subsurface soil. The only potential for exposure is from volatilization of volatile COCs (BETX and 1,2-DCA) in subsurface soil to ambient air or accumulation inside a home constructed on the site and inhalation by residents. BETX and lead are commonly detected in ambient air. Sources range from industrial use and auto exhaust to dry cleaning and household cleaning products. The national indoor background concentration range for volatiles is presented in Table 5 (ASTM, 1994). Migration from subsurface soil to groundwater through leaching is also possible.

If groundwater were used to irrigate lawns and shrubs, exposure to COCs could occur through inhalation of volatile emissions released into the ambient air while the hose was running and/or dermal contact with and incidental ingestion of those COCs that are not volatile. As with subsurface soil, the potential exists for vertical migration of volatile COCs in groundwater to accumulate inside a home constructed on the site. Residents could then inhale the COCs.

3.5 RISK-BASED CONCENTRATIONS

A risk-based concentration is the concentration of an individual chemical, using reasonable maximum exposure (RME) conditions, that would result in a:

- 1×10^{-6} excess lifetime cancer risk if the chemical is classified as a carcinogen.
- Hazard quotient of 1 for a chemical that results in a noncarcinogenic effect.

Risk-based concentrations were calculated only for those chemicals that exceed the "target risk" for a specific exposure pathway using conservative exposure parameters, the maximum detected concentration of the chemical in the media under consideration, and equations presented in EPA's *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part 3), Interim Final* (EPA, 1989a).

Risk-based concentrations were adjusted for noncarcinogens to account for exposures to multiple chemicals. Adjustments are necessary to ensure that total noncarcinogenic risk presented by site exposures following cleanup will not exceed a hazard index of 1.0 for noncarcinogenic substances producing the same toxic response.

3.5.1 *Compilation of Toxicity Information*

The toxicity factors of chemicals detected in soil and groundwater were compiled from EPA's Integrated Risk Information System (IRIS) (EPA, 1994a) and the Health Effects Assessment Summary Tables (HEAST) (EPA, 1994b). Target organs and toxic end points are identified for each COC. **Table 6** lists toxicity information, where available, for each COC.

The toxicity values presented in **Table 6** for TPH-G and TPH-D are provisional and were derived by EPA (EPA, 1992b). These values were used as opposed to a "reference compound or surrogate" approach because of the need for component chemical group data (number of carbon atoms in each component group such as the alkanes, cycloalkanes, alkenes, and aromatics) to characterize toxicity using reference compounds (MDEP, 1994). Surrogate compound data are not available for this site. Further, Heath, et al. (1993) recommends that surrogate selection be site-specific and states that the selection of surrogates can vary the outcome of the risk estimates by over 10 orders of magnitude. Therefore, in order to obtain a conservative and consistent estimate of risk, the toxicity values derived by EPA from whole product studies were used. MDEP (1994) reports that the use of EPA-derived provisional toxicity values compares favorably with the use of reference compounds; the risks generated with EPA's values were an order of magnitude more conservative than with the reference compound approach (MDEP, 1994). In an effort to remain conservative, the risks from BETX and for TPH-G were quantified separately.

A standard toxicity factor was not developed for lead because of the unique issues in evaluating lead exposure and toxicity. Two modeling approaches are available for lead: EPA's Integrated/Uptake Biokinetic (IUBK) model (EPA, 1994d) and the California DTSC Leadspread (DTSC, 1994). The EPA model predicts blood lead levels only for children 0 to 7 years of age. The DTSC model, although less pharmacokinetically correct, allows estimation of blood lead for adults and children and can be reversed to obtain a concentration that will not exceed the acceptable blood lead level of 10 micrograms of lead per deciliter (ug/dL) of blood.

3.5.2 *Estimation of Risk and Development of Risk-Based Concentrations*

Risk-based concentrations were developed using the exposure routes shown in **Table 7**. Risk-based concentrations are shown in **Table 8**.

Surface Soil : Risk from ingestion of toluene in surface soil and inhalation of toluene emissions from surface soil was not estimated since risk-based concentrations were available in the literature for this pathway using standard residential exposure parameters. For soil ingestion, the higher intake rate of children along with their lower body weight was used by EPA to calculate a risk-based concentration of 16,000 milligrams per kilogram (mg/kg) toluene in soil. **Appendix A, Table A-1** provides a sample calculation for this pathway. The chronic reference dose (RfD) was used, although this results in an overly conservative risk-based concentration because chronic RfDs are developed for lifetime exposure, not a 6-year exposure duration as used for children.

but is more for adults!

Adult inhalation rates, body weight, and a 30-year exposure duration were used by EPA to calculate the risk-based concentration for inhalation of toluene emissions from surface soil. Adult rates lead to a more conservative risk-based concentration than childhood rates because of the longer exposure duration (30 years versus 6 years).

For inhalation, volatilization of toluene from surface soil must be estimated in order to calculate a risk-based soil concentration. **Appendix A, Table A-2** presents the equations used by EPA (1994c) to calculate a soil screening level for the inhalation pathway. The equation requires a volatilization factor and is only valid if the calculated chemical concentration in soil using the volatilization factor is less than the calculated chemical concentration at which the soil pore water is saturated. If the calculated soil concentration using the volatilization factor is greater than the soil saturation concentration, the soil screening level is set equal to the soil saturation concentration. Since this is the case for toluene, the soil screening level is set equal to the soil saturation concentration of 150 mg/kg.

Table 8 presents the risk-based concentrations of toluene in soil necessary to reach a hazard quotient of 1 for the ingestion and inhalation pathways.

Subsurface Soil: There are no complete direct exposure pathways to subsurface soil; therefore, risks are not estimated for direct exposure to subsurface soil.

Exposure to COCs in subsurface soil could only occur if volatile COCs (BETX and 1,2-DCA) are released from soil as soil-gas, migrate vertically through soil, enter a home through cracks in the foundation, accumulate inside the home, and are inhaled by residents of the home. Concentrations of volatile COCs inside the home were estimated using a three step process (similar to VLEACH, as referenced by R. Arulanantham, 1993):

- Estimation of soil-gas VOC concentrations from existing soil concentrations.
- Estimation of a chemical flux in soil gas to the surface (based on Ficks first law of diffusion).
- Estimation of VOC concentrations inside the home.

The first step involves estimation of soil-gas concentrations from soil. The maximum concentration of volatile constituents in soil from any sample location on site was used as an estimate of VOC concentrations inside the home. This is a conservative use of the data.

First, equilibrium pore water concentrations were estimated from soil concentrations using a partition coefficient, K_f:

$$K_f = C_s \text{ (adsorbed) } / C_{sw} \qquad (1)$$

where:

K_f = A measure of chemical partitioning between soil and soil water: milliliters per gram (mL/g)
C_s = Chemical concentration in soil: micrograms per kilogram (µg/kg)
C_{sw} = Soil pore water concentration: micrograms per liter (µg/L)

This assumes all chemicals are in equilibrium with available soil moisture, and an unlimited reservoir of chemical.

Chemical partitioning is affected by the organic content of the soil; therefore, K_f can be defined as the product of the organic carbon partition coefficient K_{oc} (mL/g) and the fraction of organic carbon in the soil f_{oc} (dimensionless). With this information, equation (1) becomes:

0.002%
2%

$$C_{sw} = C_s \, / \, (K_{oc} \, f_{oc}) \qquad (2)$$

K_{oc} values used in the calculations are shown in **Table 9**. The fraction of organic carbon in the vicinity of soil sample collection was assumed to be 0.005, or 0.5 percent. Henry's Law constant was then applied to the estimated soil water concentration to estimate the soil gas concentration beneath the home:

$$C_{sg} = C_{sw} \;\; (H \, / \, RT) \qquad (3)$$

where:

C_{sg} = Chemical concentration in soil gas (µg/L)
H = Henry's Law Constant, a measure of the chemical partitioning between air and water at equilibrium (atm-m^3/mole)
R = Universal gas constant (8.2 x 10-5 atm-m^3/mole-K)
T = Temperature (K)

Henry's Law constants used in the calculations are shown in **Table 9.**

The next step involves the estimation of contaminant flux. Contaminant flux at the surface and the resulting VOC concentration were calculated using an approximation of Fick's first law applied to the calculated soil-gas concentrations:

$$J = D \, (C_{sg} - C_1) \, CF \, / \, L \qquad (4)$$

where:

J = Contaminant flux at ground surface (µg/ft^2/hr)
D = Diffusivity of rate of movement of chemicals (ft^2/hr)
C_{sg} = Chemical concentration in soil gas at depth L (µg/L)
C_1 = Chemical concentration at the surface (µg/L)
CF = Conversion factor (28.3L/ft^3)
L = Depth at which gas concentration is known (20 feet)

not true for gasoline Maybe true for [illegible]

Because the majority of chemicals in subsurface soil were detected at or below 20 feet, this was used as the depth at which the gas concentration is known. Diffusivities (D) were obtained from Heath, et al. (1993). **Table 9** presents air diffusion values for the volatile COCs. **Table 10** lists contaminant flux rates calculated using equation (4).

Because both the flux into the home and the concentration in the home are unknown, Ficks Law must be solved iteratively to determine the steady state contaminant flux of each chemical into the home. For the first iteration, the concentration in the home is assumed to be zero. A flux from the surface to the home is then calculated. The resulting flux is used to calculate an initial concentration in the home based on the following equation:

$$C_{ia} = (J \times PV \times R) / V \qquad (5)$$

where:

C_{ia} = Concentration of the chemical in air inside the home ($\mu g/ft^3$ and converted to mg/m^3)
J = Flux of chemical at ground surface (chemical specific) ($\mu g/ft^2/hr$)
PV = Proportion of volatiles that enter the home (0.5 percent of the 2,000 ft^2 home)
R = Residence time of air in the home (2 hrs)
V = Indoor volume (16,297 ft^3 from 2,000 ft^2 home with 8-foot ceilings)

Each time the concentration in the home is calculated in equation (5), it is substituted into equation (4) as parameter C_i; hence an iterative solution for the concentration of volatiles in a home is determined.

Three assumption were made in estimating air concentration in the home:

- The proportion of volatiles that enter the home was assumed to be 0.5 percent based on the assumption that 0.5 percent of the home's foundation was cracked and accessible to entering volatiles.
- Residence time in the home was assumed to be 2 hours as the home would be opened repeatedly through the day.

Modeled exposure point concentrations C_{ia} are reported in **Table 10**.

It was assumed that residents inhale 20 m^3 of air/day containing volatile emissions for 350 days/year for 30 years (see **Table 7** for exposure parameters). Risk from inhalation of volatiles released from subsurface soil that have accumulated inside a home constructed on the site are presented in **Table 11**. Only benzene exceeded the target risk of 1×10^{-6} and, therefore, a risk-based concentration was calculated for benzene in subsurface soil. This concentration is provided in **Table 8**. This was to be done by first calculating the concentration of benzene in air that results in a 1 by 10^{-6} risk (using the equation on **Table A-3** of **Appendix A**). Once this risk-based concentration of benzene in air was known, the input soil concentration (C_s of Equation 1) could be changed and the model continually re-run until the risk-based concentration of benzene in air was obtained. The maximum concentration of the remaining volatile COCs in subsurface soil did not exceed a 10^{-6} risk or a hazard quotient of 1; therefore, risk-based concentrations were not calculated for these chemicals through this potential exposure pathway.

Emissions of TPH-G and TPH-D could not be estimated because of the lack of physical/chemicals parameters to describe these mixtures. Cleanup concentrations for these compounds were taken from the Regional Water Quality Board's *Screening Levels for Petroleum Impacted Sites* (CRWQCB, 1994) which provides an interim approach for determining soil cleanup levels. These interim cleanup levels, reported in **Table 8**, assume depth to groundwater is approximately 50 feet and it is not used as a source of drinking water.

Groundwater: Irrigation is considered the highest beneficial use of the Shallow Zone groundwater under the site. Inhalation of volatiles released from groundwater into the ambient air while the hose is running and/or dermal contact with and incidental ingestion of water are the exposure pathways considered for groundwater.

It was assumed that residents water their lawns (typical standard yard of 5,000 ft^2) daily, year-round, with fewer minutes of watering and less water used during January and December than during July. Data obtained from EBMUD on monthly water usage data and minutes of watering per day for a typical inland area are presented in **Table 12**. It is assumed that residents inhale 0.8 m^3 of air/hr containing volatile emissions for 487 hours/year (watering for 29,200 minutes per year) for 30 years. **Table 7** presents the exposure parameters used to quantify the inhalation pathway.

Emissions of VOCs were estimated by assuming watering results in nearly complete removal of VOCs from groundwater, in a manner similar to air stripping. The emission rate was estimated from the following equation obtained from EPA (1989b):

$$ER = C_w \times Q \times CF \times (1-(RE/100)) \qquad (6)$$

where:

ER = emission rate (g/min)
C_w = concentration in groundwater (μg/L)
Q = flow rate (l/min)
CF = conversion factor (10^{-6} g/μg)
RE = removal efficiency (%) of 99.5

EBMUD indicated that the typical flow rate out of a hose bib is 10 gallons per minute (gpm) that falls to about 4 gpm (15.2 L/min) at the end of the hose. (Flow rate information was provided by EBMUD and is based on 1993 figures.) **Table 13** presents the estimated emission rates.

To estimate the ambient air concentrations of volatiles in a yard while a hose is running, the average emission rate per unit area is applied to a simple dispersion model (DTSC, 1994):

$$C_a = ER \ / \ (LS \times V \times MH) \qquad (7)$$

where:

C_a = ambient air concentration, mg/m^3
ER = emission rate, g/min
LS = length dimension perpendicular to the wind (m), default value = 22, one side of a 450 m^2 residential lot
V = average wind speed within the mixing zone (m/sec) default value = 2.25
MH = mixing height (m), default value = 2

Estimated ambient air concentrations of volatiles emitted from groundwater used for irrigation are presented in **Table 14**. These modeled concentrations were used to estimate the risk to potential future residents using the exposure parameters described above and listed in **Table 7**. The risks, presented in **Table 14**, are 10^{-12} for benzene and 10^{-13} for 1,2-DCA and the hazard quotients for ethylbenzene, toluene and xylene are all considerably less than 1. Since the maximum detected concentrations of the volatile chemicals in groundwater did not exceed the target risk levels, risk-based concentrations for COCs in groundwater were not calculated for this potential exposure pathway.

Potential future residents could come into direct contact with water while irrigating their lawns. Children often play in the sprinklers or fill small pools with water from the hose during the summer months. The potential for dermal contact and inadvertent ingestion by children, 0 to 6 years of age, was evaluated for TPH-G and TPH-D. Lead in water is not dermally absorbed to any significant degree (EPA, 1992a); therefore, only the potential for inadvertent ingestion by children was evaluated.

It is assumed that children play in wading pools for 1 hour a day, 5 days a week during June, July, and August. Further, it is assumed that dermal contact with groundwater occurs to the whole body, except the head, for an exposed surface area of 6,800 cm^2 (EPA, 1992a). Ingestion of 50 mL of groundwater could occur each time a child is playing. Exposure parameters for these pathways are listed in **Table 7**.

The chemical specific permeability coefficient (Kp) is a key parameter in estimating dermal dose. It is the ratio of the steady-state penetration rate to the concentration applied and is specific for a chemical. Permeability coefficients are not directly available for TPH-G and TPH-D; therefore, surrogate Kps were used. The Kp for toluene (1 cm/hr from EPA, 1992a) was used for TPH-G because toluene comprises a high percentage of gasoline. The Kp for pyrene (0.4 cm/hr from EPA, 1992a) was used for TPH-D because it is a middle carbon compound (C16) and may be characteristic of weathered gasoline.

The risks estimated for the dermal pathway are presented in **Table 15**. The excess lifetime cancer risk, using an oral slope factor unadjusted for absorption efficiency, was calculated as 5 x 10^{-4}. The HQs, calculated with unadjusted oral RfDs, are 17 for TPH-G and 71 for TPH-D. Risk-based concentrations were calculated for both compounds and are reported in **Table 8**. **Appendix A, Tables A-4** and **A-5** present example calculations of risk-based concentrations for dermal absorption of noncarcinogenic and carcinogenic constituents, respectively. The uncertainty in the risks estimated and the resulting risk-based concentrations for this pathway are very high. The use of surrogate Kps and provisional slope factors for these compounds renders the outcome highly uncertain.

It was assumed children ingest 50 mL of groundwater each time they play in the wading pool. Other exposure parameters necessary to quantify the ingestion pathway are listed in **Table 7**. Risks estimated for the ingestion pathway are presented in **Table 16**. Excess lifetime cancer risk from incidental ingestion of TPH-G exceeds the target risk level of 1 x 10^{-6} and a risk-based concentration was calculated. This concentration is listed in **Table 8**. The HQ for ingestion of TPH-D exceeds the target risk level of 1; therefore, a risk-based concentration was calculated for this compound. This concentration is also listed in **Table 8**. Example calculations are presented in **Appendix A, Tables A-6** and **A-7**.

The potential for adverse effects from incidental ingestion of lead in groundwater cannot be quantified. The models available are not suitable for anything less than daily exposure over a 6-year period for children. Risk and risk-based concentrations cannot be estimated. No cleanup concentrations are available in the literature for lead in water used as an irrigation source with the potential for incidental ingestion.

Constituents in groundwater identified as volatile may also be released as soil-gas and migrate vertically through cracks in the foundation of a home and accumulate inside the home. Concentrations of volatile COCs inside the home were estimated using the same process as for subsurface soil, except that pore water concentrations were not estimated but assumed to be equal to the maximum detected concentration of the chemical in groundwater. This approach assumes an unlimited source of chemicals in groundwater and transport in the gas phase via unsaturated void spaces in the overlying vadose zone. The depth to groundwater was set at 50 feet. Modeled exposure point concentrations are reported in **Table 17**.

?

Excess lifetime cancer risk for benzene calculated using residential exposure parameters and modeled indoor air concentrations exceeded the target risk level of 1 x 10^{-6} as shown in **Table 18**. Therefore, a risk-based concentration was calculated for benzene in groundwater (see **Table 8**). The maximum concentration of the remaining volatile COCs in groundwater did not exceed the target risk levels; therefore, risk-based concentrations were not calculated for these chemicals through this potential exposure pathway.

Cross-Media Contamination: Cross media contamination from subsurface soil to groundwater has occurred. The potential exists for groundwater concentrations to increase from leaching of COCs out of subsurface soil. In fact, this pattern has been identified in data taken over the last several years (see **Tables 1 through 4**) as concentrations of COCs exhibit a seasonal pattern of increasing after wet periods and decreasing during dry periods.

The potential for leaching from subsurface soil to groundwater was evaluated for benzene, the only COC in subsurface soil and groundwater that results in a risk exceeding target risk levels for the pathways evaluated. The EPAs Organic Leachate Model (OLM) (Heath, et al., 1993) was used to estimate the concentration in subsurface soil that would result in a leachate concentration of 4 mg/L or the risk-based concentration for benzene in groundwater using the volatile emission exposure pathway. The OLM equation is as follows:

$$C_L = 0.00221 \times C_s^{0.678} \times S^{0.373} \qquad (8)$$

where:

C_L = Predicated constituent concentration in the leachate
C_s = Chemical concentration in soil (mg/kg)
S = Water solubility of chemical (mg/L) (see **Table 9**)

The soil concentration necessary to result in a leachate concentration of 4 mg/L is provided in **Table 8.**

3.5.3 *Compilation of Cleanup Levels*

Potential cleanup levels for each medium are compiled in **Table 19** from the risk-based concentrations calculated according to the various exposure pathways and the regulatory levels reported in **Table 8.** To be protective of public health, the most stringent risk-based concentration should be chosen as the proposed cleanup level. However, in the case of dermal absorption, the uncertainties associated with the estimation of risk-based concentrations for TPH-G and TPH-D are so high that these values were not selected as the potential cleanup level.

The use of natural or area background when the most stringent calculated risk-based concentration is below background must be considered. For volatile emissions from groundwater that accumulate inside a home, the concentration of benzene inside a home that results in an excess lifetime cancer risk to residents inhaling the air for 24 hours/day, 350 days/year for 30 years is 0.38 $\mu g/m^3$. A concentration in groundwater was then estimated that would result in the release and accumulation of benzene to this level. However, this level is an order of magnitude below the national indoor background concentration range for benzene (see **Table 5**). If the low end of the range of the indoor background benzene concentration (3.2 $\mu g/m^3$) used to estimate a benzene concentration in groundwater that would result in the release and accumulation of benzene to this level, the groundwater concentration would be about 40 mg/L. The use of 4 mg/L is therefore conservative in view of background concentrations of benzene in indoor air.

Table 19 does not present cleanup levels for exposure routes where a risk-based concentration was not calculated because the maximum concentration does not present a risk greater than the target risk level or a literature derived cleanup level was not available.

3.6 COMPARISON OF CLEANUP LEVELS WITH SITE CONCENTRATIONS

This subsection compares cleanup levels with site concentration data to evaluate the need for further remediation.

3.6.1 *Surface Soil*

The concentrations of toluene in all samples taken from 0 to 5.5 feet are below the literature reported risk-based concentration selected as the cleanup level.

3.6.2 *Subsurface Soil*

The majority of concentrations of benzene detected in subsurface soil are below the selected cleanup level. Only four samples (out of 29 detections and 58 total analyses) had concentrations exceeding the 0.675 mg/kg cleanup level. The four sample locations, sample dates, and concentrations are as follows:

T1-W (8/89) at 12 mg/kg
T3-E (8/89) at 1.9 mg/kg
MW5 (8/90) at 9.6 mg/kg
B1 (10/90) at 1.2 mg/kg

Samples analyzed for TPH-G from F3 and F6 had concentrations exceeding the selected soil cleanup level of 1,000 mg/kg. The concentrations were reported as 2,000 mg/kg (F3) and 3,800 mg/kg (F6). None of the samples analyzed for TPH-D exceeded the suggested soil cleanup level of 10,000 mg/kg. Samples F3 and F6 also had concentrations of TPH-D that exceeded the 1,000 mg/kg soil cleanup level.

3.6.3 *Groundwater*

Concentrations of benzene detected in most of the samples taken from MW1 and MW5 exceeded the selected cleanup level of 4 mg/L. Two samples taken November 1989 and July 1990 from MW3 also exceeded the selected cleanup level at concentrations of 4.6 and 5.2 mg/L, respectively.

This same pattern is true for TPH-G. Most of the samples taken from MW1 and MW5 exceeded the selected cleanup level of 12.5 mg/L. One sample taken from MW3 in November 1989 exceeded the cleanup level, three samples taken from MW6 (October 1990, April 1991, and January 1993) exceeded the cleanup level, and two samples taken from MW10 (January 1992 and April 1992) exceeded the cleanup level.

Only one sample, taken from MW1 in July 1992, exceeded the selected cleanup level of 15 mg/L for TPH-D.

4.0 REFERENCES

American Society for Testing and Materials (ASTM). 1994. Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites. ES38-94, Philadelphia, PA.

Agency for Toxic Substances and Disease Registry (ATSDR). 1991. Draft, Toxicological Profile for Lead. U.S. Department of Health and Human Services, Public Health Service, Atlanta, GA.

Arulanantham, R. 1993. Memorandum, Risk-Based Management of Contaminated Sites. Alameda County - Department of Environmental Health, Hazardous Materials Division.

California State Water Quality Control Board (CSWQCB). 1989. Leaking Underground Fuel Tank Field (LUFT) Manual, Guidelines for Site Assessment, Cleanup, and Underground Storage Tank Closure. Sacramento, CA.

California Regional Water Quality Control Board (CRWQCB). 1994. Screening Levels for Petroleum Impacted Sites, Interim Approach. Sacramento, CA.

Clement Assoc., Inc. 1988. Multi-pathway health risk assessment input parameters guidance document. South Coast Air Quality Management District, El Monte, CA.

Department of Toxic Substances Control (DTSC). 1992. LeadSpread, beta test version spreadsheet. California Environmental Protection Agency, Sacramento, CA.

DTSC. 1994. Preliminary Endangerment Assessment Guidance Manual. California Environmental Protection Agency, Sacramento, CA.

Heath, J.S.; K. Koblis; S. Sager; and C. Day. 1993. Risk Assessment for Total Petroleum Hydrocarbons. In: Hydrocarbon Contaminated Soils, Edward J. Calabrese and Paul T. Kostecki (eds), Lewis Publishers, Chelsa, MI.

Massachusetts Department of Environmental Protection (MDEP). 1994. Interim Final Petroleum Report: Development of Health-Based Alternative to the Total Petroleum Hydrocarbons (TPH) Parameter. Bureau of Waste Site Cleanup, Office of Research and Standards, Boston, MA.

Texas Natural Resource Conservation Commission (TNRCC). 1994. Risk-Based Corrective Action for Leaking Storage Tank Sites. Austin, TX.

EPA. 1994a. Integrated Risk Information System (IRIS). Environmental Criteria and Assessment Office, Cincinnati, OH.

EPA. 1994b. Health Effects Assessment Summary Tables, Annual Update. Office of Solid Waste and Emergency Response, 9200.6-303(93-1), EPA 540-R-93-058, Cincinnati, OH.

EPA. 1994c. Technical Background Document for Draft Soil Screening Level Guidance. EPA-540/R-94/018, Publication 9355.4-14-1, Office of Solid Waste and Emergency Response, Washington D.C.

EPA. 1994d. Guidance Manual for the Integrated Exposure Uptake Biokinetic Model 0.99D for Lead in Children. EPA/540/R-93/081, Office of Emergency and Remedial Response, Washington, D.C.

EPA. 1992a. Dermal Exposure Assessment: Principles and Applications, Interim Report. EPA/600/8-91/011B, Office of Research and Development, Washington, DC.

EPA. 1992b. Memorandum: Oral Reference Doses and Oral Slope Factors for JP-4, JP-5, Diesel Fuel, and Gasoline. From: Joan S. Dollarhide, Associate Director, Superfund Health Risk Technical Support Center, Chemical Mixtures Assessment Branch, Cincinnati, OH.

EPA. 1991a. Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors". OSWER Directive 9285.6-03, Washington, DC.

EPA. 1991b. Human Health Evaluation Manual (Part B), Development of Risk-Based Preliminary Goals. OSWER Directive 9285.6-01C, Office of Emergency and Remedial Response, Washington, DC.

EPA. 1989a. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), Interim Final. EPA/540/1-89/002, Office of Emergency and Remedial Response, Washington, DC.

EPA. 1989b. Air/Superfund National Technical Guidance Study Series, Volume I - Application of Air Pathway Analyses for Superfund Activities, Interim Final. EPA-450/1-89-001, Office of Air Quality Planning and Standards, Research Triangle Park, NC.

DISTRIBUTION

3 Copies

Harbert Transportation
c/o Reed, Elliott, Creech & Roth
99 Alameda Boulevard, Eighth Floor
San Jose, California 95113

Attention: Mr. Jeffrey Lawson

3 Copies

Durham Transportation Inc.
9171 Capital of Texas Highway North
Travis Building, Suite 200
Austin, Texas 78759-7252

Attention: Mr. David Delamontte

1 Copy

Alameda County Health Agency
Department of Environmental Health
1131 Harbor Bay Parkway, 2nd Floor
Alameda, California 94502

Attention: Ms. Madula Logan

Quality Assurance/Technical Review by:

Gary Laakso
Remediation Services Manager

T
A
B
L
E
S

Table 1
Summary of Historical Soil Analytical Data

Harbert Transportation/Meekland Avenue
Hayward, California

≤3 m depth

Sample Number	Date Sampled	Depth (ft)	EPA Test Method									
			8015 Modified			8020				8010		
			TPH-G	TPH-D	TPH-MO	Benzene	Ethylbenzene	Toluene	Total Xylenes	TCE	PCE	1,2-DCA
			mg/kg			mg/kg				mg/kg		
Test Pit #8	06/20/90	2.5	NA	NA	20	ND	ND	0.069	NA	NA	NA	NA
TP4	09/04/90	2.5	ND	ND	20	ND	ND	0.069	ND	ND	ND	ND
MW5	08/31/90	5.5	ND	ND	ND	ND	ND	0.0039	ND	ND	ND	ND
B1	10/01/90	5.5	ND	ND	13 [b]	ND	ND	0.036	ND	ND	ND	ND
Test Pit #9	06/20/90	7.0	NA	NA	NA	ND	ND	0.024	NA	NA	NA	NA
TP5	09/04/90	7.0	ND	ND	ND	ND	ND	0.024	ND	NA	NA	NA
Test Pit #10	06/20/90	7.5	NA	NA	NA	ND	ND	0.005	NA	NA	NA	NA
Test Pit #11	06/20/90	7.5	NA	NA	NA	ND	ND	0.034	NA	NA	NA	NA
T4	08/11/89	7.5	ND	ND	NA	ND	0.012	0.03	0.14	NA	NA	NA
TP6	09/04/90	7.5	ND	ND	ND	ND	ND	0.005	ND	ND	ND	ND
TP8	09/04/90	7.5	ND	ND	ND	ND	ND	0.034	NA	ND	ND	ND
F-1	02/05/93	8.0	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA
F-3 [e]	02/05/93	8.0	2,000	1,300 [a]	ND	ND	2.5	1.6	120	ND	ND	ND
Test Pit #8	06/20/90	8.0						0.017	NA	NA	NA	NA
TP4	09/04/90	8.0	ND	ND	ND	ND	ND	0.017	ND	ND	ND	ND
TP1	09/04/90	8.5	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA
Test Pit #7	06/20/90	9.0	NA	NA	16	ND	ND	NA	NA	NA	NA	NA
TP2	09/04/90	9.0	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA
TP3	09/04/90	9.0	NA	ND	16	NA	NA	NA	NA	NA	NA	NA
MW5	08/31/90	10.5	ND	ND	ND	0.037	0.0035	0.016	0.019	ND	ND	0.0024
T1-W	08/11/89	11.0	5.203	NA	NA	12	67	83	420	NA	NA	NA
F-6	02/05/93	12.0	3,800	1,300 [a]	ND	ND	ND	ND	20	NA	NA	NA
F-8	02/05/93	12.0	1.1	110 [a]	67	ND	ND	ND	ND	NA	NA	NA
ABW-12-12	12/12/89	12.0	1.8	NA	NA	0.2	0.024	0.018	0.034	NA	NA	NA
T1-E	08/11/89	13.0	2.208	NA	NA	ND	33	59	180	NA	NA	NA
T2-W	08/11/89	13.0	0.0124	NA	NA	ND	ND	ND	ND	NA	NA	NA
T2-E	08/11/89	13.0	6.178	NA	NA	ND	56	68	360	NA	NA	NA
T3-W	08/11/89	13.0	ND	NA	NA	ND	0.013	0.026	0.11	NA	NA	NA
T3-E	08/11/89	13.0	2.857	NA	NA	1.9	36 [c]	17	220 [c]	NA	NA	NA
MW4	11/28/89	15.5	NA	NA	NA	0.02	0.013	0.019	NA	NA	NA	NA

tank pit

Table 1
Summary of Historical Soil Analytical Data

Harbert Transportation/Meekland Avenue
Hayward, California

Sample Number	Date Sampled	Depth (ft)	EPA Test Method									
			8015 Modified			8020				8010		
			TPH-G	TPH-D	TPH-MO	Benzene	Ethylbenzene	Toluene	Total Xylenes	TCE	PCE	1,2-DCA
			mg/kg			mg/kg				mg/kg		
MW7	10/01/90	15.5	ND	ND	ND	ND	ND	0.015	ND	ND	ND	ND
B1	10/01/90	15.5	ND	ND	ND	0.04	0.0058	0.034	0.025	ND	ND	0.014
B-4	11/28/89	15.5	ND	NA	NA	0.02	0.013	0.019	ND	NA	NA	NA
MW1	06/30/86	20.0	240 [d]	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW9	02/13/91	20.0	2.2	NA	NA	0.15	0.029	0.066	0.067	ND	ND	0.0079
MW-12-20-4	12/14/92	20.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
B-1	06/30/86	20.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B-2	06/30/86	20.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW3	11/28/89	20.5	NA	NA	NA	0.13	ND	0.022	ND	0.2	ND	ND
MW4	11/28/89	20.5	NA	NA	NA	0.075	0.026	0.02	0.015	NA	NA	NA
MW5	08/31/90	20.5	560	6.4	ND	9.6	7.4	22	45	ND	ND	0.061
MW6	08/30/90	20.5	ND	ND	ND	0.046	ND	ND	ND	ND	ND	ND
B-3	11/28/89	20.5	ND	NA	NA	0.13	ND	0.022	ND	0.2	ND	ND
B-4	11/28/89	20.5	ND	NA	NA	0.075	0.026	0.02	0.015	NA	NA	NA
MW10	01/21/92	21.0	ND	ND	NA	0.0044	0.0036	0.014	0.018	ND	ND	ND
MW11	01/24/92	21.0	ND	ND	NA	0.0043	ND	0.008	ND	ND	ND	ND
MW8	02/13/91	25.0	NA	NA	NA	ND	ND	0.0033	ND	NA	NA	NA
MW3	11/28/89	25.5	52	NA	NA	0.44	0.2	0.48	0.93	NA	NA	NA
MW7	10/01/90	25.5	ND	ND	ND	0.043	0.0034	0.0044	0.01	ND	ND	ND
B1	10/01/90	25.5	150	3.7	ND	1.2	2.1	2.4	8.4	ND	ND	0.041
B-3	11/28/89	25.5	52	NA	NA	0.44	0.2	0.48	0.93	ND	ND	ND
MW10	01/21/92	26.0	52	11 [b]	NA	ND	0.33	ND	1.5	ND	ND	ND
MW9	02/13/91	30.0	39	6	NA	0.18	0.23	0.34	1	NA	ND	0.011
MW11	01/24/92	30.0	ND	ND	NA	ND	0.0039	0.0041	ND	ND	ND	ND
MW-12-30-6		30.0	29	11 [a]	ND	0.078	0.1	ND	0.16	ND	ND	ND
MW3	11/28/89	30.5	23	NA	NA	0.54	0.21	0.188	0.4	NA	NA	NA
MW6	08/30/90	30.5	23	5.3	ND	0.07	0.06	0.096	0.059	ND	ND	0.0057
B-3	11/28/89	30.5	23	NA	NA	0.54	0.21	0.188	0.4	ND	ND	ND
MW10	01/21/92	31.0	ND	ND	NA	ND	ND	0.0025	0.0034	ND	ND	ND
MW8	02/13/91	35.0	NA	NA	NA	ND	ND	0.028	ND	NA	NA	NA

Table 1
Summary of Historical Soil Analytical Data

Harbert Transportation/Meekland Avenue
Hayward, California

			EPA Test Method									
			8015 Modified			8020				8010		
Sample Number	Date Sampled	Depth (ft)	TPH-G	TPH-D	TPH-MO	Benzene	Ethylbenzene	Toluene	Total Xylenes	TCE	PCE	1,2-DCA
			mg/kg			mg/kg				mg/kg		
MW11	01/24/92	35.0	ND	ND	NA	ND	ND	0.0045	ND	ND	ND	ND
MW7	10/01/90	35.5	ND	ND	ND	ND	ND	0.027	0.0057	ND	ND	ND
B-4	11/28/89	35.5	ND	NA	NA	ND	ND	0.013	ND	NA	NA	NA
MW9	02/13/91	40.0				ND	ND	0.011	ND	NA	NA	NA
MW-12-40-8		40.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW5	08/31/90	45.5	ND	ND	ND	0.014	0.0073	0.021	0.034	ND	ND	ND
MW6	08/30/90	45.5	1.2	ND	ND	0.02	0.015	0.035	0.056	ND	ND	ND
MW7	10/01/90	45.5	1.1	ND	ND	0.0071	0.012	0.036	0.056	ND	ND	ND
MW7	10/01/90	Auger	120	23	ND	0.31	1.7	1.4	6.9	ND	ND	0.0059
Detection Limit			1.0	1.0	10	0.0025	0.0025	0.0025	0.0025	0.002	0.002	0.002

Notes:

a) The positive result for petroleum hydrocarbons quantified as Diesel appears to be due to the presence of lighter hydrocarbons rather than diesel.

b) The positive result for the motor oil analysis on this sample appears to be a lighter hydrocarbon than diesel.

c) Xylenes and ethylbenzene are over range.

d) Reported as total hydrocarbons by EPA Method 8020.

e) Lead = 52 mg/kg.

NA - Not analyzed.
ND - Not detected at indicated detection limit.
TPH-G - Total petroleum hydrocarbons quantified as gasoline.
TPH-D - Total petroleum hydrocarbons quantified as diesel.
TPH-MO - Total petroleum hydrocarbons quantified as motor oil.
TCE - Trichloroethylene.
PCE - Tetrachloroethylene.
1,2-DCA - 1,2-Dichloroethane.
1,1-DCA - 1,1-Dichloroethane.

Table 2
Summary of Historical Groundwater Analytical Data
Harbert Transportation/Meekland Avenue
Hayward, California

Well	Date Sampled	EPA Test Methods										
		8015 Modified			8020				8010			
		TPH-G	TPH-D	TPH-MO	Benzene	Ethylbenzene	Toluene	Total Xylenes	TCE	PCE	1,2-DCA	Other
		µg/L			µg/L				µg/L			µg/L
MW1	07/86	42,000	NA	NA	5,500	NA	4,900	6,100	NA	NA	NA	
	03/90	27,000	NA	NA	2,700	491	840	800	ND	ND	ND	
	07/90	27,000	11,000	ND	4,000	ND	1,500	4,400	ND	ND	62	
	10/90	43,000	8,500	ND	3,400	1,200	2,700	5,300	0.4	ND	26	
	01/91	22,000	2,700	ND	3,000	990	1,800	2,800	ND	ND	27	
	04/91	42,000	3,100 [a]	NA	5,100	1,200	3,700	3,200	ND	ND	120	
	07/91	46,000	4,300 [a]	NA	6,500	830	2,900	3,700	ND	ND	64	
	10/91	27,000	4,300 [a]	NA	4,400	1,100	1,400	3,200	ND	ND	25	
	01/92	27,000	14,000 [a]	NA	3,300	1,200	1,600	3,800	ND	ND	24	
	04/92	33,000	11,000 [a]	NA	8,900	1,200	3,500	3,700	ND	ND	120	
	07/92	41,000	19,000 [a]	NA	5,600	1,300	2,600	4,000	ND	ND	49	
	10/92	33,000	3,500 [a]	NA	4,400	1,200	2,100	4,000	ND	ND	61	
MW3	11/89	29,000	NA	NA	4,600	680	1,100	1,100	ND	ND	36	Lead 40
	11/89	NA	NA	NA	NA	NA	NA	NA	ND	ND	36	Lead 40
	03/90	12,000	NA	NA	2,300	59	300	490	ND	ND	ND	
	07/90	7,300	990	ND	5,200	ND	440	480	ND	ND	67	
	10/90	6,200	970	ND	75	7.5	150	250	ND	ND	48	
	10/90	NA	NA	NA	NA	NA	NA	NA	ND	ND	22	Lead 3
	01/91	4,600	680	ND	2,200	220	110	89	ND	ND	40	
	04/91	8,300	640 [a]	NA	2,800	370	490	760	ND	ND	43	
	07/91	6,600	890 [a]	NA	2,000	250	230	380	ND	ND	29	
	10/91	6,300	1,700 [a]	NA	2,000	410	330	550	ND	ND	27	
	01/92	4,000	790 [a]	NA	1,200	250	60	200	ND	ND	22	
	04/92	7,400	1,800 [a]	NA	730	370	180	640	ND	ND	19	
	07/92	3,000	2,400 [a]	NA	190	ND	2.8	410	ND	ND	30	
	10/92	5,000	970 [a]	NA	1,300	320	45	340	ND	ND	26	
	01/93	2,300	680 [a]	NA (2)	630	180	31	330	ND	ND	13	
	06/93	5,000	1,100 [a]	ND	730	240	43	380	ND	ND	13	

AGI TECHNOLOGIES

Table 2

Summary of Historical Groundwater Analytical Data

Harbert Transportation/Meekland Avenue

Hayward, California

		EPA Test Methods										
		8015 Modified			8020				8010			
Well	Date Sampled	TPH-G	TPH-D	TPH-MO	Benzene	Ethylbenzene	Toluene	Total Xylenes	TCE	PCE	1,2-DCA	Other
		µg/L			µg/L				µg/L			µg/L
MW4	11/89	ND	NA	NA	33	1.3	1	5.2	NA	NA	NA	Lead 12
	03/90	ND	NA	NA	7.4	2	2	1.1	ND	ND	ND	
	07/90	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.9	
	10/90	ND	ND	ND	ND	ND	ND	ND	0.7	ND	0.5	
	01/91	80	ND	ND	9.2	2.4	1.7	0.7	ND	ND	ND	
	04/91	1,400	130 [a]	NA	2,200	72	ND	17	ND	ND	ND	
	07/91	130	ND	NA	14	3.3	9.7	ND	ND	ND	0.81	
	10/91	ND	ND	NA	5.3	1	ND	0.8	ND	ND	ND	
	01/92	ND	ND	NA	6.8	1.3	ND	ND	ND	ND	ND	
	04/92	780	130 [a]	NA	ND	51	ND	4.8	ND	ND	1.6	
	07/92	ND	ND	NA	ND	ND	ND	ND	ND	ND	1.3	
	10/92	100	ND	NA	9.5	ND	ND	2.6	ND	ND	ND	
	01/93	960	240 [a]	NA	200	41	4.6	9.4	ND	ND	1	
	06/93	650	140 [a]	ND	150	21	ND	ND	ND	ND	3.7	
MW5	10/90	9,600	1,900	ND	1,200	70	160	520	ND	ND	22	Lead 3
	01/91	10,000	1,200	ND	1,600	720	200	510	ND	ND	33	
	04/91	18,000	860 [a]	NA	2,500	550	580	500	ND	ND	61	
	07/91	15,000	2,200 [a]	NA	4,800	610	1,100	760	ND	ND	62	
	10/91	14,000	3,300 [a]	NA	5,000	530	820	800	ND	ND	49	
	01/92	12,000	1,900 [a]	NA	4,300	390	380	590	ND	ND	56	
	04/92	23,000	6,400 [a]	NA	8,600	ND	2,600	1,900	ND	ND	125	
	07/92	27,000	5,900 [a]	NA	6,000	ND	1,500	1,600	ND	ND	93	
	10/92	13,000	2,100 [a]	NA	4,600	140	470	550	ND	ND	59	
	01/93	18,000	1,900 [a]	NA	5,800	560	1,900	1,600	ND	ND	110	
	01/93	19,000	2,100 [a]	NA	4,600	370	1,600	1,400	ND	ND	120	
	06/93	22,000	2,900 [a]	ND	8,300	740	2,500	1,900	ND	ND	110	
	06/93	23,000	2,300 [a]	ND	9,600	730	3,000	1,900	ND	ND	110	

Table 2

Summary of Historical Groundwater Analytical Data

Harbert Transportation/Meekland Avenue
Hayward, California

		EPA Test Methods										
		8015 Modified			8020				8010			
Well	Date Sampled	TPH-G	TPH-D	TPH-MO	Benzene	Ethylbenzene	Toluene	Total Xylenes	TCE	PCE	1,2-DCA	Other
		µg/L			µg/L				µg/L			µg/L
MW6	10/90	27,000	4,700	ND	2,700	450	2,900	3,300	ND	ND	40	Lead 9
	01/91	7,200	1,600	ND	1,400	ND	200	830	ND	ND	23	
	04/91	17,000	800[a]	NA	2,800	610	1,200	1,800	ND	ND	53	
	07/91	11,000	1,400[a]	NA	1,200	ND	380	750	ND	ND	29	
	10/91	4,800	1,600[a]	NA	380	69	340	730	ND	ND	22	
	01/92	6,100	1,200[a]	NA	460	180	200	590	ND	ND	26	
	04/92	7,200	1,800[a]	NA	340	350	460	920	ND	ND	30	
	07/92	8,600	1,700[a]	NA	1,300	380	280	1,100	ND	ND	35	
	10/92	1,600	110[a]	NA	230	70	20	88	ND	ND	24	
	01/93	13,000	2,100[a]	NA	2,500	370	540	2,400	ND	ND	36	
	06/93	7,400	1,900[a]	ND	1,500	480	120	1,400	ND	ND	29	
MW7	10/90	14,000	2,700	ND	390	ND	18	1,200	ND	1.3	14	Lead 11
	01/91	4,500	1,400	ND	320	42	48	350	ND	ND	10	
	04/91	2,400	NA	NA	320	77	62	130	ND	0.6	11	
	07/91	2,000	910[a]	NA	470	ND	24	88	ND	ND	9.7	
	10/91	ND	370[a]	NA	ND	ND	ND	ND	ND	0.68	4.5	
	01/92	1,100	290[a]	NA	230	45	7	88	ND	3.5	6.4	
	04/92	1,700	520[a]	NA	310	78	28	170	ND	0.5	3.2	
	07/92	1,900	590[a]	NA	410	78	21	170	ND	2.1	8.7	
	07/92 (dup)	1,200	700[a]	NA	21	1	2.6	90	ND	2	8.2	
	10/92	1,800	320[a]	NA	410	31	11	75	ND	1	7.4	
	01/93	2,100	660[a]	NA	390	100	21	270	ND	0.6	3.7	
	06/93	4,400	1,100[a]	ND	830	330	49	620	ND	ND	8.6	

Table 2
Summary of Historical Groundwater Analytical Data
Harbert Transportation/Meekland Avenue
Hayward, California

AGI TECHNOLOGIES

		EPA Test Methods										
		8015 Modified			8020				8010			
Well	Date Sampled	TPH-G	TPH-D	TPH-MO	Benzene	Ethylbenzene	Toluene	Total Xylenes	TCE	PCE	1,2-DCA	Other
		µg/L			µg/L				µg/L			µg/L
MW8	02/91	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	
	04/91	ND	ND	NA	ND	ND	ND	ND	ND	0.5	ND	
	07/91	ND	ND	NA	ND	ND	2	ND	ND	1.2	ND	
	10/91	ND	ND	NA	ND	ND	0.6	ND	ND	0.4	ND	
	01/92	ND	ND	NA	ND	ND	ND	ND	ND	0.68	ND	
	04/92	ND	ND	NA	ND	ND	ND	ND	ND	0.8	ND	
	07/92	ND	ND	NA	ND	ND	3.3	ND	ND	1.6	ND	
	10/92	ND	ND	NA	ND	ND	ND	ND	ND	1.4	ND	
	01/93	ND	ND	NA	ND	ND	ND	ND	ND	0.8	ND	
	06/93	ND	ND	ND	ND	ND	ND	ND	ND	1.4	ND	
MW9	02/91	6,000	1,600	NA	180	19	170	200	ND	ND	13	
	04/91	4,200	410 [a]	NA	520	130	410	580	ND	ND	26	
	07/91	1,900	180 [a]	NA	190	12	52	77	ND	6.5	12	
	10/91	880	300 [a]	NA	160	31	44	83	ND	ND	10	
	01/92	380	120 [a]	NA	14	7.6	2.2	14	ND	ND	9.6	
	04/92	2,900	700 [a]	NA	510	80	260	260	ND	ND	11	
	07/92	4,400	1,300 [a]	NA	860	210	340	640	ND	ND	22	
	10/92	200	290 [a]	NA	6.8	1.4	2.1	7.8	ND	ND	12	
	01/93	8,500	740 [a]	NA	2,400	390	620	1,500	ND	ND	29	
	06/93	8,200	1,300 [a]	ND	2,400	360	480	1,500	ND	ND	29	
MW10	01/92	13,000	3,700 [a]	NA	130	580	110	3,000	ND	ND	33	
	05/92	15,000	5,000 [a]	NA	180	ND	18	2,700	ND	ND	20	
	05/92 (dup)	13,000	7,500 [a]	NA	240	490	65	2,500	ND	ND	22	
	07/92	8,100	4,400 [a]	NA	74	360	ND	1,100	ND	ND	29	
	10/92	3,200	1,500 [a]	NA	ND	ND	ND	320	ND	ND	25	
	01/93	7,500	2,200 [a]	NA	130	170	20	710	ND	ND	18	
	06/93	8,000	2,100 [a]	ND	69	7.9	ND	490	ND	ND	16	

Table 2
Summary of Historical Groundwater Analytical Data

Harbert Transportation/Meekland Avenue
Hayward, California

		EPA Test Methods										
		8015 Modified			8020				8010			
	Date	TPH-G	TPH-D	TPH-MO	Benzene	Ethylbenzene	Toluene	Total Xylenes	TCE	PCE	1,2-DCA	Other
Well	Sampled	µg/L			µg/L				µg/L			µg/L
MW11	01/92	8,200	3,200 [a]	NA	23	250	ND	1,100	ND	ND	ND	
	04/92	160	1,200 [a]	NA	ND	ND	ND	ND	ND	ND	ND	
	07/92	2,100	710 [a]	NA	39	100	2.3	53	ND	ND	ND	
	10/92	660	220 [a]	NA	2.9	19	ND	3.8	ND	ND	ND	
	10/92	770	230 [a]	NA	3.2	26	ND	5.7	ND	ND	ND	
	01/93	780	370 [a]	NA	10	2.1	ND	39	ND	ND	ND	
	06/93	2,500	160 [a]	ND	27	99	ND	34	ND	ND	ND	
MW12	12/92	2,800	1,700 [a]	NA	14	ND	ND	ND	ND	ND	ND	
	06/93	1,100	750 [a]	ND	19	21	ND	57	ND	ND	ND	
B1	01/93	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	
	06/93	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
F3	02/93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Well Abandoned	12/89	1,800	NA	NA	200	24	18	34	ND	ND	0.15	Lead 2,100
Laboratory Detection Limit		50	50	500	0.5	0.5	0.5	0.5	0.4	0.4	0.4	

Notes:

a) The detection for petroleum hydrocarbons as diesel appears to be due to the presence of lighter hydrocarbons rather than diesel.
µg/L - Micrograms per liter is approximately equivalent to parts per billion, depending on density of water.
NA - Not analyzed.
ND - Not detected.
TPH-G - Total petroleum hydrocarbons quantified as gasoline.
TPH-D - Total petroleum hydrocarbons quantified as diesel.
TPH-MO - Total petroleum hydrocarbons quantified as motor oil.

TCE - Trichloroethylene.
PCE - Tetrachloroethylene.
1,2-DCA - 1,2-Dichloroethane.

Table 3
Frequency of Detections for Subsurface Soil (below 5.5 feet)
Harbert Transportation/Meekland Avenue
Hayward, California

Constituent	Total Number of Analyses	Number of Positive Detections	Overall Detection Frequency (%)	Positive Detections Below 20 feet	Detection Frequency Below 20 feet (%)
TPH-G	52	24	46	15	63
TPH-D	38	10	26	7	70
TPH-MO	32	6	19	3	50
Benzene	58	29	50	22	76
Ethylbenzene	58	32	55	20	63
Toluene	58	49	84	28	57
Xylenes	58	33	57	22	67
TCE	35	2	6	ND	0
PCE	35	0	0	ND	0
1,2-DCA	35	8	23	6	75

Note:

ND - Not detected.
TPH-G - Total petroleum hydrocarbons quantified as gasoline.
TPH-D - Total petroleum hydrocarbons quantified as diesel.
TPH-MO - Total petroleum hydrocarbons quantified as motor oil.

AGI TECHNOLOGIES

Table 4
Frequency of Detections for Groundwater
Harbert Transportation/Meekland Avenue
Hayward, California

	Upgradient Wells						Source Area Wells								
	MW-8			MW-4			MW-1			MW-5			MW-7		
Constituent	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD
TPH-G	10	0	0%	14	7	50%	12	12	100%	11	11	100%	11	10	91%
TPH-D	10	0	0%	12	4	33%	10	10	100%	11	11	100%	10	10	100%
TPH-MO	1	0	0%	4	0	0%	3	0	0%	3	0	0%	3	0	0%
Benzene	10	0	0%	14	10	71%	12	12	100%	11	11	100%	11	10	91%
Ethylbenzene	10	0	0%	14	10	71%	11	10	91%	11	9	82%	11	8	73%
Toluene	10	3	30%	14	5	36%	12	12	100%	11	11	100%	11	10	91%
Xylenes	10	0	0%	14	8	57%	12	12	100%	11	11	100%	11	10	91%
TCE	10	0	0%	13	1	8%	11	1	9%	11	0	0%	11	0	0%
PCE	10	9	90%	13	0	0%	11	0	0%	11	0	0%	11	8	73%
1,2-DCA	10	0	0%	13	8	62%	11	10	91%	11	11	100%	11	11	100%
Lead				1	1	100%	2	1	50%	1	1	100%	1	1	100%

	Downgradient On-Site Wells									Downgradient Off-Site Wells								
	MW-3			MW-6			MW-9			MW-10			MW-11			MW-12		
Constituent	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD	Total # Analyses	Detections	FOD
TPH-G	14	14	100%	11	11	100%	10	10	100%	7	7	100%	7	7	100%	2	2	100%
TPH-D	12	12	100%	11	11	100%	10	10	100%	7	7	100%	7	7	100%	2	2	100%
TPH-MO	4	0	0%	3	0	0%	1	0	0%	1	0	0%	1	0	0%	1	0	0%
Benzene	14	14	100%	11	11	100%	10	10	100%	7	6	86%	7	6	86%	2	2	100%
Ethylbenzene	14	12	86%	11	9	82%	10	10	100%	7	5	71%	7	6	86%	2	1	50%
Toluene	14	14	100%	11	11	100%	10	10	100%	7	4	57%	7	1	14%	2	0	0%
Xylenes	14	14	100%	11	11	100%	10	10	100%	7	7	100%	7	6	86%	2	1	50%
TCE	16	0	0%	11	0	0%	10	0	0%	7	0	0%	7	0	0%	2	0	0%
PCE	16	0	0%	11	0	0%	10	1	10%	7	0	0%	7	0	0%	2	0	0%
1,2-DCA	16	15	94%	11	11	100%	10	10	100%	7	7	100%	7	0	0%	2	0	0%
Lead	2	1	0.5	1	1	100%												

	All Samples Taken		
Constituent	Total Analyses	Total Detections	FOD
TPH-G	123	91	74%
TPH-D	114	84	74%
TPH-MO	29	0	0%
Benzene	123	92	75%
Ethylbenzene	122	80	66%
Toluene	123	81	66%
Xylenes	123	90	73%
TCE	125	2	2%
PCE	125	18	14%
1,2-DCA	125	83	66%
Lead			

Note:

FOD - Frequency of detection.

Table 5
National Indoor Background Concentrations

Harbert Transportation/Meekland Avenue
Hayward, California

Constituent	Concentration Range ($\mu g/m^3$)		
Benzene	3.2E-01	to	2.2E+01
Ethylbenzene	2.2E+00	to	9.7E+00
Toluene	9.6E-01	to	2.9E+01
Xylenes	4.9E+00	to	4.8E+01

Note:

$\mu g/m^3$ - Micrograms per cubic meter.

Table 6
Toxicity Values and Critical Effects for Chemicals of Concern
Harbert Transportation/Meekland Avenue
Hayward, California

Constituent	Cancer Slope Factors				Weight of Evidence	Type of Cancer
	Oral (mg/kg-d)$^{-1}$	Ref	Inhalation (mg/kg-d)$^{-1}$	Ref		
Benzene	0.029	I	0.029	I	A	Leukemia
Ethylbenzene						
Toluene						
Xylenes						
1,2-DCA	0.091	I	0.091	I	B2	Tumor induction
TPH-G	0.0017	E	0.0017	E	C	Liver tumors
TPH-D						
Lead					B2	

Constituent	Oral RfD (mg/kg-d)	Ref	Inhalation RfD (mg/kg-d)	Ref	Uncert./ Modifying Factor	Confidence in RfD	Critical Effect
Benzene							
Ethylbenzene	0.1	I	0.29	I	1000/1:300/1	Low:Low	Liver& kidney toxicity:Developmental toxicity
Toluene	0.2	I	0.11	I	1000/1:300/1	Med:Med	Liver & kidney weight changes:Neurological effects
Xylenes	2	I	2	C	100/1	Med	Hyperactivity, decreased body weight
1,2-DCA							
TPH-G	0.2	E			1000	Low	Weight loss
TPH-D	0.008	E			10000	Low	Liver changes
Lead							

Notes:

I - EPA, 1994b.
E - EPA, 1992b.
C - DTSC, 1994.
mg/kg-d - Milligrams per kilograms of body weight per day.
RfD - Reference dose.

TPH-G - Total petroleum hydrocarbons quantified as gasoline.
TPH-D - Total petroleum hydrocarbons quantified as diesel.

Table 7
Exposure Parameters

Harbert Transportation/Meekland Avenue
Hayward, California

Exposure Scenario	Exposure Route	Receptor	Body Weight [a] (kg)	Intake Rate	Exposure Frequency	Exposure Duration (years)	Exposure Time	Averaging Time for Carcinogens [a] (Days)	Averaging Time for Noncarcinogens [a] (Days)
Potential Future Resident	Surface soil ingestion	Adult	70	100 mg/day [a]	350 days/yr [b]	24 [b]	N/A	25,550	8,760
		Child	15	200 mg/day [a]	350 days/yr [b]	6 [b]	N/A	25,550	2,190
	Indoor inhalation	Adult	70	20 m^3/day [a]	350 days/yr [b]	30 [b]	N/A	25,550	10,950
	Inhalation while irrigating	Adult	70	0.8 m^3/hr [b]	50 days/yr	30 [b]	487 hr/yr [c]	25,550	10,950
	Incidental ingestion of water from the hose	Child	15	0.05 L/day [a]	60 days/yr [c]	6	1 hr/day	25,550	2,190
	Dermal contact with water from the hose	Child	15	Skin surface of 6,800 cm^2 [d]	60 days/yr [c]	6	1 hr/day	25,550	2,190

Notes:

a) Source: EPA, 1989a.
b) Source: EPA, 1991b.
c) Site-specific parameters.
d) Source: EPA, 1992a.
N/A - Not applicable.

Table 8
Summary of Risk-Based Concentrations and Suggested Regulatory Concentrations
Harbert Transportation/Meekland Avenue
Hayward, California

Constituent	Surface Soil (mg/kg)		Subsurface Soil (mg/kg)			Groundwater (µg/L)			
	Ingestion	Inhalation	Indoor Inhalation	Regulatory	Leaching Potential	Inhalation via Irrigation	Dermal	Incidental Ingestion	Indoor Inhalation
Benzene	NA	NA	0.675		1,100	> max.	NA	NA	4,000
Ethylbenzene	NA	NA	> max.		NC	> max.	NA	NA	> max.
Toluene	16,000	150	> max.		NC	> max.	NA	NA	> max.
Xylenes	NA	NA	> max.		NC	> max.	NA	NA	> max.
1,2-DCA	NA	NA	> max.		NC	> max.	NA	NA	> max.
TPH-G	NA	NA	NA	1,000	NC	NA	95	12,500	NA
TPH-D	NA	NA	NA	10,000	NC	NA	270	15,000	NA
Lead	NA	NA	NA		NC	NA	NA	NC	NA

Notes:

> max. - The risk-based concentration is greater than the maximum detected concentration in the medium.
mg/kg - Milligrams per kilogram.
µg/L - Micrograms per liter.
NA - Pathway not applicable.
NC - Not calculated.

Table 9
Physical and Chemical Parameters for COCs
Harbert Transportation/Meekland Avenue
Hayward, California

		MW	Henry's Law Constant [H] [a]	[Koc] [b]	Diffusivity [b]	Solubility [c]
Constituent	CAS #	g/mole	atm-m^3/mole	mL/g	cm^2/s	mg/L
Benzene	74-43-2	78	5.59E-03	83	0.093	1,750
Ethylbenzene	100-41-4	106	6.43E-03	1,100	0.067	152
Toluene	108-88-3	95	6.37E-03	300	0.078	535
Xylene	1330-20-7	106	7.04E-03	240	0.072	198
1,2-DCA	107-06-2	98.96	9.10E-04	65	0.09451	8,520
TPH-G						
TPH-D						
Lead [d]	7439-92-1	207.2				Insoluble

Notes:

a) Source: TNRCC, 1994.
b) Source:Heath,et al., 1993.
c) Source: ATSM, 1994.
d) Source: ATSDR, 1991.

atm-m^3/mole - Atmosphere-cubic meter per mole.
cm^2/s - Square centimeters per second.
g/mole - Grams per mole.
mg/L - Milligrams per liter.
mL/g - Milliliters per gram.

Table 10
Flux Rates and Indoor Air Concentrations from Subsurface Soil Emissions

Harbert Transportation/Meekland Avenue
Hayward, California

Constituent	Maximum Soil Concentration (C_s) mg/kg	Pore-Water Concentration (C_{sw}) µg/L	Soil-Gas Concentration (C_{sg}) µg/ft^3	Flux (J) µg/ft^2/hr	Indoor Air (C_{ia}) mg/m^3
Benzene	12	2.9E+04	6.6E+03	2.1E+02	6.7E-03
Ethylbenzene	67	1.2E+04	3.2E+03	7.2E+01	2.3E-03
Toluene	83	5.5E+04	1.4E+04	3.8E+02	1.2E-02
Xylenes	420	3.5E+05	1.0E+05	2.5E+03	8.0E-02
1,2-DCA	0.067	2.1E+02	7.7E+00	2.5E-01	8.0E-06

Notes:

mg/m^3 - Milligrams per cubic meter.

µg/ft^3 - Micrograms per cubic foot.

µg/ft^2/hr - Micrograms per square foot per hour.
mg/kg - Milligrams per kilogram.
µg/L - Micrograms per liter.

Table 11
Risk through Inhalation of Indoor Volatiles Released from Subsurface Soil
Harbert Transportation/Meekland Avenue
Hayward, California

	Modeled Indoor Air Concentration Max.	Chronic Daily Chemical Intake RME	Lifetime Daily Chemical Intake RME	Inhalation RfD [a]		Inhalation Slope Factor [a]	Excess Lifetime Cancer Risk
Volatile Constituent	mg/m^3	mg/kg-day	mg/kg-day	mg/kg-day	Noncarcinogenic HQ	kg-day/mg	
Benzene	6.7E-03	1.84E-03	7.87E-04			0.029	2.3E-05
Ethylbenzene	2.3E-03	6.30E-04	2.70E-04	0.29	2.2E-03		
Toluene	1.2E-02	3.37E-03	1.44E-03	0.11	2.9E-02		
Xylene	8.0E-02	2.18E-02	9.35E-03	2	1.1E-02		
1,2-DCA	8.0E-06	2.18E-06	9.35E-07			0.091	8.5E-08
				HI =	4.3E-02	Total Risk =	2E-05

Media Intake Factor		
CDI RME	2.74E-01	m^3/kg-day
LDI RME	1.17E-01	m^3/kg-day

Notes:

a) See Table 6 for toxicity values.
HI - Hazard index.
HQ - Hazard quotient
kg-day/mg - Kilogram day per milligram.
mg/m^3 - Milligrams per cubic meters of body weight per day.
m^3/kg-day - Cubic meters per kilogram day.
mg/kg-day - Milligrams per kilogram of body weight per day.
RfD - Reference dose.
RME - Reasonable maximum exposure.

Table 12
Irrigation Times for a Standard Yard (5,000 ft^2)

Harbert Transportation/Meekland Avenue
Hayward, California

Month	Days per Month	Watering Duration [a] min/day @ 4 gpm	Water Useage [a] gal/day	Monthly Watering min/mo
January	31	13	50	388
February	28	21	84	588
March	31	50	201	1,559
April	30	91	364	2,730
May	31	139	554	4,294
June	30	169	676	5,070
July	21 [b]	176	705	3,702
August	26 [c]	164	654	4,251
September	30	117	468	3,510
October	31	63	252	1,953
November	30	26	104	780
December	31	13	50	388
Total (min/yr)				29,200
Total (hrs/yr)				487

Notes:

a) Source: EBMUD, 1994.
b) 31 days in the month minus 10 vacation days.
c) 31 days in the month minus 5 vacation days.
gal/day - Gallons per day.
min/day @ 4 gpm - Minutes per day at 4 gallons per minute.
min/mo - Minutes per month.

Table 13
Emission Rates and Estimated Ambient Air Concentrations while Using a Hose at 4 gpm
Harbert Transportation/Meekland Avenue
Hayward, California

Constituent	Maximum Water Concen. mg/L	Emission Rate g/min	Emission Rate mg/sec	Ambient Air Conc. mg/m^3
Benzene	9.6	1.5E-07	2.4E-06	2.4E-08
Ethylbenzene	1.3	2.0E-08	3.3E-07	3.3E-09
Toluene	4.9	7.4E-08	1.2E-06	1.2E-08
Xylene	6.1	9.2E-08	1.5E-06	1.6E-08
1,2-DCA	0.125	1.9E-09	3.2E-08	3.2E-10

Notes:

g/min - Grams per minute.
mg/L - Milligrams per liter.
mg/m^3 - Milligrams per cubic meter.
mg/sec - Milligrams per second.

Table 14
Risk Through Inhalation of Volatiles Released During Irrigation

Harbert Transportation/Meekland Avenue
Hayward, California

	Estimated On-site Ambient Air Concentration Max.	Chronic Daily Chemical Intake RME	Lifetime Daily Chemical Intake RME	Inhalation RfD [a]	Noncarcinogenic	Inhalation Slope Factor [a]	Excess Lifetime Cancer
Volatile Constituent	mg/m^3	mg/kg-d	mg/kg-d	mg/kg-d	HQ	kg-day/mg	Risk
Benzene	2.4E-08	3.73E-10	1.60E-10			0.029	4.6E-12
Ethylbenzene	3.3E-09	5.05E-11	2.16E-11	0.29	1.7E-10		
Toluene	1.2E-08	1.90E-10	8.15E-11	0.11	1.7E-09		
Xylene	1.6E-08	2.37E-10	1.01E-10	2	1.2E-10		
1,2-DCA	3.2E-10	4.85E-12	2.08E-12			0.091	1.9E-13
				HI =	2.0E-09	Total Risk =	5E-12

Media Intake Factor	
CDI RME	1.52E-02 m^3/kg-day
LDI RME	6.53E-03 m^3/kg-day

Notes:

a) See Table 6 for source of toxicity values.
HI - Hazard index.
HQ - Hazard quotient.
kg-day/mg - Kilogram day per milligram.
mg/kg-d - Milligrams per kilogram of body weight per day.
mg/m^3 - milligrams per cubic meter.
m^3/kg-day - Cubic meters per kilogram per day.
RfD - Reference dose.
RME - Reasonable maximum exposure.

Table 15
Childhood Dermal Absorption from Groundwater While Playing
Harbert Transportation/Meekland Avenue
Hayward, California

Constituent	Max. Groundwater Concentration µg/L	Kp[a] cm/hr	Chronic Daily Chemical Absorption mg/kg-day	Lifetime Daily Chemical Absorption mg/kg-day	Oral RfD mg/kg-day	Noncarcinogenic HQ	Oral Slope Factor kg-day/mg	Excess Lifetime Cancer Risk
TPH-G	46,000	1	3.4E+00	2.9E-01	0.2	17	0.0017	5.0E-04
TPH-D	19,000	0.4	5.7E-01	4.9E-02	0.008	71	0.0017	8.3E-05
					HI =	88	Total Risk =	6E-04

Media Absorption Factor		
CDA	7.45E+01	cm^2-hr/kg-day
LDA	6.39E+00	cm^2-hr/kg-day

Notes:

a) Source: EPA, 1992a.

cm^2-hr/kg-day - Square centimeter hour per kilogram per day.
cm/hr - Centimeters per hour.
HI - Hazard index.
HQ - Hazard quotient.
kg-day/mg - Kilogram day per milligram.
mg/kg-day - Milligrams per kilogram of body weight per day.
RfD - Reference dose.
µg/L - Micrograms per liter.

Table 16
Childhood Risk through Incidental Ingestion of Groundwater While Playing

Harbert Transportation/Meekland Avenue
Hayward, California

Constituent	Max. Concentration	Chronic Daily Chemical Intake RME	Lifetime Daily Chemical Intake RME	Oral RfD [a]	Noncarcinogenic HQ	Oral Slope Factor [a]	Excess Lifetime Cancer Risk
	mg/L	mg/kg-d	mg/kg-d	mg/kg-d		kg-day/mg	
TPH-G	4.6E+01	2.52E-02	2.16E-03	0.2	1.3E-01	0.0017	3.7E-06
TPH-D	1.9E+01	1.04E-02	8.92E-04	0.008	1.3E+00		
Lead	4.0E-02	2.19E-05	1.88E-06				
				HI =	**1.4E+00**	**Total Risk =**	**4E-06**

Child Media Intake Factor	
CDI RME	5.48E-04 L/kg-day
LDI RME	4.70E-05 L/kg-day

Notes:

a) See Table 6 for source of toxicity values.
HI - Hazard index.
HQ - Hazard quotient.
L/kg-day - Liters per kilogram day.
kg/day/mg - Kilograms of body weight per day per milligram.
mg/kg-d - Milligrams per kilograms of body weight per day.
mg/L - Milligrams per liter.
RfD - Reference dose.
RME - Reasonable maximum exposure.

Table 17

Flux Rates and Indoor Air Concentrations from Groundwater Emissions

Harbert Transportation/Meekland Avenue
Hayward, California

	Maximum Groundwater Concentration	Soil-Gas Concentration (C_{sg})	Flux (J)	Indoor Air (C_{ia})
Constituent	µg/L	µg/ft^3	µg/ft^2-hr	mg/m^3
Benzene	9,600	2.2E+03	2.8E+01	9.0E-04
Ethylbenzene	1,300	3.4E+02	3.1E+00	1.0E-04
Toluene	4,900	1.3E+03	1.3E+01	4.4E-04
Xylene	6,100	1.8E+03	1.7E+01	5.6E-04
1,2-DCA	125	4.7E+00	5.9E-02	1.9E-06

Notes:

mg/m^3 - Milligrams per cubic meter.

µg/ft^2/hr - Micrograms per square foot-hour.

µg/ft^3 - Micrograms per cubic foot.
µg/L - Micrograms per liter.

Table 18
Risk through Inhalation of Indoor Volatiles Released from Groundwater
Harbert Transportation/Meekland Avenue
Hayward, California

Volatile Constituent	Modeled Indoor Air Concentration mg/m^3	Chronic Daily Chemical Intake RME mg/kg-d	Lifetime Daily Chemical Intake RME mg/kg-d	Inhalation RfD mg/kg-d	Noncarcinogenic HQ	Inhalation Slope Factor kg-day/mg	Excess Lifetime Cancer Risk
Benzene	9.0E-04	2.45E-04	1.05E-04			0.029	3.1E-06
Ethylbenzene	1.0E-04	2.77E-05	1.19E-05	0.29	9.5E-05		
Toluene	4.4E-04	1.20E-04	5.13E-05	0.11	1.0E-03		
Xylene	5.6E-04	1.52E-04	6.52E-05	2	7.6E-05		
1,2-DCA	1.9E-06	5.29E-07	2.27E-07			0.091	2.1E-08
				HI =	1.2E-03	Total Risk =	3E-06

Media Intake Factor		
CDI RME	2.74E-01	m^3/kg-day
LDI RME	1.17E-01	m^3/kg-day

Notes:

HI - Hazard index.
HQ - Hazard quotient.
kg-day/mg - Kilogram day per milligram.
mg/m^3 - Milligrams per cubic meter.
mg/kg-d - Milligrams per kilogram of body weight per day.
m^3/kg-day - Cubic meters per kilogram day.
RfD - Reference dose.
RME - Reasonable maximum exposure.

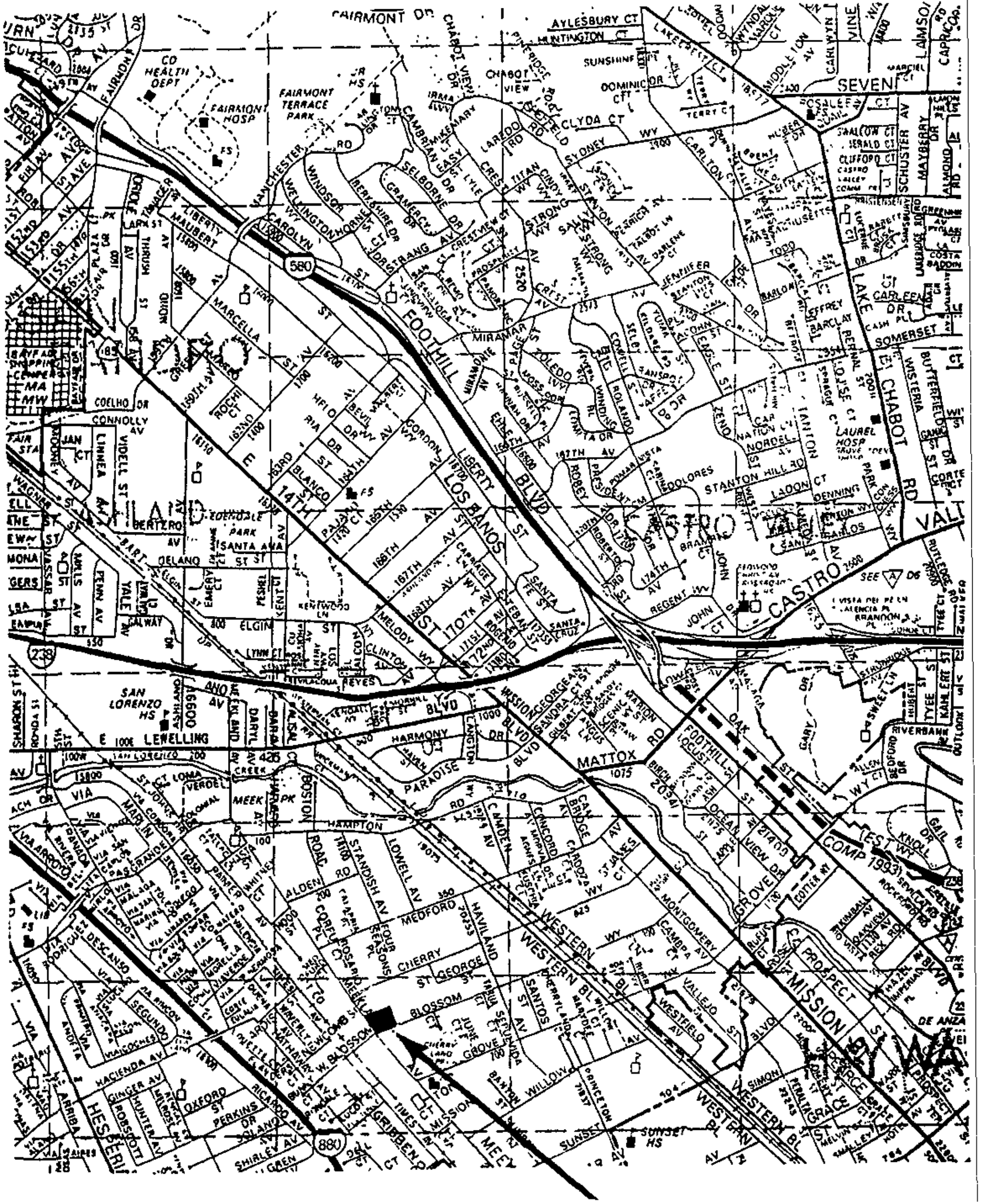
Table 19
Potential Risk-Based Cleanup Levels
Harbert Transportation/Meekland Avenue
Hayward, California

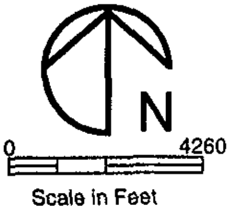
Constituent	Surface Soil mg/kg	Subsurface Soil mg/kg	Groundwater mg/L	Comments
Benzene	NC	0.675	4	
Ethylbenzene		NC	NC	
Toluene		NC	NC	
Xylenes		NC	NC	
1,2-Dichloroethane		NC	NC	
TPH-G		1,000	12.5	The most stringent concentration was not selected for groundwater because derivation using the dermal exposure pathway is too uncertain.
TPH-D		1,000	15	The cleanup level selected for soil is that for TPH-G since the product identified as TPH-D is actually weathered gasoline. The most stringent concentration was not selected for groundwater because derivation using the dermal exposure pathway is too uncertain.
Lead		N/A	N/A	

Notes:

mg/kg - Milligrams per kilogram.
mg/L - Milligrams per liter.
N/A - No concentration was available.
NC - No concentration selected. Maximum concentration detected was below risk-based concentration.
TPH-G - Total petroleum hydrocarbons quantified as gasoline.
TPH-D - Total petroleum hydrocarbons quantified as diesel.

FIGURES





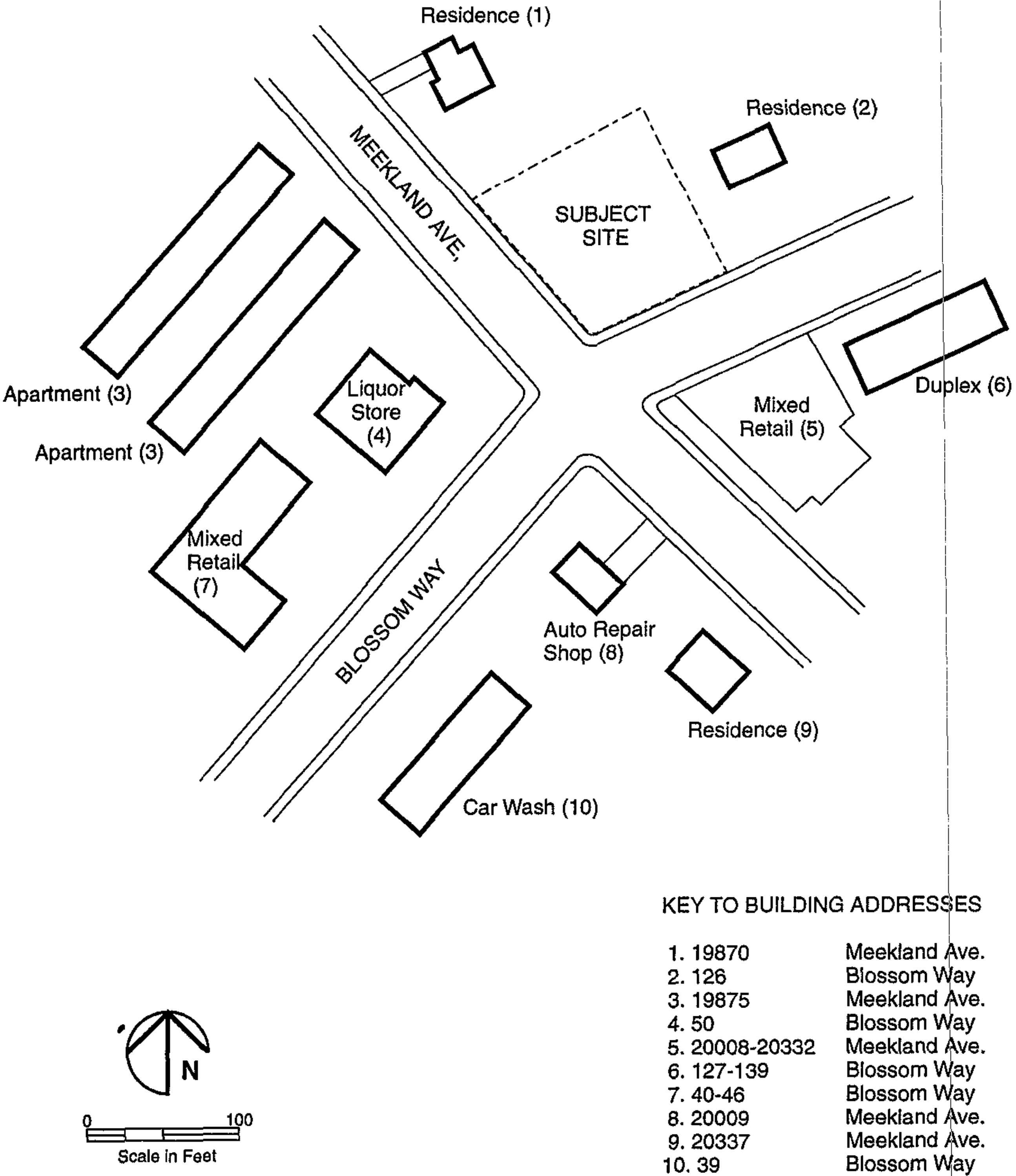
AGI
TECHNOLOGIES

Vicinity Map

Harbert Transportation/Meekland Avenue
Hayward, California

FIGURE
1

PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
15,833.001	DFF	15 Aug 94		DFF	7 Jul 95



KEY TO BUILDING ADDRESSES

1. 19870	Meekland Ave.
2. 126	Blossom Way
3. 19875	Meekland Ave.
4. 50	Blossom Way
5. 20008-20332	Meekland Ave.
6. 127-139	Blossom Way
7. 40-46	Blossom Way
8. 20009	Meekland Ave.
9. 20337	Meekland Ave.
10. 39	Blossom Way

Reference: Map from CTTS, Inc., Toxic Technology Services, Rodeo, Calif.

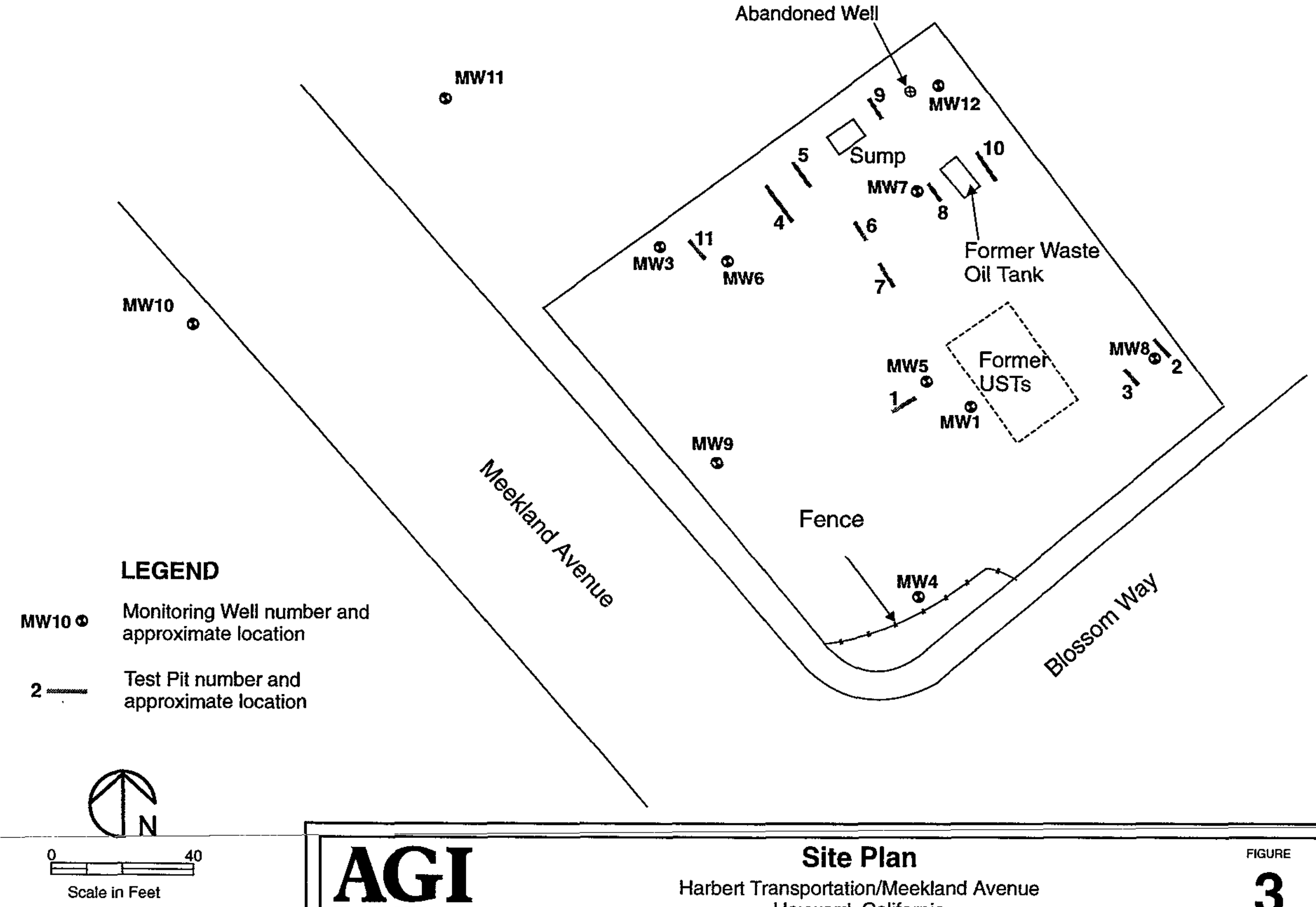
AGI TECHNOLOGIES

Area Plan Map

Harbert Transportation/Meekland Avenue
Hayward, California

FIGURE 2

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
vicinity.cdr	15,833.001	DFF	7 Jul 95	DTH	DFF	16 Aug 95



AGI TECHNOLOGIES

Site Plan

Harbert Transportation/Meekland Avenue
Hayward, California

FIGURE
3

	PROJECT NO.	DRAWN	DATE	APPROVED	REVISED	DATE
siteplan.cdr	15,833.001	DFF	29 August 94	DTH	DFF	16 Aug 95

APPENDIX A

APPENDIX A

Example Calculations

Appendix A
Table A-1
Example Calculation:
Screening Level Equation for Ingestion of Noncarcinogenic Contaminants in Residential Soil [a]

$$\text{Screening Level (mg/kg)} = \frac{\text{THQ x BW x AT x 365 d/yr}}{1/\text{RfD}_o \text{ x } 10^{-6} \text{ kg/mg x EF x ED x IR}}$$

Where:

THQ = Target hazard quotient (1 unitless)
BW = Body weight (70 kg)
AT = Averaging time (6 yrs *)
RfD_o = Oral reference dose (toluene - 0.2 mg/kg-d)
EF = Exposure frequency (350 d/yr)
ED = Exposure duration (6 yr)
IR = Soil ingestion rate (200 mg/d)

* For noncarcinogens, AT is equal to ED

$$\text{Screening Level (mg/kg)} = \frac{\text{1 x 15 kg x 6 yrs x 365 d/yr}}{1/0.2 \text{ x } 10^{-6} \text{ mg/kg x 350 d/yr x 6 yr x 200 mg/d}}$$

Screening Level (mg/kg) = 15,642.9 mg/kg or 16,000 mg/kg

---

a From: EPA, 1994.

Toluene

Appendix A
Table A-2
Example Calculation:
Screening Level Equation for Inhalation of Noncarcinogenic Contaminants in Residential Soil [a]

Screening Level (mg/kg) =

$$\frac{THQ \times BW \times AT \times 365\ d/yr}{EF \times ED \times [1/RfC \times (1/VF + 1/PEF)]}$$

Where:

THQ = Target hazard quotient (1 unitless)
BW = Body weight (70 kg)
AT = Averaging time (30 yrs *)
RfC = Inhalation reference concentration (toluene - 0.4 mg/m^3)
EF = Exposure frequency (350 d/yr)
ED = Exposure duration (30 yr)
PEF = Particulate emission factor (4.51×10^9 m^3/kg)
VF = Soil to air volatilization factor (chemical specific m^3/kg)

* For noncarcinogens, AT is equal to ED

Soil to Air Volatilization Factor

$$VF = (Q/C) \times \frac{(3.14 \times \alpha \times T)^{1/2}}{(2 \times D_{ei} \times P_a \times K_{as})} \times 10\text{-}4\ m^2/cm^2$$

$$\alpha = \frac{D_{ei} \times P_a}{P_a + (\rho_s)(1-P_a)/K_{as}}$$

Where:

Q/C = Inverse of the mean concentration at the center of a 0.5 acre square source (101.8 g/m^2-s per kg/m^3)
T = Exposure interval (7.9 x 108 s)
D_{ei} = Effective diffusivity ($D_i(P_a^{3.33}/P_t^2$ cm^2/s)
P_a = Air filled soil porosity (P_t-$\Theta\beta$ unitless)
P_t = Total soil porosity (1 - (β/ρ_s)
Θ = Soil moisture content (0.1 cm^3-water/g-soil)
β = Soil bulk density (1.5 g/cm^3)
ρ_s = True soil density (2.65 g/cm^3)
K_{as} = Soil-air partition coefficient (chemical specific - H/K_d x 41 g-soil/cm^3-air)
D_i = Diffusivity in air (chemical specific cm^2/s)
H = Henrly's law constant (chemical specific atm-m^3/mol)
K_d = Soil-water partition coefficient (K_{oc} x OC cm^3/g)
K_{oc} = Organic carbon partition coefficient (chemical specific cm^3/g)
OC = Organic carbon content of soil (0.02 unitless)

default
vs 68.81

Particulate Emission Factor ?

$$PEF = (Q/C) \times \frac{3{,}600 \text{ s/h}}{0.036 \times (1-G) \times (U_m/U_t)^3 \times F(x)}$$

Where:

Q/C = Inverse of the mean concentration at the center of a 0.5 acre square source (101.8 g/m^2-s per kg/m^3)
0.036 = Respirable fraction (unitless)
G = Fraction of vegetative cover (0 unitless)
U_m = Mean annual wind speed (4.5 m/s)
U_t = Equivalent threshold value of wind speed at 10 m (12.8 m/s)
$F(x)$ = Function dependent on U_m/U_t derived using Coward (EPA, 1985) (0.0497 unitless)

Soil Saturation Limit

$$C_{sat} = \frac{(K_d \times C_w \times \beta) + (C_w \times P_w) + (C_w \times H' \times P_a)}{\beta}$$

Where:

K_d = Soil-water partition coefficient (K_{oc} x OC cm^3/g)
K_{oc} = Organic carbon partition coefficient (chemical specific cm^3/g)
OC = Organic carbon content of soil (0.02 unitless)
C_w = Upper limit of free moisture in soil ($S \times \Theta_m$ mg/L-water)
S = Solubility (chemical specific mg/L-water)
Θ_m = Soil moisture content (0.1 kg-water/kg-soil)
β = Soil bulk density (1.5 g/cm^3)
P_a = Air filled soil porosity (P_t-$\Theta\beta$ unitless)
P_w = Water-fille soil porosity (P_t - P_a unitless)
P_t = Total soil porosity ($1 - (\beta/\rho_s)$
H' = Henry's law constant (chemical specific - H x 41 unitless)
H = Henrly's law constant (chemical specific atm-m^3/mol)
Θ = Soil moisture content (0.1 L-water/kg-soil)
ρ_s = True soil density (2.65 kg/L)

a. From: EPA, 1994.

Appendix A
Table A-3
Example Calculation:
Risk-Based Concentration Equation for Inhalation of Benzene from Subsurface Soil [a]

Screening Level (mg/kg) =

$$\frac{\mathrm{TR \times BW \times AT \times 365\ d/yr}}{\mathrm{EF \times ED \times SF_i \times IR}}$$

Where:

TR = Target risk (10^{-6} unitless)
BW = Body weight (70 kg)
AT = Averaging time (70 yrs)
EF = Exposure frequency (350 d/yr)
ED = Exposure duration (30 yr)
SF_i = Inhalation cancer slope factor ((0.029 mg/kg-day)$^{-1}$)
IR = Inhalation rate (20 m^3/day)

Risk-based Concentration (mg/m^3) =

$$\frac{10^{-6} \times 70\ \mathrm{kg} \times 70\ \cancel{\mathrm{yrs}} \times 365\ \cancel{\mathrm{d/yr}}}{350\ \cancel{\mathrm{d/yr}} \times 30\ \cancel{\mathrm{yr}} \times 0.029 \times 20\ \mathrm{m^3/day}}$$

Risk-based Concentration (mg/m^3) = 0.00029

---

a From: EPA, 1991b.

Appendix A
Table A-4
Example Calculation:
Risk-Based Concentration Equation for Dermal Absorption of Noncarcinogenic Constituents from Groundwater

$$\text{Risk-Based Concentration (mg/L)} = \frac{THQ \times BW \times AT \times 365\ \text{d/yr}}{SA \times K_p \times EF \times ED \times ET \times 1/RfD \times 1\text{L}/1000\ \text{cm}^3}$$

Where:

THQ = Target hazard quotient (1unitless)
BW = Body weight (15 kg)
AT = Averaging time (6 yrs) *
SA = Surface area (6800 cm^2)
K_p = Permeability Coefficient (chemical specific, 0.4 cm/hr for TPHd)
EF = Exposure frequency (60 d/yr)
ED = Exposure duration (6 yr)
ET = Exposure time (1 hr/d)
RfD = Oral reference dose (chemical specific, 0.008 mg/kg-day for TPHd)

* For noncarcinogens, AT is equal to ED

$$\text{Risk-based Concentration (mg/L)} = \frac{1 \times 15\ \text{kg} \times 6\ \text{yrs} \times 365\ \text{d/yr}}{6800\ \text{cm}^2 \times 0.4\ \text{cm/hr} \times 60\ \text{d/yr} \times 6\ \text{yr} \times 1\ \text{hr/d} \times 1/0.008\ \text{mg/kg-d} \times 1\text{L}/1000\ \text{cm}^3}$$

Risk-based Concentration (mg/L) = 0.27 for TPHd

Appendix A
Table A-5
Example Calculation:
Risk-Based Concentration Equation for Dermal Absorption of Carcinogenic Constituents from Groundwater

$$\text{Risk-Based Concentration (mg/L)} = \frac{TR \times BW \times AT \times 365\ d/yr}{SA \times K_p \times EF \times ED \times ET \times SF_o \times 1L/1000\ cm^3}$$

Where:

TR = Target risk (10^{-6} unitless)
BW = Body weight (15 kg)
AT = Averaging time (70 yrs)
SA = Surface area (6800 cm^2)
K_p = Permeability Coefficient (chemical specific, 1 cm/hr for TPHg)
EF = Exposure frequency (60 d/yr)
ED = Exposure duration (6 yr)
ET = Exposure time (1 hr/d)
SF_o = Oral cancer slope factor (chemical specific, 0.0017 $mg/kg\text{-}day^{-1}$ for TPHg)

$$\text{Risk-based Concentration (mg/L)} = \frac{10^{-6} \times 15\ kg \times 70\ yrs \times 365\ d/yr}{6800\ cm^2 \times 1\ cm/hr \times 60\ d/yr \times 6\ yr \times 1\ hr/d \times 0.0017\ mg/kg\text{-}d^{-1} \times 1L/1000\ cm^3}$$

Risk-based Concentration (mg/L) = 0.095 for TPHg

Appendix A
Table A-6
Example Calculation:
Risk-Based Concentration Equation for Ingestion of Noncarcinogenic Constituents from Groundwater During Wading

Risk-Based Concentration (mg/L) =

$$\frac{\text{THQ x BW x AT x 365 d/yr}}{\text{EF x ED x 1/RfD x IR}}$$

Where:

THQ = Target hazard quotient (1unitless)
BW = Body weight (15 kg)
AT = Averaging time (6 yrs) *
EF = Exposure frequency (60 d/yr)
ED = Exposure duration (6 yr)
RfD = Oral reference dose (chemical specific, 0.008 mg/kg-day for TPHd)
IR = Ingestion rate (0.05 L/d)

* For noncarcinogens, AT is equal to ED

Risk-based Concentration (mg/L) =

$$\frac{\text{1 x 15 kg x 6 yrs x 365 d/yr}}{\text{60 d/yr x 6 yr x 1/0.008 mg/kg-d x 0.05 L/d}}$$

Risk-based Concentration (mg/L) = 14.6 (rounded to 15) for TPHd

Appendix A
Table A-7
Example Calculation:
Risk-Based Concentration Equation for Ingestion of Carcinogenic Constituents from Groundwater During Wading

$$\text{Risk-Based Concentration (mg/L)} = \frac{TR \times BW \times AT \times 365\ d/yr}{EF \times ED \times ET \times SF_o \times IR}$$

Where:

TR = Target risk (10^{-6} unitless)
BW = Body weight (15 kg)
AT = Averaging time (70 yrs)
EF = Exposure frequency (60 d/yr)
ED = Exposure duration (6 yr)
SF_o = Oral cancer slope factor (chemical specific, 0.0017 mg/kg-day^{-1} for TPHg)
IR = Ingestion rate (0.05 L/d)

$$\text{Risk-based Concentration (mg/L)} = \frac{10^{-6} \times 15\ kg \times 70\ yrs \times 365\ d/yr}{60\ d/yr \times 6\ yr \times 0.0017\ mg/kg\text{-}d^{-1} \times 0.05\ L/d}$$

Risk-based Concentration (mg/L) = 12.5 for TPHg

Appendix A
Table A-1
Example Calculation:
Screening Level Equation for Ingestion of Noncarcinogenic Contaminants in Residential Soil [a]

$$Conc = BW \times AT \times$$

Screening Level (mg/kg) = $\dfrac{THQ \times BW \times AT \times 365\ d/yr}{1/RfD_o \times 10^{-6}\ kg/mg \times EF \times ED \times IR}$

Where:

THQ = Target hazard quotient (1 unitless)
BW = Body weight (70 kg)
AT = Averaging time (6 yrs *)
RfD_o = Oral reference dose (toluene - 0.2 mg/kg-d)
EF = Exposure frequency (350 d/yr)
ED = Exposure duration (6 yr)
IR = Soil ingestion rate (200 mg/d)

* For noncarcinogens, AT is equal to ED

Screening Level (mg/kg) = $\dfrac{1 \times 15\ kg \times 6\ yrs \times 365\ d/yr}{1/0.2 \times 10^{-6}\ mg/kg \times 350\ d/yr \times 6\ yr \times 200\ mg/d}$

Screening Level (mg/kg) = 15,642.9 mg/kg or 16,000 mg/kg

a From: EPA, 1994.

$$Conc. \times Uptake \times Toxicity = Risk$$

$$Conc = \frac{Risk}{Uptake \times Toxicity}$$

$$= \frac{10^{-6} \times BW \times AT}{IR \times EF \times ED \times THQ}$$

Toxicity =

Appendix A
Table A-2
Example Calculation:
Screening Level Equation for Inhalation of Noncarcinogenic Contaminants in Residential Soil [a]

Screening Level (mg/kg) =

$$\frac{THQ \times BW \times AT \times 365\ d/yr}{EF \times ED \times [1/RfC \times (1/VF + 1/PEF)]}$$

Where:

THQ = Target hazard quotient (1 unitless)
BW = Body weight (70 kg)
AT = Averaging time (30 yrs *)
RfC = Inhalation reference concentration (toluene - 0.4 mg/m^3)
EF = Exposure frequency (350 d/yr)
ED = Exposure duration (30 yr)
PEF = Particulate emission factor (4.51×10^9 m^3/kg)
VF = *Soil to air volatilization factor (chemical specific m^3/kg)*

* For noncarcinogens, AT is equal to ED

Soil to Air Volatilization Factor

$$VF = (Q/C) \times \frac{(3.14 \times \alpha \times T)^{1/2}}{(2 \times D_{ei} \times P_a \times K_{as})} \times 10\text{-}4\ m^2/cm^2$$

$$\alpha = \frac{D_{ei} \times P_a}{P_a + (\rho_s)(1-P_a)/K_{as}}$$

Where:

Q/C = Inverse of the mean concentration at the center of a 0.5 acre square source (101.8 g/m^2-s per kg/m^3)
T = Exposure interval (7.9 x 108 s)
D_{ei} = Effective diffusivity ($D_i(P_a^{3.33}/P_t^2$ cm^2/s)
P_a = Air filled soil porosity ($P_t - \Theta\beta$ unitless)
P_t = Total soil porosity ($1 - (\beta/\rho_s)$)
Θ = Soil moisture content (0.1 cm^3-water/g-soil)
β = Soil bulk density (1.5 g/cm^3)
ρ_s = True soil density (2.65 g/cm^3)
K_{as} = Soil-air partition coefficient (chemical specific - $H/K_d \times 41$ g-soil/cm^3-air)
D_i = Diffusivity in air (chemical specific cm^2/s)
H = Henrly's law constant (chemical specific atm-m^3/mol)
K_d = Soil-water partition coefficient (K_{oc} x OC cm^3/g)
K_{oc} = Organic carbon partition coefficient (chemical specific cm^3/g)
OC = Organic carbon content of soil (0.02 unitless)

Particulate Emission Factor

$$PEF = (Q/C) \times \frac{3{,}600 \text{ s/h}}{0.036 \times (1\text{-}G) \times (U_m/U_t)^3 \times F(x)}$$

Where:

Q/C = Inverse of the mean concentration at the center of a 0.5 acre square source (101.8 g/m^2-s per kg/m^3)
0.036 = Respirable fraction (unitless)
G = Fraction of vegetative cover (0 unitless)
U_m = Mean annual wind speed (4.5 m/s)
U_t = Equivalent threshold value of wind speed at 10 m (12.8 m/s)
$F(x)$ = Function dependent on U_m/U_t derived using Coward (EPA, 1985) (0.0497 unitless)

Soil Saturation Limit

$$C_{sat} = \frac{(K_d \times C_w \times \beta) + (C_w \times P_w) + (C_w \times H' \times P_a)}{\beta}$$

Where:

K_d = Soil-water partition coefficient (K_{oc} x OC cm^3/g)
K_{oc} = Organic carbon partition coefficient (chemical specific cm^3/g)
OC = Organic carbon content of soil (0.02 unitless)
C_w = Upper limit of free moisture in soil ($S \times \Theta_m$ mg/L-water)
S = Solubility (chemical specific mg/L-water)
Θ_m = Soil moisture content (0.1 kg-water/kg-soil)
β = Soil bulk density (1.5 g/cm^3)
P_a = Air filled soil porosity (P_t-$\Theta\beta$ unitless)
P_w = Water-fille soil porosity ($P_t - P_a$ unitless)
P_t = Total soil porosity ($1 - (\beta/\rho_s)$)
H' = Henry's law constant (chemical specific - H x 41 unitless)
H = Henrly's law constant (chemical specific atm-m^3/mol)
Θ = Soil moisture content (0.1 L-water/kg-soil)
ρ_s = True soil density (2.65 kg/L)

a. From: EPA, 1994.

Appendix A
Table A-3
Example Calculation:
Risk-Based Concentration Equation for Inhalation of Benzene from Subsurface Soil [a]

Screening Level (mg/kg) = $$\frac{TR \times BW \times AT \times 365\ \mathrm{d/yr}}{EF \times ED \times SF_i \times IR}$$

Where:

TR = Target risk (10^{-6} unitless)
BW = Body weight (70 kg)
AT = Averaging time (70 yrs)
EF = Exposure frequency (350 d/yr)
ED = Exposure duration (30 yr)
SF_i = Inhalation cancer slope factor ((0.029 mg/kg-day)$^{-1}$)
IR = Inhalation rate (20 m^3/day)

Risk-based Concentration (mg/m^3) = $$\frac{10^{-6} \times 70\ \mathrm{kg} \times 70\ \mathrm{yrs} \times 365\ \mathrm{d/yr}}{350\ \mathrm{d/yr} \times 30\ \mathrm{yr} \times 0.029 \times 20\ \mathrm{m^3/day}}$$

Risk-based Concentration (mg/m^3) = 0.00029

a From: EPA, 1991b.

Appendix A
Table A-4
Example Calculation:
Risk-Based Concentration Equation for Dermal Absorption of Noncarcinogenic Constituents from Groundwater

$$\text{Risk-Based Concentration (mg/L)} = \frac{\text{THQ x BW x AT x 365 d/yr}}{\text{SA x } K_p \text{ x EF x ED x ET x 1/RfD x 1L/1000 } cm^3}$$

Where:

THQ = Target hazard quotient (1unitless)
BW = Body weight (15 kg)
AT = Averaging time (6 yrs) *
SA = Surface area (6800 cm^2)
K_p = Permeability Coefficient (chemical specific, 0.4 cm/hr for TPHd)
EF = Exposure frequency (60 d/yr)
ED = Exposure duration (6 yr)
ET = Exposure time (1 hr/d)
RfD = Oral reference dose (chemical specific, 0.008 mg/kg-day for TPHd)

* For noncarcinogens, AT is equal to ED

$$\text{Risk-based Concentration (mg/L)} = \frac{\text{1 x 15 kg x 6 yrs x 365 d/yr}}{6800\ cm^2 \text{ x 0.4 cm/hr x 60 d/yr x 6 yr x 1 hr/d x 1/0.008 mg/kg-d x 1L/1000 } cm^3}$$

Risk-based Concentration (mg/L) = 0.27 for TPHd

Appendix A
Table A-5
Example Calculation:
Risk-Based Concentration Equation for Dermal Absorption of Carcinogenic Constituents from Groundwater

Risk-Based Concentration (mg/L) $= \dfrac{TR \times BW \times AT \times 365\ d/yr}{SA \times K_p \times EF \times ED \times ET \times SF_o \times 1L/1000\ cm^3}$

Where:

TR = Target risk (10^{-6} unitless)
BW = Body weight (15 kg)
AT = Averaging time (70 yrs)
SA = Surface area (6800 cm^2)
K_p = Permeability Coefficient (chemical specific, 1 cm/hr for TPHg)
EF = Exposure frequency (60 d/yr)
ED = Exposure duration (6 yr)
ET = Exposure time (1 hr/d)
SF_o = Oral cancer slope factor (chemical specific, 0.0017 mg/kg-day^{-1} for TPHg)

Risk-based Concentration (mg/L) $= \dfrac{10^{-6} \times 15\ kg \times 70\ yrs \times 365\ d/yr}{6800\ cm^2 \times 1\ cm/hr \times 60\ d/yr \times 6\ yr \times 1\ hr/d \times 0.0017\ mg/kg\text{-}d^{-1} \times 1L/1000\ cm^3}$

Risk-based Concentration (mg/L) = 0.095 for TPHg

Appendix A
Table A-6
Example Calculation:
Risk-Based Concentration Equation for Ingestion of Noncarcinogenic Constituents from Groundwater During Wading

Risk-Based Concentration (mg/L) =

$$\frac{\text{THQ x BW x AT x 365 d/yr}}{\text{EF x ED x 1/RfD x IR}}$$

Where:

THQ = Target hazard quotient (1unitless)
BW = Body weight (15 kg)
AT = Averaging time (6 yrs) *
EF = Exposure frequency (60 d/yr)
ED = Exposure duration (6 yr)
RfD = Oral reference dose (chemical specific, 0.008 mg/kg-day for TPHd)
IR = *Ingestion rate* (0.05 L/d)

* For noncarcinogens, AT is equal to ED

Risk-based Concentration (mg/L) =

$$\frac{\text{1 x 15 kg x 6 yrs x 365 d/yr}}{\text{60 d/yr x 6 yr x 1/0.008 mg/kg-d x 0.05 L/d}}$$

Risk-based Concentration (mg/L) = 14.6 (rounded to 15) for TPHd

Appendix A
Table A-7
Example Calculation:
Risk-Based Concentration Equation for Ingestion of Carcinogenic Constituents from Groundwater During Wading

Risk-Based Concentration (mg/L) =

$$\frac{TR \times BW \times AT \times 365\ d/yr}{EF \times ED \times ET \times SF_o \times IR}$$

Where:

TR = Target risk (10^{-6} unitless)
BW = Body weight (15 kg)
AT = Averaging time (70 yrs)
EF = Exposure frequency (60 d/yr)
ED = Exposure duration (6 yr)
SF_o = Oral cancer slope factor (chemical specific, 0.0017 mg/kg-day^{-1} for TPHg)
IR = Ingestion rate (0.05 L/d)

Risk-based Concentration (mg/L) =

$$\frac{10^{-6} \times 15\ kg \times 70\ yrs \times 365\ d/yr}{60\ d/yr \times 6\ yr \times 0.0017\ mg/kg\text{-}d^{-1} \times 0.05\ L/d}$$

Risk-based Concentration (mg/L) = 12.5 for TPHg