2/3/97

FLUOR DANIEL GTI

**RISK-BASED CORRECTIVE ACTION**
**OF SOIL AND GROUNDWATER**
**GENERAL MOTORS CORPORATION**
**WHITE TRUCK CENTER**
**8099 COLISEUM WAY**
**OAKLAND, CA**

1/9/97 # 547

Fluor Daniel GTI Project 052600487

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## 1.0 INTRODUCTION

Fluor Daniel GTI, Inc. (Fluor Daniel GTI) was contracted by the General Motors Corporation (GMC) to conduct a risk assessment for the Coliseum GMC Truck Center located at 8099 Coliseum Way, Oakland, California. The purpose of the risk assessment is to determine whether the chemical levels detected at the site will pose unacceptable health risks to human and environmental receptors. If the results of the assessment indicate that the chemical concentrations are within acceptable levels of risk, then the site will be proposed for no further action and eventual closure.

The site evaluation and assessment will follow the approach recommended by the American Society for Testing and Materials (ASTM) in the Standard Guide for Risk-Based Corrective Action (RBCA) Applied at Petroleum Release Sites E 173-95 (ASTM, 1995). Although the ASTM's RBCA methodology has not been officially adopted in California, this risk-based decision process has been applied successfully at a number of sites.

RBCA is a three-tiered approach in evaluating a site so that the appropriate risk management decision can be implemented. Each tier increases in complexity and site-specificity. Tier 1 compares maximum detected chemical concentrations to risk-based screening levels (RBSLs). These RBSLs are calculated through equations that typically use conservative default assumptions. The premise is that if the maximum chemical concentrations at a site do not exceed the acceptable levels under the most conservative exposure assumptions, then the site does not pose a potential risk to human receptors. Tier 2 calculates site-specific target levels (SSTLs) by incorporating site-specific parameters into the same equations used to calculate the Tier I RBSLs. The Tier 2 assessment allows the flexibility of using specific geological, physical, and environmental characteristics of the site in determining chemical exposures and consequential health risks. Tier 3 applies a significantly higher level of detail and complexity in the calculation of SSTLs. Tier 3 includes a detailed site assessment, a probabilistic evaluation of chemical concentrations and chemical exposures, and a sophisticated fate and transport modeling effort.

The overall framework of the ASTM RBCA consists of the following steps:

1. Initial Site Assessment
2. Site Classification and Initial Response Action
3. Comparison of Site Conditions with RBSLs
4. Evaluation of Tier 1 Results
5. Tier 2 Evaluation - SSTLs and/or Selection of more appropriate exposure points
6. Evaluation of Tier 2 Results
7. Tier 3 Evaluation

8. Evaluation of Tier 3 Results
9. Implementation of Selected Corrective Action Program
10. Compliance Monitoring and Site Maintenance

The results of steps 1 through 4 will determine whether steps 5 through 10 will be required.

## 2.0 STEP 1: INITIAL SITE ASSESSMENT

An overview of current site conditions and a summary of previous environmental investigations conducted at the site are presented in the following documents:

- *Phase I, Level II Environmental Site Assessment,* DRAFT, Clayton Environmental Consultants. August 9, 1993 (CECI, 1993);
- *Work Plan for Further Site Assessment Report,* Groundwater Technology, Inc. January 26, 1995 (GTI, 1995a);
- *Summary of Work Completed,* Groundwater Technology, Inc. May 9, 1995 (GTI, 1995b);
- *Sampling and Analysis Report for June 26, 1995,* Groundwater Technology, Inc. DRAFT February 2, 1996 (GTI, 1996a);
- *Sampling and Analysis Report for February and March, 1996.* DRAFT. Groundwater Technology, Inc. April 12, 1996 (GTI, 1996b); and
- *Aquifer Characterization Report.* DRAFT. Groundwater Technology, Inc. May 1, 1996 (GTI, 1996c).

### 2.1 Site Location and Description

The GMC Truck Center is located on a 6.6-acre lot at 8099 South Coliseum Way, Oakland, California, as shown in the site location map (Figure 1). The subject site is surrounded by CalTrans property and Highway 880 to the south, Coliseum Way to the north, Hegenberger Road and CalTrans property to the east, and vacant land to the west (Figure 2).

This facility is comprised of one permanent structure and two trailers. The permanent structure is currently used to house the showroom, parts, sales, and service departments (Figure 2). One of the trailers was used as a sales office for used truck sales.

## 2.2 Hydrogeological Setting

The site is located approximately 1 mile east of the San Francisco Bay at an elevation of 10 feet above mean sea level. The surrounding topography slopes gently down to the northwest towards the bay.

The local geology and hydrogeology have been reported in the site assessment (CECI, 1993). In summary, the lithology is reported to consist of unconsolidated sediment, primarily clay (Bay Mud) with some interbedded sand, gravel, and fill material. The fill material primarily consists of gravelly clay and was reported just below the paved ground surface down to 2 to 15 feet below surface grade (bsg). At the location of the test well, fill was reported to 6 feet bsg which was underlain by clay to 14 feet bsg. The clay bed was underlain by gravel and sand to 18 feet, followed by clay to the bottom of the boring at 20 feet bsg. Groundwater is reported between approximately 3 and 10 feet bsg at the site. Groundwater elevations in the site monitoring wells recorded on April 3, 1996, prior to pumping, ranged from 0.10 feet to 6.04 feet above mean sea level (Table 1).

The aquifer material is comprised of a 4 foot thick sand and gravel bed located approximately 12 to 18 feet below grade surface in the area of MW-2 and PZ-1 through PZ-3. These materials are likely stream channel deposits that are discontinuous and were not found in monitoring wells MW-1 and MW-3 through MW-8. The deposits in the shallow water bearing zone in the area of wells MW-1 and MW-3 through MW-8 were reported as primarily sandy clay and gravelly clay.

Groundwater flow beneath the site is reported to the north under a gradient of approximately 0.01 feet per foot. Groundwater appears under confined conditions in the area of MW-2.

The aquifer transmissivity obtained using AQTESOLV™ was 2,385 gallons per day per foot (gpd/ft) at PZ-1, 2,934 gpd/ft at PZ-2, and 2,182 gpd/ft at PZ-3. Aquifer storativity was calculated at 0.000126, 0.000312, and 0.000062, respectively. Hydraulic conductivity values were calculated at 596 gpd/ft$^2$, 733 gpd/ft$^2$, and 545 gpd/ft$^2$, respectively (GTI, 1996c).

Electrical conductivity of the water from the monitoring wells sampled during February 1996 ranged from 640 µmhos/cm to 16,000 µmhos/cm, with an average of 5,580 µmhos/cm. Based on a conversion factor of 0.65 (Freeze & Cherry, 1979), the average total dissolved solids of these wells is 3,677 mg/L.

A drainage ditch crosses the northwestern section of the site. Flow within this ditch is intermittent, based on runoff from this site and properties to the north and east. This ditch drains to a larger ditch which flows west to San Leandro Bay which then flows to San Francisco Bay.

### 2.3 Land Use

The site is located in a commercial area, is surrounded by CalTrans property and Highway 880 to the south, Coliseum Way to the north, Hegenberger Road and CalTrans property to the east, and vacant land to the west. The closest residential areas are located approximately ½-mile away, to the north, east, and southeast. The current and future land use of the site is assumed to remain commercial.

### 2.4 Previous Investigations

In January 1993, a Phase I, Level II environmental assessment was initiated at the GMC Truck Center. The purpose of that assessment was to determine whether soil and groundwater contamination was present at the subject property. During this assessment, five soil borings (BH-1 through BH-5) were drilled at the site: four adjacent to existing CalTrans underground storage tanks (USTs) and one in the west corner of the site. The Phase I, Level II assessment was documented in a report dated August 6, 1993, by Clayton Environmental Consultants (CECI, 1993). The results of that report concluded that hydrocarbon contamination was present at the site in areas adjacent to the USTs located on CalTrans property and in an area at the far west corner where engine blocks were formerly stored (Figure 2). Cumulative laboratory results for groundwater and soil samples are listed in Tables 2 and 3.

On August 5, 1993, GMC removed the four USTs south of the main building. The tanks included: a 2,000-gallon diesel fuel tank, a 2,000-gallon gasoline tank, a 1,000-gallon oil storage tank, and a 1,000-gallon used oil tank. Ten soil samples (1-A through 4-B) were collected from beneath the tanks and pumps after removal (Figure 3) and analyzed as required by the Alameda County Health Care Services Agency (ACHCSA). The data are presented in Table 3. The tanks were manifested and disposed at a licensed disposal facility.

On August 10, 1993, GM filed an Underground Storage Tank Unauthorized Release (Leak)/ Contamination Site Report with ACHCSA. This report indicated that the source of the fugitive hydrocarbons detected in soil was corrosion to piping and overfilling the tanks.

Soil excavated from the tank pits were stockpiled on site and sampled for disposal. Results of these analyses indicated detectable concentrations of hydrocarbons. Soil from the excavations were subsequently manifested and hauled on October 7, 1993, to a licensed facility for disposal.

Following closure of the Permit to Operate the former USTs on site, 25 additional soil borings (B1-O to B11-O and B1-D to B14-D) were drilled in the area adjacent to the former tank locations on September 9, 10, and 15, 1993 (Figure 3). Selected soil and groundwater samples were collected from the bore holes and submitted for laboratory analysis. The results of the analyses from this work were reported to the ACHCSA in a November 2, 1993, letter from Mr. G. Keith West of General Motors to Mr. Barney M. Chan, Hazardous Materials specialist, ACHCSA. The results of analyses from these samples are included in Tables 2 and 3.

On March 23 and 24, 1995, Groundwater Technology drilled 17 soil cores (SB-1 through SB-17) using a Geoprobe direct push sampling rig. Cores were completed to depths between 8 and 16 feet bsg. Samples were collected at 5- and 10-foot intervals. One sample from each boring was submitted for laboratory analysis. The locations of these borings are shown in Figure 3 and the results of the soil analyses are given in Table 3. Groundwater samples were collected before the cores were grouted. These results are given in Table 2.

On June 26, 1995, Groundwater Technology drilled 10 additional soil cores (SB-18 through SB-27) using a Geoprobe direct push sampling rig. Cores were completed to depths between 8 and 16 ft. bsg. Samples were collected at 5- and 10-foot intervals from SB-20 through SB-23, and SB-27. One sample from each boring was submitted for laboratory analysis. The locations of these borings are shown in Figure 3 and the results of the soil analyses are given in Table 3. Groundwater samples were collected before the cores were grouted. These results are given in Table 2.

Between February 20 and March 1, 1996, Groundwater Technology installed eight monitoring wells at the site (Figure 4). One soil sample was collected from each boring and submitted for laboratory analysis. After installation, purging and gauging of the wells, a groundwater sample was obtained from each well and submitted for laboratory analysis. These results are given in Table 2.

## 2.5 Pathway Analysis

The pathway analysis uses the site information to identify potential exposure to human and environmental receptors. The exposure characterization identifies the complete exposure pathways through which the chemicals at the site may be transported from the point of release to a potential receptor.

### *2.5.1 Current and Future Land Use*

The site is currently capped with concrete and asphalt. The site is currently used for sales and service of trucks, and the future use of the site is expected to remain the same. The surrounding properties are a mixture of:

- commercial: Coliseum Way and commercial properties to the north; and
- municipal: CalTrans property (a former maintenance facility) to the south and east, and Highway 880 to the south and west.

### *2.5.2 Identification of Exposure Pathways Under Current and Future Use*

***2.5.2.1 Sources, Migration Pathways, and Receiving Media***. The source of fuel-related compounds at this site is thought to be from the former USTs. The receiving media from these sources are soil and groundwater. Currently, TEX. and other petroleum constituents have been identified in groundwater monitor wells and soil samples.

***2.5.2.2 Identification of Receptor Populations.*** Based on current and potential future site conditions, the following receptor populations have been identified:

- Current and future on-site workers,
- Current and future on-site customers,
- Current and future trespassers, and
- Current and future off-site workers.

***2.5.2.3 Identification of Exposure Pathways***. Based on the current and future land use, and the nature of the chemicals detected at the site, the following pathways of exposure for the specified receptors were identified as being *complete* or *incomplete:*

- Current and future on-site workers may be exposed to volatiles migrating from soil and groundwater into indoor or outdoor air. The potential exposure route identified for this scenario is inhalation.
- Current and future on-site workers, customers, and trespassers will not have direct contact with chemicals in soil, since the site is paved.
- Current and future on-site customers may be exposed to volatiles migrating from soil and groundwater into indoor or outdoor air. The potential exposure route identified for this scenario is inhalation. However, since these exposures will be equal to or less than on-site worker exposures, they will not be separately evaluated.

- Current and future on-site trespassers may be exposed to volatiles migrating from soil and groundwater into outdoor air. The potential exposure route identified for this scenario is inhalation. However, since these exposures will be less than on-site worker exposures, they will not be separately evaluated.

- Future off-site commercial worker exposures to chemicals in groundwater and soil are not likely to occur since the nearest commercial property is up-gradient of the site, and the petroleum hydrocarbons from the site have not been proven to have left the property boundaries.

- Environmental receptors, such as plants, animals, and surface water bodies, were not evaluated since no obvious evidence of environmental degradation such as barren soil, stressed or dead vegetation, unhealthy animals, or unusual environmental occurrences have been reported. Could be of concern w/ closeness of drainage ditch

Therefore, the only complete pathways are on-site commercial worker exposure to volatile chemicals in soil and groundwater, through inhalation exposure.

## 3.0 STEP 2: SITE CLASSIFICATION AND INITIAL RESPONSE ACTION

Table 4 summarizes the information on the site conditions so that an initial response action can be formulated. Based on ASTM E173-95, "Classification 1" sites are associated with immediate threats to human health and the environment. "Classification 2" sites are associated with short-term (0 to 2 years) threats to human health and the environment. "Classification 3" sites are associated with long-term (greater than 2 years) and "Classification 4" are associated with no reasonable potential threat to human health or to the environment.

Based on the information presented in Table 4, the site is initially classified as Classification 3 or potentially posing long-term (>2 years) threat to human health. This classification is based primarily on the qualitative information about the site and does not consider the presence or absence of potential impact due to the chemical levels detected at the site. Additional evaluation of the chemical concentrations may reclassify the site.

## 4.0 STEP 3: COMPARISON OF SITE CONDITIONS WITH RISK-BASED SCREENING LEVELS

Table 5 presents the ASTM's RBSLs based on the inhalation of vapors from soil and groundwater exposure pathways for commercial/industrial use of the site. ASTM lists RBSLs which correspond to a potential cancer risk level range of one additional cancer in 10,000 cases of exposure ($1 \times 10^{-4}$) to one additional cancer in 1 million cases of exposure (1 x $10^{-6}$), and a Hazard Index of 1.0 for non-cancer health effects. Values listed in Table 5 are given for the mid-range risk level of one additional cancer in 100,000 cases of exposure (1 x $10^{-5}$). California Environmental Protection Agency (CalEPA) has promulgated a cancer slope factor for benzene of 0.1 $(mg/kg\text{-}day)^{-1}$ which differs from the value of 0.029 $(mg/kg\text{-}day)^{-1}$ used by ASTM (CalEPA, 1994). The ASTM RBSLs for benzene have therefore been modified to coincide with the use of the CalEPA slope factor.

The results of the comparison to RBSLs demonstrate that the maximum detected concentrations of toluene, ethylbenzene, and xylenes in soil and groundwater do not exceed the risk-based screening levels. The maximum detected benzene concentrations in soil exceeds all the soil RBSLs for exposure via inhalation. However, the maximum detected benzene concentration in groundwater is lower than all the RBSLs for commercial receptors. It should be noted that there is no RBSL for total petroleum hydrocarbons (TPH) since ASTM's opinion is that in general, "*TPH should not be used for individual constituent risk assessments because the general measure of TPH provides insufficient information about the amounts of individual compounds present.*"

In addition to a comparison with RBSLs, ASTM recommends that "aesthetic, ecological, other relevant criteria, and background levels" be considered. Since the chemicals of concern are in a commercial/industrial area, there are no aesthetic or ecological issues. Therefore, no other criteria were considered.

possibly

## 5.0 STEP 4: EVALUATION OF TIER 1 RESULTS

After the comparison to RBSLs, one of the following options is selected for the site:

- **No Action** - may be appropriate when source concentrations do not exceed applicable screening level concentrations. Monitoring may be needed to confirm that current conditions persist or improve with time.

- **Final Corrective Action** - may be implemented to achieve applicable screening level concentrations if they are exceeded at the site.

- **Interim Corrective Action** - may be implemented when it is impossible to achieve screening level concentrations due to technological limitations. More limited action may be effective in removing hot spots or reducing the immediate potential for exposure.

- **Tier Upgrade - Further Analysis** - may be recommended when site-specific conditions are likely to allow calculation of more realistic RBSLs.

Based on the results of the comparison to RBSLs, as discussed in Section 4.0, the maximum concentration of benzene in soil at the GMC Truck Center exceeds the RBSL for industrial receptors. Therefore, a Tier 2 evaluation is warranted.

## 6.0 STEP 5: TIER 2 EVALUATION

Since the most restrictive RBSL for benzene in soil is for exposure to vapors within a building, a site-specific target level (SSTL) for this exposure was developed. This SSTL was developed using the Heuristic Model of Johnson and Ettinger (1991), which is referenced in ASTM E 1739 and described in Appendix A.

Parameter values used to describe the soil, building, and commercial exposure to indoor vapors are given in Tables 6, 7, and 8. Based on the results of this model, the SSTL for benzene in soil at this site is 1.75 mg/kg, as calculated in Appendix B.

## 7.0 EVALUATION OF TIER 2 RESULTS

One sample (MW-3 10') exceeds the SSTL for benzene in soil. The closest samples to this point (SB-2, -20, and -22) have nondetectable concentrations of benzene, thus limiting the area of soil which exceeds acceptable concentrations. The area defined by the closest sample locations to this well is approximately 6,500 square feet. This represents the upper-bound estimate of soil area which exceeds the SSTL.

Since the SSTL is derived based on volatilization of benzene from soil beneath a building, and the area of soil which exceeds the SSTL does not extend beneath the existing building, no current health risk is predicted for this site. However, construction of a building on top of this soil could result in an unacceptable risk.

To mitigate the potential future inhalation exposure to indoor vapors from the soil, the following measures are considered. These general approaches are discussed in greater detail in the accompanying document: Remediation Feasibility Study.

1. **In-situ Remediation** - This could include various methods including groundwater pumping of dissolved hydrocarbons; soil vapor extraction of volatile organic compounds; bioremediation of adsorbed and dissolved hydrocarbons and aquifer sparging with soil vapor extraction of volatile organic compounds in the soil and groundwater.

All of the approaches, except possibly for bioremediation, involve mass transfer of the benzene to the atmosphere and/or vessels which must be handled by human receptors. The potential for human exposure is increased, although at dilute concentrations in the case of atmospheric discharge of volatile organic compounds.

2. **Ex-situ Remediation** - This would involve excavation and proper disposal of the soils in the area identified with the highest benzene concentrations.

   This approach would potentially expose remediation workers to low levels of benzene in addition to safety issues involving excavation and possibly shoring and pumping of the excavation area. The impacted soils would be disposed of off-site at a permitted disposal facility involving land farming or simple disposal. Both of these options would involve mass transfer of the contaminants during handling and final disposition.

3. **Intrinsic Remediation** - This technique would allow for the natural degradation of the hydrocarbon and volatile organics via indigenous microorganisms. This technique has been well documented in recent studies by Lawrence Livermore Laboratories and others. Provided the source of the hydrocarbons has been eliminated the concentrations of hydrocarbons will naturally attenuate over time.

   Given the current calculated risk for in-door inhalation, the current location of the benzene beneath exterior pavement, and no current plans to excavate or expand the truck service structure over this area, intrinsic remediation would result in the least potential for human exposure.

4. **Institutional Controls** - This could take the form of a deed restriction on future activities in the area of the elevated benzene concentrations and/or requirements for the installation of a vapor barrier beneath future building, as yet unplanned, in this area.

   This technique would effectively eliminate human exposure to benzene via inhalation.

Based on this risk assessment it is recommended that intrinsic remediation be implemented in conjunction with a deed restriction on future building activities be implemented. The deed restriction would require the engineer obtaining a building permit to take into consideration the hydrocarbons in the subsurface prior to construction on this site. This would protect future contractors and in-door workers prior to completion of intrinsic remediation.

## 8.0 REFERENCES

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**TABLE 1**
Well Parameters

GMC Truck Center
8099 Coliseum Way
Oakland, California

April 3, 1996

| Well | Depth to Groundwater (feet) | Water Elevation (feet) | Well Screen Interval (feet bsg) | Use |
|---|---|---|---|---|
| MW-1 | 6.59 | 3.20 | 5-20 | Monitoring |
| MW-2 | 9.62 | 0.10 | 5-20 | Test Well |
| MW-3 | 8.02 | 2.39 | 5-20 | Monitoring |
| MW-4 | 3.78 | 6.04 | 5-20 | Monitoring |
| MW-5 | 7.03 | 3.71 | 3-18 | Monitoring |
| MW-6 | 8.05 | 1.62 | 3-18 | Monitoring |
| MW-7 | 7.98 | 2.57 | 3-18 | Monitoring |
| MW-8 | 5.27 | 4.76 | 5-20 | Monitoring |
| PZ-1 | 9.82 | 0.15 | 5-20 | Observation |
| PZ-2 | 9.98 | 0.61 | 5-20 | Observation |
| PZ-3 | 9.60 | 0.10 | 5-20 | Observation |

*Notes:* Depth-to water measurements recorded prior to pumping, 4/3/96 (measured from top of the well casings). Screen intervals are in feet below surface grade.

## TABLE 2
## CUMULATIVE LABORATORY RESULTS FOR GROUNDWATER SAMPLES
## GENERAL MOTORS CORPORATION - WHITE TRUCK CENTER
## OAKLAND, CALIFORNIA

| Sample ID | Date Collected | Benzene (µg/L) | Toluene (µg/L) | Ethylbenzene (µg/L) | Xylenes (µg/L) | TPH as gasoline (µg/L) | TPH as diesel (µg/L) | TPH as mineral spirits (µg/L) | TPH as kerosene (µg/L) | TPH as motor oil (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| BH-1 | 7/23/93 | -- | -- | -- | -- | 780 | 1,300 | -- | -- | -- |
| BH-3 | 7/23/93 | -- | -- | -- | -- | -- | 47,000 | -- | -- | -- |
| B8-D | 9/15/93 | -- | -- | -- | -- | -- | 7,700 | -- | -- | -- |
| B9-D | 9/15/93 | -- | -- | -- | -- | -- | 110,000 | -- | -- | -- |
| B10-D | 9/15/93 | -- | -- | -- | -- | -- | 8,500 | -- | -- | -- |
| B14-D | 9/15/93 | <0.4 | <0.3 | <0.3 | <0.4 | <50 | 10,000 | -- | -- | -- |
| B3-O | 9/15/93 | -- | -- | -- | -- | -- | -- | -- | -- | 150,000 T |
| B4-O (h) | 9/15/93 | <0.4 | <0.3 | <0.3 | <0.4 | <50 | 5,600 | -- | -- | 18,000 T |
| B6-O (h) | 9/15/93 | <0.4 | <0.3 | <0.3 | <0.4 | <50 | 1,400 | -- | -- | <5,000 T |
| B11-O | 9/15/93 | <0.4 | <0.3 | <0.3 | <0.4 | <50 | 6,000 | -- | -- | 10,000 T |
| SB-1 | 03/23/95 | 0.4 | <0.3 | <0.3 | 0.6 | <50 | 260 | <50 | <50 | <250 |
| SB-2 | 03/23/95 | <0.3 | <0.3 | <0.3 | <0.5 | <50 | <500 | <500 | <500 | 4000 |
| SB-3 | 03/23/95 | <0.3 | <0.3 | <0.3 | <0.5 | <50 | -- | PSH | -- | -- |
| SB-4 | 03/23/95 | <0.3 | <0.3 | <0.3 | <0.5 | <50 | 300 | <50 | <50 | <250 |
| SB-5 | 03/23/95 | 1.3 | <0.3 | <0.3 | <0.5 | <50 | 500 | <50 | <50 | <250 |
| SB-6 | 03/24/95 | <0.3 | <0.3 | <0.3 | <0.5 | <50 | <250 | <250 | <250 | 2,100 |
| SB-7 | 03/23/95 | <0.3 | <0.3 | <0.3 | <0.5 | <50 | 2,300 | <50 | <50 | <250 |
| SB-8 | 03/23/95 | <0.3 | <0.3 | <0.3 | <0.5 | <50 | <50 | <50 | <50 | 480 |
| SB-9 | 03/23/95 | <0.3 | <0.3 | <0.3 | <0.5 | <50 | <1,000 | <1,000 | <1,000 | 7,600 |



*(Table 2 continues)*

## TABLE 2
## CUMULATIVE LABORATORY RESULTS FOR GROUNDWATER SAMPLES
## GENERAL MOTORS CORPORATION - WHITE TRUCK CENTER
## OAKLAND, CALIFORNIA

| Sample ID | Date Collected | Benzene (µg/L) | Toluene (µg/L) | Ethylbenzene (µg/L) | Xylenes (µg/L) | TPH as gasoline (µg/L) | TPH as diesel (µg/L) | TPH as mineral spirits (µg/L) | TPH as kerosene (µg/L) | TPH as motor oil (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| SB-10 | 03/23/95 | <0.3 | <0.3 | <0.3 | <0.5 | <50 | <500 | <500 | <500 | 4,200 |
| SB-11 | 03/23/95 | <0.3 | <0.3 | <0.3 | <0.5 | <50 | <250 | <250 | <250 | 2,000 |
| SB-12 | 03/24/95 | <0.3 | <0.3 | <0.3 | <0.5 | <50 | <500 | <500 | <500 | <2,500 |
| SB-13 | 03/27/95 | <0.3 | <0.3 | <0.3 | <0.5 | <50 | <250 | <250 | <250 | <1,250 |
| SB-14 | 03/23/95 | <0.3 | <0.3 | <0.3 | <0.5 | <50 | <40 | <50 | <50 | 1,000 |
| SB-15 | 03/23/95 | <0.3 | <0.3 | <0.3 | <0.5 | <50 | <50 | <50 | <50 | 720 |
| SB-16 | 03/23/95 | 0.4 | <0.3 | <0.3 | <0.5 | <50 | <50 | <50 | <50 | 1,200 |
| SB-17 | 03/23/95 | <0.3 | <0.3 | <0.3 | <0.5 | <50 | <250 | <250 | <250 | <1,250 |
| SB-18 | 06/26/95 | <0.3 | 8.1 | <0.3 | <0.5 | <50 | <1,000 | <1,000 | <1,000 | <5,000 |
| SB-19 | 06/26/95 | <0.3 | 0.3 | <0.3 | <0.5 | <50 | <2,500 | <2,500 | <2,500 | 44,000 |
| SB-20 | 06/26/95 | <0.3 | <0.3 | 60 | 150 | <500 | <2,500 | 520,000 | <2,500 | 170,000 |
| SB-21 | 06/26/95 | <0.3 | 0.5 | 0.7 | <0.5 | <50 | <1,000 | <1,000 | <1,000 | <5,000 |
| SB-22 | 06/26/95 | <0.3 | 0.6 | <0.3 | <0.5 | <50 | <1,000 | <1,000 | <1,000 | <5,000 |
| SB-23 | 06/26/95 | 0.5 | <0.3 | 1.0 | 2.8 | 150 | <2,500 | <2,500 | 39,000 | 23,000 |
| SB-24 | 06/26/95 | <0.3 | 0.4 | <0.3 | <0.5 | <50 | <1,000 | <1,000 | <1,000 | 13,000 |
| SB-25 | 06/26/95 | <0.3 | <0.3 | <0.3 | <0.5 | <50 | <1,000 | <1,000 | <1,000 | 17,000 |
| SB-26 | 06/26/95 | <0.6 | <0.6 | <0.6 | <1.0 | <100 | <1,000 | <1,000 | <1,000 | <5,000 |
| SB-27 | 06/26/95 | <0.3 | <0.3 | <0.3 | <0.5 | <50 | <1,000 | <1,000 | <1,000 | 16,000 |



(Table 2 continues)

## TABLE 2
## CUMULATIVE LABORATORY RESULTS FOR GROUNDWATER SAMPLES
## GENERAL MOTORS CORPORATION - WHITE TRUCK CENTER
## OAKLAND, CALIFORNIA

| Sample ID | Date Collected | Benzene (µg/L) | Toluene (µg/L) | Ethylbenzene (µg/L) | Xylenes (µg/L) | TPH as gasoline (µg/L) | TPH as diesel (µg/L) | TPH as mineral spirits (µg/L) | TPH as kerosene (µg/L) | TPH as motor oil (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| MW-1 | 03/01/96 | <0.5 | <1.0 | <1.0 | <2.0 | <100 | <100 | -- | -- | 8,606 |
| MW-2 | 03/01/96 | <0.5 | <1.0 | <1.0 | <2.0 | <100 | <400 | -- | -- | 1,600 |
| MW-3 | 03/01/96 | <0.5 | <1.0 | <1.0 | <2.0 | <100 | <100 | -- | -- | 680 |
| MW-4 | 03/01/96 | <0.5 | <1.0 | <1.0 | <2.0 | <100 | <100 | -- | -- | 1,400 |
| MW-5 | 03/01/96 | <0.5 | <1.0 | <1.0 | <2.0 | <100 | <2,500 | -- | -- | 8,000 |
| MW-6 | 03/01/96 | <0.5 | <1.0 | <1.0 | <2.0 | <100 | <3,500 | -- | -- | 11,000 |
| MW-7 | 03/01/96 | <0.5 | <1.0 | <1.0 | <2.0 | <100 | <800 | -- | -- | 2,900 |
| MW-8 | 03/01/96 | 4.6 | <1.0 | <1.0 | <2.0 | 160 | <850 | -- | -- | 3,600 |

NOTES:
< = Below Detection Limit
-- = Not analyzed
PSH = Phase Separated Hydrocarbons

## TABLE 3
## CUMULATIVE LABORATORY RESULTS FOR SOIL SAMPLES
## GENERAL MOTORS CORPORATION - WHITE TRUCK CENTER
## OAKLAND, CALIFORNIA

| Sample ID | Sample Depth (feet) | Date Collected | Benzene (mg/kg) | Toluene (mg/kg) | Ethyl-benzene (mg/kg) | Xylenes (mg/kg) | TPH as gasoline(mg/kg) | TPH as diesel (mg/kg) | TPH as mineral spirits (mg/kg) | TPH as kerosene (mg/kg) | TPH as motor oil (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BH-1 | 6 | 7/23/93 | -- | -- | -- | -- | 340 | 280 | -- | -- | 480 * |
| BH-1 | 10.5 | 7/23/93 | -- | -- | -- | -- | 20 | 8 | -- | -- | <50 * |
| BH-1 | 15.5 | 7/23/93 | -- | -- | -- | -- | 0.5 | 10 | -- | -- | 140 * |
| BH-3 | 5.5 | 7/23/93 | -- | -- | -- | -- | 6.3 | 44 | -- | -- | 180 * |
| BH-4 | 5.5 | 7/23/93 | -- | -- | -- | -- | 51 | 17 | -- | -- | 70 * |
| BH-5 | 5.5 | 7/23/93 | -- | -- | -- | -- | 0.5 | 700 | -- | -- | 820 * |
| BH-5 | 10.5 | 7/23/93 | -- | -- | -- | -- | <0.3 | 3 | -- | -- | <50 * |
| 1-A | 2 | 8/5/93 | 0.1 | 1.1 | 1.6 | 9.8 | 47 | -- | -- | -- | -- |
| 1-B | 12.5 | 8/5/93 | 0.010 | 0.013 | <0.005 | 0.008 | 0.6 | 330 | -- | -- | -- |
| 1-C | 12.5 | 8/5/93 | <0.005 | <0.005 | 0.010 | 0.026 | 1.4 | -- | -- | -- | -- |
| 2-A | 2 | 8/5/93 | 1.0 | 2.8 | 3.5 | 13.6 | -- | 14,000 | -- | -- | -- |
| 2-B | 12.5 | 8/5/93 | -- | -- | -- | -- | 74 | 13,000 | -- | -- | -- |
| 2-C | 12.5 | 8/5/93 | -- | -- | -- | -- | -- | 890 | -- | -- | -- |
| 3-A (h,m,s) | 8.5 | 8/5/93 | 0.60 | 0.21 | 0.15 | 1.13 | 24 | 1,200 | -- | -- | 670 T |
| 3-B | ??? | 8/5/93 | -- | -- | -- | -- | -- | -- | -- | -- | 3,300 T |
| 4-A | ??? | 8/5/93 | -- | -- | -- | -- | -- | -- | -- | -- | 2,500 T |
| 4-B | ??? | 8/5/93 | -- | -- | -- | -- | -- | -- | -- | -- | 1,900 T |
| B2-D | 2.5 | 9/15/93 | <0.005 | <0.005 | <0.005 | <0.005 | -- | | -- | -- | -- |
| B4-D | 5 | 9/9/93 | -- | -- | -- | -- | -- | 1.4 | 1,700 | -- | 580 T |

FLUOR DANIEL GTI



(Table 3 continues)

## TABLE 3
## CUMULATIVE LABORATORY RESULTS FOR SOIL SAMPLES
## GENERAL MOTORS CORPORATION - WHITE TRUCK CENTER
## OAKLAND, CALIFORNIA

| Sample ID | Sample Depth (feet) | Date Collected | Benzene (mg/kg) | Toluene (mg/kg) | Ethyl-benzene (mg/kg) | Xylenes (mg/kg) | TPH as gasoline(mg/kg) | TPH as diesel (mg/kg) | TPH as mineral spirits (mg/kg) | TPH as kerosene (mg/kg) | TPH as motor oil (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B4-D | 7 | 9/9/93 | -- | -- | -- | -- | -- | <0.3 | 27 | -- | -- |
| B6-D | 2 | 9/15/93 | <0.005 | 0.005 | <0.005 | <0.005 | -- | -- | -- | -- | -- |
| B7-D | 5 | 9/9/93 | -- | -- | -- | -- | -- | <0.3 | 1,900 | -- | -- |
| B8-D | 4.5 | 9/9/93 | -- | -- | -- | -- | -- | <0.3 | 1,500 | -- | -- |
| B9-D | 5.5 | 9/9/93 | -- | -- | -- | -- | -- | <0.3 | 900 | -- | -- |
| B10-D | 10 | 9/9/93 | -- | -- | -- | -- | -- | 1.1 | 7,000 | -- | -- |
| B11-D | 4.5 | 9/9/93 | -- | -- | -- | -- | -- | <0.3 | 3,800 | -- | -- |
| B12-D | 4.5 | 9/15/93 | -- | -- | -- | -- | -- | 1,100 | -- | -- | -- |
| B12-D | 7 | 9/15/93 | -- | -- | -- | -- | -- | 2,400 | -- | -- | -- |
| B13-D | 3.5 | 9/15/93 | <0.005 | <0.005 | <0.005 | <0.005 | -- | 5,400 | -- | -- | -- |
| B14-D | 10 | 9/15/93 | <0.005 | 0.005 | <0.005 | <0.005 | -- | 1,000 | -- | -- | -- |
| BH1-B | 4.5 | 9/10/93 | -- | -- | -- | -- | -- | 6 | -- | -- | <50 T |
| BH2-B | 5 | 9/10/93 | -- | -- | -- | -- | -- | 490 | -- | -- | 540 |
| BH3-B | 5.5 | 9/10/93 | -- | -- | -- | -- | -- | 470 | -- | -- | 440 |
| BH4-B | 5 | 9/10/93 | -- | -- | -- | -- | -- | 570 | -- | -- | 580 |
| B1-O | 5.5 | 9/15/93 | -- | -- | -- | -- | -- | 92 | -- | -- | 230 T |
| B2-0 | 6.5 | 9/15/93 | -- | -- | -- | -- | -- | 1,400 | -- | -- | 1,400 T |
| B3-O | 6 | 9/15/93 | -- | -- | -- | -- | -- | 1,200 | -- | -- | 1,100 T |
| B7-O | 4.5 | 9/15/93 | -- | -- | -- | -- | -- | 350 | -- | -- | 3,900 T |



*(Table 3 continues)*

**TABLE 3**
**CUMULATIVE LABORATORY RESULTS FOR SOIL SAMPLES**
**GENERAL MOTORS CORPORATION - WHITE TRUCK CENTER**
**OAKLAND, CALIFORNIA**

| Sample ID | Sample Depth (feet) | Date Collected | Benzene (mg/kg) | Toluene (mg/kg) | Ethyl-benzene (mg/kg) | Xylenes (mg/kg) | TPH as gasoline(mg/kg) | TPH as diesel (mg/kg) | TPH as mineral spirits (mg/kg) | TPH as kerosene (mg/kg) | TPH as motor oil (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B7-O | 9.5 | 9/15/93 | -- | -- | -- | -- | -- | 5 | -- | -- | <50 T |
| B9-O | 5.5 | 9/15/93 | -- | -- | -- | -- | -- | 1,500 | -- | -- | 2,100 T |
| B9-O | 9 | 9/15/93 | -- | -- | -- | -- | -- | 3 | -- | -- | <50 T |
| B10-O | 4.5 | 9/15/93 | -- | -- | -- | -- | -- | 170 | -- | -- | 160 T |
| B11-O | 4.5 | 9/15/93 | -- | -- | -- | -- | -- | 1,300 | -- | -- | 1,100 T |
| B11-O | 6.5 | 9/15/93 | -- | -- | -- | -- | -- | 1,100 | -- | -- | 2,500 T |
| B1-R | 6 | 9/15/93 | -- | -- | -- | -- | -- | 1,100 | -- | -- | <50 T |
| SB-1 | 10 | 03/23/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <10 | <10 | <10 | <100 |
| SB-2 | 10 | 03/23/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <10 | <10 | <10 | <100 |
| SB-3 | 10 | 03/23/95 | <0.25 | <0.25 | 5.4 | 87 | 3500 | <500 | <500 | 1800 | <1000 |
| SB-4 | 10 | 03/23/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <10 | <10 | <10 | <100 |
| SB-5 | 10 | 03/23/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <10 | <10 | <10 | <100 |
| SB-6 | 10 | 03/23/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <100 | <100 | <100 | <1000 |
| SB-7 | 10 | 03/23/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <10 | <10 | <10 | <100 |
| SB-8 | 10 | 03/23/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <100 | <100 | <100 | <1000 |
| SB-9 | 10 | 03/23/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <100 | <100 | <100 | <1000 |
| SB-10 | 5 | 03/23/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <100 | <100 | <100 | <1000 |
| SB-11 | 10 | 03/23/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <10 | <10 | <10 | <100 |
| SB-12 | 10 | 03/23/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <10 | <10 | <10 | <100 |


*(Table 3 continues)*

## TABLE 3
## CUMULATIVE LABORATORY RESULTS FOR SOIL SAMPLES
## GENERAL MOTORS CORPORATION - WHITE TRUCK CENTER
## OAKLAND, CALIFORNIA

| Sample ID | Sample Depth (feet) | Date Collected | Benzene (mg/kg) | Toluene (mg/kg) | Ethyl-benzene (mg/kg) | Xylenes (mg/kg) | TPH as gasoline(mg/kg) | TPH as diesel (mg/kg) | TPH as mineral spirits (mg/kg) | TPH as kerosene (mg/kg) | TPH as motor oil (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SB-13 | 10 | 03/23/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <10 | <10 | <10 | <100 |
| SB-14 | 10 | 03/23/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <10 | <10 | <10 | <100 |
| SB-15 | 5 | 03/23/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <50 | <50 | <50 | <500 |
| SB-16 | 5 | 03/23/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <100 | <100 | <100 | <1000 |
| SB-17 | 10 | 03/23/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <50 | <50 | <50 | <500 |
| SB-18 | NS | 06/26/95 | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| SB-19 | NS | 06/26/95 | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| SB-20 | 10 | 06/26/95 | <0.10 | <0.10 | 1.6 | 17 | <20 | <200 | 1400 | <200 | <2000 |
| SB-21 | 10 | 06/26/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <10 | <10 | <10 | <100 |
| SB-22 | 10 | 06/26/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <10 | <10 | <10 | <100 |
| SB-23 | 10 | 06/26/95 | <0.025 | 0.042 | 0.061 | 0.32 | 28 | <10000 | <1000 | <1000 | <10000 |
| SB-24 | NS | 06/26/95 | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| SB-25 | NS | 06/26/95 | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| SB-26 | NS | 06/26/95 | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| SB-27 | 10 | 06/26/95 | <0.005 | <0.005 | <0.005 | <0.015 | <1.0 | <200 | <200 | <200 | <2000 |
| MW-1 | 15 | 03/01/96 | <0.001 | <0.002 | <0.002 | <0.004 | <0.1 | <10 | <10 | -- | <10 |
| MW-2 | 10 | 03/01/96 | <0.001 | <0.002 | <0.002 | <0.004 | <0.1 | <10 | <10 | -- | 22 |
| **MW-3** | **10** | **03/01/96** | **310** | **<0.5** | **<0.5** | **260** | **8,400** | **<300** | **1,900** | **--** | **1,300** |
| MW-4 | 10 | 03/01/96 | <0.001 | <0.002 | <0.002 | <0.004 | <0.1 | <100 | <100 | -- | 1,100 |

FLUOR DANIEL GTI



(Table 3 continues)

**TABLE 3**
**CUMULATIVE LABORATORY RESULTS FOR SOIL SAMPLES**
**GENERAL MOTORS CORPORATION - WHITE TRUCK CENTER**
**OAKLAND, CALIFORNIA**

| Sample ID | Sample Depth (feet) | Date Collected | Benzene (mg/kg) | Toluene (mg/kg) | Ethyl-benzene (mg/kg) | Xylenes (mg/kg) | TPH as gasoline(mg/kg) | TPH as diesel (mg/kg) | TPH as mineral spirits (mg/kg) | TPH as kerosene (mg/kg) | TPH as motor oil (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MW-5 | 16 | 03/01/96 | <0.001 | <0.002 | <0.002 | 0.0055 | 6.4 | <100 | <100 | -- | 800 |
| MW-6 | 15 | 03/01/96 | <0.001 | <0.002 | <0.002 | <0.004 | 0.49 | <50 | <50 | -- | 370 |
| MW-7 | 10 | 03/01/96 | 0.0014 | <0.002 | <0.002 | <0.004 | 0.27 | <50 | <50 | -- | 460 |
| MW-8 | 10 | 03/01/96 | 0.0022 | <0.002 | <0.002 | <0.004 | 0.14 | <100 | <100 | -- | 2,200 |

NOTES:
< = Not detected at detection limit
NA = Not analyzed
NS = Not Sampled
??? = Data not noted in report
* = Oil and Grease
T = Total Hydrocarbons
(m) = Sample analyzed for metals
(h) = Sample analyzed for halocarbons
(s) = Sample analyzed for semi-volatiles



*(Table 3 continues)*

**TABLE 4**
**SITE CLASSIFICATION DATA**
**GENERAL MOTORS CORPORATION - WHITE TRUCK CENTER**
**OAKLAND, CALIFORNIA**

| | |
|---|---|
| Current and future land use | Commercial |
| Subsurface soils (5.5 to 11 ft bgs) are impacted | Yes |
| Depth to groundwater | 3 to 10 feet bgs |
| Direction of groundwater flow | North - Northwest |
| Monitor wells on site are impacted | Yes |
| Downgradient on-site and off-site monitor wells are impacted | Yes |
| Is groundwater potable? | No |
| Distance from point of release to nearest municipal well supply | Greater than 7,500 feet |
| Distance from point of release to nearest private well | Greater than 7,500 feet |
| Sensitive environmental receptors potentially | No |

## TABLE 5
## COMPARISON TO TIER I RISK-BASED CLEANUP LEVELS
## GMC TRUCK CENTER
## 8099 SOUTH COLISEUM WAY, OAKLAND, CALIFORNIA

Soil

values in mg/kg

| Chemical | Site Maximum | Vol. to Indoor Air ASTM | Vol. to Indoor Air Cal. corr. | Vol. to Outdoor Air ASTM | Vol. to Outdoor Air Cal. corr. | Direct contact ASTM | Direct contact Cal. corr. |
|---|---|---|---|---|---|---|---|
| Benzene | 310 | **0.109** | **0.032** | **4.57** | **1.325** | **100** | **29** |
| Ethylbenzene | 5.4 | 1100 | | RES | | 11500 | |
| Toluene | 2.8 | 54.5 | | RES | | 18700 | |
| Xylenes | 260 | RES | | RES | | 208000 | |

Cal. corr. = RBSL corrected to use of CalEPA benzene cancer slope factor by dividing by 3.45 (0.1/0.029)

RES = risk level not exceeded by pure compound

**Bold indicate values exceeded by site maximum**

Groundwater

values in mg/L

| Chemical | Site Maximum | Vol. to Indoor Air ASTM | Vol. to Indoor Air Cal. corr. | Vol. to Outdoor Air ASTM | Vol. to Outdoor Air Cal. corr. | Ingestion ASTM | Ingestion Cal. corr. |
|---|---|---|---|---|---|---|---|
| Benzene | 0.0046 | 0.739 | 0.214 | 184 | 53.360 | 0.0987 | 0.029 |
| Ethylbenzene | 0.06 | >S | | >S | | 10.2 | |
| Toluene | 0.0081 | 85 | | >S | | 20.4 | |
| Xylenes | 0.15 | >S | | >S | | >S | |

Cal. corr. = RBSL corrected to use of CalEPA benzene cancer slope factor by dividing by 3.45 (0.1/0.029)

>S = risk level not exceeded by pure compound solubility

**Bold indicate values exceeded by site maximum**

T1RBCS.XLS

FLUOR DANIEL GTI

## TABLE 6

## SOIL PROPERTIES
## GENERAL MOTORS CORPORATION - WHITE TRUCK CENTER
## OAKLAND, CALIFORNIA

| Property | Value | Reference |
|---|---|---|
| Organic carbon | 0.0053 | average of samples from SB-10 and SB-11 |
| Total porosity | 0.33 | sample from SB-11 |
| Particle density | 2.66 g/mL | sample from SB-11 |
| Moisture content | 0.136 | sample from SB-10 |
| Air Permeability | $1x10^{-13}$ $cm^2$ | sample from SB-11 |

## TABLE 7

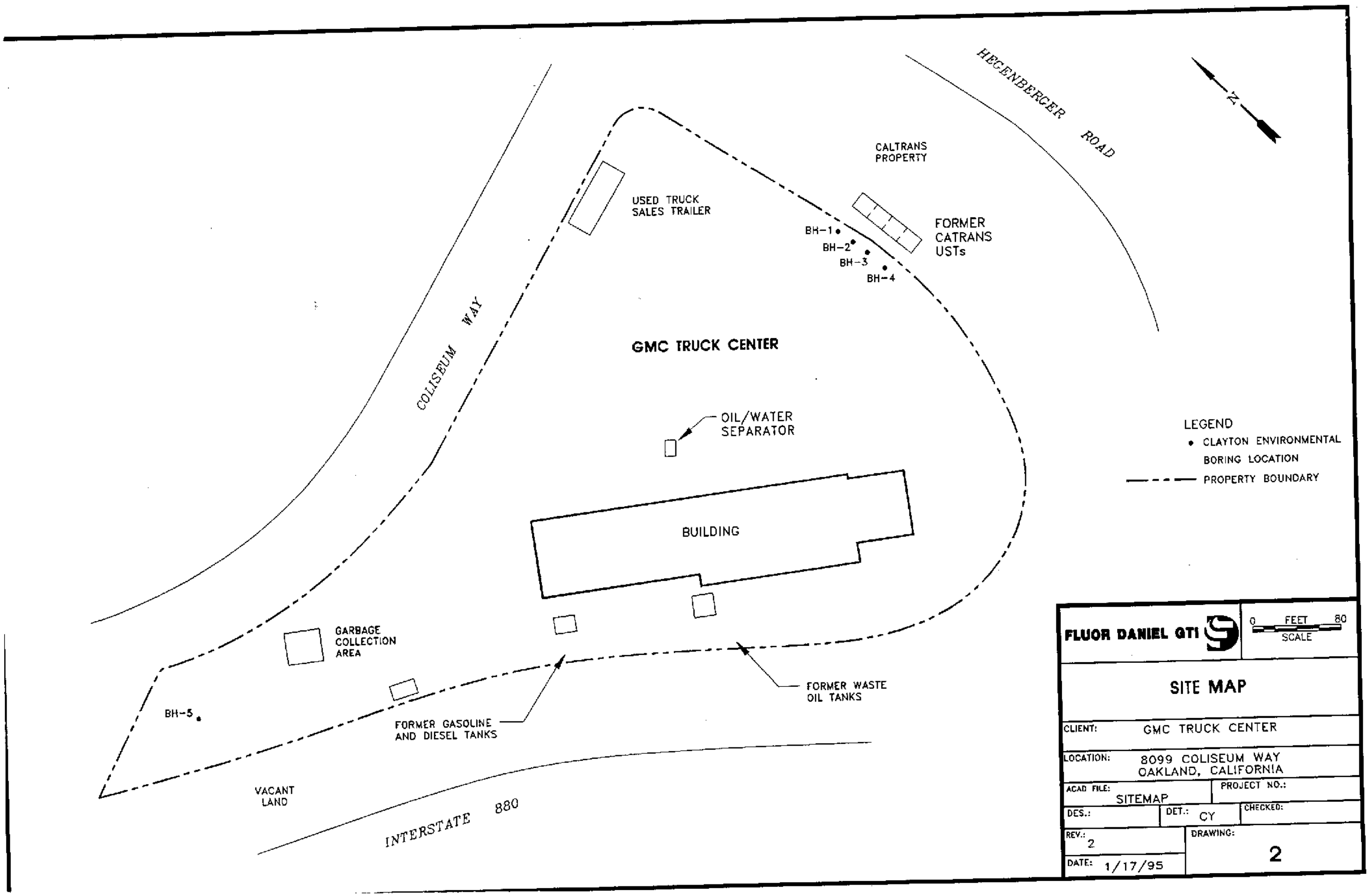
### BUILDING PARAMETERS
### GENERAL MOTORS CORPORATION - WHITE TRUCK CENTER
### OAKLAND, CALIFORNIA

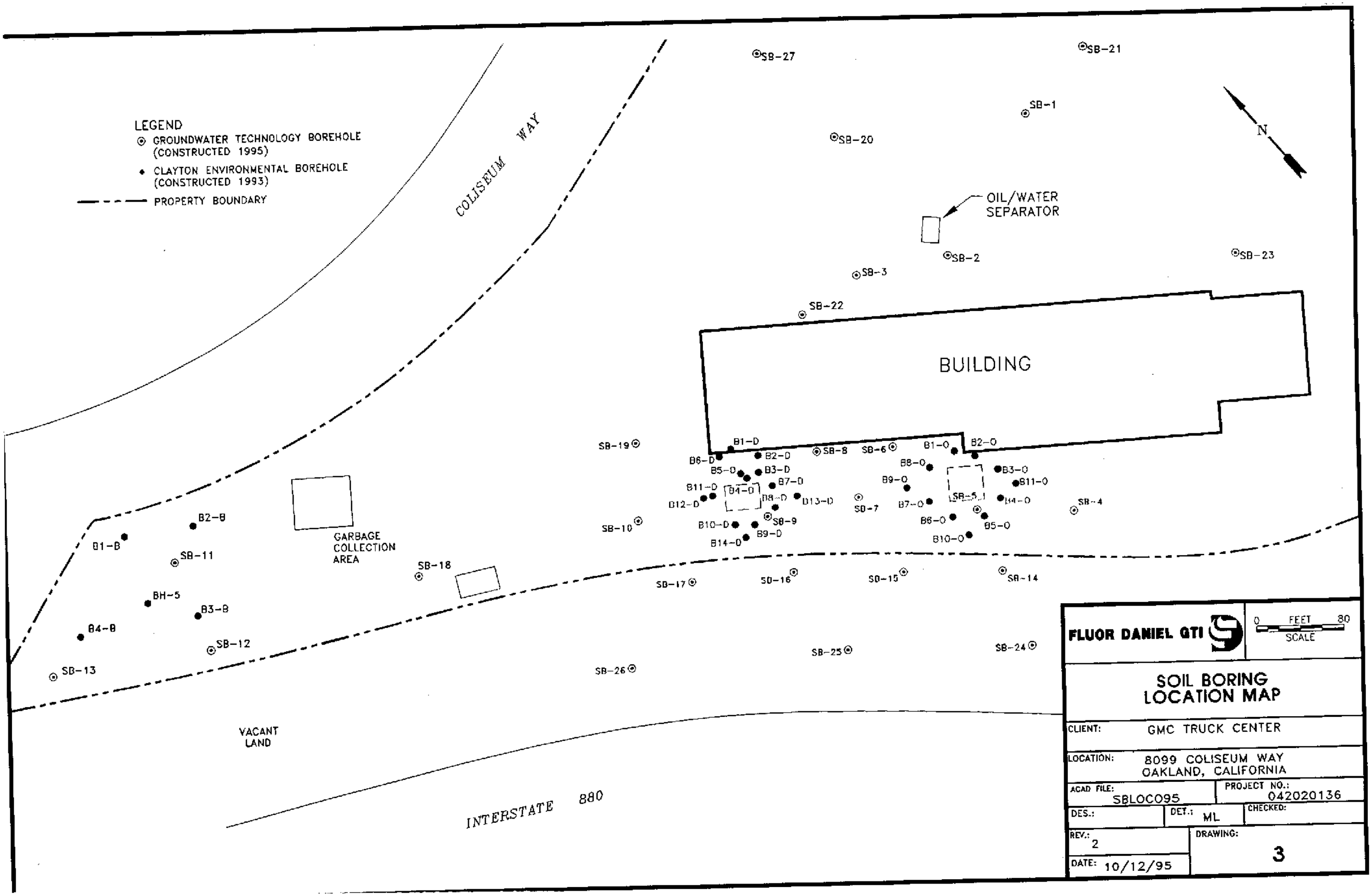
| Parameter | Value | Reference |
|---|---|---|
| Building Area | 557,400 $cm^2$ | site map |
| Building Volume | 144,000,000 $cm^3$ | assumed 8.5 foot ceiling |
| Crack fraction | 0.001 | Johnson and Ettinger, 1991 |
| Crack depth | 30 cm | assumed 1 foot foundation |
| Distance from source to foundation floor | 10 cm | assumption |
| Distance from foundation floor to grade | 167 cm (current off-site) | depth to groundwater at site |
| Indoor/Outdoor pressure differential | 10 $g/cm\text{-}s^2$ | Johnson and Ettinger, 1991 |
| Air exchange rate | 1 volume/hour | Prichard and Gesell, 1981 |

## TABLE 8

## COMMERCIAL EXPOSURE PARAMETERS
## GENERAL MOTORS CORPORATION - WHITE TRUCK CENTER
## OAKLAND, CALIFORNIA

| Parameter | Value |
| --- | --- |
| Inhalation rate | 20 $m^3$/day |
| Exposure frequency | 250 days/year |
| Exposure duration | 25 years |
| Body weight | 70 kg |
| Averaging time | 25,550 days - carcinogens |


HEGENBERGER ROAD
CALTRANS PROPERTY
N
USED TRUCK SALES TRAILER
FORMER CATRANS USTs
BH-1
BH-2
BH-3
BH-4
COLISEUM WAY
GMC TRUCK CENTER
OIL/WATER SEPARATOR
LEGEND
• CLAYTON ENVIRONMENTAL BORING LOCATION
PROPERTY BOUNDARY
BUILDING
GARBAGE COLLECTION AREA
BH-5
FORMER GASOLINE AND DIESEL TANKS
FORMER WASTE OIL TANKS
VACANT LAND
INTERSTATE 880
FLUOR DANIEL GTI
0 FEET 80
SCALE
SITE MAP
CLIENT: GMC TRUCK CENTER
LOCATION: 8099 COLISEUM WAY OAKLAND, CALIFORNIA
ACAD FILE: SITEMAP
PROJECT NO.:
DES.:
DET.: CY
CHECKED:
REV.: 2
DRAWING: 2
DATE: 1/17/95




FLUOR DANIEL GTI

SOIL BORING LOCATION MAP

CLIENT: GMC TRUCK CENTER

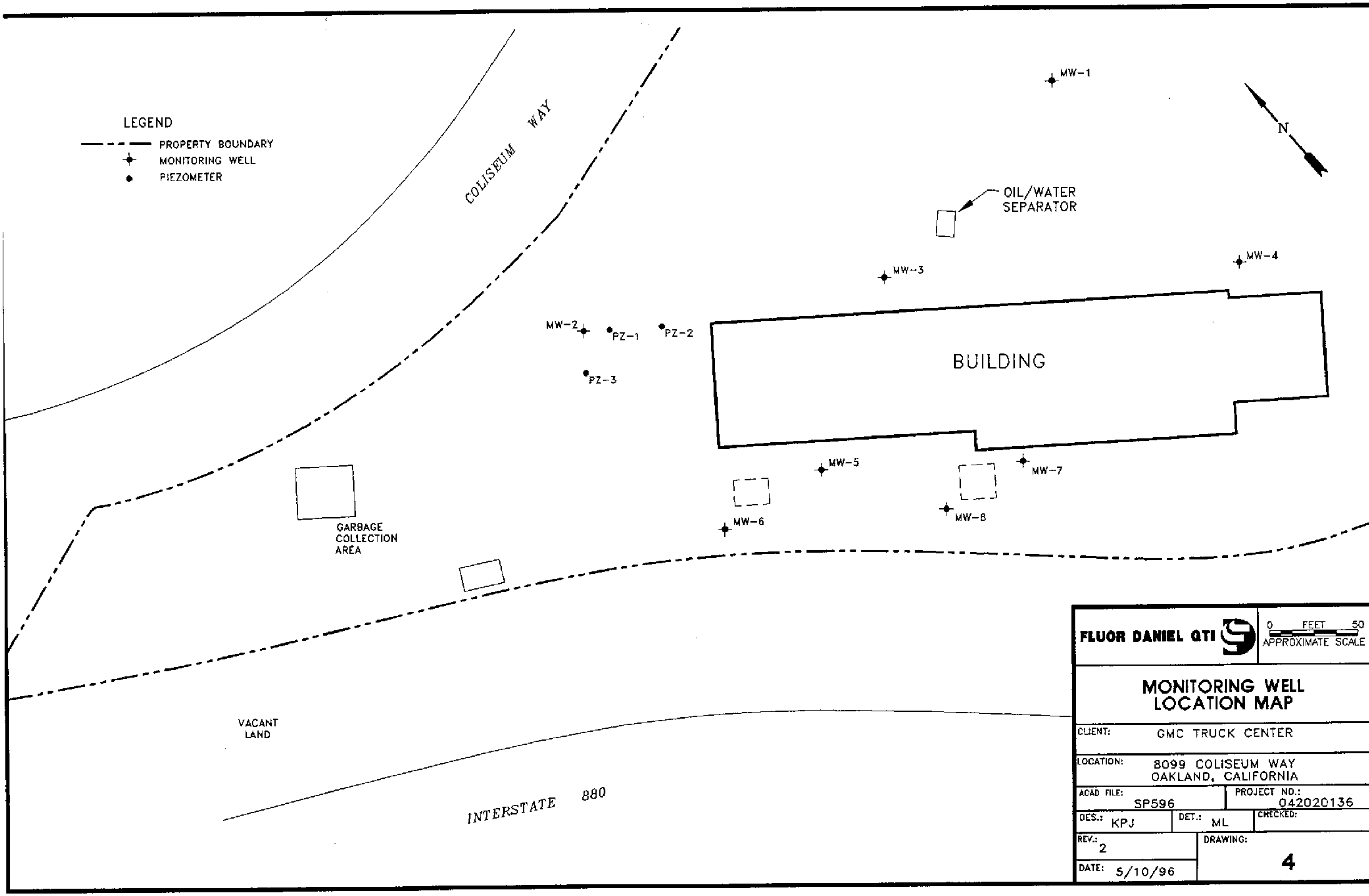
LOCATION: 8099 COLISEUM WAY OAKLAND, CALIFORNIA

ACAD FILE: SBLOC095 | PROJECT NO.: 042020136

DES.: | DET.: ML | CHECKED:

REV.: 2 | DRAWING: 3

DATE: 10/12/95




**FLUOR DANIEL GTI**

## MONITORING WELL LOCATION MAP

| | |
|---|---|
| CLIENT: | GMC TRUCK CENTER |
| LOCATION: | 8099 COLISEUM WAY OAKLAND, CALIFORNIA |
| ACAD FILE: SP596 | PROJECT NO.: 042020136 |
| DES.: KPJ | DET.: ML |
| CHECKED: | |
| REV.: 2 | DRAWING: 4 |
| DATE: 5/10/96 | |

## APPENDIX A

### Description of Model Used to Evaluate Volatilization of Chemicals from Soil into Buildings

Volatilization of chemicals into indoor air from soil may occur, thereby exposing individuals inside a building. Therefore, it is necessary to evaluate the potential risks associated with indoor air concentrations of chemicals as a result of vapor migration from impacted soils.

A volatilization model developed by Johnson and Ettinger (1991) was used to determine the soil concentrations at a site which would result in indoor concentrations of indicator chemicals

*Method Used in the Estimation of Indoor Air Concentration Resulting From Migration of Indicator Chemicals From Soil*

The volatility of a chemical largely determines the significance of this route of exposure. Indoor air concentrations of a chemical will be influenced by the physical and chemical properties of the substance, especially solubility and vapor pressure. Low aqueous solubilities and high vapor pressures increase the likelihood that organic compounds found in water will also be found in air (Roberts and Dandliker, 1983). Additionally, the physical properties of the soil can have a great influence on the rate of diffusion of chemicals through the soil. For example, the rate of diffusion of benzene through soil has been shown to be inversely proportional to the water content of the soil, and proportional to the square of the air filled porosity of the soil.

The model for estimating concentrations of chemicals in indoor air consists of four steps. These are: (1) estimation of chemical concentration in soil pore gas; (2) determination of effective diffusion coefficients in soil; (3) estimation of flow rate through the concrete foundation; and (4) determination of the concentration in indoor air. The model assumes: (1) diffusion and convection of vapors from soil through the foundation are the only contributors of chemicals to the air in a building; (2) indoor air exchange with the outside air is the only mechanism for dilution of chemicals in air in a building; (3) vapor concentrations in the building and in the soil pore spaces are at steady state and in equilibrium with a constant soil concentration; (4) there are no sources of chemicals to the building other than volatilization through the foundation; (5) diffusion, as quantified by diffusivity coefficients and concentration gradients, is equal in all directions (vertical and horizontal); and (6) all soil at a depth of four feet beneath the foundation of the building contains equal concentrations of the chemical.

STEP 1: Calculation of Soil Gas Concentration

This step is used to calculate the pore gas concentration of a chemical in a soil at the shallowest depth at which the chemical is present. Soil in the vadose zone is comprised of three components; soil particles, pore water, and pore gas. Each of these components comprises a fraction of the total soil volume. These fractions can be defined as follows. The porosity of a soil, $n$, is the fraction of the volume that is not taken up by soil particles. Thus, the fraction of the volume occupied by particles is equal to 1-$n$. The void volume is equivalent to the porosity times the total volume of the soil. This volume can be occupied by either pore gas or pore water. By using the laboratory measurement of moisture content, W, the water filled porosity, $n_w$, can be determined by the following equation:

$$n_w = \frac{P_b * W}{P_w} \qquad (1)$$

where:

$P_b$ = the bulk density of the soil

$P_w$ = the density of water

The air filled porosity, $n_a$, can then be determined as $n - n_w$, since the sum of air filled porosity and water filled porosity equals total porosity.

Based on fugacity, the escaping tendency of a chemical from a phase, a chemical in soil is distributed between the three soil components. Thus it can be present as 1) vapor in pore gas, 2) dissolved in pore water, and 3) sorbed to soil particles. The concentrations of the chemical in these phases can be different based on the partitioning characteristics of the chemical, and properties of the soil. The relationship between the volumes and concentrations of the phases and the total volume and concentration is:

$$C_t*P_b*V_t = C_a*V_t*n_a + C_w*V_t*n_w + C_p*P_p*V_t*(1-n) \qquad (2)$$

where:

$C_t$ = total concentration in soil (mass/mass)

$V_t$ = total volume of soil

$P_b$ = bulk density of soil

$C_a$ = total concentration in soil pore gas (mass/volume)

$C_w$ = total concentration in soil pore water (mass/volume)

$C_p$ = total concentration sorbed to soil particles (mass/mass)

$P_p$ = density of soil particles

This equation is written on a volume basis. Since the concentrations $C_t$ and $C_p$ are expressed on a mass basis, the terms $P_b$ and $P_p$ are required.

For diffusion of vapors from groundwater, the total concentration of chemical in the aquifer ($C_{taq}$) was substituted for the concentration of chemical in soil ($C_t$). To calculate the total concentration of chemical in the aquifer, $C_{taq}$, the following equation is used.

$$C_{taq} = \frac{C_{waq} * n_{aq} + C_{paq} * P_{paq} * (1-n_{aq})}{P_{baq}} \quad (3)$$

in which:

$C_{paq}$ = Concentration sorbed to aquifer particles
$C_{waq}$ = Concentration in aquifer water
$P_{paq}$ = Density of aquifer particles
$P_{baq}$ = Bulk density of aquifer material
$n_{aq}$ = Total porosity of aquifer

The concentration of chemical that is sorbed to the aquifer particles is determined by the following equation.

$$C_{paq} = C_{waq} * K_{daq} \quad (4)$$

in which the distribution coefficient of the aquifer ($K_{daq}$) is determined by the following equation.

$$K_{daq} = K_{oc} * f_{ocaq} \quad (5)$$

in which:

$K_{oc}$ = Organic carbon partition coefficient
$f_{ocaq}$ = Fraction organic carbon content of the aquifer

The concentrations in the pore water and the pore gas are related by the following equation.

$$C_w = \frac{C_a}{H} \quad (6)$$

in which H is the dimensionless Henry's Law Coefficient. In a similar manner the relationship between pore water concentration and sorbed concentration is described by the following equation.

$$C_p = K_d * C_w \quad (7)$$

where:

$K_d$ = soil distribution coefficient (L/kg) which is determined from:

$$K_d = K_{oc} * f_{oc} \tag{8}$$

in which:

$K_{oc}$ = organic carbon/water partition coefficient (L/kg)
$f_{oc}$ = fractional organic carbon content of the soil

Incorporating these relationships and those that describe the parameters $n_a$ and $n_w$ into equation (5) gives the following equation relating $C_t$ and $C_a$.

$$C_t * P_b = C_a * \left( n - \frac{P_b * W}{P_w} \right) + \frac{C_a}{H} * \left( \frac{P_b * W}{P_w} \right) + \frac{C_a}{H} * K_d * (1-n) * P_p \tag{9}$$

However, laboratory measurements of total soil concentrations will probably not include the quantification of the entire soil pore gas component. Thus the first term on the right hand side of Equation (9), representing the pore gas concentration, is conservatively assumed to be zero. Making this substitution and rearranging to solve for $C_a$ gives the equation:

$$C_a = \frac{C_t * P_b}{\frac{P_b * W}{H * P_w} + \frac{K_d * (1-n) * P_p}{H}} \tag{10}$$

**This equation calculates the pore gas concentration of a chemical in a soil from a laboratory measurement of total soil concentration of the chemical.**

STEP 2: Calculation of Effective Diffusion Coefficient

Diffusion coefficients describe the transport of a chemical in a media that is caused by the intermolecular collisions between molecules resulting from concentration gradients (Lyman, et al., 1990). In soil, diffusion can occur in both the pore gas and the pore water. Values of diffusion coefficients for a wide variety of chemicals in both air, $D_g$, and water, $D_l$, are available in the literature. However, the unadjusted use of these values for evaluating the diffusion of chemicals in soil is not recommended (Jury, et al., 1983). The reasoning for this is two-fold. First, diffusion in soil takes place only in the pore space. Thus, the area of flow is reduced and the effective distance traveled is increased. Second, when a chemical diffuses in soil it is subject to partitioning between the three phases as previously described. Thus, the diffusion is slower than if only one phase existed.

To account for the reduced flow in soil, the diffusion coefficients are multiplied by a tortuosity factor. This tortuosity factor has been defined by the Millington-Quirk model (Farmer, *et al.*, 1972). In this model, the fractional volume occupied by that matrix in the soil, raised to a power of 3.33, is divided by the total porosity, raised to a power of 2. Thus, the coefficient of diffusion in soil gas, $D_{sg}$, is defined by:

$$D_{sg} = \frac{n_a^{3.33}}{n^2} * D_g \quad (11)$$

and the coefficient of diffusion in pore water, $D_{sw}$, is defined by:

$$D_{sw} = \frac{n_w^{3.33}}{n^2} * D_l \quad (12)$$

Since diffusion can occur in both the pore water and the pore gas, and since chemicals partition into the three phases, an effective diffusion coefficient, $D_e$, has been defined by Jury, *et al.* (1983) which incorporates both $D_{sg}$ and $D_{sw}$:

$$D_e = \frac{H * D_{sg} + D_{sw}}{P_b * K_d + n_w + n_a * H} \quad (13)$$

STEP 3: Calculation of Emission Rate

The emission rate calculated by the Johnson and Ettinger (1991) model is based on both convective and diffusive transport mechanisms. To determine the relative significance of these two pathways, the dimensionless Peclet number, Pe, is determined by the equation:

$$Pe = \frac{k * \Delta P * L_d}{D_e * \mu * L_p} \quad (14)$$

where:

- k = permeability of the soil
- $\Delta P$ = pressure differential between soil and basement
- $L_D$ = distance from groundwater to basement floor
- $\mu$ = vapor viscosity
- $L_P$ = distance from basement floor to surface

If Pe is much greater than 1, convective transport is dominant, and if Pe is much less than 1, diffusive transport is dominant. For Pe values of close to 1, both transport mechanisms are important. For many volatile compounds the latter is usually the case.

Transport from the source through the soil pores will occur as the result of diffusion. Convective transport from the soil into the basement will occur only within a limited area surrounding cracks in the foundation. The flow rate of soil gas, $Q_s$, to these cracks is estimated based on an analytical solution to flow to a cylinder. By using the dimensions of the cracks as the dimensions of the cylinder, the following equation is obtained:

$$Q_s = \frac{2 * \pi * \Delta P * k * X_c}{\mu * \ln\left(\frac{2 * Z_c}{r_c}\right)} \tag{15}$$

where:

$X_c$ = total length of cracks
$Z_c$ = crack depth (foundation thickness)
$r_c$ = crack radius

STEP 4: Calculation of Indoor Concentration of Chemical

The concentration of chemical in the basement, $C_b$, is dependent on a number of factors, including the gas flow rate in the soil due to both diffusion and convection, the volume of the basement, and the ventilation rate of the basement. Johnson and Ettinger (1991) derive a steady state equation for soil gas transport by assuming that the flow rate of soil gas to the foundation must equal the flow rate through the foundation. This yields the equation:

$$= \frac{\frac{D_e * A_b * C_g}{Q_b * L_d} * \exp\left(\frac{Q_s * Z_c}{D_e * A_c}\right)}{\exp\left(\frac{Q_s * Z_c}{D_e * A_c}\right) + \frac{D_e * A_b}{Q_b * L_d} + \frac{D_e * A_b}{Q_s * L_d} * \left[\exp\left(\frac{Q_s * Z_c}{D_e * A_c}\right) - \right.} \tag{16}$$

where:

$A_b$ = basement area
$Q_b$ = basement ventilation rate
$A_c$ = crack area

in which $Q_b$ is the product of air exchange rate, E, and the basement volume $V_b$.

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## APPENDIX B

## CALCULATION OF SITE-SPECIFIC TARGET LEVEL FOR BENZENE IN SOIL

*GMC Truck Center - Oakland, CA*
**On-Site Future Industrial Receptor**
***Exposure Pathway: INHALATION OF VAPORS FROM SOIL***
***Calculation Endpoint: CONCENTRATION OF CHEMICAL IN PORE GAS***

## EQUATIONS

Pb = (1 - n) * Pp
Pf = Pb(1 + W)
nw = (Pf - Pp * (1 - n)) / Pw
Cg = (Ct * Pf)/(((Pf * W)/(H + Pw)) + ((Kd * (1 - n) * Pp)/H))

Cw = Cg/H
Kd = Koc * foc
Cp = Kd * Cw
na = n - nw

| SYMBOLS AND DESCRIPTION | UNITS | VALUES |
|---|---|---|
| n = Total porosity of soil | unitless | 0.33 |
| Pb = Soil bulk density | g soil/mL | 1.78 |
| Pf = Soil field density | g soil/mL | 2.02 |
| Pw = Density of water | g/mL | 1.00 |
| Pp = Density of soil particles | g/mL | 2.66 |
| na = Air filled porosity of soil | unitless | 0.09 |
| nw = Water filled porosity of soil | unitless | 0.24 |
| W = moisture content of soil | g water/g soil | 0.136 |
| H = Henry's Constant | dimensionless | see table 1 |
| Ct = Total concentration of chemical in soil | µg/kg | see table 1 |
| Koc = Organic carbon partition coefficient | L/kg | see table 1 |
| foc = Fraction organic carbon in soil | unitless | 0.0053 |
| Kd = Water:Soil partitioning coefficient | L/kg soil | see table 1 |
| Cw = Concentration in soil pore water | µg/L | see table 1 |
| Cp = Concentration sorbed to soil particles | µg/kg | see table 1 |
| Cg = Concentration in soil pore gas | µg/L | see table 1 |

Table 1

| Compounds | H | Koc | Kd | Ct | Cw | Cp | Cg |
|---|---|---|---|---|---|---|---|
| Benzene | 0.222 | 83 | 0.4399 | 29000 | 70398 | 30968 | 15628 |

## EQUATIONS

**Dsg = (na^3.33/n^2) * Da**
**Dsw = (nw^3.33/n^2) * Dl**
**De = (H * Dsg + Dsw)/(Pf * Kd * CF1 * CF2 + nw + na * H)**

| SYMBOLS AND DESCRIPTION | UNITS | VALUES |
|---|---|---|
| Da = Diffusion coefficient in air | cm^2/s | see table 2 |
| Dsg = Diffusion coefficient in soil gas | cm^2/s | see table 2 |
| Dl = Diffusion coefficient in water | cm^2/s | see table 2 |
| Dsw = Diffusion coefficient in soil water | cm^2/s | see table 2 |
| CF1 = Conversion Factor | mL/L | 1.00E+03 |
| CF2 = Conversion Factor | kg/g | 1.00E-03 |
| De = Effective diffusion coefficient | cm^2/s | see table 2 |

**Table 2**

| Compounds | Da | Dsg | Dl | Dsw | De |
|---|---|---|---|---|---|
| Benzene | 9.32E-02 | 2.58E-04 | 1.00E-05 | 8.19E-07 | 5.0E-05 |

*GMC Truck Center - Oakland, CA*
**On-Site Future Industrial Receptor**
***Exposure Pathway: INHALATION OF VAPORS FROM SOIL***
***Calculation Endpoints: PECLET NUMBER, FLOW RATE OF SOIL GAS INTO BUILDING, and BUILDING VENTILATION RATE***

## EQUATIONS

Pe = k * dP * Ld/(De * μ * Lp)
ñ = Ac/Ab
rc = ñ * Ab/Xc
Qs = (2 * ¶ * dP * k * Xc)/(μ * ln(2 * Zc/rc))
Qb = Vb * E * CF3

| SYMBOLS AND DESCRIPTION | UNITS | VALUES |
|---|---|---|
| k = Soil permeability | cm^2 | 1.00E-13 |
| dP = Pressure differential indoor/outdoor | g/cm-s^2 | 10 |
| Ld = Distance from source to building floor | cm | 60 |
| Lp = Distance from building floor to surface | cm | 30 |
| De = Effective diffusion coefficient | cm^2/s | see table 3 |
| μ = Vapor viscosity | g/cm-s | 0.00018 |
| Pe = Peclet number | unitless | see table 3 |
| Ab = Area of building | cm^2 | 63754711 |
| Ac = Area of cracks | cm^2 | 63755 |
| ñ = Crack fraction | unitless | 0.001 |
| Xc = Crack length | cm | 5500 |
| rc = Crack radius | cm | 11.59 |
| Zc = Crack depth | cm | 30 |
| Qs = Soil gas flow rate | cm^3/s | 1.2E-04 |
| Vb = Volume of Building | cm^3 | 1.94E+10 |
| E = Air Exchange rate | 1/hour | 2 |
| CF3 = Conversion factor 3 | hour/s | 2.78E-04 |
| Qb = Ventilation Rate of building | cm^3/s | 1.1E+07 |

**Table 3**

| Compounds | De | Pe |
|---|---|---|
| Benzene | 5.04E-05 | 2.2E-04 |

*GMC Truck Center - Oakland, CA*

**On-Site Future Industrial Receptor**

***Exposure Pathway:* *INHALATION OF VAPORS FROM SOIL***

***Calculation Endpoints:* *INDOOR CONCENTRATIONS OF CHEMICAL VAPORS and HAZARD INDEX FOR INHALATION OF CHEMICAL VAPORS***

## EQUATIONS

$$Cb = \frac{De*Ab*Cg/(Qb*Ld)*\exp(Qs*Zc/(De*Ac))}{\exp(Qs*Zc/(De*Ac)) + De*Ab/(Qb*Ld) + De*Ab/(Qs*Ld)*(\exp(Qs*Zc/(De*Ac))-1)}$$

ADD = Ca * IR * AC * EH * ED * EY * 1/ATn * CF3 * CF4 * 1/BW

HI = ADD/RfD

LADD = Ca * IR * AC * EH * ED * EY * 1/ATc * CF3 * CF4 * 1/BW

RISK = LADD * CSF

| SYMBOLS AND DESCRIPTIONS | UNITS | VALUES |
|---|---|---|
| Cb = Chemical concentration in building | μg/L | see table 4 |
| IR = Human inhalation rate | m^3/hour | 2.5 |
| AC = Absorption coefficient | unitless | see table 4 |
| EH = Exposure duration | hours/day | 8 |
| ED = Exposure duration | days/year | 240 |
| EY = Exposure duration | years | 25 |
| ATc = Averaging Time (carcinogens) | days | 25550 |
| BW = Body weight | kg | 70 |
| CF3 = Conversion factor | L/m^3 | 1000 |
| CF4 = Conversion factor | mg/μg | 0.001 |
| LADD = Lifetime Average Daily Dose | mg/kg-day | see table 4 |
| CSF = Cancer Slope Factor | kg-day/mg | see table 4 |
| RISK = Incremental Carcinogenic Risk | unitless | see table 4 |

Table 4

| Compounds | Cb | AC | LADD | CSF | RISK |
|---|---|---|---|---|---|
| Benzene | 1.55E-04 | 1 | 1.04E-05 | 0.1 | 1.0E-06 |