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June 23, 1999

Mr. Barney M. Chan
Alameda County
Department of Environmental Health
1131 Harbor Bay Parkway, Suite 250
Alameda, CA 94502-6577

Subject: Tony's Express Auto Services
3609 International Boulevard, Oakland, California
(formerly 3609 E. 14th Street)

Dear Mr. Chan:

Enclosed for you review is SOMA's report entitled "Further Site Characterization and Conducting Risk Based Corrective Action" at the subject site.

Thank you for your time in reviewing this report. I am looking forward to our meeting next week. Meanwhile, if you have any questions, please call me at (925) 244-6600.

Sincerely,

Mansour Sepehr, Ph.D.,P.E.
Principal Hydrogeologist

MS/jb

Enclosure

cc: Mr. Abolghassem Razi

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FURTHER SITE CHARACTERIZATION AND CONDUCTING RISK BASED CORRECTIVE ACTION AT TONY'S EXPRESS AUTO SERVICES SITE 3609 INTERNATIONAL BOULEVARD OAKLAND, CALIFORNIA

June 21, 1999

Project No. 99-2330

Prepared for

Tony's Express Auto Services
3609 International Boulevard
Oakland, California

Prepared by

SOMA Environmental Engineering, Inc.
2680 Bishop Drive, Suite 203
San Ramon, California

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EXECUTIVE SUMMARY

SOMA Environmental Engineering, Inc. on behalf of Mr. Abolghassem Razi, the owner of the site has prepared this report. The site is known as Tony's Express Auto Services located at 3609 International Boulevard, Oakland, California. This report has been prepared based on the Alameda County Environmental Health Services (ACEHS) approved work plan dated April 21, 1999.

The site is located at the southeast corner of the intersection 36th Avenue and International Boulevard formerly known as East 14th Street, Oakland, California, (the "Site") see Figure 1. It is currently used as a gasoline service station and mechanic shop. The Site is relatively flat, and the surrounding properties are primarily commercial businesses and residential housing. Figure 2 shows the location of the main building, fuel tank areas, on and off-site groundwater monitoring wells. Currently, the groundwater monitoring wells are being monitored on a quarterly basis. The results of the groundwater monitoring program have indicated elevated levels of petroleum hydrocarbons in groundwater beneath the Site. The source of petroleum hydrocarbons in the groundwater is believed to be the former underground storage tanks (USTs), which were used to store gasoline at the Site.

The purpose of this investigation was to:

1. Compile existing soil and groundwater data, and produce 3-D plots of current soil and groundwater contamination in order to estimate the total mass of petroleum chemicals in soil and groundwater;
2. Evaluate the horizontal extent of groundwater chemical plumes by conducting additional site investigation including the installation of one groundwater monitoring well down-gradient from the Site; and conducting hydraulic testing and;

3. Re-evaluate the site's regulatory status (i.e., high risk or low risk) by conducting groundwater flow and chemical transport modeling and risk based corrective action (RBCA) studies.

The proposed off-site groundwater monitoring well which was supposed to be installed in the south of MW-10 and MW-11 within the Bay Area Rapid Transit (BART) property was not installed. This was due to the lengthy process of acquiring necessary permit from the BART authority.

ASTM-RBCA (E1739-95 Standard) Tier I and Tier II study was conducted to develop the site-specific target levels (SSTLs) of chemicals in order to compare them with the current chemical concentration in groundwater. The future extent of chemical plumes in groundwater was estimated using U.S. Geological Survey 3-Dimensional Modular Groundwater Flow Model (MODFLOW) combined with a 3-Dimensional Modular Transport (MT-3D) Model developed by Zheng (1998).

Based on the results of our investigation, data review, risk assessment and fate transport modeling and according to the Regional Water Board Supplemental Instructions dated December 8, 1995 the site does not fit to the "Low-Risk" Petroleum Release Site Category for the following reasons:

1) The source of petroleum hydrocarbons has not completely been removed. As our evaluation indicated still over 2,265 pounds of petroleum hydrocarbons exist beneath the Site. Considerable amounts of residual NAPL may still be present in both saturated and unsaturated soils;

2) Significant amounts of petroleum hydrocarbons has been released into the groundwater, as a result the beneficial use of water has already been impacted;

3) The results of the chemical transport modeling indicated that the existing plume of chemicals in the groundwater is an expanding plume (some of the

groundwater monitoring wells show an increasing trend) and continues to migrate down-gradient;

4) Historical benzene concentration in on-site and off-site groundwater monitoring wells indicate that during recent years the concentration of benzene, in certain groundwater monitoring wells, has been increased dramatically and still show an increasing trend; and

5) Based on the results of the ASTM-RBCA study, under the current and future conditions the site poses a significant health risk to the on-site workers as well as the off-site residents via inhalation of vapors in indoor air. The results of our evaluation indicates that the current soil and groundwater benzene concentrations are about two orders of magnitude greater than the calculated site specific target levels.

Based on our evaluation the soil and groundwater beneath the site should be remediated to prevent any further migration of the chemicals to off-site areas and to protect current and probable future human health and beneficial uses of groundwater. The results of groundwater flow and chemical transport modeling indicated that installation of French drain behind the store/mechanic shop building could effectively remove groundwater contaminants and act as an effective barrier for preventing further migration of Site related chemicals to off-site areas.

1.O INTRODUCTION

This report has been prepared by SOMA Environmental Engineering, Inc. (SOMA) on behalf of Mr. Abolghassem Razi, the owner of the Tony's Express Auto Services, located at 3609 International Boulevard, Oakland, California, see Figure 1.

The recent investigation by SOMA was conducted based on the approved Workplan by the Alameda County Environmental Health Services (ACEHS). The objective of SOMA's recent investigation was to develop a database using the results of the recent and previous site investigations to evaluate the total mass of hydrocarbons beneath the Site, conduct an additional field investigation and perform a risk based corrective action (RBCA) study at the project Site. In addition, SOMA hired Environmental Data Resources, Inc (EDR) of Southport, Connecticut to conduct a database search and locate hazardous waste sites, drinking water wells and other sensitive receptors within a one-mile radius from the Site. The current report will utilize the database, results of our current field activities and information supplied by EDR to conduct a risk based corrective action (RBCA) using American Society for Testing Material (ASTM) RBCA guidelines. The results of Tier I and Tier II ASTM-RBCA evaluation will reveal the risk-based screening levels (RBSLs) and the site-specific target levels (SSTLs) of soil and groundwater that is protective of human health and environment.

1.1 Site Physical Setting

The Site is relatively flat and located at the southeast corner of International Boulevard and 36th Street, see Figure 2. The Site is bound by International Boulevard to the north, 36th Street to the west, the Las Bougainvilleas (LB) residential facility, 12th Street and BART Station parking lot to the south.

Currently, the Site and the surrounding land are zoned for a neighborhood center mixed use and mixed housing type residential purposes. The Site is expected to remain for the neighborhood center mixed use in the future. Immediately down-gradient from the Site, in the groundwater flow direction, LB residential facility is located. Figure 3 presents the existing zoning at the Site and the surrounding land use type.

Groundwater beneath the Site is flowing from north to the southwesterly direction. Based on the recent groundwater monitoring report (SOMA, June,1999) the total dissolved solid concentration (TDS) of groundwater beneath the Site is less than 3,000 mg/l. As the available data indicate, the specific conductance of groundwater ranges between 550 to 950 µmho/cm, which is roughly equivalent to 350 and 600 mg/l respectively. Based on the SOMA pumping test results, the groundwater wells can potentially produce more than 200 gallons per day. Therefore, based on State Water Board Resolution 88-63, the groundwater beneath the Site can potentially be used for drinking water purposes. However, currently no drinking water well is exclusively utilizing drinking water from the shallow water-bearing zone beneath the Site. According to the EDR report, the closest public water supply (PWS) well is located 1.28 mile west of the Site, EDR (1999). No irrigation or domestic water wells have been reported in the immediate vicinity of the Site, see Appendix D.

2.0 Site Characterization

2.1 Previous Site Investigations

Currently, the Site is used as a gasoline service station. The environmental investigation at the subject property started since 1992, when Mr. Razi, the property owner retained Soil Tech Engineering, Inc. (STE) of San Jose to conduct a limited subsurface investigation. The purpose of STE investigation was to determine whether or not the soil near the product lines and underground storage tanks (USTs) had been impacted by the petroleum hydrocarbons. STE drilled six soil borings to a depth of 15 feet below the ground (bgs). The results of this investigation revealed elevated levels of petroleum hydrocarbons as TPH-g (up to 460 mg/kg) and detectable levels of benzene, toluene, ethylbenzene and xylenes (BTEX) in soil samples.

In July 1993, STE removed one- single-walled 10,000-gallon gasoline tank and one single-walled 6,000-gallon gasoline tank along with a 550-gallon waste oil tank from the Site. These tanks were replaced with similar sized double-walled USTs. **Currently, there is one-10,000 gallon double-walled gasoline tank and two-6,000 gallon double-walled gasoline tanks beneath the Site.** During USTs upgrade, STE collected soil samples from the bottom and side-walls of excavated pits at 12 and 7 feet depths as well as underneath the piping area and analyzed for TPH-g and BTEX. The results of laboratory analysis on soil samples collected from the bottom of the excavation showed up to 460 mg/kg TPH-g. However, the samples collected below the piping showed elevated levels of TPH-g (up to 4,100 mg/kg).

Due to the presence of elevated levels of TPH-g, ACEHS requested a work plan for subsurface investigation. In August 1993, STE drilled thirteen soil borings and converted three of them into groundwater monitoring wells of MW-1, MW-2 and MW-3. To allow for future in-situ remediation of impacted soils, STE drilled four vertical 6-inch diameter soil vapor extraction probes. In addition, two horizontal perforated pipes were installed connecting four soil borings together through a manifold. The manifold was connected to a vault in front of the northeast corner of the mechanic shop building.

In August 1995, STE installed five additional groundwater monitoring wells (MW-4 through MW-8). In August 1996, STE conducted additional site characterization activities. During this period, STE drilled five soil borings and converted three of them to groundwater monitoring wells of MW-9 through MW-11.

In December 1997, Mr. Razi retained Western Geo-Engineers (WEGE) to conduct additional investigation including a slug test and risk based corrective action (RBCA) using groundwater monitoring data. The results of slug tests conducted by WEGE indicated that hydraulic conductivity of the saturated sediment ranges between 0.4 and 10.4 feet per day. The results of hydraulic conductivity measurement conducted by WEGE contradict the lithologic logs of groundwater monitoring wells prepared by STE. As the lithologic logs of the groundwater monitoring wells indicate, the saturated sediments beneath the Site is primarily comprised of fine-grained sediments of silty clay.

Reviewing the RBCA report conducted by WEGE, indicated that assumptions made by WEGE is unrealistic and does not support the actual conditions at the Site. For instance, using the shallow groundwater beneath the Site by the future Site's workers and the nearby residents as a drinking water source is unrealistic. From the other hand, the study does not consider the indoor air concentration for the current and future off-site residents as an exposure media. As results of the report offer minimal information to the reader, the results cannot be used as a decision-making tool.

Since December 1997, Mr. Razi has retained WEGE to conduct groundwater monitoring on a quarterly basis. Today after almost 6-years of monitoring and site investigation the plume of groundwater contaminants are reportedly migrating to off-sites and impacting the nearby residents. Among the chemicals of potential concern are benzene and MTBE, which reportedly have migrated beyond the property's boundary.

2.2 Site Hydrogeology

Based on the available data, the groundwater beneath the Site is unconfined and occurs between 7 and 11.6 feet in on- and off-site areas. Historical water level elevations at different groundwater monitoring wells have been presented in the groundwater monitoring reports (SOMA 1999). The groundwater elevation contour map (based on the June 1999 groundwater-monitoring event) is presented in Figure 4. As Figure 4 indicates, groundwater flows from the north to southwest with an average gradient of 0.01 ft/ft. Results of recent pumping test conducted by SOMA indicate that hydraulic conductivity of the shallow saturated material beneath the Site ranges from 2 to 18 feet per day. The measured value of hydraulic conductivity of saturated material does not correlate with the type of aquifer materials, encountered during drilling of the groundwater monitoring wells by STE. Based on the lithological logs of groundwater monitoring wells, the saturated sediments beneath the Site are primarily composed of fined grained (silty clay) sediments. Using Darcy's Law, groundwater actual velocity ranges between 21 to 188 feet per year (by assuming that the effective porosity of saturated sediments is 0.35).

2.4 Nature and Extent of Groundwater Contamination

Since October 1994, groundwater samples have been collected from the groundwater monitoring wells and analyzed on a quarterly basis for the presence of BTEX and TPH. Since December 1998, the MTBE has also been included in the laboratory analysis. The results of the laboratory analysis for different chemicals at different groundwater monitoring events have been presented in Appendix C. Appendix C also presents the statistical information such as average, standard deviation and 95 percent upper confidence limit (95% UCL) of each contaminant at a given groundwater monitoring well location.

Reviewing the historical water quality data collected in on-site monitoring wells of MW-2, MW-3, MW-6 and MW-8 shows an increasing trend of benzene concentrations. An off-site groundwater monitoring well MW-10 also shows an increasing pattern of benzene concentration. In the latest groundwater-sampling event (March 1999) benzene was detected at 4,100 ppb in MW-3 (WEGE, March 1999). Benzene at a maximum concentration of 190,000 ppb has been reported in a groundwater sample collected at MW-3 in October 1994. MW-3 is an on-site well and located in close proximity of the store/mechanic shop building. Figures 5 through 9 present the historical benzene concentrations in the groundwater monitoring wells of MW-2, MW-3, MW-6, MW-8, and MW-10 respectively.

Since December 1998, groundwater samples also have been analyzed for MTBE. The results of the laboratory analysis indicate that the concentration of MTBE ranges between non-detect and 2,800 ppb. The maximum concentration of MTBE was detected in the off-site groundwater monitoring well MW-10. The higher concentration of MTBE in the off-site area may suggest presence of an additional source of MTBE down-gradient from the Site.

Appendix C presents the historical concentration of MTBE, benzene, toluene, ethylbenzene, xylenes and TPH-g at different groundwater monitoring wells in on- and off-site areas.

2.4 Nature and Extent of Soil Contamination

The majority of soil chemical data belongs to 1993, when STE conducted an extensive soil and groundwater investigation beneath the Site. The presence of petroleum hydrocarbons is limited to the on-site areas where the release of petroleum hydrocarbons occurred. Appendix C contains available soil chemical data in tabulated form. **Appendix C also presents the 95% UCL concentrations of BTEX and TPHg, which were used in calculating the mass of chemicals beneath the Site.**

A review of the soil analytical results from samples taken at each on-site soil boring from different depths show that the maximum concentration of chemicals were detected in samples collected from the borings located closest to the underground tank pad, (B1, B-3, B-6, B-7 and B-11), see Figure 10. The maximum concentration of TPH-g at 1,800 mg/kg was detected in a soil sample taken from B-6 at a depth of 14 feet. The highest TPH-g concentrations were typically found at depths ranging from 10 feet to 14 feet bgs.

The maximum concentration of benzene was found at 11 mg/kg in a soil sample collected from soil boring B-6 at 14 feet depth where the maximum concentration of TPH-g was reported. The concentration of benzene ranged between non-detect to 11 mg/kg and generally detected at 10 to 14 feet depths. No soil samples were analyzed for MTBE.

2.5 Estimation of the Total Mass of Petroleum Beneath the Site

The following describes the methodology used to calculate the total mass of petroleum hydrocarbon in soil and groundwater in on and off-site areas.

2.5.1 Estimation of Petroleum Mass in Soils and Sediments

To calculate the chemical mass present in soil, the chemical concentrations detected at different depth intervals reported by the previous investigations were utilized. Using the soil data, it was assumed that soil concentrations of BTEX and TPHg since 1993 have not been changed. We realize that this is a conservative assumption, because biodegradation, volatilization and leaching processes more likely have reduced the soil concentration since 1993.

Using the previous soil chemical data along with x and y coordinates of the soil sampling locations, three-dimensional contour plots of TPHg, BTEX were developed. The three-dimensional contour plots depicting the concentrations of TPHg and BTEX in soil are presented in Figures 11 through 15. Using this Site specific data and three-dimensional concentration contours, the volume of petroleum impacted soils and sediments were calculated as follows:

1. The soil volume at each contour interval was calculated using the Department of Defense Groundwater modeling system (GMS) package developed by the Engineering Computer Graphics Laboratory of Brigham Young University in partnership with the U.S. Army Engineer Waterways Experiment Station.

2. Using the site-specific soil bulk density data the mass of soil at each given contour interval was calculated;

3. The mass of petroleum hydrocarbon was estimated by multiplying the estimated mass of soil by the average soil concentration bound between two consecutive contour interval;

4. The total mass of petroleum hydrocarbons in soil was calculated by adding the estimated mass at each contour interval. Table 1 presents the data and total calculated TPH-g in the vadose zone.

2.5.2 Calculation of Petroleum Mass in Groundwater

Chemicals in the groundwater are either in a dissolved phase or adsorbed phase. To calculate the total mass of chemical (dissolved or adsorbed phase) the 95% UCL concentration of each chemical at different monitoring wells was utilized. The calculations were conducted using the following steps:

1. A grid of 20 x 20 feet with 24 rows and 10 columns were overlaid at the top of the Site's base map.

2. Using the linear interpolation routine and utilizing 95% UCL concentration of each chemical at the groundwater monitoring location, the

concentration of TPHg and MTBE were calculated at the center of each grid cell.

3. Based on the lithologic logs, it was assumed that the saturated thickness of the water bearing formation is approximately 20 feet. Using porosity value of 0.35 (literature value, Freeze and Cherry, 1979) as a representative porosity value for silty clay sediments, the volume of the water at each grid cell was estimated by multiplying the grid dimensions (20ft. x 20ft.) and thickness of the saturated sediments (20ft.) by the soil porosity (0.35).

4. Total mass of each chemical at any given cell was calculated by multiplying its estimated concentration by volume of water and its retardation coefficient. The calculated retardation coefficient of each chemical has been presented in Table A1-2 of Appendix A. Multiplying by retardation coefficient takes into account the absorbed mass as well as the dissolved mass of any given chemical in groundwater. The overall retardation coefficient of TPH-g is assumed to be 6. It should be noted that the heavier components of petroleum products might have a higher retardation coefficient. However, the lighter components such as BTEX have lower retardation coefficients than 6. Therefore, the average value of retardation coefficient for TPH-g was assumed to be 6.

The total mass of hydrocarbons was estimated by adding the calculated total mass of soil and groundwater. Table 2 shows the estimated total mass of TPH-g and MTBE in saturated sediments in on- and off-site areas.

Appendix F shows the methodology used in estimating the total mass of hydrocarbons (TPH-g) and MTBE in groundwater in on- and off-site areas.

2.6 Additional Site Investigation

To evaluate hydraulic conductivity of saturated sediments, a pumping test was also conducted. Using the results of the pumping test, a groundwater flow and chemical transport modeling was performed.

2.6.1 Conducting Pumping Test

On May 27, 1999 a pumping test was conducted on MW-3 to evaluate the hydraulic conductivity of saturated sediments beneath the Site. The hydraulic conductivity of the saturated sediments plays a major role in simulation of chemical transport, and designing a remedial system for aquifer restoration. The pumping test was conducted on MW-3 while the groundwater monitoring wells of MW-1, MW-2, MW-6 and MW-7 were used as the observation wells. Appendix B includes a detailed description of procedure, analysis technique and results of the pumping test. The result of the pumping test was used in conducting groundwater flow and chemical transport modeling.

2.7 Conducting Groundwater Flow and Chemical Transport Modeling

Groundwater flow and chemical transport modeling was conducted to evaluate the groundwater flow condition beneath the Site in order to design a groundwater extraction system for aquifer restoration. Chemical transport modeling was conducted to simulate the future extent of present groundwater chemical plume under ambient conditions as well as different management alternatives. In conducting chemical transport modeling two scenarios were utilized, The first scenario was a no-action alternative, while the second alternative was installation of a French drain to capture chemical plume. To evaluate the groundwater flow conditions and designing a groundwater extraction system, the U.S. Geological Survey Three-Dimensional Groundwater Flow Model of MODFLOW was utilized. To simulate the future extent of groundwater chemical plumes under no-action and pumping scenarios using a French drain, the Three Dimensional Modular Transport Model (MT-3D) of Zheng (1998) was utilized. The results of chemical transport modeling were used to evaluate whether or not the chemical plumes beneath the Site will expand during the next 30 years. Appendix A presents a detailed description of methodology, assumptions and results of groundwater flow and chemical transport modeling.

The results of the chemical transport modeling were also used in defining site regulatory status and to evaluate whether or not the Site can be categorized as a low risk site using the State Water Board Interim Guidance Document guidelines.

3.0 Risk Based Corrective Action (RBCA)

The purpose of this RBCA is to provide a site specific-target levels of concentration of chemicals beyond which a potential adverse health effects may result from exposure to contaminants (BTEX and MTBE) in soil and groundwater beneath the on- and off-site areas.

3.1 Conceptual Site Model (CSM)

The conceptual model developed for the Site is based on the results of previous and recent Site investigations. The CSM synthesizes site characterization data (geology, hydrogeology, contaminant distribution, migration pathways and potential human receptors) to provide a framework for selecting pathways for quantitative analysis in conducting ASTM-RBCA analysis. The CSM is shown graphically in Figure 16.

The primary source of chemical contamination is identified at the point of release of gasoline from the on-site underground storage tanks. Secondary sources of contamination include the dissolved groundwater plume, affected subsurface soils and saturated sediments. Potential transport mechanisms from subsurface soils are by volatilization and atmospheric dispersion. Potential transport mechanisms from dissolved water plume are by volatilization and entering into the closed spaces. The chemicals of concern (COC) such as BTEX and MTBE, detected in groundwater can volatilize and travel by diffusion toward the land surface and enter into commercial buildings or ambient air. At these exposure points, they may cause adverse health effects to the commercial/construction workers via exposure route of inhalation. Presently the on-site store, the mechanic shop and down-gradient LB residential units have been identified as the points of exposure (POE). The full time store, mechanic shop workers and future residents at LB (adult and child) have been evaluated as the receptors to potential exposure from the Site's contaminants. An exposure duration of ten years has been assumed for the LB residents.

Soil and saturated sediments may serve as a secondary source of contamination to future construction workers. There is a potential threat to the future construction workers that may be exposed to the COCs present in wet soils in the saturated zone or by direct exposure to groundwater, if the soil is excavated to depths below the water table. The COCs in the wet soils will come in contact with construction workers through exposure routes of volatilization, incidental ingestion and dermal contact. The chemicals in the freely exposed groundwater will come in contact with the construction workers through the exposure route of volatilization and dermal contact.

Reportedly, a public water supply well is located within 1.28-mile from the Site in a westerly direction from the Site, EDR (1999), see Appendix D. However, it is highly unlikely that in the conceivable future the Site related contaminant would reach to the public water supply well.

3.2 Identification of Exposure Pathways and Potential Receptors

Based on our evaluation as we discussed in section 2.5.1 and 2.5.2, currently there is about 511 kilogram (1,127 pounds) of petroleum hydrocarbons in vadose zone beneath the Site. Based on SOMA evaluations there is also 516 kilograms (1,139 pounds) of petroleum hydrocarbons in dissolved and adsorbed phases in the saturated sediments in on- and off-site areas. The estimated mass of MTBE and benzene in dissolved and adsorbed phases in saturated sediments are 17 and 28 pounds respectively. According to the CSM (see Figure 16), the exposed population/receptors to the on- and off-site contaminants are:

1. Current on-site retail/mechanic shop workers
2. Current off-site full time LB residents
3. Future off-site residents (see site's zoning map, Figure 3)

For the off-site receptors the only source of chemicals is the contaminated groundwater. For the on-site office/mechanic shop workers, both the contaminated soil and groundwater are the source of chemicals. It appears that the only exposure pathway at off-site areas is the inhalation of volatile emissions from groundwater. A hypothetical worker was therefore evaluated with potential exposure to the on-site contaminants from inhalation of volatile emissions from soil and groundwater. In addition, a construction worker scenario was also assumed in the RBCA evaluation.

3.2 Exposure Point Concentrations

Appendix C includes soil and historical groundwater chemical data. The 95 percent upper confidence limit (95% UCL) concentration of chemicals at on- and off-site areas were used as a representative of the current exposure point concentrations in groundwater in on- and off-site areas. The 95% UCL concentration of chemicals in on-site soil borings was also used as the representative of the chemical concentrations for on-site soils. Off-site soils were assumed to be clean.

U.S. Geological Survey 3-Dimensional Groundwater Flow Model (MODFLOW) (1988) in combination with Modular 3-Dimensional Transport Model (MT-3D) of Zheng (1998) was used to conduct chemical transport modeling in on- and off-site areas. The chemical transport modeling was conducted to simulate the future groundwater chemical concentration down-gradient from the site.

However, it is anticipated that under ambient conditions (no groundwater remediation, i.e., pump and treat) the plume of chemicals will pass through the LB facility in the near future. Appendix A presents a detailed description of the modeling study, the simulated results and the model output.

3.3 Calculation of Risk Based Screening Levels

To evaluate the RBSL in soil and groundwater, ASTM-RBCA model was utilized. RBCA is an Excel spreadsheet model designed to perform risk-based corrective action calculations for selected exposure pathways. SOMA compiled critical information regarding source conditions (soil and groundwater chemical data and parameters), exposure pathways, transport mechanisms and potential receptors to the RBCA spreadsheet. The evaluation was conducted in two different steps; the first step involved using default soil, groundwater and exposure parameters to evaluate risk-based screening levels (RBSLs). The second step involved using site-specific parameters to calculate site-specific target levels (SSTLs). The first step is called Tier I and the second step is called Tier II analysis, respectively.

3.4 Tier I Analysis

RBSLs evaluation was performed based on the exposure pathways identified in the CSM. To evaluate the RBSLs, the ASTM-RBCA model was run using generic and default soil, groundwater and exposure parameters. The default soil, groundwater and exposure parameters used in Tier I analysis are presented in Table-3. The Tier I analysis also takes into account the construction worker whom may be exposed to the Site's contaminants via inhalation, ingestion and dermal contact. In conducting Tier I analysis the following scenarios were considered:

1. Soil and groundwater RBSLs were calculated for the on-site assuming that the on-site retail/mechanic shop workers will be exposed to the Site's contaminants in soil and groundwater through the inhalation of the indoor air.

2. Groundwater RBSLs was calculated for the off-site assuming that the LB residents will be exposed to groundwater contaminants through the inhalation of the indoor air.

All parameters used for RBSL calculations were based on the conservative assumptions. The exposure duration for the LB residents was assumed to be 365 days per year for the next 30 years. An accepted target risk value (defined by US EPA) of $1X10^{-6}$ was used.

Conservative values for soil parameters were assumed in modeling the soil-to-air volatilization. The soil parameters include physical soil properties and the dimensions of the affected soil zone. Table-3 presents the conservative input values in conducting Tier I analysis.

3.5 Tier II Analysis

Tier II is a special analysis to determine the Site Specific Target Levels (SSTLs). Generally, SSTL values will result in significantly higher cleanup levels (lower remediation costs) than the RBSL values calculated in Tier I. To determine SSTL values, SOMA compiled and collected additional site data as needed to identify site specific parameters for soil and groundwater. The Tier II goals are consistent with US EPA recommended practices.

In general, the Tier II analysis is almost similar to the Tier I analysis. The only difference between the Tier II and the Tier I analysis is using the site-specific soil, groundwater and exposure parameters. In conducting Tier II the same scenarios as discussed previously were considered. These scenarios included:

1. Soil and groundwater SSTLs were calculated for the on-site assuming that the on-site retail/mechanic shop workers will be exposed to the Site's contaminants through the inhalation of the indoor air.

2. Groundwater SSTLs were calculated for the off-site assuming that the LB residents (child and adult) will live in the facility (24 hours a day) and will be exposed to groundwater contaminants through the inhalation of the indoor air, for an exposure duration of 10 years.

All parameters used for SSTLs calculations were based on site-specific parameters. The exposure duration for the residing LB was determined to be 365 days per year for the next 10 years. A 10-year residing period in LB was assumed to be a reasonable period of time for an adult individual who is living in that facility. An accepted target risk value (defined by the US EPA) of $1X10^{-6}$ was used. During this time, the complete exposure pathway of the residential employee was assumed to be inhalation of volatile organic compounds (VOCs) from groundwater through the diffusion process into the indoor and outdoor air. **Table 4 and 5 present the site-specific input values used in conducting Tier II** analysis.

3.6 Comparison of RBSLs and SSTLs with Site Contaminants Levels

The calculated RBSLs are the threshold concentrations of chemicals in soil and groundwater beyond which the adverse health effects can be expected in the exposed population. Generally, if the observed soil and groundwater chemical concentrations become less than calculated RBSLs, no soil or groundwater remediation is required. However, due to the conservative nature of the involved assumptions in calculation of RBSLs, if the observed soil or groundwater chemical concentration exceeds the RBSLs the soil and or groundwater remediation is not necessarily required. To better define the soil and groundwater cleanup levels, a more refined RBSLs values through Tier II analysis was conducted. The refinement was achieved by using the site-specific soil, groundwater and exposure parameters. The calculated clean-up levels using the Tier II analysis is called site-specific target levels (SSTLs). The calculated SSTLs are considered to be protective of human life and environment. In order to decide if the present and future chemical concentration in soil and groundwater beneath the Site are protective of the human health, they were compared against the calculated RBSLs and SSTLs. Table-6 presents such comparison and indicates whether or not the soil and groundwater remediation beneath the Site is warranted.

4.0 Results

The results of the SOMA investigation indicates that still significant amounts of petroleum hydrocarbons in soil and groundwater in on- and off-site areas exists. The remaining petroleum hydrocarbons in the vadose zone and saturated sediments acts as a large reservoir and will maintain a high concentration of petroleum constituents such as BTEX and MTBE in groundwater for a long period of time. The total estimated petroleum hydrocarbons (TPH-g) in soil and groundwater beneath the Site is about 2,265 pounds.

The results of chemical transport modeling have indicated that due to the presence of chemical sources in the soil and groundwater, **the current plume of chemicals are expanding plumes despite** the fact that a bio-degradation process was assumed and is occurring in groundwater. Reviewing the historical benzene concentration in on- and off-site groundwater monitoring wells also show an increasing trend. As the data indicates, the benzene concentration in certain groundwater monitoring wells has increased dramatically since 1996. Among the petroleum chemicals, benzene is a carcinogenic (cancer producing) chemical and may cause adverse health effects to the exposed population.

Comparison of the simulated SSTLs of benzene (for inhalation pathway only) for soil and groundwater with the present on-site soil and groundwater benzene concentration, indicates that the present concentrations of benzene in soil and groundwater are significantly higher than SSTLs. As discussed earlier, the SSTLs are the threshold level concentration of chemicals beyond which an adverse health effect in the exposed human receptors can be expected. As Table-6 presents, the current on-site benzene concentrations in soil and groundwater are significantly higher than the SSTLs. The on-site receptors were assumed to be the store/mechanic shop workers that may be exposed to the Site's contaminants through inhalation of indoor air.

Table 6 also indicates that the current and future benzene concentrations in the groundwater around the LB facility is about two orders of magnitude higher than the benzene SSTL value in groundwater. Although it was assumed that LB residents for an exposure period of 10 years will be exposed to the groundwater contaminants, the calculated SSTL for benzene in the groundwater is significantly lower than the current and the simulated future benzene concentrations.

For the future off-site residents who will live in the nearby areas the carcinogenic health risk associated with inhalation of benzene-affected indoor air is higher than acceptable levels.

5.0 Conclusions and Recommendations

Based on the California Regional Water Quality Control Board's Interim Guidance Document dated December 8, 1995, the Site does not fit into the "Low-Risk" Petroleum Release Site Category for the following reasons:

1) The source of petroleum hydrocarbons has not completely been removed. As discussed earlier, still a significant amount of petroleum hydrocarbons exist beneath the Site.
2) A Significant amount of petroleum hydrocarbons has been released into the groundwater, as such the beneficial use of water has been impacted;
3) The existing plume of chemicals in groundwater is an expanding plume and MTBE and benzene plumes will continue to migrate to off-site areas.
4) In recent years benzene concentrations in on- and off-site groundwater monitoring wells has shown an increasing trend; significant concentration of benzene and MTBE have been reported in the vicinity of the LB; and
5) Based on the results of ASTM-RBCA study, under the current and future conditions the Site poses a significant health risk to on-site workers as well as the off-site residents. The current soil and groundwater benzene concentrations are significantly higher than calculated SSTL values.

Therefore, to reduce the carcinogenic health risks and further migration of chemicals to down-gradient areas we recommend the following:

1) Remediation of the on-site soils around the fuel tank area. This can be accomplished by using a soil-venting air sparging technique. However, the cost associated with each remedial alternative should be evaluated and the most economical and cost-effective alternative should be selected. Remediation of the petroleum-impacted soils will remove the source of groundwater contamination and help to reduce the further migration of chemicals from vadose zone into the shallow groundwater beneath the Site.

2) The benzene groundwater concentration beneath the Site should be reduced to SSTL levels in order to protect human health. To prevent further migration of chemicals under LB and restore the beneficial use of groundwater in on- and off-site areas, a combination of pump-and-treat and air sparging may yield a better result. SOMA is currently evaluating the various remedial technologies comparing their effectiveness, implementability and associated costs in order to select the most cost-effective alternative.

6.0 References

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FIGURES

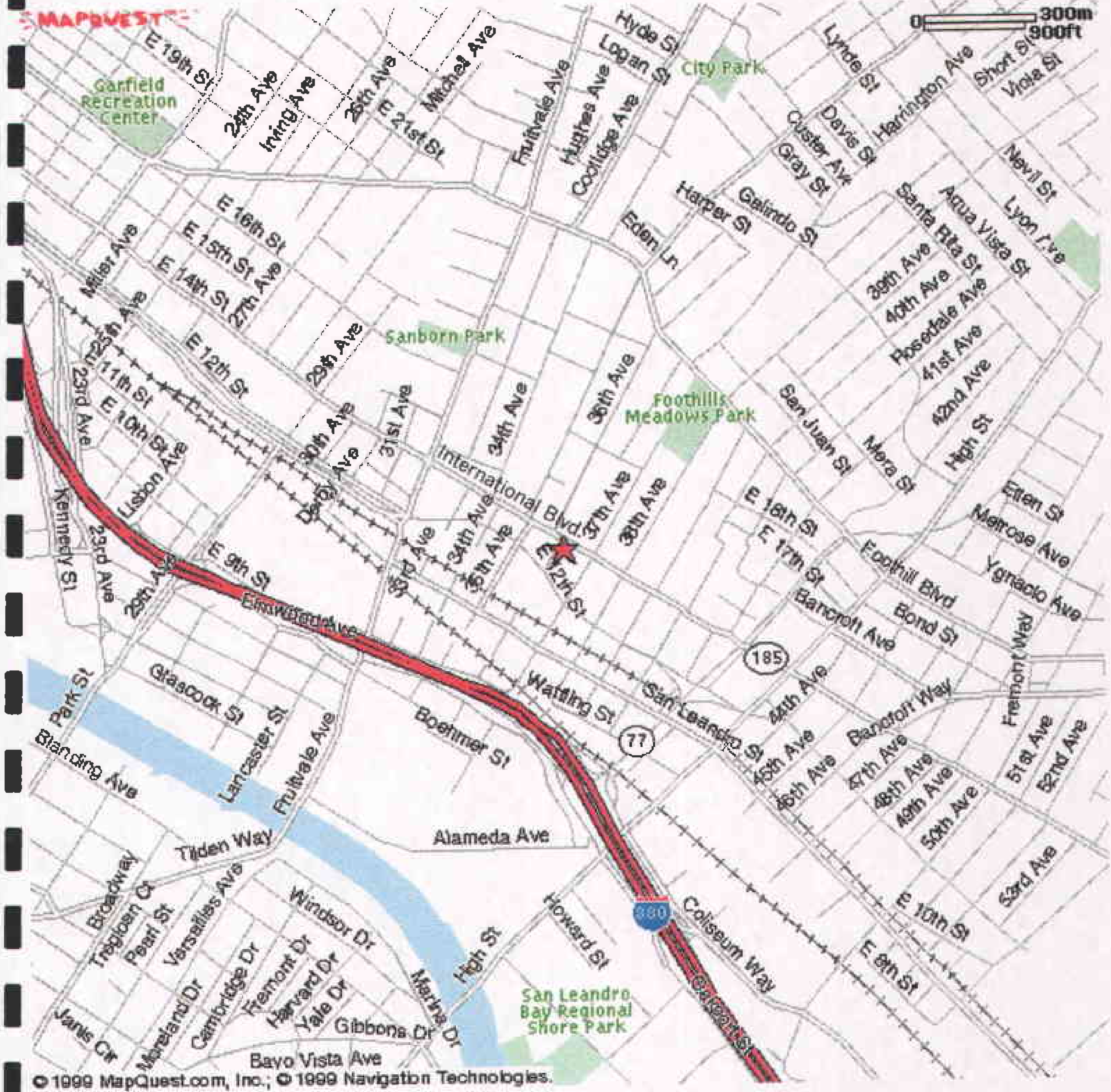

Figure 1: Site Location Map

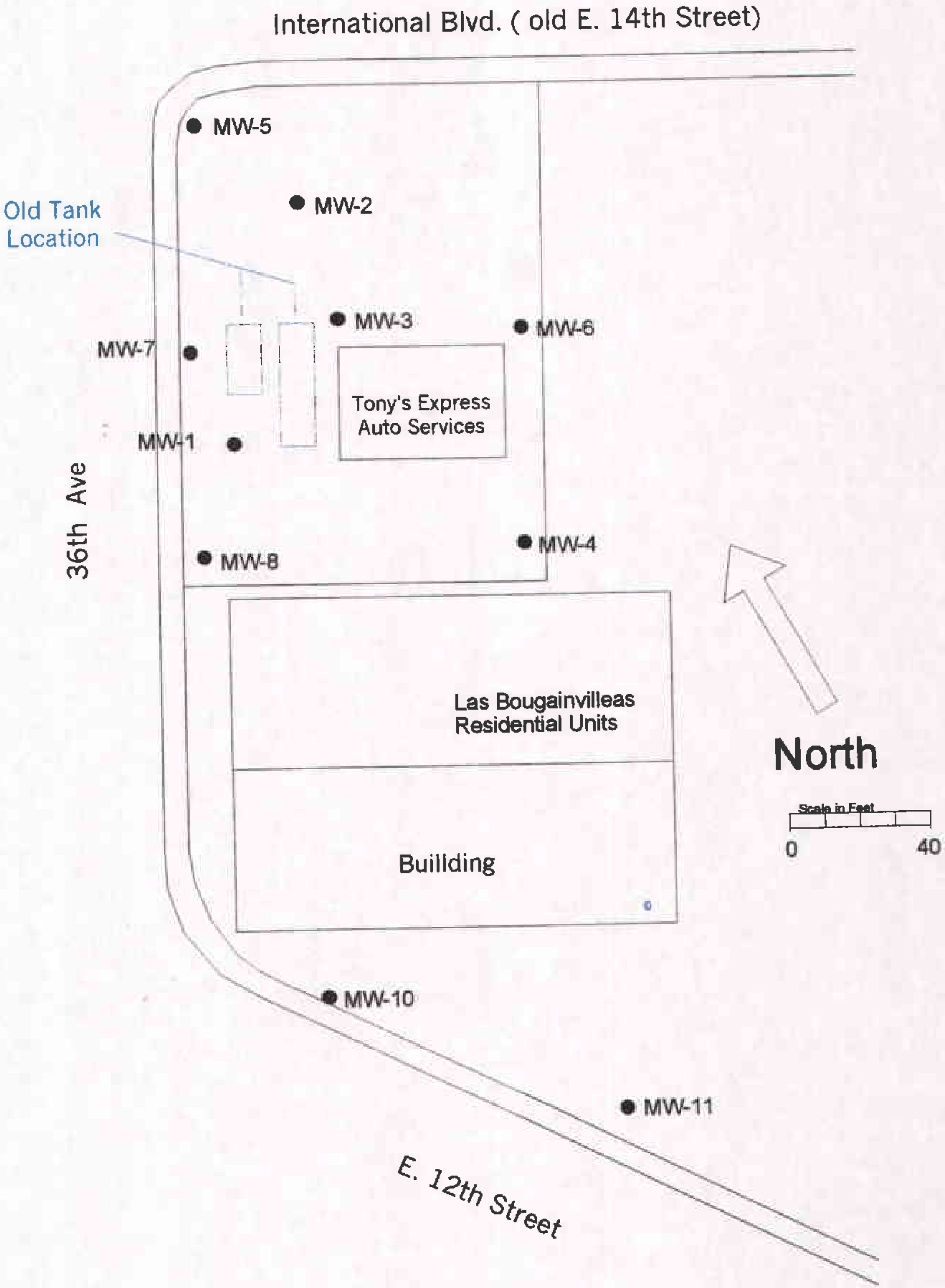

Figure 2: Site Map Showing Existing Well Locations

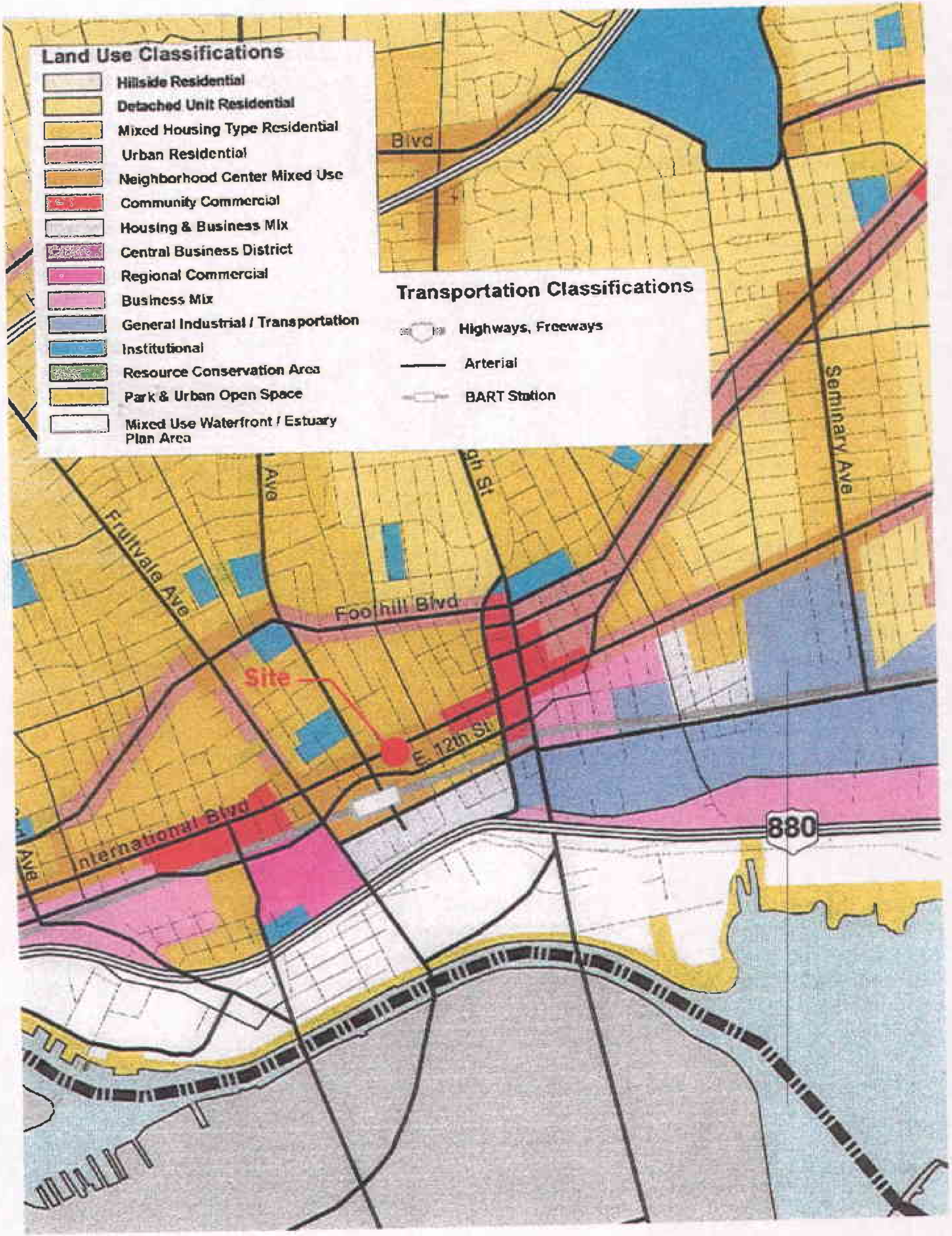

Figure 3: Existing Zoning of the Site and the Surrounding Areas

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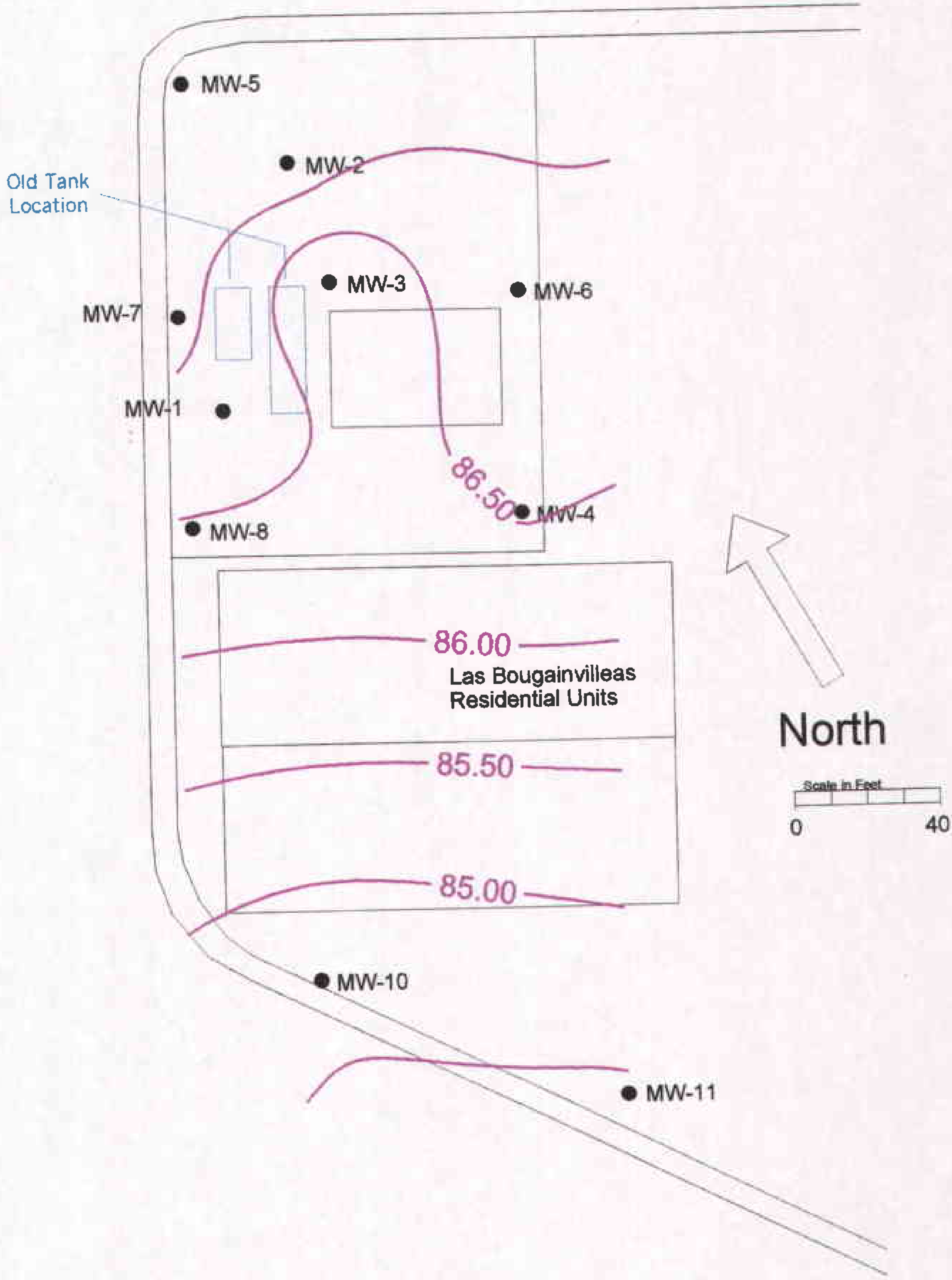

Figure 4: Groundwater Elevation Contour Map in June 1999

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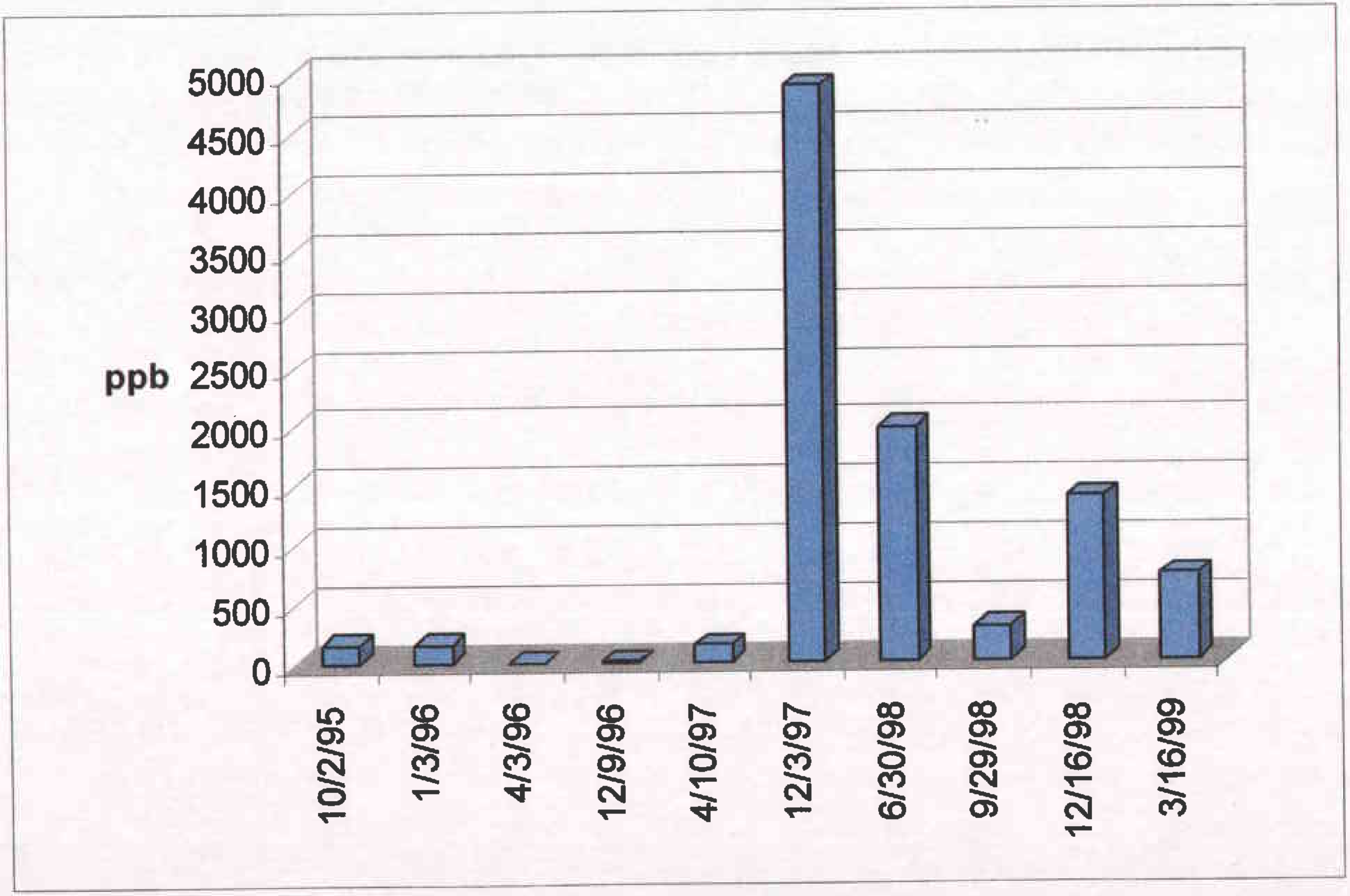

Figure 5: Historical Benzene Concetnration at Monitoring Well MW-2

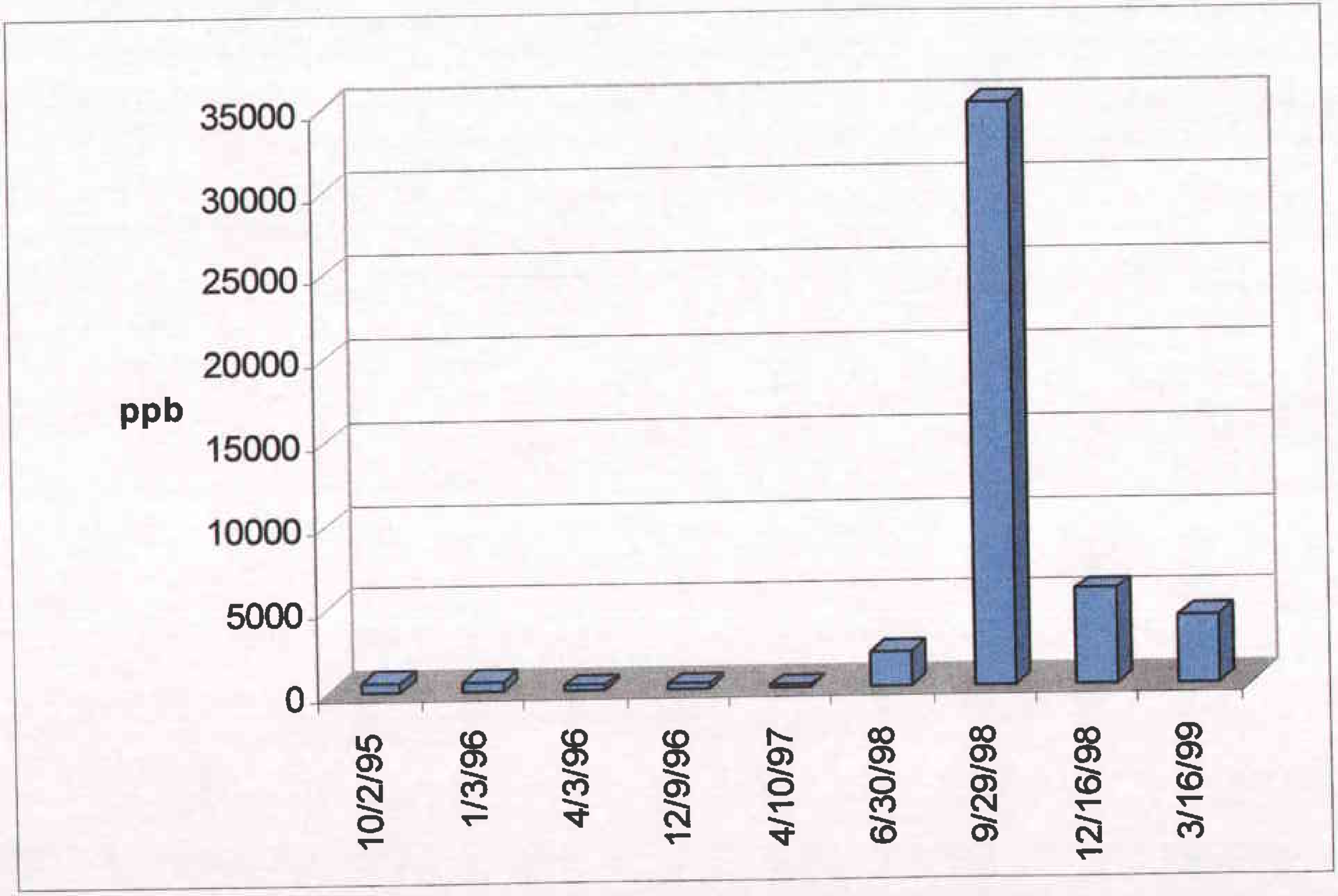

Figure 6: Historical Benzene Concetnration at Monitoring Well MW-3

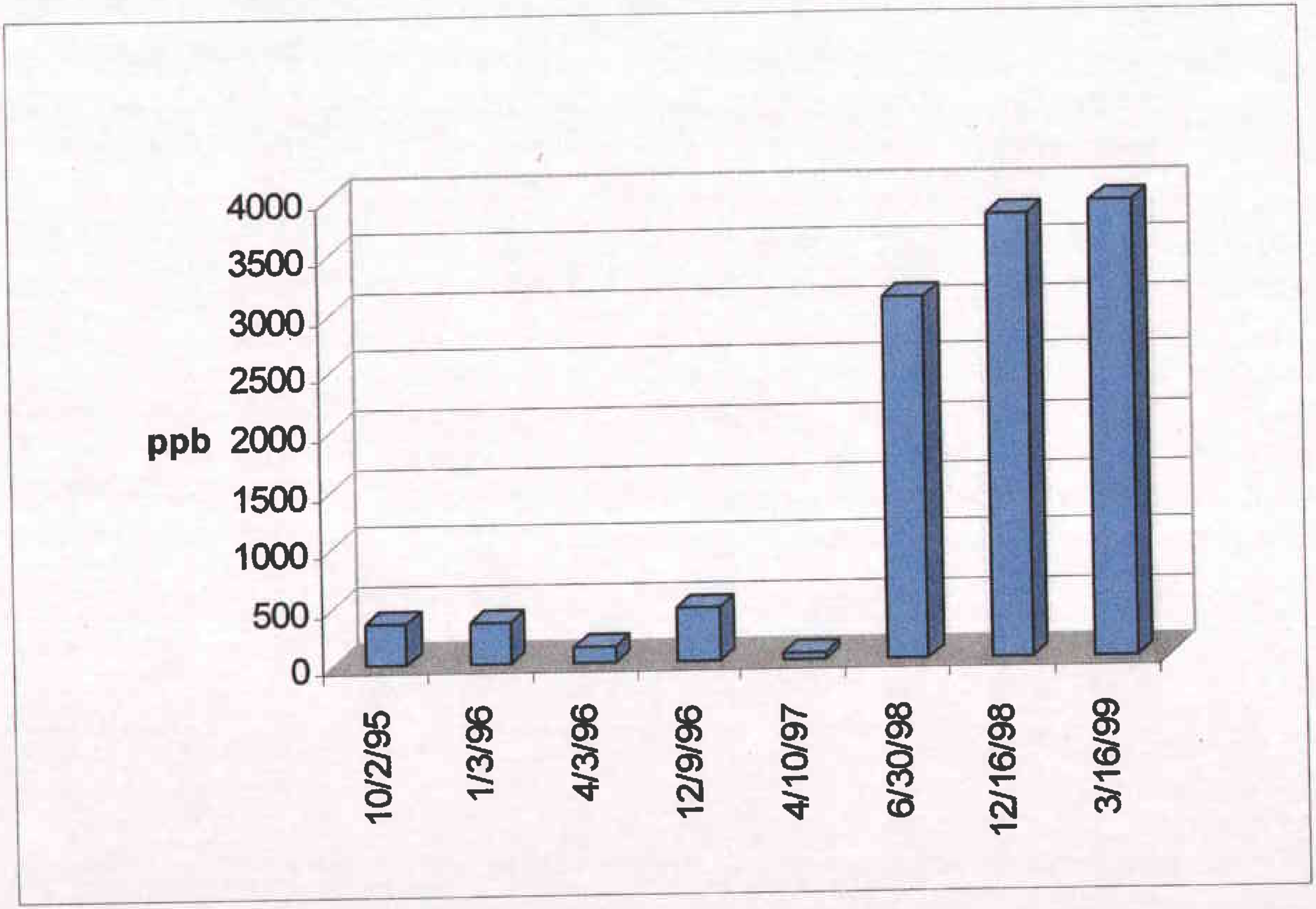

Figure 7: Historical Benzene Concentration at Monitoring Well MW-6

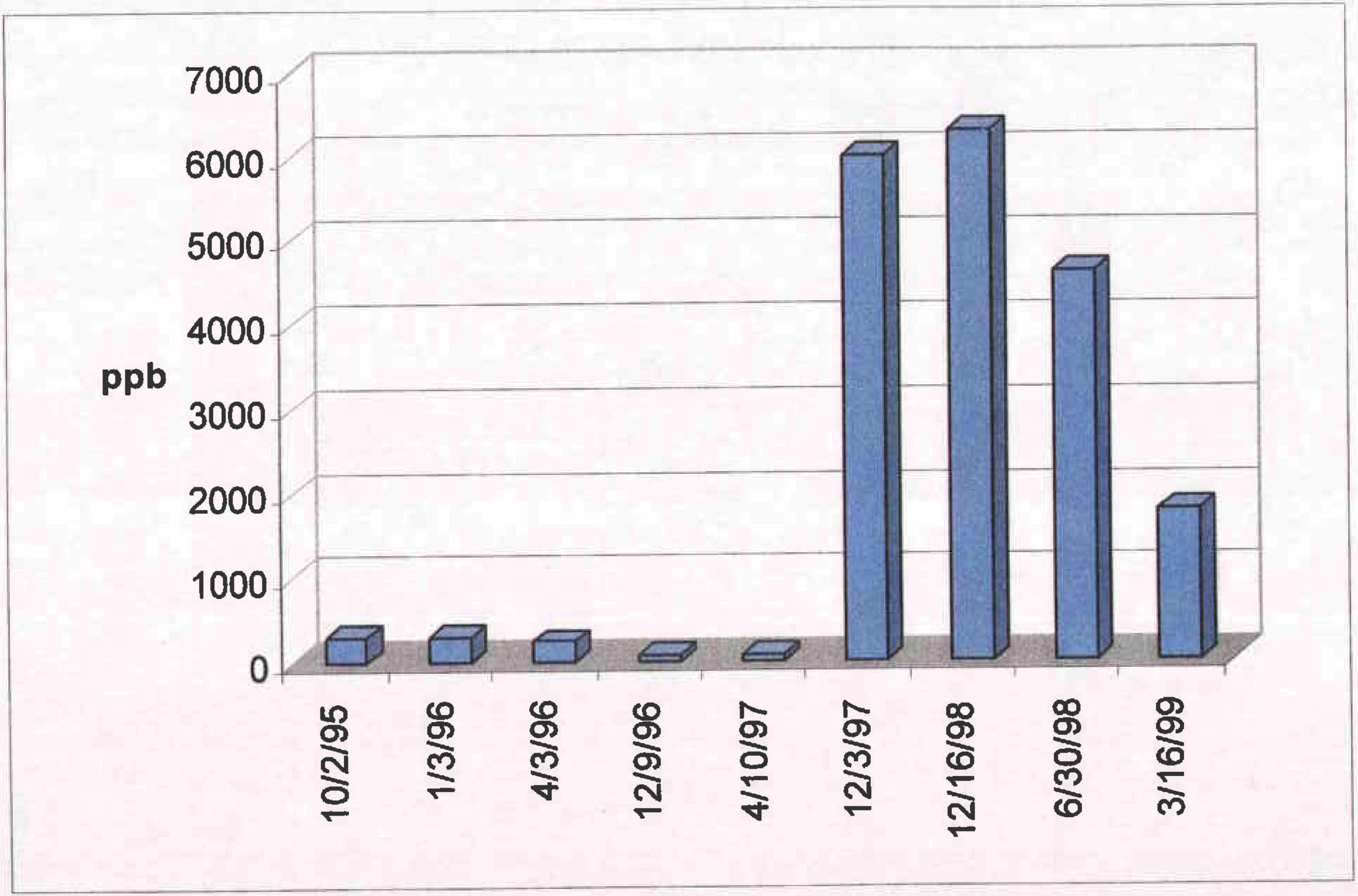

Figure 8: Historical Benzene Concetnration at Monitoring Well MW-8

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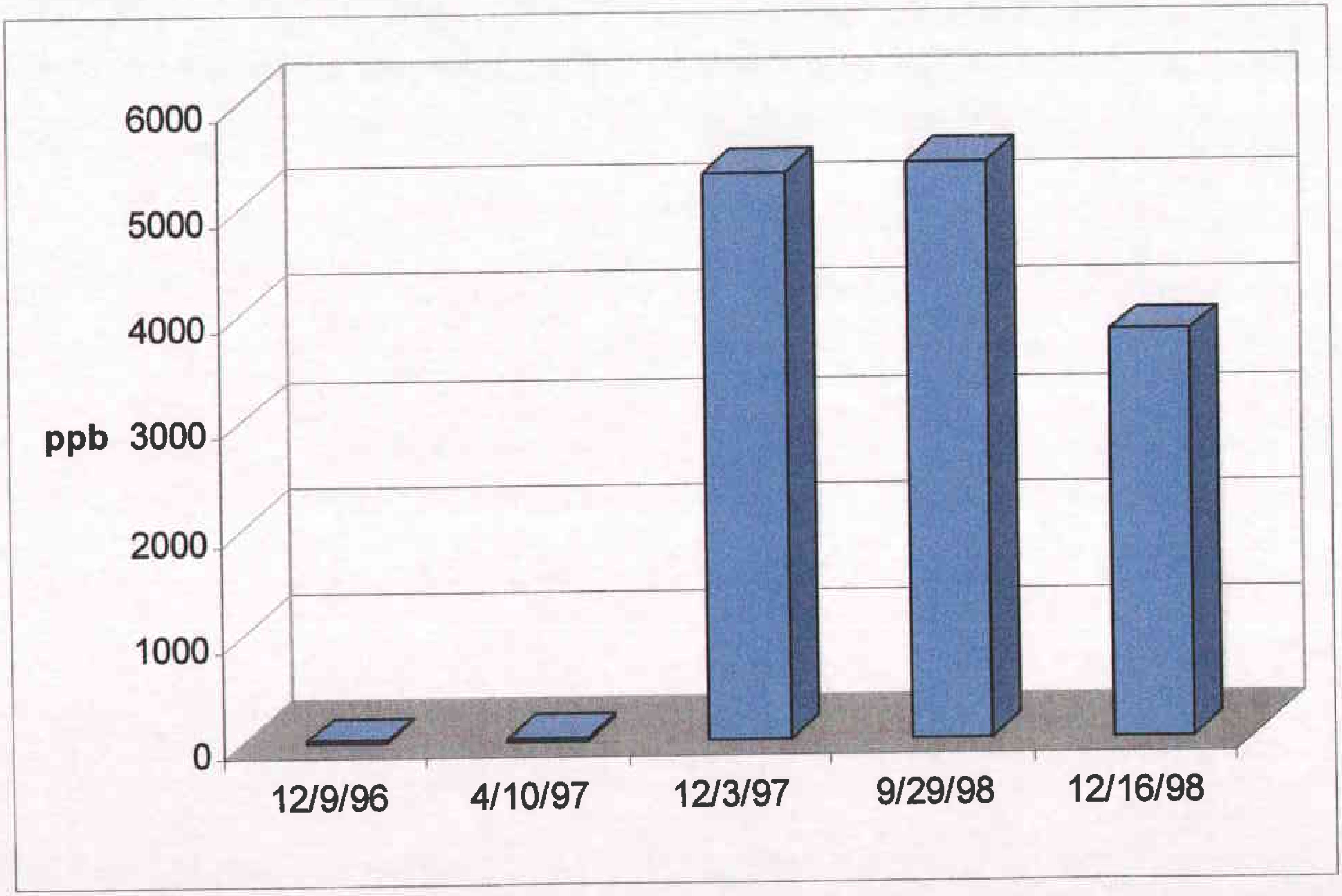

Figure 9: Historical Benzene Concetnration at Monitoring Well MW-10

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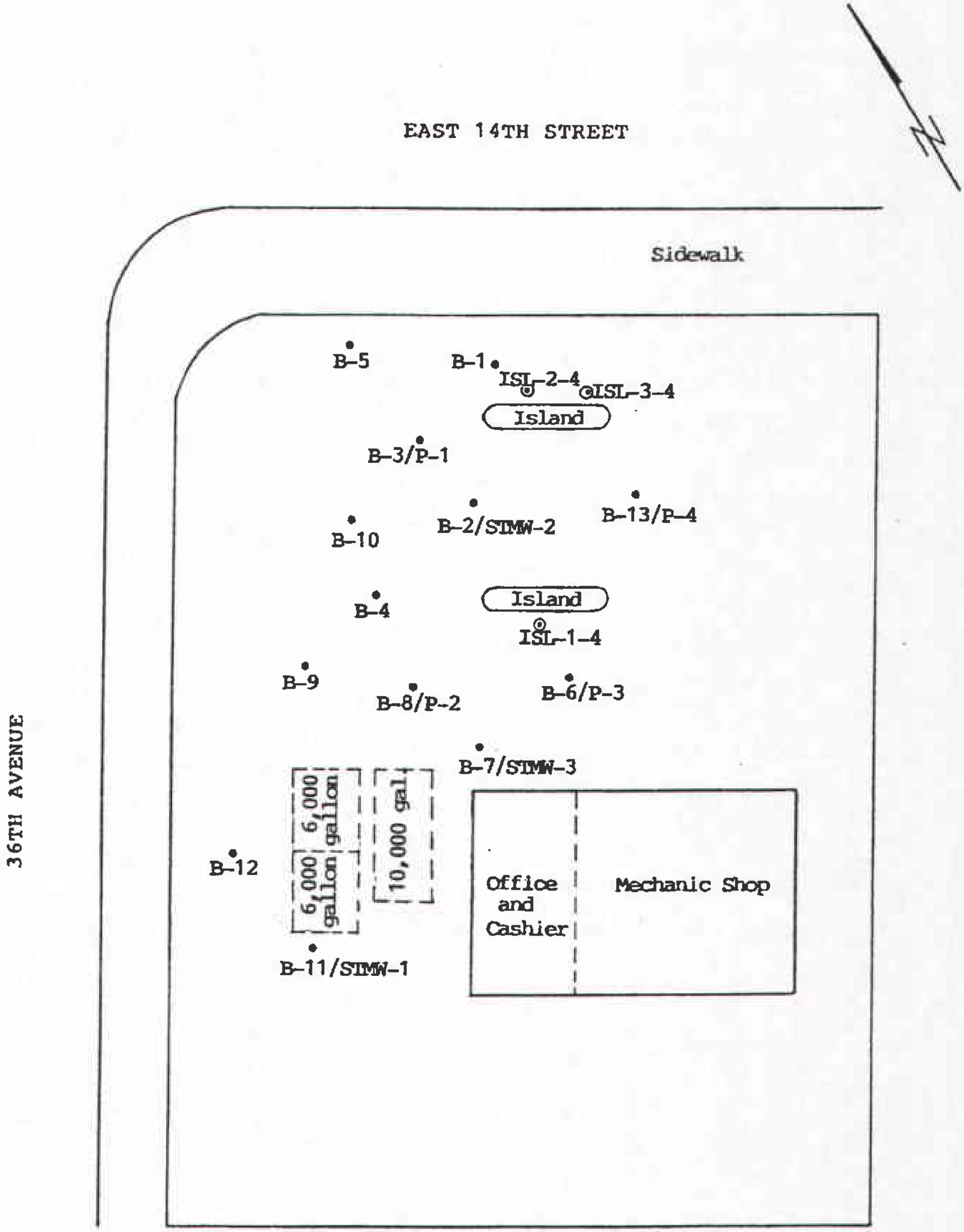

Figure 10: Locations of Soil Borings Drilled By STE

SOMA ENVIRONMENTAL ENGINEERING, INC

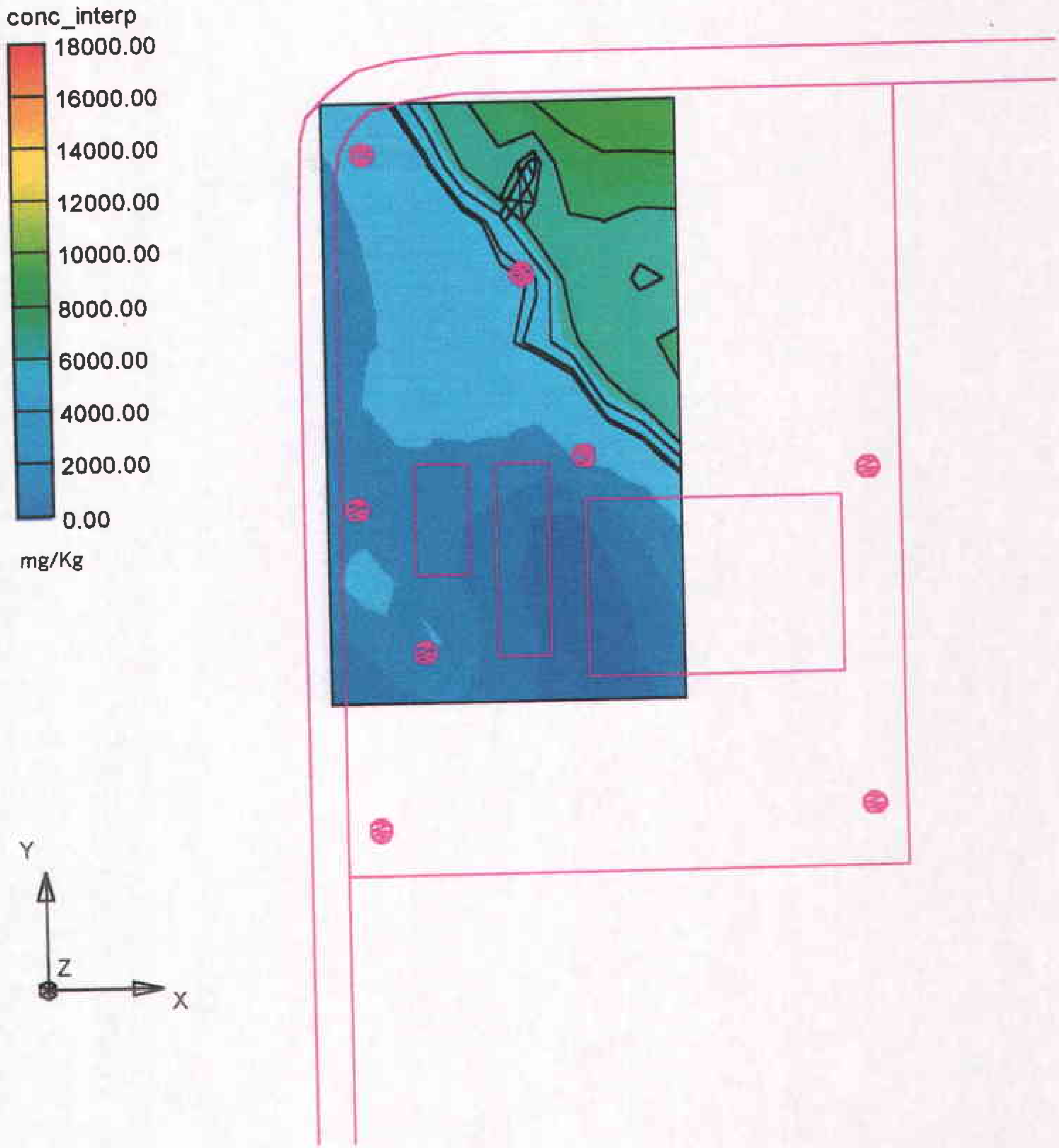

Figure 11: Two Dimensional Distribution of TPH-g in Vadose Zone

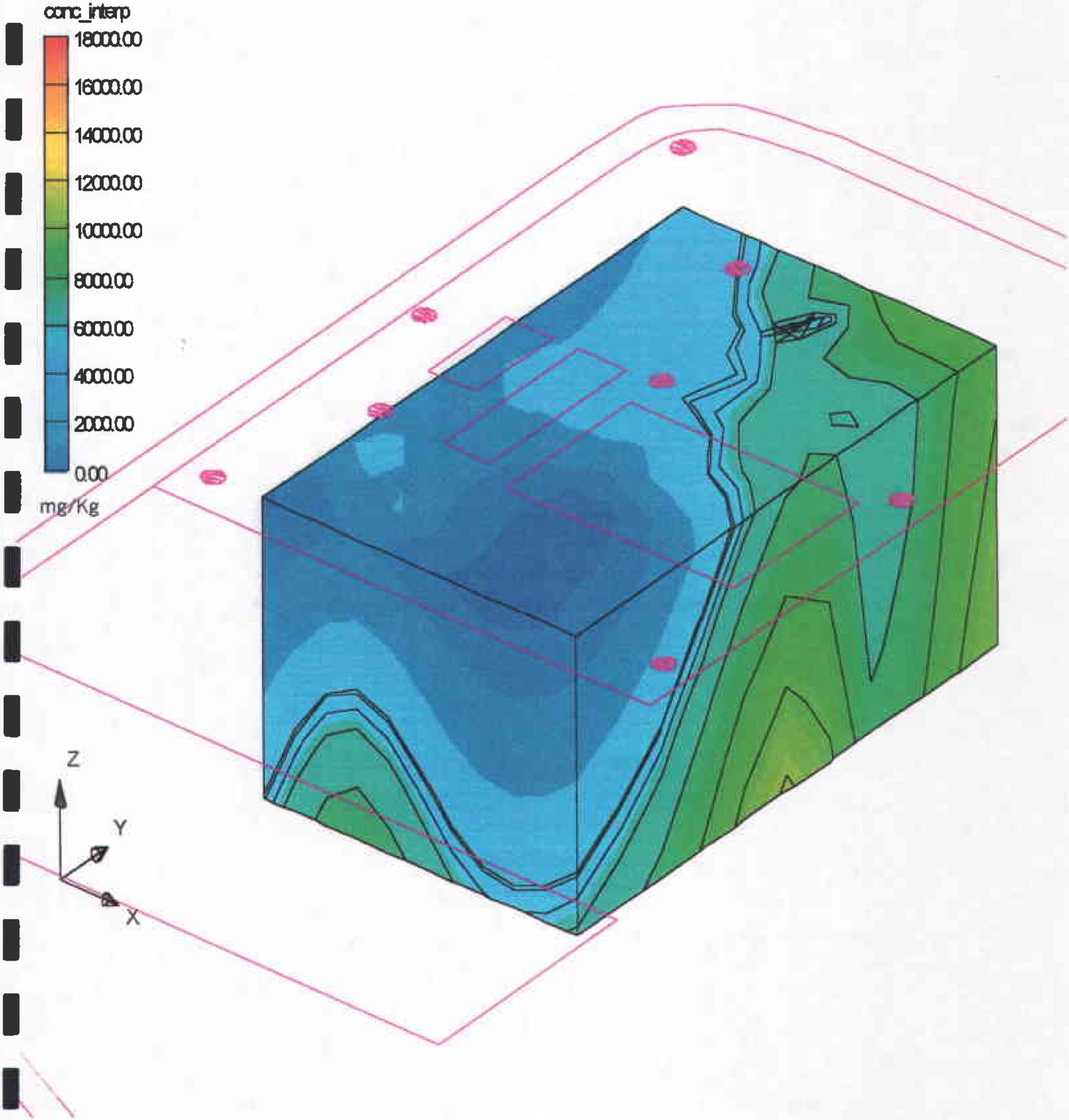

Figure 12: Three Dimensional Distribution of TPH-g in Vadose Zone

SOMA ENVIRONMENTAL ENGINEERING, INC.

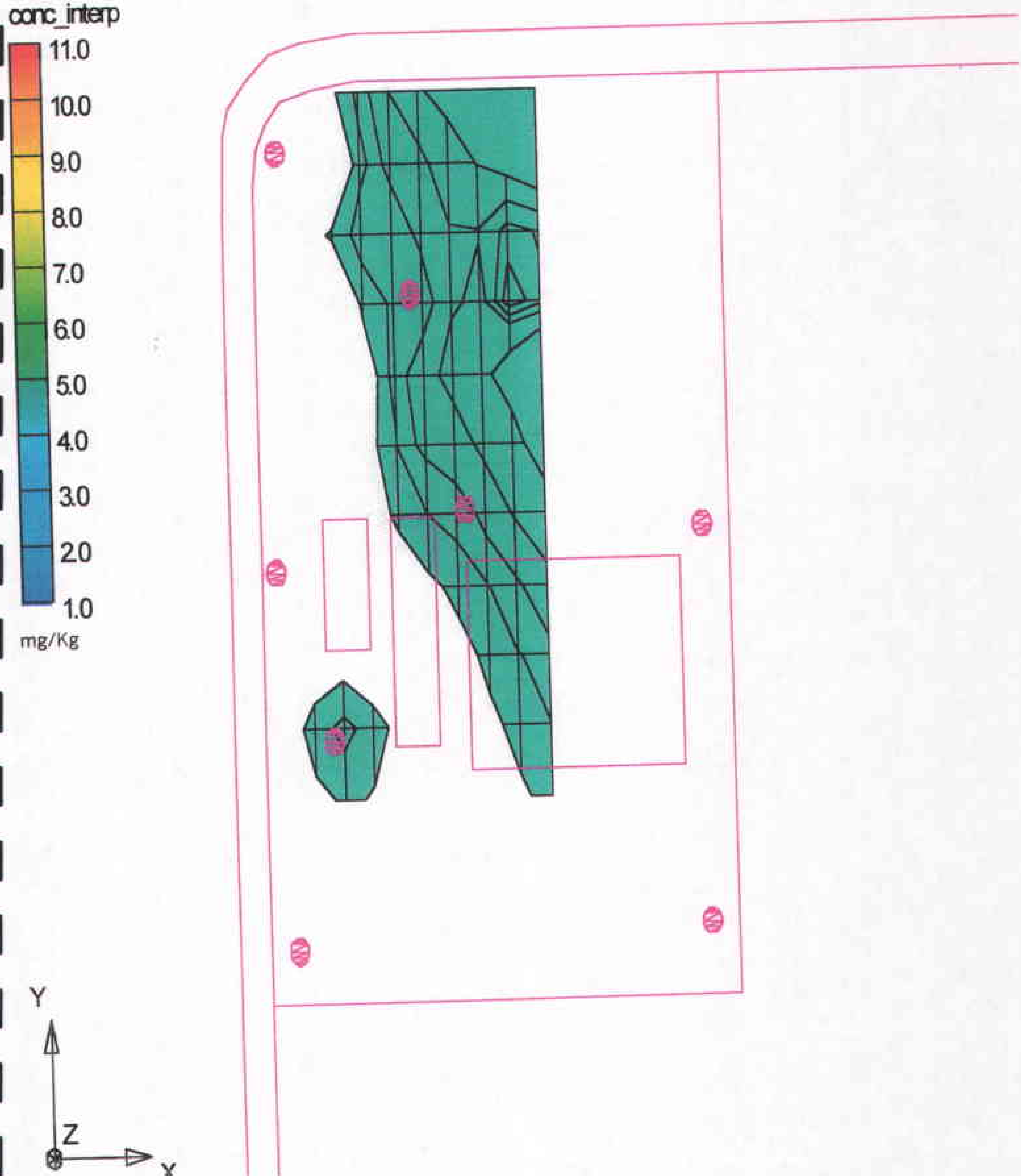

Figure 13: Two Dimensional Distribution of Benzene in Vadose Zone

SOMA ENVIRONMENTAL ENGINEERING, INC.

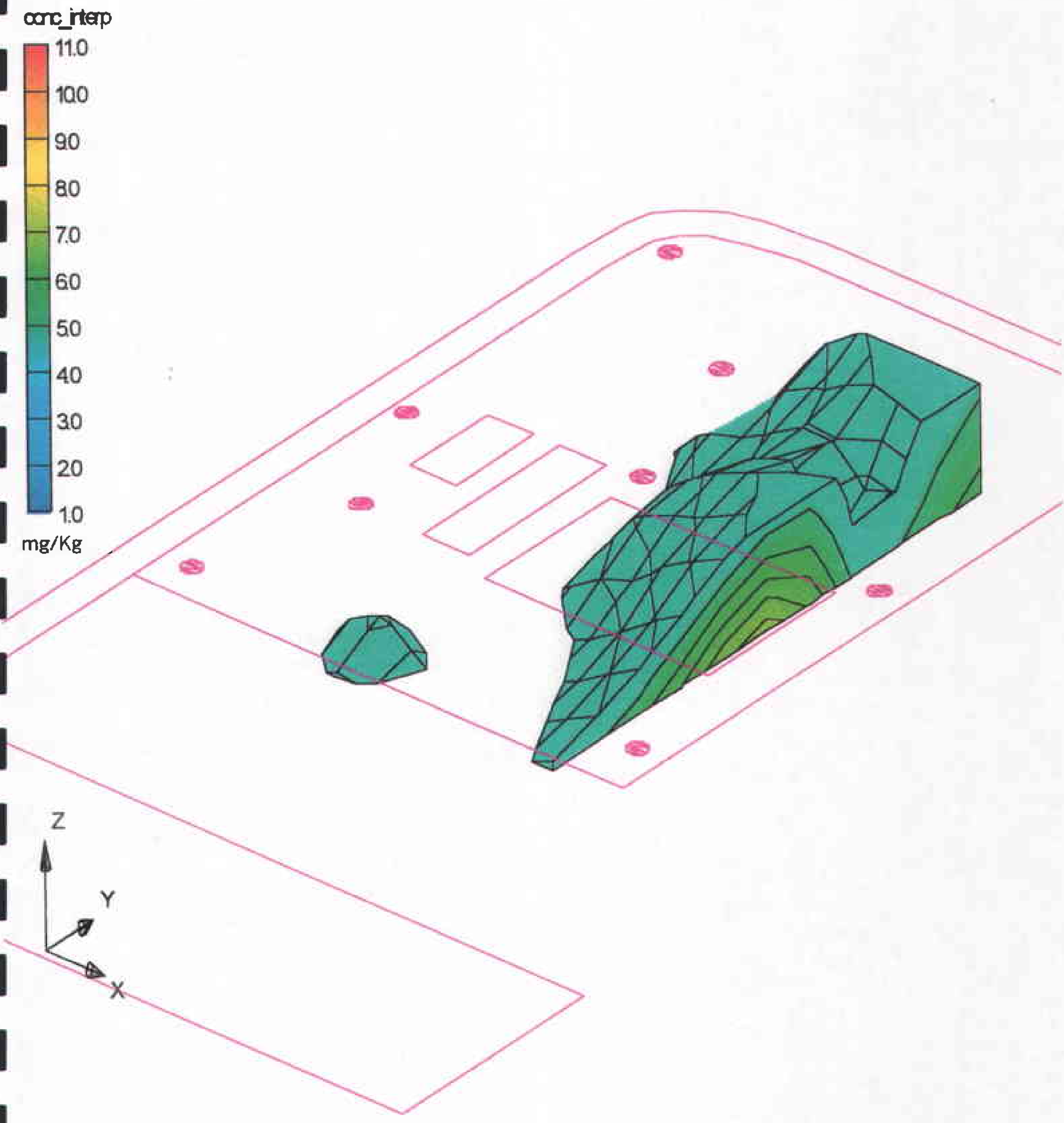

Figure 14: Three Dimensional Distribution of Benzene in Vadose Zone

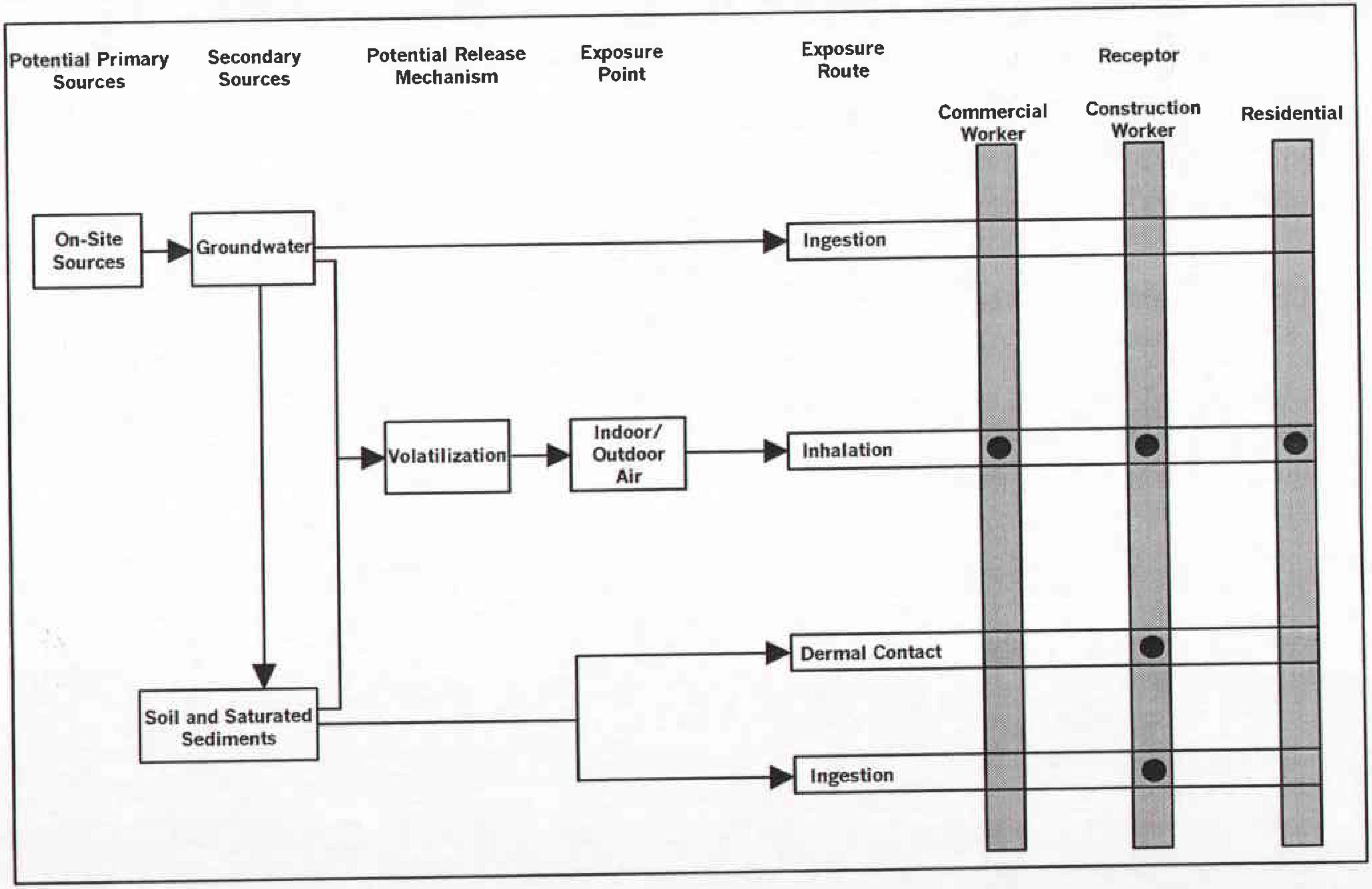

Figure 15: Conceptual Site Model

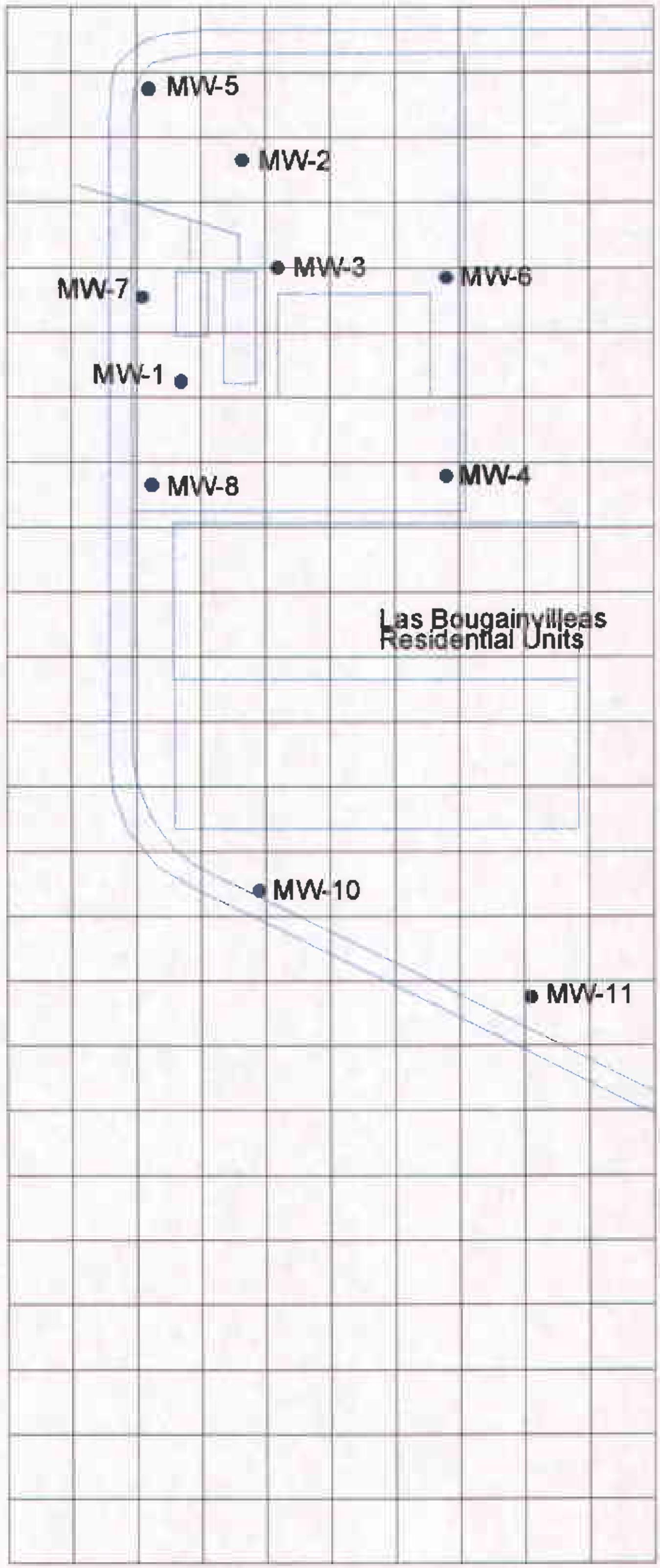

Figure A-1: Model Domain - Finite Difference Grid System

TABLES

Table-1: Estimation of Total Mass of TPH-g and Benzene in the Vadose Zone
Tony's Express Auto Services, Oakland, California

	Average Concentration (mg/kg)	Volume (ft^3)	Density (g/cm^3)	Contaminant Mass (g)
TPH-g	* 5	1706	1.46	353 ✓
	30	6826	1.46	8466
	75	5100	1.46	15812
	175	10949	1.46	79216
	375	11827	1.46	183360
	625	6643	1.46	171642
	875	1174	1.46	42469
	1125	160	1.46	7451
	1375	29	1.46	1671
	1625	3	1.46	195
	Total Volume	44416	Total Mass	510633
Benzene	1.5	14146	1.46	877
	2.5	4650	1.46	481
	3.5	1601	1.46	232
	4.5	902	1.46	168
	5.5	560	1.46	127
	6.5	234	1.46	63
	7.5	65	1.46	20
	8.5	21	1.46	7
	9.5	6	1.46	2
	10.5	0	1.46	0
	Total Volume	22185	Total Mass	1977

* $5\times10^{-6} \times 1.706\times10^{3}\ ft^3 \times 1.46\ g/cm^3 \times (30.5\ cm/ft)^3 \approx 353\ g$ ✓

Table-2: Estimation of Total Mass of TPH-g, Benzene, and MTBE in the Groundwater

Tony's Express Auto Services, Oakland, California

Chemical	Mass (grams)
Benzene	12,714
MTBE	7,494
TPH-g	515,887

Table-3

Soil and Groundwater Parameters Used in Conducting ASTM-RBCA
Tony's Express Auto Services, Oakland California

Soil/Groundwater Parameters	Tier 1	Tier 2	
		On-Site Commercial Scenario	Off-Site Residential Scenario
	9.68	11	11
Capillary Zone Thickness (ft.)	0.164	0.164	0.164
Depth to Groundwater (ft.)	9.844	11.164	11.164
Thickness of Affected Surface Soils (ft.)	3.28	0	NA
Depth to Top of Affected Subsurface Soils (ft.)	3.28	5	NA
Depth to Base of Affected Subsurface Soils (ft.)	9.844	11	NA
Contaminated Soil Area ($ft.^2$)	2420	6700	NA
Length of Affected Soil Parallel to Wind Direction (ft.)	49.2	60	NA
Length of Affected Soil Parallel to Groundwater Flow Direction (ft.)	49.2	50	NA
Soil Density (g/cm^3)	1.7	1.7	1.7
Soil pH	6.5	6.5	6.5
Fraction Organic Carbon	0.01	0.01	0.01
Porosity	0.38	0.38	0.38
Volumetric Water Content (capillary fringe)	0.34	0.34	0.34
Volumetric Water Content (vadose zone)	0.12	0.17	0.17
Volumetric Air Content (capillary fringe)	0.04	0.04	0.04
Volumetric Air Content (vadose zone)	0.26	0.19	0.19

Table-4
Exposure Parameters Used in Conducting ASTM-RBCA
Tony's Express Auto Services, Oakland, California
Tier 1/Tier 2 for On-Site Commercial and Tier 1 for Off-Site LB Residents

Exposure Parameters	Residential		Commercial
	Adult	Child (1-6 yrs)	Chronic
Averaging Time for Carcinogens (yr.)	70	70	70
Averaging Time for Non-Carcinogens (yr.)	30	6	25
Body Weight (kg)	70	15	70
Exposure Duration (yr)	30	6	25
Exposure Frequency (d/yr)	350	350	250
Dermal Exposure Frequency (d/yr)	350	350	250
Skin Surface Area (cm^2)	5800	2023	5800
Ingestion Rate of Water (L/d)	2	2	1
Ingestion Rate of Soil (mg/d)	100	200	50
Inhalation rate indoor (m^3/d)	15	10	20
Inhalation rate outdoor (m^3/d)	20	20	20

Tier 2 for LB Residents

Exposure Parameters	Residential	
	Adult	Child (1-6 yrs)
Averaging Time for Carcinogens (yr.)	70	NA
Averaging Time for Non-Carcinogens (yr.)	10	NA
Body Weight (kg)	70	NA
Exposure Duration (yr)	**10**	NA
Exposure Frequency (d/yr)	350	NA
Inhalation rate indoor (m^3/d)	15	NA
Inhalation rate outdoor (m^3/d)	20	NA

Table-5
Building Parameters Used in Conducting ASTM-RBCA
Tony's Express Auto Services, Oakland, California

Building Parameters	Tier 1		Tier 2	
	Residential	Commercial	Residential	Commercial
Building Volume/Area Ratio (cm)	200	300	200	300
Building Air Exchange Rate (1/s)	0.00014	0.00023	0.00014	0.00023
Foundation Crack Thickness (cm)	15	15	15	15
Foundation Crack Fraction	0.01	0.01	0.01	0.01
Volumetric Water Content of Crack	0.12	0.12	0.2	0.2
Volumetric Air Content of Crack	0.26	0.26	0.1	0.1

0.01

ok

Table-6

Comparison Between Site-Specific Target Levels and Actual Soil and Groundwater Chemical Data Tony's Express Auto Service, ~~Vallejo,~~ California

Chemicals of Concern	RBSL		SSTL		Measured 95% UCL				Remediation ?
					Soil		Groundwater		
	Soil	Groundwater	Soil	Groundwater	Current	Future	Current	Future	
On-Site Commercial									
Benzene	79	74	100	91	1,290	NA	3,621	3,621	Yes
Toluene	93,000	85,000	120,000	100,000	2,210	NA	2,885	2,885	
Ethylbenzene	> Res	> Sol*	> Res**	> Sol	3,860	NA	939	939	
Xylenes	> Res	> Sol	> Res	> Sol	8,790	NA	3,177	3,177	
MTBE	700,000	3,700,000	920,000	5,400,000	NA	NA	293	293	
Off-Site LB Residents									
Benzene	NA	24	NA	76	NA	NA	2,424	2,424	Yes
Toluene	NA	33,000	NA	100,000	NA	NA	39	39	
Ethylbenzene	NA	77,000	NA	> Sol	NA	NA	548	548	
Xylenes	NA	> Sol	NA	> Sol	NA	NA	347	347	
MTBE	NA	1,400,000	NA	5,200,000	NA	NA	1,440	1,440	

Notes:
*) > Sol is greater than solubility
**) > Res is greater than residual saturation
Concentrations units are in ppb

APPENDIX A

GROUNDWATER FLOW AND CHEMICAL TRANSPORT MODELING

A1.0 Groundwater Flow Modeling

The following describes the methodology used to conduct groundwater flow and chemical transport modeling at Tony's Express Auto Services Site, Oakland, California. The groundwater modeling was conducted to design a groundwater extraction system and simulate the extent of benzene and MTBE concentration in groundwater under ambient and pumping conditions.

A1.1 Model Description

The U.S. Geological Survey (USGS) Modular Three-Dimensional Finite-Difference Ground-Water Flow Model (MODFLOW) (USGS 1988) was used to simulate groundwater flow within the model domain beneath the Site. MODFLOW is a finite-difference flow model designed to simulate in two dimensions (and in quasi-3-dimensional form), the response of a water-yielding unit to imposed stress conditions. MODFLOW may be used to simulate confined or unconfined (water table) conditions or a combination of both conditions. This model may also be used to simulate heterogeneous and anisotropic geologic units as well as geologic units with irregular boundaries. MODFLOW can be used to simulate a single-or a multi-layer system. It also permits leakage from streams and confining beds, variable flux boundary conditions and well-discharge simulations.

For this study, MODFLOW was used to evaluate steady-state groundwater flow under ambient conditions. The model domain used in groundwater flow and chemical transport modeling is shown in Figure A-1.

A1.2 Overview of Modeling Procedures

Groundwater flow modeling was accomplished through the following steps:

1) Conceptualizing a hydrogeologic flow regime;
2) Designing a finite-difference grid system;

3) Assigning model boundary conditions;

4) Assigning a hydraulic conductivity to aquifer materials;

5) Calibrating the computer model using field-measured data;

6) Designing a Groundwater Extraction System

These modeling steps are described in the following sections.

A1.2.1 Hydrogeologic Flow Regime

The model domain illustrated in Figure A-1 consists of a 200-ft by 480-ft area that includes the Site and areas to the north and northwest of the Site. The depth of groundwater beneath the Site occurs approximately between 7 and 11.6 feet. Groundwater flows from a north to southwest direction beneath the Site. The average hydraulic gradient is about 0.01 ft/ft beneath the study area.

For modeling purposes, it was assumed that the shallow groundwater zone beneath the study area consists of a single unconfined layer and is generally comprised of fine to medium grained sandy materials. The thickness of this layer was assumed to be equal to 20 ft everywhere within the model domain.

A1.2.2 Finite-Difference Grid System

The model domain was subdivided into a uniform finite-difference grid covering an area with dimensions of 200 ft by 480 ft (Figure A-1). The grid is comprised of 20 feet - by 20-feet cells arranged in 24 rows and 10 columns. By convention, the model solution nodes are considered to be located at the center of each cell.

A1.2.3 Model Boundary Conditions

Water level data from monitoring wells located within the study area indicate that the groundwater flow direction underneath the Site is generally toward the southwest. Based on the results of previous water level measurements, the groundwater flow gradient is relatively consistent and does not change significantly with time.

A general head boundary condition (GHB) was used along all four boundaries of the model domain. This boundary condition specifies that groundwater enters the model domain at a rate that is a function of the hydraulic conductivity of the sediments at the boundary, the cross-sectional area of the flow through the cell, and the hydraulic gradient at the edge of the model domain. Thus, flow conditions are considered to be continuous across the model boundary. The boundary heads rise and fall based on flow conditions within the model domain. The GHB along the boundaries of the model domain specifies a hydraulic gradient across each boundary that remains constant.

A1.2.4 Hydraulic Conductivity of Aquifer Materials

A review of the lithologic logs of sediments beneath the Site indicates that saturated sediments beneath the Site are composed of fine-grained silty-clay materials. Results of slug tests conducted by WEGE indicated that hydraulic conductivity of the saturated sediments beneath the Site ranges from 0.4 to 10 feet per day. The result of the pumping test conducted by SOMA on MW-3, indicated that the hydraulic conductivity of the saturated material ranges between 1.5 feet to 18 feet per day. In conducting groundwater flow modeling, the hydraulic conductivity of the saturated sediments ranged between 2 to 6 feet per day.

A1.2.5 Model Calibration

Model calibration was performed to establish the model as adequately representing the groundwater flow system. The model was calibrated using water level measurement data from individual observation wells from the July 1996 groundwater-monitoring event.

The groundwater flow model was calibrated by adjusting hydraulic input parameters (e.g., boundary conditions and hydraulic conductivity values) and comparing the resulting simulated values with observed groundwater elevations at each monitoring well location. Table A-1 presents a comparison between the measured groundwater elevations and simulated groundwater elevations at monitoring well locations predicted by the calibrated groundwater flow model. Figure A-2 presents the simulated water level contours.

A1.2.6 Designing a Remedial System

Following the flow model calibration, a groundwater extraction system was designed to capture the chemical plume and prevent from further migration of chemicals to the off-site areas (i.e., under the LB facility). Due to the fined-grained nature of saturated sediments and low hydraulic conductivity of the material beneath the Site, installation of a French drain seemed to be more suitable. Therefore, a French drain with a total depth of 20 feet, length of 80 feet and width of 4-feet was simulated. Figure A-3 Location of the proposed French drain. The results of simulation runs indicated that a total flow rate of 5 gallons per minute (gpm) could be pumped from the French drain under steady state conditions. However, during the rainy periods due to the excess groundwater recharge higher flow rates can be extracted from groundwater. Figure A-4 shows the simulated groundwater elevation contour map under pumping conditions. Figure A-5 presents the simulated capture zone under 5 gpm flow rate.

A2.0 Groundwater Chemical Transport Modeling

A2.1 Model Description

Chemical transport in groundwater was simulated using MT3D, a modular three-dimensional transport model for simulation of advection, dispersion and chemical reactions of contaminants in groundwater systems developed by S.S. Papadopulos & Associates, Inc. (Zheng 1992). MT3D is a finite-difference transport model that uses a mixed Eulerian-Lagrangian approach to the solution of three-dimensional advective-dispersive-reactive equations in the method of characteristics, the modified method of characteristics, and a hybrid of the two methods, making it uniquely suitable for a wide range of field problems.

MT3D can be used in conjunction with any block-centered finite-difference flow model such as MODFLOW and is based on the assumption that the flow field is not measurably affected by any change in the concentration field, allowing separate conceptualization and calibration of a flow model.

Water-quality simulations were accomplished in two steps. In the first step, MODFLOW was run to generate the potentiometric head distribution for the single-layer system. The simulated hydraulic heads and other related flow terms were saved to a data file. In the second step, MT3D was run to simulate the chemical transport. MT3D retrieves the hydraulic heads and the flow and sink/source terms saved by the flow model, automatically incorporating the specified boundary conditions.

A2.2 Chemical Transport Processes

Advection (flow with the groundwater) is the dominant transport mechanism of dissolved chemicals in groundwater. The two other primary processes that can influence the distribution of chemicals in groundwater are dispersion and sorption. Dispersion results from small-scale variations of groundwater flow velocity and causes spreading of chemicals in a transverse direction or in the direction of groundwater flow. The process of sorption of chemicals onto sediments impedes the transport of those chemicals through soil and groundwater. The effects of sorption were simulated using the retardation coefficient, which is the ratio between calculated groundwater velocity and the apparent chemical velocity in a particular porous medium. The following sections describe how dispersion and sorption processes were simulated in the chemical transport modeling.

A2.2.1 Dispersion

The dispersion process is responsible for the spreading of contaminants over a greater region than would be predicted solely from the groundwater velocity vectors. Dispersion occurs both longitudinally and transverse to the flow direction. In this simulation, the porous medium was assumed to be isotropic and molecular diffusion was considered to be negligible relative to dispersion. Input data that controls the dispersion process include values of longitudinal and transverse dispersivity of the water-yielding sediments. Actual measurement of dispersivity values requires intensive field studies and such field data were not available. For modeling purposes, the saturated sediments beneath the Site were assigned values of 15 and 9.75 feet for longitudinal and transverse dispersivity, respectively.

A2.2.2 Retardation (Sorption)

MT3D assumes that retardation of contaminant transport is mainly due to sorption, which refers to the mass transfer process between the contaminants dissolved in groundwater (aqueous phase) and the contaminants sorbed on the porous medium (sorbed phase).

The functional relationship between sorbed and dissolved concentrations, called a sorption isotherm, is classified in MT3D in three types: linear, Freundlich and Langmuir. Linear sorption was used in this simulation. The linear sorption assumes that there is a linear relationship between the sorbed concentration and the dissolved concentration.

The retardation of a concentration front in groundwater relative to the bulk mass of water is described by the retardation factor (R) in the following equation:

$$R = 1+\frac{\rho}{\eta}K_d$$

Where:

R = retardation factor (dimensionless);

ρ = Bulk density of Aquifer material (lbs/ft^3);

η = Effective porosity and

K_d = soil-water partition coefficient (ft^3/lbs).

This approach is based on the assumption that the organic carbon contents of the porous medium control the sorption process. The values of Kd and R used in the modeling are shown in Table A -2 for each chemical simulated.

A2.2.3 Biodegradation

Based on the groundwater monitoring reports prepared by the previous consultants and SOMA, a biodegradation process is occurring beneath the Site. As the data indicates, elevated levels of ferrous iron and low levels of electron acceptors such as oxygen, nitrate and sulfate are indicative of the aerobic biodegradation process in subsurface. The biodegradation process results in the reduction of contaminant levels such as benzene and other petroleum chemicals in soil and groundwater. For modeling purposes, a half-life period of 2-years was assumed for the petroleum chemicals. This value is consistent with literature values and other similar sites such as the San Francisco Airport site, which SOMA has been involved in the past.

A2.3 Chemical Source Assumptions Used in Transport Modeling

Important factors in simulating chemical transport in groundwater are the identification of the chemical source area(s) and the rate and duration of release of each chemical into the groundwater flow system.

MT3D was used to simulate future chemical concentration distribution in groundwater (after 30 years), assuming that the concentrations of chemicals in the groundwater at the on-site monitoring well locations will remain constant. The use of a non-diminishing source term constitutes a conservative assumption that would be expected to result in an overestimation of future chemical concentrations in groundwater. The 95% UCL concentrations of the chemicals at groundwater monitoring wells were used as the initial conditions in the simulations (see Appendix C). It was then conservatively assumed that these chemicals would persist at these same concentrations over the next 30 years.

The model was then used to simulate chemical transport under steady-state groundwater flow conditions for a period of thirty years, based on the previously stated assumptions. Volatilization process that would be expected to significantly reduce chemical concentrations in groundwater over time, was not included in the simulations.

A2.4 Chemical Transport Simulations

As stated earlier, MT3D was used to simulate future chemical concentrations in groundwater (after 30 years), assuming that the concentrations of chemicals at the on-site monitoring wells will remain constant. Given this conservative assumption, the estimated future chemical concentrations in groundwater were simulated by MT3D to represent a worst-case scenario. This simulation assumes that no future groundwater remediation or source removal actions will be implemented, and also neglects natural processes such as volatilization, which would tend to cause concentrations to decrease over time.

One of the main objectives in this study was to predict the groundwater chemical concentration down-gradient from the site beneath the LB and the surrounding areas, see Figure 2. Figures A-6 and A-7 depict the configurations of the benzene, and MTBE plumes after a period of 30 years. As indicated by the extent of the benzene plume, after 30 years, the leading edge of benzene will migrate beyond the 12th Street despite using the biodegradation process as a sink for removing chemicals from the impacted groundwater.

In order to evaluate the impact of French drain in controlling the chemical plumes additional chemical transport modeling was conducted. Figures A-8 and A-9 present the simulated benzene and MTBE plumes under steady state conditions

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+                                                                       +
+                                M T 3 D                                +
+              A Modular Three-Dimensional Transport Model              +
+   For Simulation of Advection, Dispersion and Chemical Reactions      +
+             of Contaminants in Groundwater Systems                    +
+                                                                       +
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 | M T | Water Quality Modeling for Tony's Express Auto Sit,Oakland, California
 | 3 D | SOMA Environmental Engineering June 1999
 -----
THE TRANSPORT MODEL CONSISTS OF     1 LAYER(S)   24 ROW(S)   10 COLUMN(S)
NUMBER OF STRESS PERIOD(S) IN SIMULATION =    1
UNIT FOR TIME IS  DAY;  UNIT FOR LENGTH IS   FT;  UNIT FOR MASS IS UNDF
MAJOR TRANSPORT COMPONENTS TO BE SIMULATED:
 1  ADVECTION
 2  DISPERSION
 3  SINK AND SOURCE MIXING
 4  CHEMICAL REACTIONS (DECAY AND/OR SORPTION)

BTN1 -- BASIC TRANSPORT PACKAGE, VER DOD_1.5, JULY 1996, INPUT READ FROM UNIT  1
    2948 ELEMENTS OF THE  X ARRAY USED BY THE BTN PACKAGE
     241 ELEMENTS OF THE IX ARRAY USED BY THE BTN PACKAGE

ADV1 -- ADVECTION PACKAGE, VER DOD_1.5, JULY 1996, INPUT READ FROM UNIT  2
ADVECTION IS SOLVED WITH THE HYBRID [MOC]/[MMOC] SCHEME
COURANT NUMBER ALLOWED IN SOLVING THE ADVECTION TERM =  .700
MAXIMUM NUMBER OF MOVING PARTICLES ALLOWED =   10000
   40000 ELEMENTS OF THE  X ARRAY USED BY THE ADV PACKAGE
     240 ELEMENTS OF THE IX ARRAY USED BY THE ADV PACKAGE

DSP1 -- DISPERSION PACKAGE, VER DOD_1.5, JULY 1996, INPUT READ FROM UNIT  3
    1203 ELEMENTS OF THE  X ARRAY USED BY THE DSP PACKAGE
       0 ELEMENTS OF THE IX ARRAY USED BY THE DSP PACKAGE

SSM1 -- SINK & SOURCE MIXING PACKAGE, VER DOD_1.5, JULY 1996, INPUT READ FROM UNIT  4
MAJOR STRESS COMPONENTS PRESENT IN THE FLOW MODEL:
 1  DRAIN
 2  GENERAL-HEAD-DEPENDENT BOUNDARY
MAXIMUM NUMBER OF POINT SINKS/SOURCES =      71
     426 ELEMENTS OF THE  X ARRAY USED BY THE SSM PACKAGE
       0 ELEMENTS OF THE IX ARRAY BY THE SSM PACKAGE

RCT1 -- CHEMICAL REACTIONS PACKAGE, VER DOD_1.5, JULY 1996, INPUT READ FROM UNIT  9
TYPE OF SORPTION SELECTED IS [LINEAR]
FIRST-ORDER RATE REACTION [DECAY OR BIODEGRADATION] IS SIMULATED
       5 ELEMENTS OF THE  X ARRAY USED BY THE RCT PACKAGE
       0 ELEMENTS OF THE IX ARRAY USED BY THE RCT PACKAGE

.........................................................
   44583 ELEMENTS OF THE  X ARRAY USED OUT OF  3000000
     482 ELEMENTS OF THE IX ARRAY USED OUT OF   300000
.........................................................

LAYER NUMBER  AQUIFER TYPE
------------  ------------
      1             1
                                      WIDTH ALONG ROWS (DELR)  =   20.00000
                                      WIDTH ALONG COLS (DELC)  =   20.00000

                         TOP ELEV. OF 1ST LAYER   READ ON UNIT  1 USING FORMAT: "         (10G15.6)"
                         ---------------------------------------------------------------------------

                   CELL THICKNESS (DZ)      FOR LAYER  1 READ ON UNIT  1 USING FORMAT: "         (10G15.6)"
                   -----------------------------------------------------------------------------------
                                      EFFECTIVE POROSITY       =  .3500000     FOR LAYER  1

                   CONCN. BOUNDARY ARRAY    FOR LAYER  1 READ ON UNIT  1 USING FORMAT: "            (10I3)"
                   -----------------------------------------------------------------------------------

                   INITIAL CONCENTRATION    FOR LAYER  1 READ ON UNIT  1 USING FORMAT: "         (10G15.6)"
                   -----------------------------------------------------------------------------------

VALUE INDICATING INACTIVE CONCENTRATION CELLS =   .0000000
```

OUTPUT CONTROL OPTIONS

PRINT CELL CONCENTRATION USING FORMAT CODE: 1
DO NOT PRINT PARTICLE NUMBER IN EACH CELL
DO NOT PRINT RETARDATION FACTOR
DO NOT PRINT DISPERSION COEFFICIENT
SAVE CONCENTRATION IN UNFORMATTED FILE [MT3D.UCN] ON UNIT 18

NUMBER OF TIMES AT WHICH SIMULATION RESULTS ARE SAVED = 1
TOTAL ELAPSED TIMES AT WHICH SIMULATION RESULTS ARE SAVED:
365.00

NUMBER OF OBSERVATION POINTS = 0

A ONE-LINE SUMMRY OF MASS BALANCE FOR EACH STEP SAVED IN FILE [MT3D.MAS] ON UNIT 19

MAXIMUM LENGTH ALONG THE X (J) AXIS = 200.0000
MAXIMUM LENGTH ALONG THE Y (I) AXIS = 480.0000
MAXIMUM LENGTH ALONG THE Z (K) AXIS = 25.52000

ADVECTION SOLUTION OPTIONS

METHOD FOR PARTICLE TRACKING IS [MIXED ORDER]
CONCENTRATION WEIGHTING FACTOR = .500
THE CONCENTRATION GRADIENT CONSIDERED NEGLIGIBLE [DCEPS] = .1000000E-04
INITIAL PARTICLES ARE PLACED RANDOMLY WITHIN CELL BLOCK
PARTICLE NUMBER PER CELL IF DCCELL =< DCEPS = 1
PARTICLE NUMBER PER CELL IF DCCELL > DCEPS = 2
MINIMUM PARTICLE NUMBER ALLOWD PER CELL = 2
MAXIMUM PARTICLE NUMBER ALLOWD PER CELL = 20
MULTIPLIER OF PARTICLE NUMBER AT SOURCE = 1.00
SCHEME FOR CONCENTRATION INTERPOLATION IS [LINEAR]
PARTICLES FOR APPROXIMATING A SINK CELL IN THE [MMOC] SCHEME
ARE PLACED RANDOMLY WITHIN CELL BLOCK
NUMBER OF PARTICLES USED TO APPROXIMATE A SINK CELL IN THE [MMOC] SCHEME = 2
CRITICAL CONCENTRATION GRADIENT USED IN THE "HMOC" SCHEME [DCHMOC] = .2000E-02
THE "MOC" SOLUTION IS USED WHEN DCCELL > DCHMOC
THE "MMOC" SOLUTION IS USED WHEN DCCELL =< DCHMOC

DISPERSION PARAMETERS

LONG. DISPERSIVITY (AL) = 15.00000 FOR LAYER 1
H. TRANS./LONG. DISP. = .6500000
V. TRANS./LONG. DISP. = .0000000
DIFFUSION COEFFICIENT = .0000000

SORPTION AND 1ST ORDER RATE REACTION PARAMETERS

BULK DENSITY (RHOB) = 106.2000
SORPTION CONSTANT NO. 1 = .1560000E-02
SORPTION CONSTANT NO. 2 = .0000000
DISSOLVED RATE CONSTANT = .1400000E-02
SORBED RATE CONSTANT = .0000000

MAXIMUM STEPSIZE WHICH MEETS STABILITY CRITERION OF THE REACTION TERM
= 357.1 AT K= 1, I= 24, J= 10

RETARD. FACTOR IN LAYER 1 FOR TIME STEP 1, STRESS PERIOD 1

	1	2	3	4	5	6	7	8	9	10
1	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
2	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
3	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
4	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
5	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
6	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
7	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
8	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
9	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
10	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
11	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
12	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47

13	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
14	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
15	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
16	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
17	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
18	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
19	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
20	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
21	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
22	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
23	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
24	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47

++

STRESS PERIOD NO. 001

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LENGTH OF CURRENT STRESS PERIOD = 10950.00
NUMBER OF TIME STEPS FOR CURRENT STRESS PERIOD = 1
TIME STEP MULTIPLIER = 1.000000
USER-SPECIFIED TRANSPORT STEPSIZE = .0000000 DAY
MAXIMUM NUMBER OF TRANSPORT STEPS ALLOWED IN ONE TIME STEP = 5000

NO	LAYER	ROW	COLUMN	CONCENTRATION	TYPE
1	1	1	1	.0000000	HEAD DEP BOUND
2	1	1	2	.0000000	HEAD DEP BOUND
3	1	1	3	.0000000	HEAD DEP BOUND
4	1	1	4	.0000000	HEAD DEP BOUND
5	1	1	5	.0000000	HEAD DEP BOUND
6	1	1	6	.0000000	HEAD DEP BOUND
7	1	1	7	.0000000	HEAD DEP BOUND
8	1	1	8	.0000000	HEAD DEP BOUND
9	1	1	9	.0000000	HEAD DEP BOUND
10	1	1	10	.0000000	HEAD DEP BOUND
11	1	2	1	.0000000	HEAD DEP BOUND
12	1	3	1	.0000000	HEAD DEP BOUND
13	1	4	1	.0000000	HEAD DEP BOUND
14	1	5	1	.0000000	HEAD DEP BOUND
15	1	6	1	.0000000	HEAD DEP BOUND
16	1	7	1	.0000000	HEAD DEP BOUND
17	1	8	1	.0000000	HEAD DEP BOUND
18	1	9	1	.0000000	HEAD DEP BOUND
19	1	10	1	.0000000	HEAD DEP BOUND
20	1	11	1	.0000000	HEAD DEP BOUND
21	1	12	1	.0000000	HEAD DEP BOUND
22	1	13	1	.0000000	HEAD DEP BOUND
23	1	14	1	.0000000	HEAD DEP BOUND
24	1	15	1	.0000000	HEAD DEP BOUND
25	1	16	1	.0000000	HEAD DEP BOUND
26	1	17	1	.0000000	HEAD DEP BOUND
27	1	18	1	.0000000	HEAD DEP BOUND
28	1	19	1	.0000000	HEAD DEP BOUND
29	1	20	1	.0000000	HEAD DEP BOUND
30	1	21	1	.0000000	HEAD DEP BOUND
31	1	22	1	.0000000	HEAD DEP BOUND
32	1	23	1	.0000000	HEAD DEP BOUND
33	1	24	1	.0000000	HEAD DEP BOUND
34	1	24	2	.0000000	HEAD DEP BOUND
35	1	24	3	.0000000	HEAD DEP BOUND
36	1	24	4	.0000000	HEAD DEP BOUND
37	1	24	5	.0000000	HEAD DEP BOUND
38	1	24	6	.0000000	HEAD DEP BOUND
39	1	24	7	.0000000	HEAD DEP BOUND
40	1	24	8	.0000000	HEAD DEP BOUND
41	1	24	9	.0000000	HEAD DEP BOUND
42	1	24	10	.0000000	HEAD DEP BOUND
43	1	2	10	.0000000	HEAD DEP BOUND
44	1	3	10	.0000000	HEAD DEP BOUND
45	1	4	10	.0000000	HEAD DEP BOUND
46	1	5	10	.0000000	HEAD DEP BOUND
47	1	6	10	.0000000	HEAD DEP BOUND
48	1	7	10	.0000000	HEAD DEP BOUND
49	1	8	10	.0000000	HEAD DEP BOUND
50	1	9	10	.0000000	HEAD DEP BOUND
51	1	10	10	.0000000	HEAD DEP BOUND
52	1	11	10	.0000000	HEAD DEP BOUND
53	1	12	10	.0000000	HEAD DEP BOUND
54	1	13	10	.0000000	HEAD DEP BOUND
55	1	14	10	.0000000	HEAD DEP BOUND

56	1	15	10	.0000000	HEAD DEP BOUND
57	1	16	10	.0000000	HEAD DEP BOUND
58	1	17	10	.0000000	HEAD DEP BOUND
59	1	18	10	.0000000	HEAD DEP BOUND
60	1	19	10	.0000000	HEAD DEP BOUND
61	1	20	10	.0000000	HEAD DEP BOUND
62	1	21	10	.0000000	HEAD DEP BOUND
63	1	22	10	.0000000	HEAD DEP BOUND
64	1	23	10	.0000000	HEAD DEP BOUND

TIME STEP NO. 001

FROM TIME = .00000 TO 10950.

"THKSAT " FLOW TERMS FOR TIME STEP 1, STRESS PERIOD 1 READ UNFORMATTED ON UNIT 10

"QXX " FLOW TERMS FOR TIME STEP 1, STRESS PERIOD 1 READ UNFORMATTED ON UNIT 10

"QYY " FLOW TERMS FOR TIME STEP 1, STRESS PERIOD 1 READ UNFORMATTED ON UNIT 10

MAXIMUM STEPSIZE DURING WHICH ANY PARTICLE CANNOT MOVE MORE THAN ONE CELL
= 27.47 (WHEN MIN. R.F.=1) AT K= 1, I= 8, J= 3

MAXIMUM STEPSIZE WHICH MEETS STABILITY CRITERION OF THE ADVECTION TERM
(FOR PURE FINITE-DIFFERENCE OPTION, MIXELM=0)
= 12.16 (WHEN MIN. R.F.=1) AT K= 1, I= 9, J= 8

"CNH " FLOW TERMS FOR TIME STEP 1, STRESS PERIOD 1 READ UNFORMATTED ON UNIT 10

"DRN " FLOW TERMS FOR TIME STEP 1, STRESS PERIOD 1 READ UNFORMATTED ON UNIT 10

"GHB " FLOW TERMS FOR TIME STEP 1, STRESS PERIOD 1 READ UNFORMATTED ON UNIT 10

TOTAL NUMBER OF POINT SOURCES/SINKS PRESENT IN THE FLOW MODEL = 71

MAXIMUM STEPSIZE WHICH MEETS STABILITY CRITERION OF THE SINK & SOURCE TERM
= 32.96 (WHEN MIN. R.F.=1) AT K= 1, I= 8, J= 1

MAXIMUM STEPSIZE WHICH MEETS STABILITY CRITERION OF THE DISPERSION TERM
= 8.648 (WHEN MIN. R.F.=1) AT K= 1, I= 8, J= 8

TRANSPORT STEP NO. 29

TOTAL ELAPSED TIME SINCE BEGINNING OF SIMULATION = 365.0000 DAY

CONCENTRATIONS IN LAYER 1 AT END OF TRANSPORT STEP 29, TIME STEP 1, STRESS PERIOD 1

	1	2	3	4	5	6	7	8	9	10
1	11.5	21.9	44.2	196.	312.	262.	167.	117.	90.3	63.2
2	22.2	43.2	35.0	720.	1.015E+03	767.	396.	238.	143.	79.3
3	71.2	147.	528.	2.074E+03	4.091E+03	1.713E+03	866.	452.	286.	146.
4	155.	323.	919.	3.983E+03	1.515E+04	3.616E+03	1.583E+03	744.	343.	171.
5	368.	785.	58.0	5.300E+03	1.113E+04	5.359E+03	2.978E+03	1.015E+03	332.	195.
6	644.	2.368E+03	8.698E+03	5.996E+03	6.952E+03	4.455E+03	2.447E+03	969.	424.	179.
7	785.	2.013E+03	5.947E+03	5.810E+03	5.747E+03	3.733E+03	1.728E+03	717.	365.	148.
8	737.	1.885E+03	4.246E+03	4.564E+03	4.525E+03	2.771E+03	560.	461.	227.	103.
9	467.	880.	2.290E+03	2.445E+03	3.343E+03	2.702E+03	451.	228.	126.	55.5
10	236.	336.	802.	990.	1.228E+03	818.	246.	125.	71.8	28.5
11	108.	180.	306.	450.	493.	305.	125.	63.2	30.5	13.6
12	49.3	88.2	177.	322.	294.	171.	63.7	31.9	19.2	10.5
13	27.7	53.3	144.	286.	242.	90.1	40.6	19.5	9.99	6.52
14	18.6	32.9	114.	197.	176.	64.6	25.9	12.9	6.44	5.06
15	12.9	26.2	49.9	132.	120.	25.5	16.1	8.72	4.84	3.39
16	5.68	7.57	16.3	30.1	11.0	7.32	9.69	7.51	4.36	2.54

17	2.52	2.41	3.59	4.98	1.39	2.53	5.18	4.90	3.09	1.88
18	.609	.680	.795	.990	.339	1.01	2.36	2.51	1.77	1.45
19	.327	.214	.186	.208	9.730E-02	.382	.944	1.09	.820	.597
20	.115	7.109E-02	4.639E-02	4.434E-02	2.921E-02	.132	.339	.423	.356	.352
21	3.075E-02	2.301E-02	1.195E-02	9.411E-03	8.619E-03	4.161E-02	.110	.147	.138	.120
22	9.633E-03	7.347E-03	3.082E-03	1.969E-03	2.421E-03	1.202E-02	3.237E-02	4.647E-02	5.082E-02	6.270E-02
23	6.105E-03	2.385E-03	7.875E-04	4.096E-04	6.640E-04	3.233E-03	8.767E-03	1.356E-02	1.742E-02	2.065E-02
24	1.584E-03	1.237E-03	5.930E-04	2.757E-04	7.028E-04	2.068E-03	3.504E-03	4.070E-03	7.294E-03	1.379E-02

TOTAL PARTICLES USED IN THE CURRENT STEP = 742
PARTICLES ADDED AT BEGINNING OF THE STEP = 30
PARTICLES REMOVED AT END OF LAST STEP = 48

CUMMULATIVE MASS BUDGETS AT END OF TRANSPORT STEP 29, TIME STEP 1, STRESS PERIOD 1

	IN	OUT
CONSTANT CONCENTRATION:	.1375363E+10	-.3006290E+09
CONSTANT HEAD:	.0000000	.0000000
DRAINS:	.0000000	-.6507165E+09
HEAD-DEPENDENT BOUNDARY:	.0000000	-38.16804
DECAY OR BIODEGRADATION:	.0000000	-.1887973E+09
MASS STORAGE (SOLUTE):	.3845049E+09	-.5046121E+09
MASS STORAGE (ADSORBED):	.1820048E+09	-.2388574E+09
[TOTAL]:	.1941873E+10 UNDF	-.1883612E+10 UNDF

NET (IN - OUT): .5826048E+08
DISCREPANCY (PERCENT): 3.045913

TRANSPORT STEP NO. 860

TOTAL ELAPSED TIME SINCE BEGINNING OF SIMULATION = 10950.00 DAY

CONCENTRATIONS IN LAYER 1 AT END OF TRANSPORT STEP 860, TIME STEP 1, STRESS PERIOD 1

	1	2	3	4	5	6	7	8	9	10
1	14.3	23.6	57.1	256.	371.	226.	134.	59.0	25.0	10.5
2	36.1	61.8	35.0	584.	1.242E+03	692.	224.	116.	54.4	19.6
3	63.8	163.	437.	2.074E+03	4.033E+03	1.657E+03	692.	266.	104.	37.6
4	156.	358.	828.	4.163E+03	1.515E+04	4.208E+03	1.641E+03	462.	191.	69.2
5	338.	714.	58.0	4.896E+03	1.011E+04	5.218E+03	2.978E+03	890.	280.	95.9
6	641.	1.674E+03	8.698E+03	6.068E+03	7.076E+03	4.803E+03	2.572E+03	810.	303.	105.
7	778.	2.035E+03	5.899E+03	5.627E+03	5.474E+03	3.777E+03	1.757E+03	667.	247.	86.4
8	581.	1.657E+03	4.246E+03	5.386E+03	4.493E+03	2.509E+03	560.	303.	156.	60.4
9	442.	834.	2.513E+03	3.629E+03	3.600E+03	1.900E+03	424.	174.	116.	45.3
10	226.	501.	846.	1.281E+03	1.142E+03	744.	267.	102.	49.7	26.8
11	94.1	169.	288.	412.	399.	263.	110.	54.0	30.1	13.2
12	29.4	61.1	91.4	126.	127.	89.7	50.5	25.6	18.7	9.71
13	13.1	25.0	39.8	42.1	46.3	31.1	21.0	16.2	9.86	7.25
14	7.38	13.6	16.7	21.6	21.3	16.4	10.3	7.23	5.10	4.03
15	4.78	6.36	7.35	8.02	7.34	5.83	4.32	3.30	2.69	2.10
16	3.00	3.11	3.21	3.01	2.41	1.87	1.69	1.60	1.47	1.11
17	1.66	1.78	1.73	1.50	1.07	.841	.889	.922	.927	.745
18	1.04	1.13	1.09	.947	.701	.554	.576	.602	.612	.608
19	.730	.780	.756	.663	.511	.411	.411	.424	.433	.433
20	.522	.556	.549	.488	.390	.320	.310	.313	.312	.282
21	.360	.410	.411	.371	.306	.257	.244	.242	.235	.223
22	.278	.313	.317	.290	.247	.212	.199	.194	.187	.171
23	.248	.255	.256	.236	.207	.183	.170	.164	.158	.153
24	.220	.226	.227	.215	.195	.176	.164	.154	.149	.144

TOTAL PARTICLES USED IN THE CURRENT STEP = 681
PARTICLES ADDED AT BEGINNING OF THE STEP = 10
PARTICLES REMOVED AT END OF LAST STEP = 0

CUMMULATIVE MASS BUDGETS AT END OF TRANSPORT STEP 860, TIME STEP 1, STRESS PERIOD 1

	IN	OUT
CONSTANT CONCENTRATION:	.3941523E+11	-.9408025E+10
CONSTANT HEAD:	.0000000	.0000000
DRAINS:	.0000000	-.2201404E+11

HEAD-DEPENDENT BOUNDARY:	.0000000	-394575.9
DECAY OR BIODEGRADATION:	.0000000	-.5543962E+10
MASS STORAGE (SOLUTE):	.1141994E+11	-.1152340E+11
MASS STORAGE (ADSORBED):	.5405621E+10	-.5454585E+10
[TOTAL]:	.5624079E+11 UNDF	-.5394440E+11 UNDF

NET (IN - OUT): .2296386E+10
DISCREPANCY (PERCENT): 4.168229

| M T |
| 3 D | End of Model Output

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1                    U.S. GEOLOGICAL SURVEY MODULAR FINITE-DIFFERENCE GROUND-WATER MODEL
0Ground Water Modeling ForTony's Auto Express Facility                    June 1999 SOMA ENVIRONMENTAL ENGINEERING INC.

    1 LAYERS        24 ROWS        10 COLUMNS
   1 STRESS PERIOD(S) IN SIMULATION
 MODEL TIME UNIT IS DAYS
0I/O UNITS:
 ELEMENT OF IUNIT:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
         I/O UNIT: 11  0  0  0  0  0 17  0 19  0  0  0 13  0  0  0  0  0  0  0  0  0  0  0
0BAS1 -- BASIC MODEL PACKAGE, VERSION 1, 12/08/83 INPUT READ FROM UNIT  1
 ARRAYS RHS AND BUFF WILL SHARE MEMORY.
 START HEAD WILL BE SAVED
   2198 ELEMENTS IN X ARRAY ARE USED BY BAS
   2198 ELEMENTS OF X ARRAY USED OUT OF 450000
0BCF1 -- BLOCK-CENTERED FLOW PACKAGE, VERSION 1, 12/08/83 INPUT READ FROM UNIT 11
 STEADY-STATE SIMULATION
 CELL-BY-CELL FLOWS WILL BE RECORDED ON UNIT 40
      LAYER  AQUIFER TYPE
      ------------------
        1         1
    481 ELEMENTS IN X ARRAY ARE USED BY BCF
   2679 ELEMENTS OF X ARRAY USED OUT OF 450000
0GHB1 -- GHB PACKAGE, VERSION 1, 12/08/83 INPUT READ FROM UNIT 17
 MAXIMUM OF   64 HEAD-DEPENDENT BOUNDARY NODES
    384 ELEMENTS IN X ARRAY ARE USED FOR HEAD-DEPENDENT BOUNDARIES
   3063 ELEMENTS OF X ARRAY USED OUT OF 450000
0SIP1 -- STRONGLY IMPLICIT PROCEDURE SOLUTION PACKAGE, VERSION 1, 12/08/83 INPUT READ FROM UNIT 19
 MAXIMUM OF 150 ITERATIONS ALLOWED FOR CLOSURE
   5 ITERATION PARAMETERS
   1565 ELEMENTS IN X ARRAY ARE USED BY SIP
   4628 ELEMENTS OF X ARRAY USED OUT OF 450000
1Ground Water Modeling ForTony's Auto Express Facility                    June 1999 SOMA ENVIRONMENTAL ENGINEERING INC.

0                                                BOUNDARY ARRAY =              1 FOR LAYER  1
0AQUIFER HEAD WILL BE SET TO 0.00000     AT ALL NO-FLOW NODES (IBOUND=0).
0

                                  INITIAL HEAD FOR LAYER  1 WILL BE READ ON UNIT  1 USING FORMAT:  (10F8.2)
                         ------------------------------------------------------------------------------------

0DEFAULT OUTPUT CONTROL -- THE FOLLOWING OUTPUT COMES AT THE END OF EACH STRESS PERIOD:
 TOTAL VOLUMETRIC BUDGET
          HEAD
          DRAWDOWN
0                                          COLUMN TO ROW ANISOTROPY =   1.000000
0                                                             DELR =   20.00000
0                                                             DELC =   20.00000
0

                               HYD. COND. ALONG ROWS FOR LAYER  1 WILL BE READ ON UNIT 11 USING FORMAT:  (10F8.2)
                         ------------------------------------------------------------------------------------
```

	1	2	3	4	5	6	7	8	9	10
0 1	5.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 2	5.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 3	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 4	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 5	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 6	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
0 7	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 8	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
0 9	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 10	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 11	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 12	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 13	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 14	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 15	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 16	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 17	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 18	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 19	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 20	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 21	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 22	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 23	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
0 24	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00

0

```
                                        BOTTOM FOR LAYER  1 WILL BE READ ON UNIT 11 USING FORMAT:  (10F8.2)
                          ------------------------------------------------------------------------------------
0

                                                      SOLUTION BY THE STRONGLY IMPLICIT PROCEDURE
                                                      -------------------------------------------
0                                       MAXIMUM ITERATIONS ALLOWED FOR CLOSURE =       150
                                                         ACCELERATION PARAMETER =     1.3600
                                            HEAD CHANGE CRITERION FOR CLOSURE =    0.10000E-01
                                            SIP HEAD CHANGE PRINTOUT INTERVAL =        1
0                                           CALCULATE ITERATION PARAMETERS FROM MODEL CALCULATED WSEED
1                                          STRESS PERIOD NO.    1, LENGTH =   3650.000
                                           ---------------------------------------------

                                           NUMBER OF TIME STEPS =      1

                                            MULTIPLIER FOR DELT =     1.000

                                         INITIAL TIME STEP SIZE =   3650.000
0

    64 HEAD-DEPENDENT BOUNDARY NODES
0AVERAGE SEED = 0.00422451
 MINIMUM SEED = 0.00330126
0
    5 ITERATION PARAMETERS CALCULATED FROM AVERAGE SEED:

          0.0000000E+00  0.7450565E+00  0.9350038E+00  0.9834296E+00  0.9957755E+00
0
     6 ITERATIONS FOR TIME STEP   1 IN STRESS PERIOD  1
0MAXIMUM HEAD CHANGE FOR EACH ITERATION:
0 HEAD  CHANGE  LAYER,ROW,COL  HEAD  CHANGE  LAYER,ROW,COL  HEAD  CHANGE  LAYER,ROW,COL  HEAD  CHANGE  LAYER,ROW,COL  HEAD  CHANGE
LAYER,ROW,COL

-----------------------------------------------------------------------------------------------------------------------------------
-------
   0.5542     (  1,   5,   5) -0.1441     (  1,  24,   1) -0.1345     (  1,  24,   9)  0.4071E-01 (  1,  10,   8)  0.2855E-01 (  1,   5,
5)
   0.3789E-02 (  1,  10,   1)
0
1                     HEAD IN LAYER  1 AT END OF TIME STEP  1 IN STRESS PERIOD  1
                 ---------------------------------------------------------------------
```

	1	2	3	4	5	6	7	8	9	10
0 1	88.51	88.47	88.43	88.38	88.34	88.31	88.29	88.28	88.28	88.28
0 2	88.34	88.28	88.23	88.19	88.15	88.12	88.10	88.09	88.09	88.09
0 3	88.13	88.07	88.02	87.99	87.95	87.93	87.91	87.91	87.90	87.90
0 4	87.90	87.84	87.81	87.78	87.75	87.73	87.72	87.71	87.71	87.71
0 5	87.65	87.61	87.58	87.55	87.53	87.51	87.50	87.50	87.50	87.51
0 6	87.45	87.42	87.39	87.36	87.35	87.34	87.33	87.33	87.33	87.34
0 7	87.24	87.21	87.19	87.17	87.16	87.15	87.14	87.15	87.15	87.17
0 8	87.02	87.00	86.98	86.96	86.95	86.95	86.94	86.95	86.96	86.98
0 9	86.80	86.78	86.76	86.75	86.74	86.73	86.73	86.74	86.75	86.77
0 10	86.51	86.50	86.49	86.48	86.47	86.47	86.46	86.47	86.47	86.49
0 11	86.22	86.22	86.21	86.21	86.20	86.20	86.20	86.19	86.19	86.19
0 12	85.94	85.94	85.94	85.94	85.93	85.93	85.93	85.92	85.91	85.89
0 13	85.66	85.67	85.67	85.67	85.67	85.66	85.65	85.65	85.63	85.60
0 14	85.40	85.41	85.41	85.40	85.40	85.39	85.39	85.38	85.36	85.34
0 15	85.13	85.13	85.13	85.12	85.12	85.11	85.10	85.09	85.08	85.07
0 16	84.85	84.84	84.83	84.82	84.82	84.81	84.80	84.80	84.79	84.79
0 17	84.57	84.55	84.54	84.52	84.51	84.51	84.50	84.50	84.50	84.50

0 18	84.28	84.25	84.23	84.22	84.21	84.21	84.20	84.20	84.20	84.21
0 19	83.98	83.95	83.93	83.91	83.90	83.90	83.89	83.89	83.89	83.90
0 20	83.67	83.64	83.62	83.61	83.59	83.59	83.58	83.58	83.58	83.59
0 21	83.35	83.32	83.30	83.29	83.28	83.28	83.27	83.27	83.27	83.28
0 22	83.01	82.99	82.98	82.97	82.97	82.96	82.96	82.96	82.96	82.96
0 23	82.66	82.65	82.65	82.65	82.65	82.65	82.65	82.64	82.64	82.64
0 24	82.28	82.30	82.32	82.33	82.34	82.34	82.33	82.32	82.31	82.30

1 DRAWDOWN IN LAYER 1 AT END OF TIME STEP 1 IN STRESS PERIOD 1

	1	2	3	4	5	6	7	8	9	10
0 1	-1.0139E-02	5.8136E-03	2.4490E-03	-3.2677E-02	-9.0652E-02	-0.1372	-0.1460	-0.1272	-7.8217E-02	5.9967E-03
0 2	5.9624E-02	7.9819E-02	5.1598E-02	-6.7039E-02	-0.1616	-0.1737	-0.1246	-3.4225E-02	1.9615E-02	6.1287E-02
0 3	0.1453	0.1316	2.8458E-02	-0.1451	-0.2847	-0.2611	-0.1246	3.4920E-02	8.8989E-02	9.9869E-02
0 4	0.2225	0.1767	3.2692E-02	-0.2565	-0.4707	-0.4009	-0.1674	3.9749E-02	0.1315	0.1290
0 5	0.2380	0.2248	7.4402E-02	-0.2895	-0.5883	-0.4526	-0.1627	8.1284E-02	0.1796	0.1625
0 6	0.1461	0.1445	3.2570E-02	-0.2348	-0.4273	-0.3451	-9.8122E-02	0.1132	0.1985	0.1777
0 7	5.5809E-02	8.5686E-02	2.9106E-02	-0.1221	-0.2280	-0.1689	5.2032E-03	0.1841	0.2461	0.2297
0 8	4.8317E-02	6.3095E-02	3.2143E-02	-5.2750E-02	-0.1118	-6.5407E-02	8.5693E-02	0.2431	0.2924	0.2807
0 9	3.4882E-02	-1.5221E-02	-5.0385E-02	-9.8595E-02	-0.1199	-7.4692E-02	2.7061E-02	0.1432	0.2227	0.2912
0 10	-2.7260E-02	-0.1059	-0.1568	-0.1789	-0.1626	-0.1279	-6.4598E-02	3.2654E-02	0.1360	0.2512
0 11	-0.1180	-0.2161	-0.2726	-0.2782	-0.2436	-0.1994	-0.1557	-6.3583E-02	2.7809E-02	0.1177
0 12	-0.1754	-0.2799	-0.3602	-0.3381	-0.2945	-0.2302	-0.1750	-0.1085	-5.8563E-02	-5.1872E-02
0 13	-0.1734	-0.2598	-0.3215	-0.3298	-0.2962	-0.2313	-0.1549	-9.5627E-02	-8.0528E-02	-0.1442
0 14	-0.1286	-0.1764	-0.2169	-0.2437	-0.2488	-0.1831	-9.6230E-02	-3.6774E-02	-4.2053E-02	-0.1077
0 15	-7.0526E-02	-6.1867E-02	-6.8237E-02	-0.1024	-0.1259	-8.9447E-02	-1.2695E-02	5.5099E-02	7.5172E-02	9.0027E-03
0 16	-4.3411E-03	4.7440E-02	6.7123E-02	2.5833E-02	-6.3400E-03	1.0620E-02	7.7042E-02	0.1526	0.1970	0.1287
0 17	4.0039E-02	7.9758E-02	0.1046	8.6044E-02	6.5071E-02	8.2115E-02	0.1183	0.1820	0.2122	0.1768
0 18	5.3123E-02	8.7112E-02	0.1053	9.8831E-02	9.8640E-02	0.1046	0.1316	0.1644	0.1825	0.1749
0 19	7.3051E-02	8.0154E-02	9.0340E-02	0.1051	0.1058	0.1036	0.1185	0.1301	0.1475	0.1601
0 20	0.1008	7.9971E-02	9.0492E-02	0.1150	0.1157	0.1148	9.7633E-02	9.8618E-02	0.1162	0.1496
0 21	0.1300	0.1187	0.1369	0.1487	0.1572	0.1337	9.7702E-02	7.9437E-02	0.1079	0.1421
0 22	0.1066	0.1489	0.1903	0.2265	0.2310	0.2055	0.1498	0.1130	0.1232	0.1674
0 23	6.1836E-02	0.1809	0.2702	0.3273	0.3563	0.3387	0.2940	0.2405	0.2246	0.2107
0 24	3.9017E-02	0.2332	0.3831	0.4674	0.5093	0.5101	0.4783	0.4212	0.3541	0.2629

0

VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP 1 IN STRESS PERIOD 1

0 CUMULATIVE VOLUMES L**3 RATES FOR THIS TIME STEP L**3/T

CUMULATIVE VOLUMES	L**3	RATES FOR THIS TIME STEP	L**3/T
IN:		IN:	
STORAGE =	0.00000	STORAGE =	0.00000
CONSTANT HEAD =	0.00000	CONSTANT HEAD =	0.00000
HEAD DEP BOUNDS =	0.75873E+06	HEAD DEP BOUNDS =	207.87
TOTAL IN =	0.75873E+06	TOTAL IN =	207.87

0

0 OUT:

STORAGE =	0.00000
CONSTANT HEAD =	0.00000
HEAD DEP BOUNDS =	0.76036E+06
TOTAL OUT =	0.76036E+06
IN - OUT =	-1621.8
PERCENT DISCREPANCY =	-0.21

OUT:

STORAGE =	0.00000
CONSTANT HEAD =	0.00000
HEAD DEP BOUNDS =	208.32
TOTAL OUT =	208.32
IN - OUT =	-0.44434
PERCENT DISCREPANCY =	-0.21

0
0
0

0

TIME SUMMARY AT END OF TIME STEP 1 IN STRESS PERIOD 1

	SECONDS	MINUTES	HOURS	DAYS	YEARS
TIME STEP LENGTH	0.315360E+09	0.525600E+07	87600.0	3650.00	9.99316
STRESS PERIOD TIME	0.315360E+09	0.525600E+07	87600.0	3650.00	9.99316
TOTAL SIMULATION TIME	0.315360E+09	0.525600E+07	87600.0	3650.00	9.99316

1

Figure A-2: Simulated Groundwater Elevation Contours Map

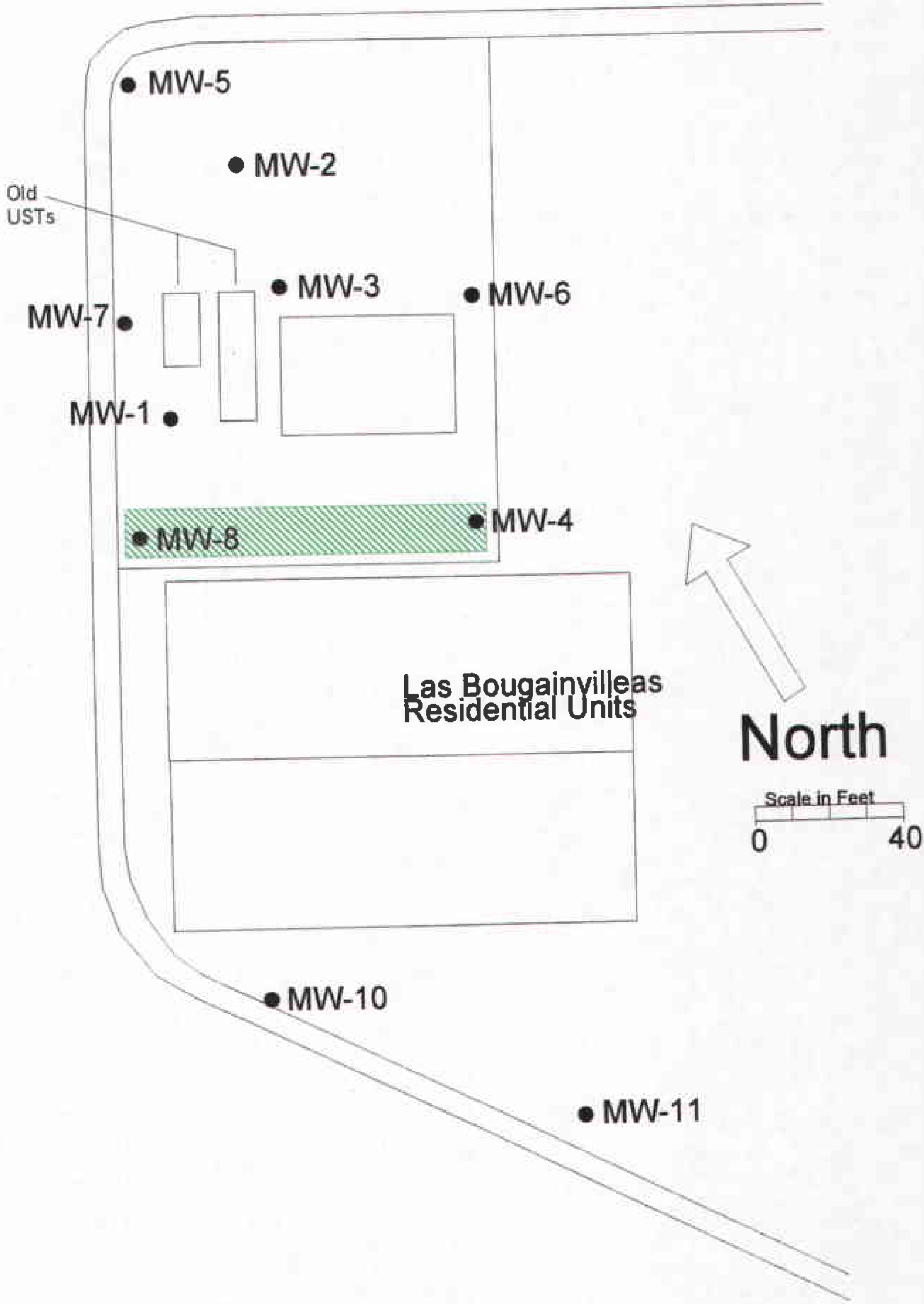


Figure A-3: Location of the Proposed French Drain

SOMA ENVIRONMENTAL ENGINEERING, INC

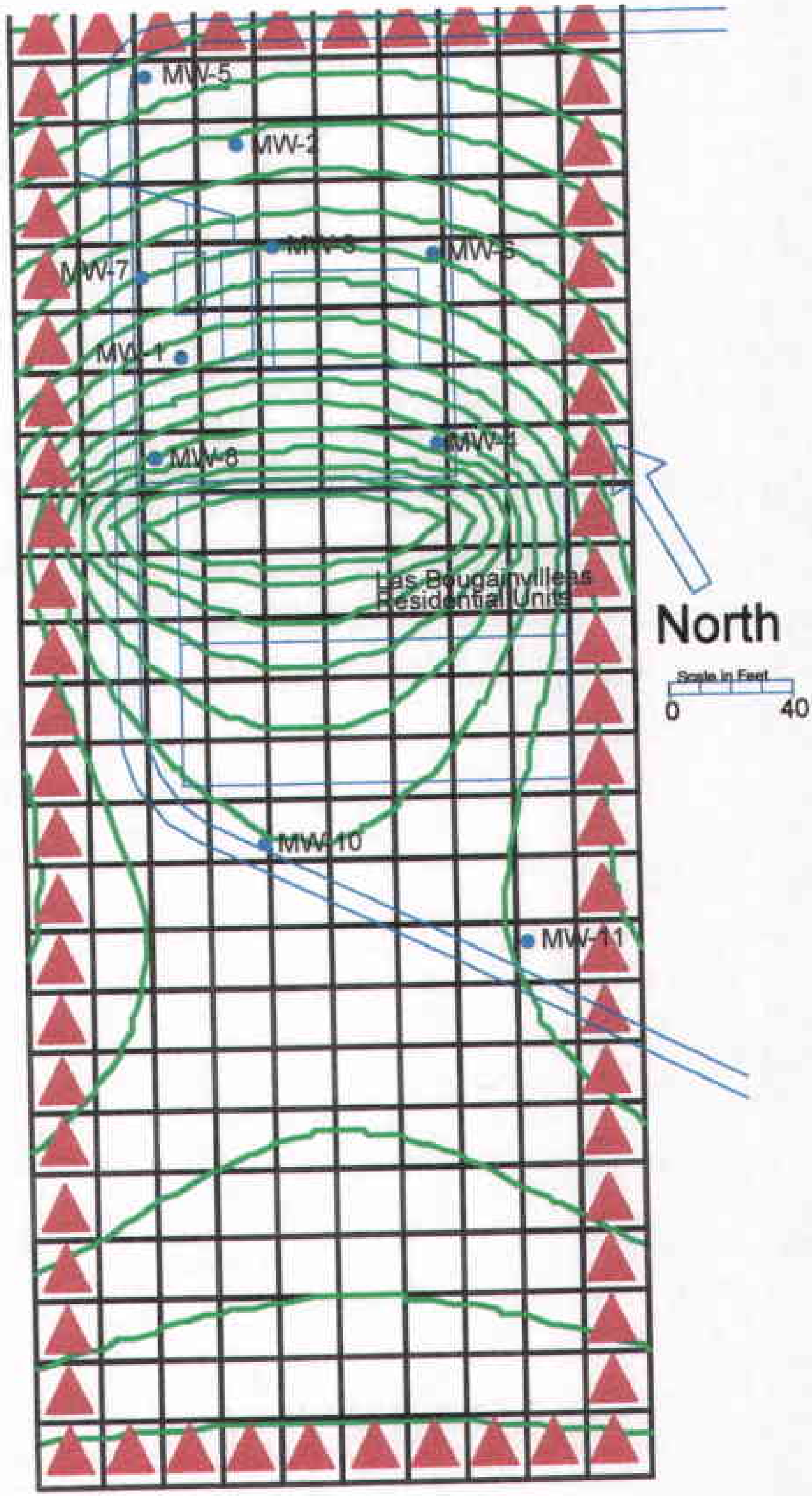


Figure A-4: Simulated Water Level Elevations Under Pumping Conditions

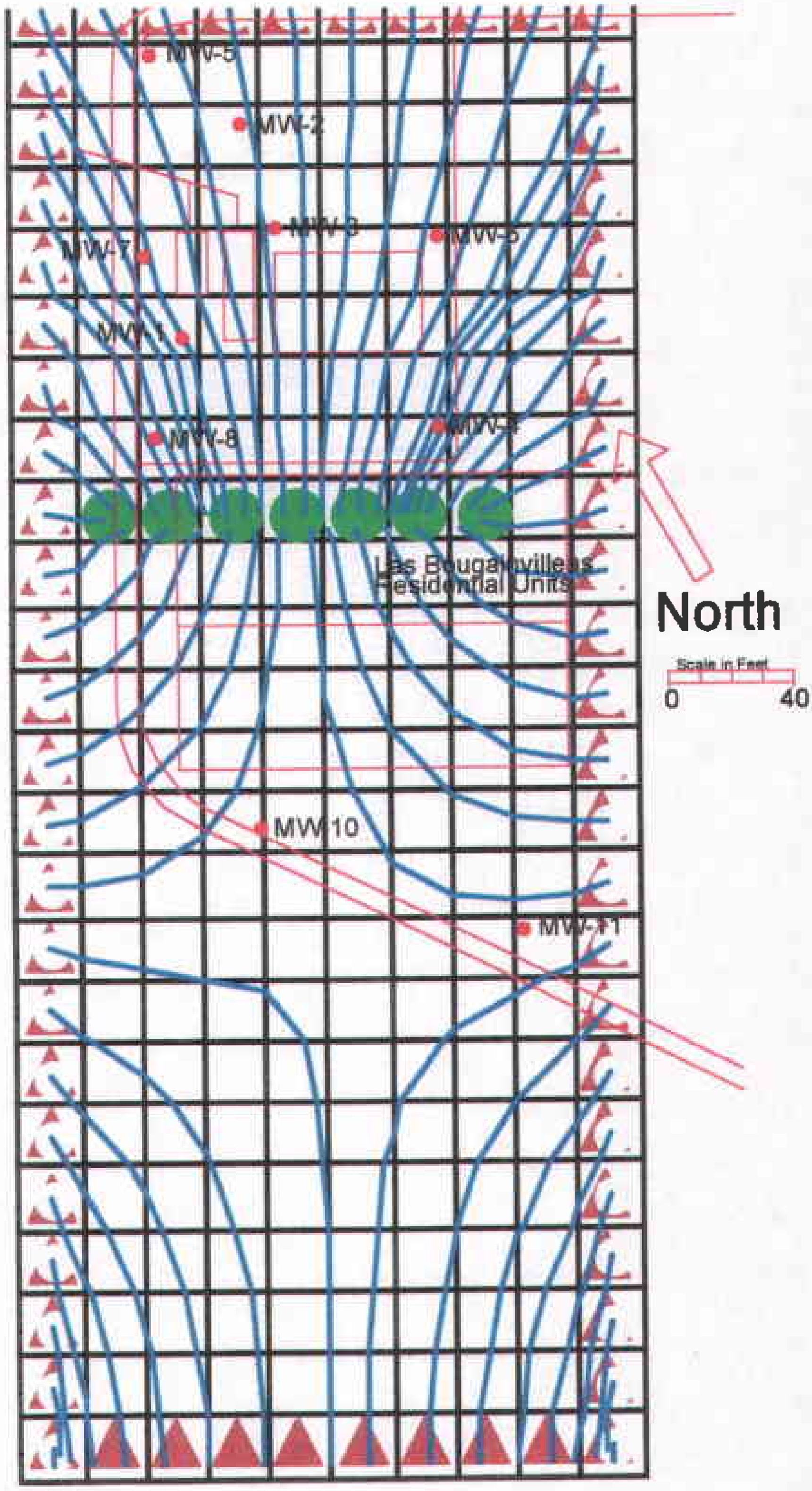


Figure A-5: Capture Zone of the French Drain

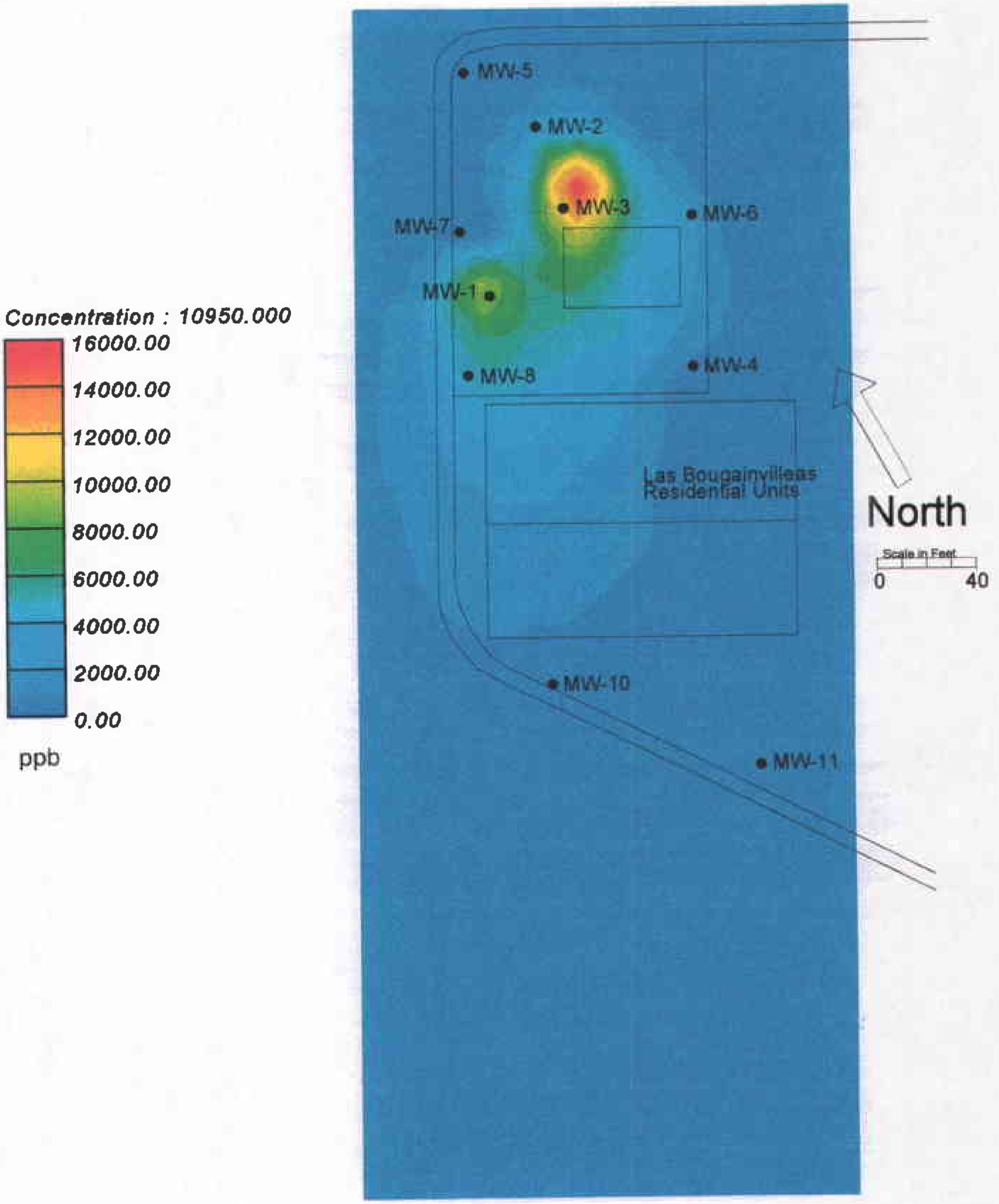


Figure A-6: Simulated Benzene Concentration in Groundwater after 30 Years Under Ambient Conditions

SOMA ENVIRONMENTAL ENGINEERING, INC.

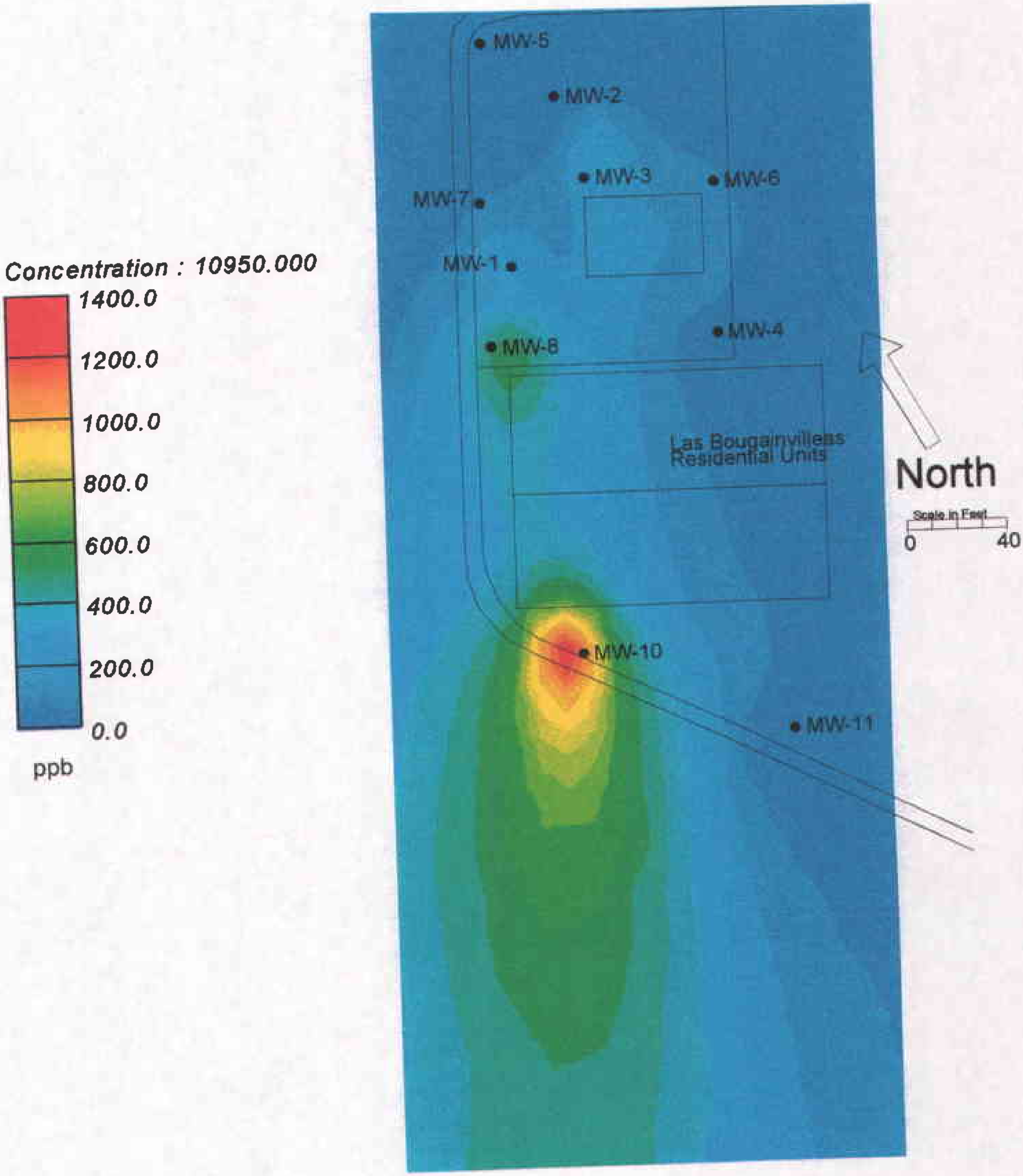


Figure A-7: Simulated MTBE Concentration in Groundwater after 30 Years Under Ambient Conditions

SOMA ENVIRONMENTAL ENGINEERING, INC.

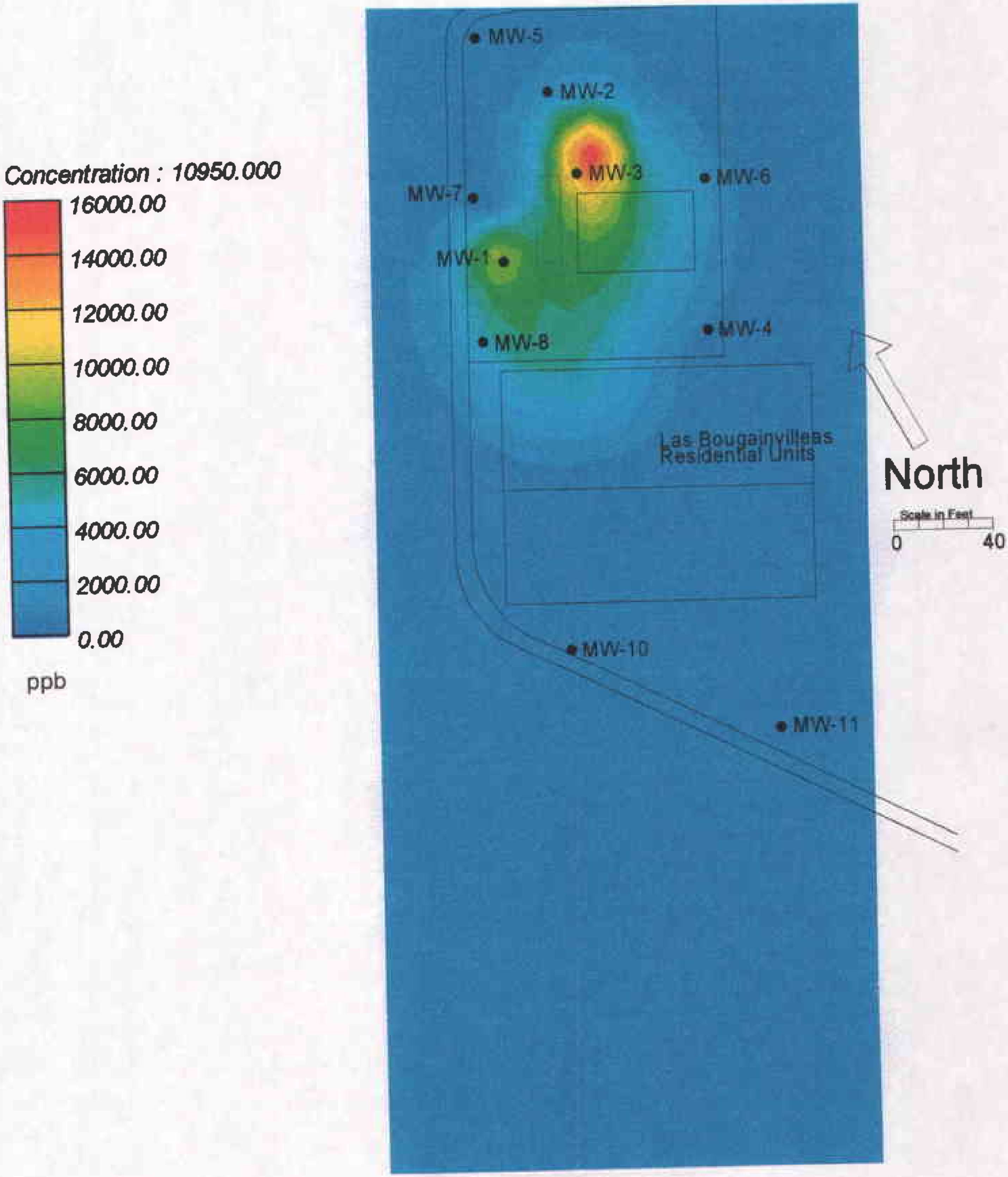


Figure A-8: Simulated Benzene Concentration in Groundwater after 30 Years Under Pumping Conditions

SOMA ENVIRONMENTAL ENGINEERING, INC.

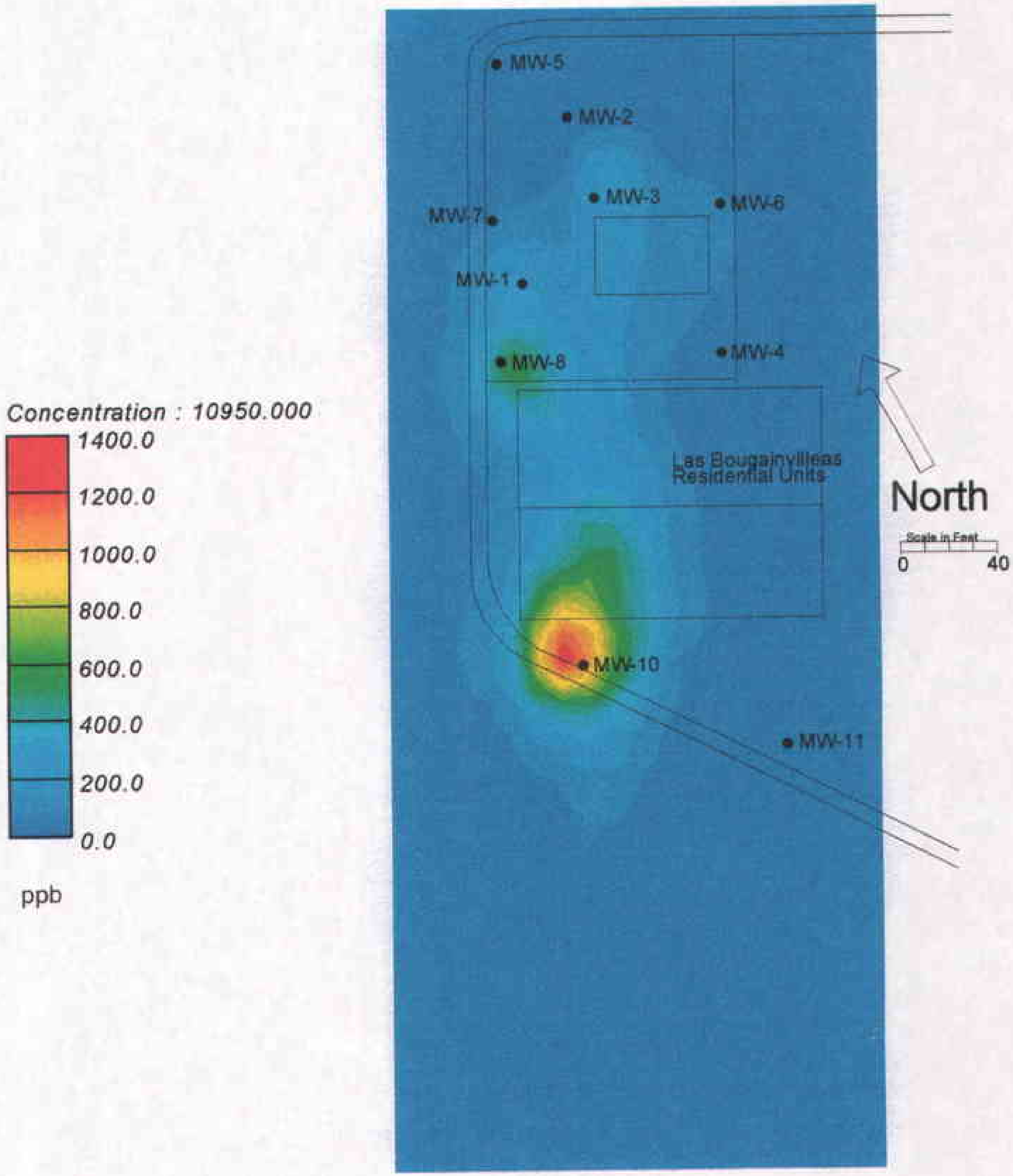


Figure A-9: Simulated MTBE Concentration in Groundwater after 30 Years Under Pumping Conditions

Table A-1
Difference Between Simulated and Measured Water Levels
Tony's Express Auto Services, Oakland, California

Well Name	Layer No.	Row No.	Column No.	Measure Elev. (ft)	Simulated Elev. (ft)	Difference Elev. (ft)
MW-05	1.00	2.00	2.00	88.19	88.28	0.09
MW-02	1.00	3.00	4.00	88.00	87.99	-0.01
MW-03	1.00	4.00	5.00	86.65	87.75	1.10
MW-07	1.00	5.00	3.00	87.61	87.58	-0.03
MW-06	1.00	5.00	7.00	87.51	87.50	-0.01
MW-08	1.00	8.00	3.00	86.92	86.98	0.06
MW-04	1.00	8.00	7.00	87.13	86.94	-0.19
MW-10	1.00	14.00	4.00	85.02	85.40	0.38
MW-10	1.00	16.00	8.00	84.92	84.80	-0.12
MW-01	1.00	6.00	3.00	87.37	87.39	0.02

Table A-2
Chemical Parameters Used in MT3D

Chemical	Organic Carbon Water Partition Coefficient (Koc) (cm^3/g)	foc	Distribution Coefficient (Kd) (cm^3/g)	Retardation Factor (R)
Benzene	98.0	0.001	0.098	1.48
MTBE	11.7	0.001	0.012	1.06

APPENDIX B

PUMPING TEST PROCEDURE

ANALYSIS AND RESULTS

B1.0 Pumping Test

A pump test was conducted using monitoring well MW-3. Monitoring wells MW-1, MW-2, MW-6 and MW-7 were used as observation wells during the test. Pumping was maintained at an approximate constant rate of 1 gpm. Based on the discussion presented in Section 2.2 on site hydrogeology, the aquifer is unconfined. However, the full thickness of the aquifer is currently unknown because monitoring wells only tap the top 20 feet of the aquifer. To account for the uncertainty associated with the aquifer thickness, the analyses were conducted assuming the monitoring wells partially penetrated the aquifer. The partial penetration equations for flow in unconfined aquifers (Neuman, 1974) was used to estimate the hydraulic parameters. Because the pump test was conducted over a relatively short duration (280 minutes), delayed yield effects were not observed and consequently, the short duration part of the Neuman curves (Type Curve A) were used in the analyses. Such analyses are only capable of estimating the storage coefficient of the aquifer. The specific yield of the aquifer cannot be estimated.

Note that because of potentially high well losses, the drawdown data obtained from the pumped well (MW-3) was not analyzed. The recovery data was analyzed using the Theis (1935) equation for fully penetrating wells. The Neuman equations are not suited for analyzing recovery data. Further note that only data from monitoring well MW-2 was analyzed because there was practically no response (less than 0.05 ft of drawdown) in the other observation wells. The following analyses were used to estimate the aquifer parameters:

1. Theis equation was used to analyze the recovery data as shown in Figure B-1. The lack of linearity in the data suggests that the aquifer is probably heterogeneous. From the analyses, the aquifer transmissivity was estimated

to be about 30 ft^2/day or hydraulic conductivity of 1.5 ft/day assuming a 20-foot thick aquifer. The estimated storage coefficient should be ignored because pumped wells are incapable of accurately estimating it.

2. The aquifer is 20 feet thick with the pumping and monitoring well MW-2 fully penetrating the aquifer. The analysis for this scenario is presented in Figure B-2. Based on this assumption, the transmissivity of the aquifer was estimated to be about 290 ft^2/day or hydraulic conductivity of 14.5 ft/day. This estimated value is about one order of magnitude greater than was obtained from the recovery data. Storage coefficient was estimated to be 0.004.

3. The aquifer is 30 feet thick and monitoring well MW-2 and the pumping well partially penetrating (2/3 penetration) the aquifer. With this assumption, the aquifer transmissivity was estimated to be about 527 ft^2/day or hydraulic conductivity of about 17.5 ft/day. Again, the estimated hydraulic conductivity is about one order of magnitude greater than was obtained from the recovery data. Storage coefficient was estimated to be 0.007. The analysis for this scenario is presented in Figure B-3.

4. The aquifer is 50 feet thick while the monitoring well MW-2 and the pumping well MW-3 are partially penetrating (2/5penetration) the aquifer. With this assumption, the aquifer transmissivity was estimated to be about 915 ft^2/day or hydraulic conductivity of about 18.3 ft/day. Again, the estimated hydraulic conductivity is about one order of magnitude greater than was obtained from the recovery data. Storage coefficient was estimated to be 0.01. The analysis for this scenario is presented in Figure B-4.

Note that although good curve fits were obtained using the data for monitoring well MW-2, the results obtained from those analyses must be interpreted with caution for the following reasons:

- The estimated hydraulic conductivity values appear to be much higher than what would be expected for the silty clay materials encountered at the site. Published data such as Freeze and Cherry (1979) indicate the hydraulic conductivity of such materials to be less than 3 ft/day.
- The measured drawdowns are very small (less than 0.15 ft) and consequently, the estimated parameters can be significantly affected by natural background fluctuation.
- The slight response to the pumping recorded at monitoring well MW-6 (about 51 ft away from the pumped well) and no response at all at monitoring wells MW-1 and MW-7 (located about 41 and 43 ft away from the pumped well) suggest that the aquifer may be anisotropic and/or heterogeneous. If this is the case, the results obtained from monitoring well MW-2 should be viewed with suspicion because the equations used to analyze the data are not capable of analyzing such conditions.

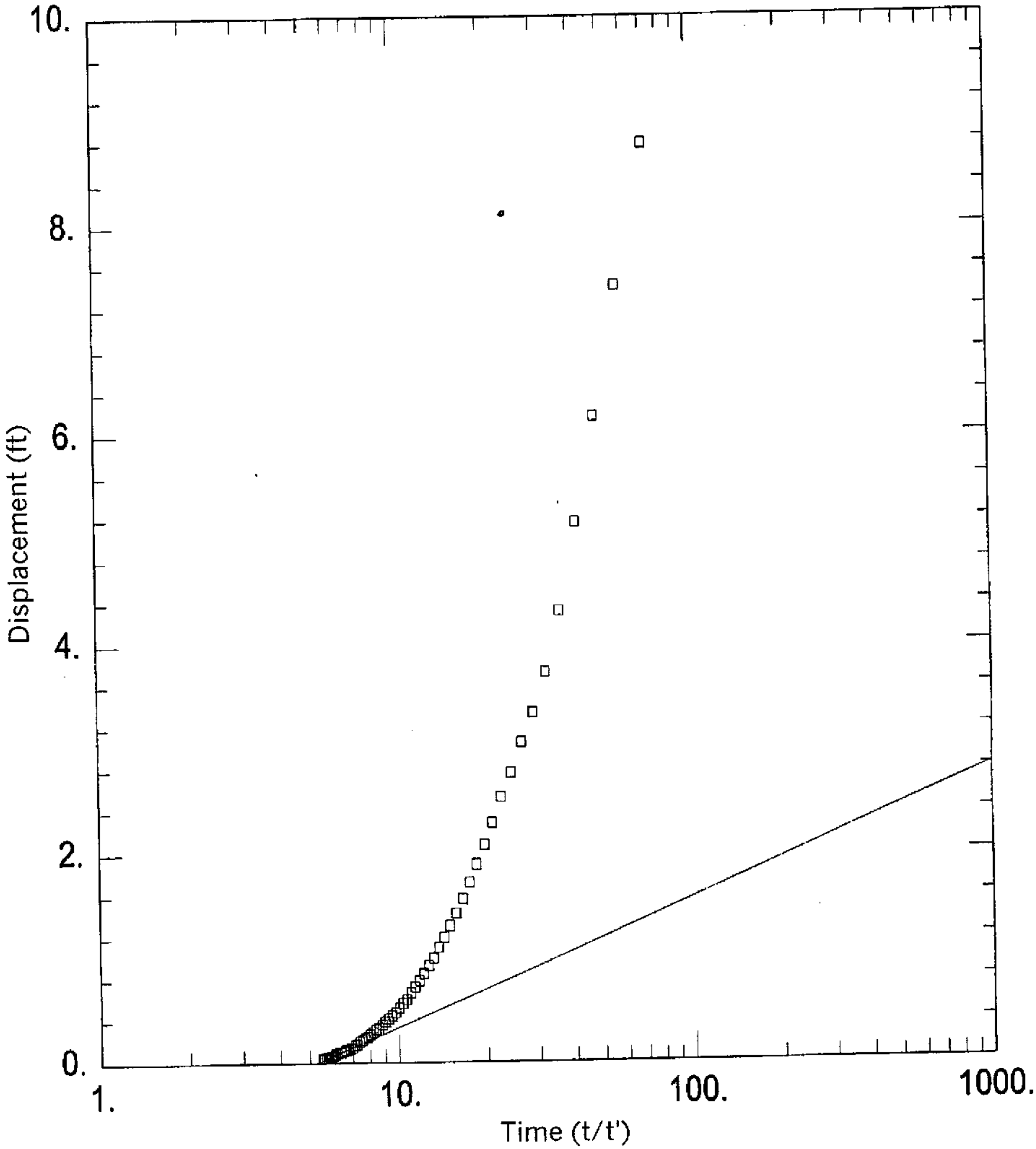


Figure B-1: Evaluation of Auifer Transmissivity using Theis Recovery Method
Assuming Saturated Thickness is 20 ft

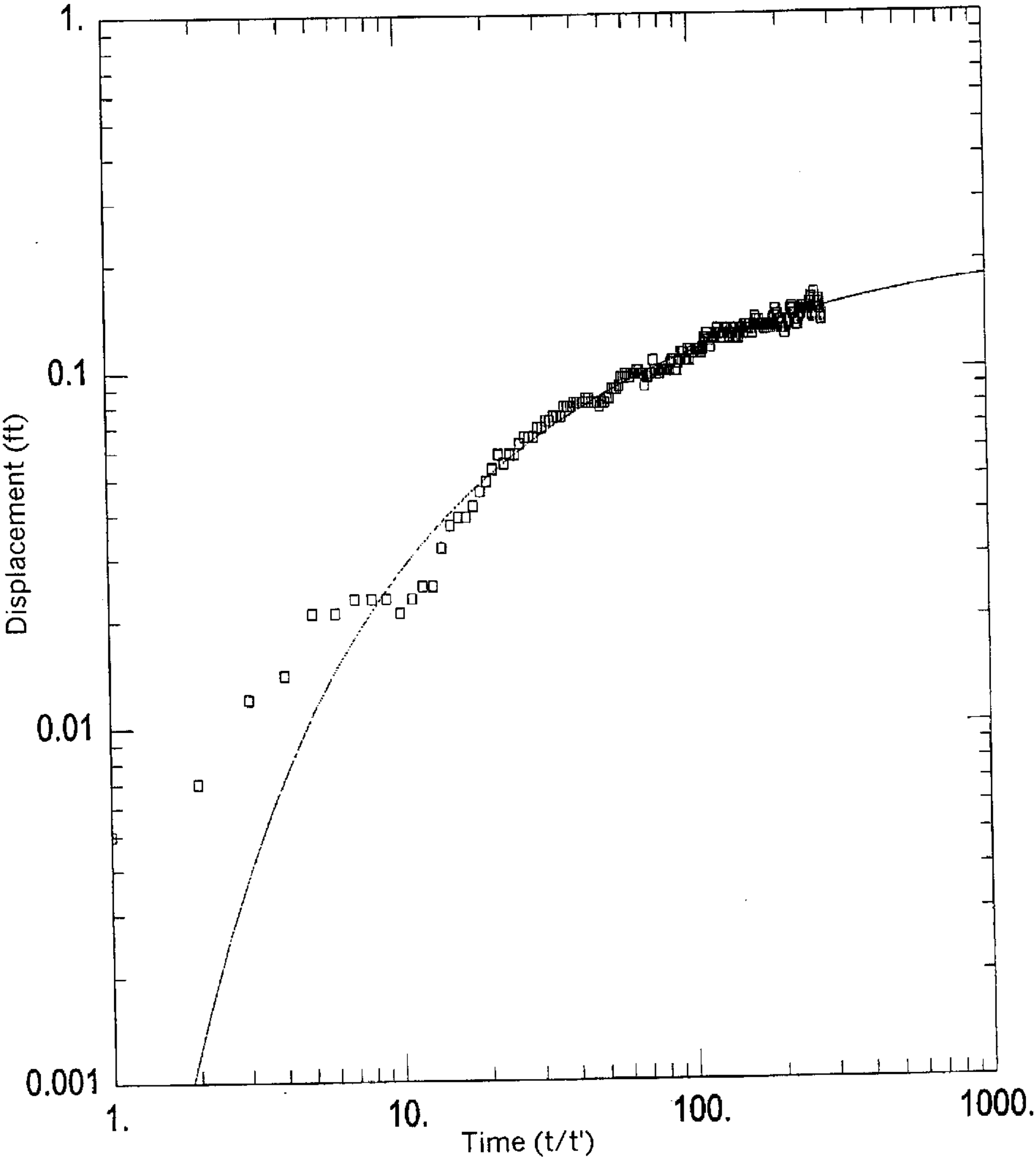


Figure B-2: Evaluation of Auifer Transmissivity using Neuman Method
Assuming Saturated Thickness is 20 ft

SOMA ENVIRONMENTAL ENGINEERING, INC.

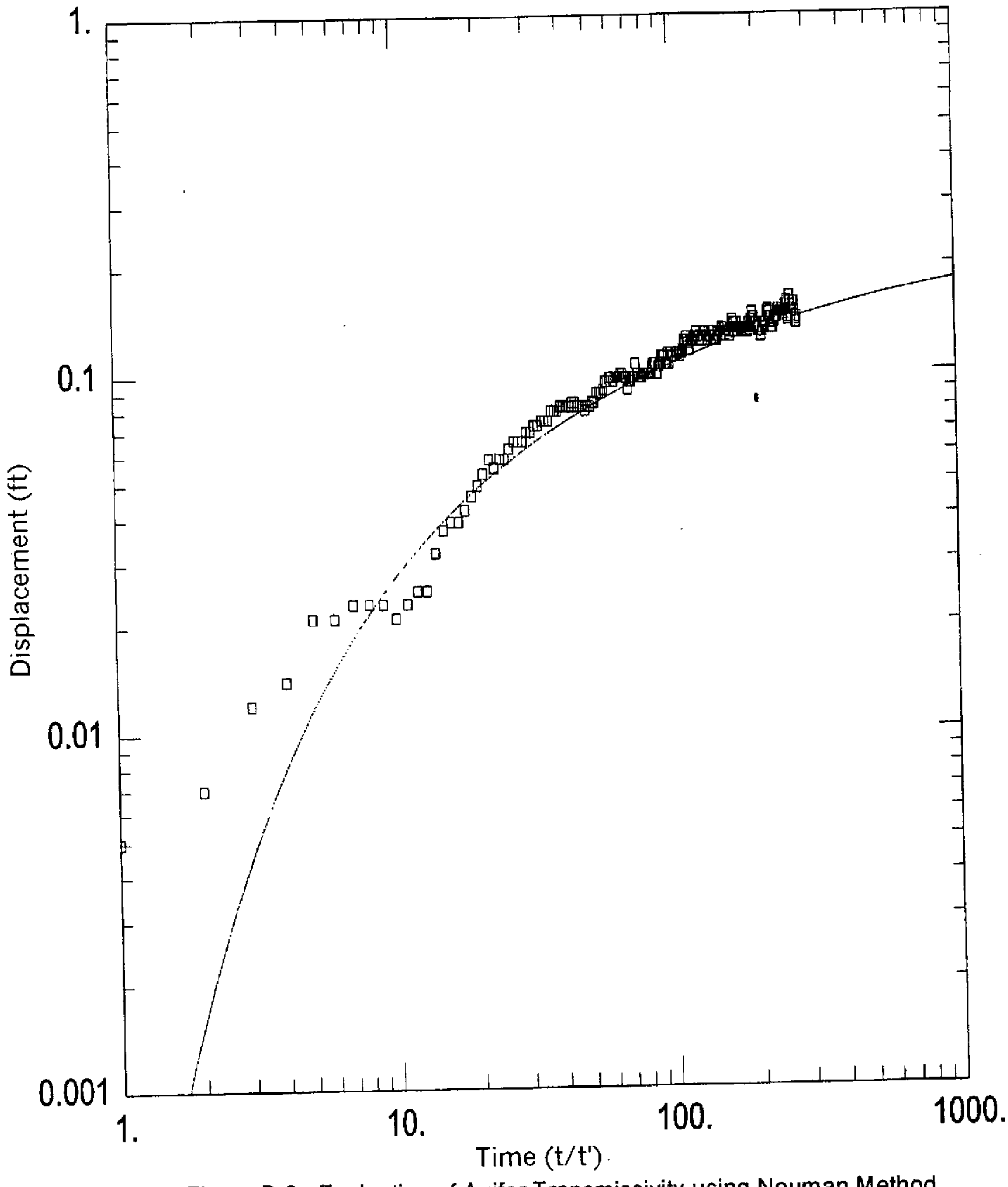


Figure B-3: Evaluation of Auifer Transmissivity using Neuman Method
Assuming Saturated Thickness is 30 ft

SOMA ENVIRONMENTAL ENGINEERING, INC.

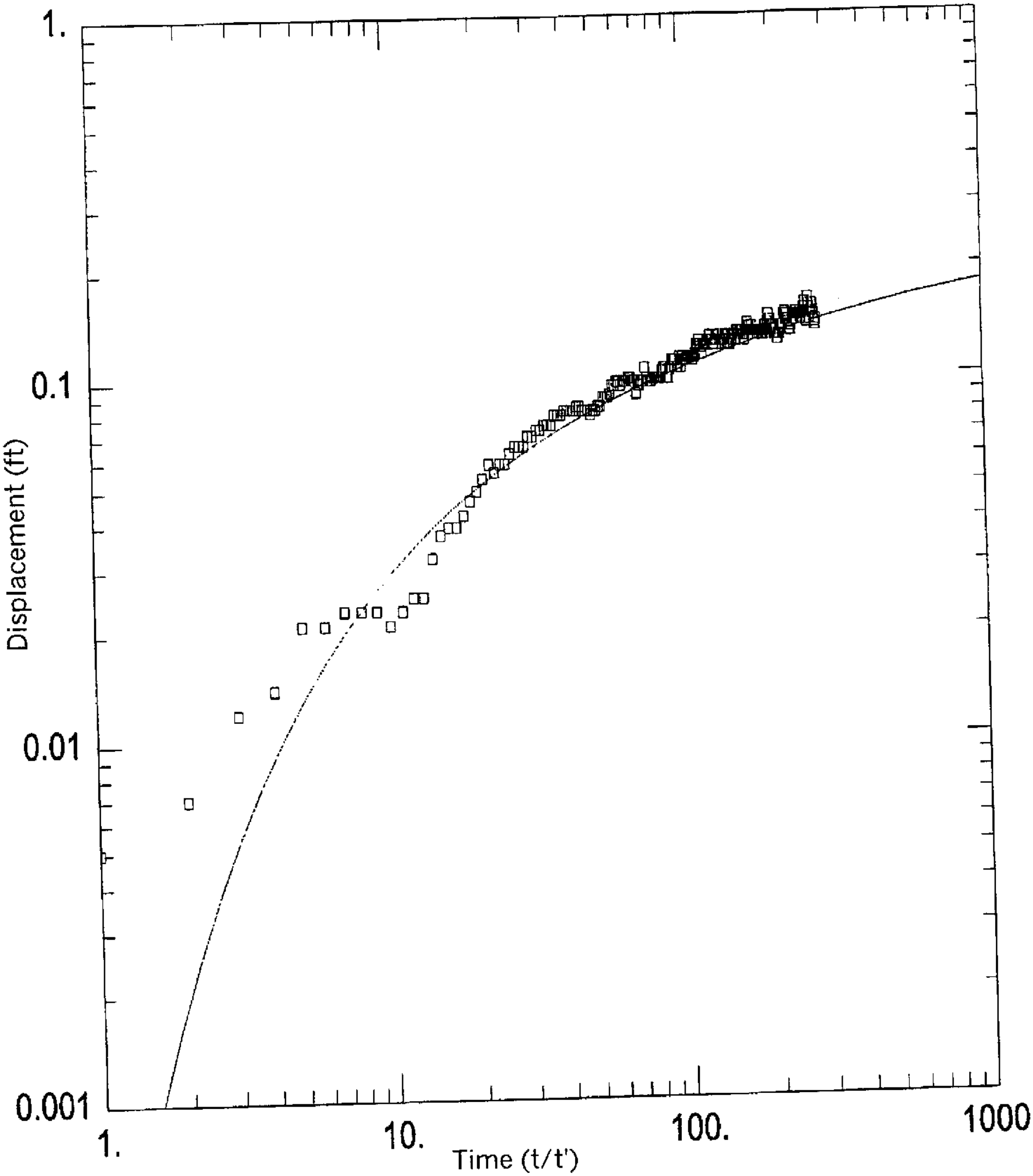


Figure B-4: Evaluation of Auifer Transmissivity using Neuman Method
Assuming Saturated Thickness is 50 ft

APPENDIX C

SUMMARY OF CHEMICAL ANALYSIS RESULTS OF SOIL AND GROUNDWATER

Appendix C: Groundwater Analytical Results at Well MW-1

Date	Benzene (ppb)	Toluene (ppb)	Ethyl-Benzene (ppb)	Xylenes (ppb)	MTBE (ppb)	TPH-g (ppb)
10/5/94	24000	21000	2600	15000	NA	320000
12/2/94	3800	6600	2300	11000	NA	80000
3/6/95	190	160	150	490	NA	32000
6/5/95	950	650	570	150	NA	21000
10/2/95	140	130	140	390	NA	59000
1/3/96	71	73	50	120	NA	30000
4/3/96	98	120	63	170	NA	31000
12/3/97	2300	2100	1400	5100	NA	27000
12/16/98	2500	2400	2300	9500	160	6500
3/16/99	480	860	850	3000	190	17000
SD	7333	6495	1029	5477	21	92971
Count	10	10	10	10	2	10
T Value	2.262	2.262	2.262	2.262	-	2.262
95% UCL	8698	8056	1778	8409	190	128853
Average	3453	3409	1042	4492	175	62350
Maximum	24000	21000	2600	15000	190	320000

Appendix C: Groundwater Analytical Results at Well MW-2

Date	Benzene (ppb)	Toluene (ppb)	Ethyl-Benzene (ppb)	Xylenes (ppb)	MTBE (ppb)	TPH-g (ppb)
10/5/94	17000	19000	570	10000	NA	260000
12/2/94	1700	2200	1200	3600	NA	42000
3/6/95	3	3	3	1	NA	490
6/5/95	220	330	350	660	NA	8000
10/2/95	160	130	93	240	NA	46000
1/3/96	160	130	93	240	NA	46000
4/3/96	0.1	92	44	13	NA	27000
12/9/96	11	7	2	14	0	6200
4/10/97	150	110	37	0.12	0	53000
12/3/97	4900	4900	1600	7000	NA	35000
6/30/98	2000	2000	1300	4300	NA	25000
9/29/98	290	180	160	360	0	29000
12/16/98	1400	1600	880	9500	0	26000
3/16/99	730	830	610	1900	55	7600
SD	1530	1542	589	3433	25	15582
Count	10	10	10	10	5	10
T Value	2.262	2.262	2.262	2.262	-	2.262
95% UCL	2074	2101	903	4812	55	41226
Average	980	998	482	2357	11	30080
Maximum	17000	19000	1600	10000	55	260000

Appendix C: Groundwater Analytical Results at Well MW-3

Date	Benzene (ppb)	Toluene (ppb)	Ethyl-Benzene (ppb)	Xylenes (ppb)	MTBE (ppb)	TPH-g (ppb)
10/5/94	190000	740000	310000	130000	NA	3000000
12/2/94	19000	22000	4400	28000	NA	250000
3/6/95	20000	42000	5800	36000	NA	350000
6/5/95	20000	42000	5800	36000	NA	350000
10/2/95	510	410	210	65	NA	150000
1/3/96	510	410	210	650	NA	150000
4/3/96	310	260	89	280	NA	70000
12/9/96	320	280	90	250	0	54000
4/10/97	130	120	38	120	0	54000
6/30/98	2000	1900	900	4600	NA	3300
9/29/98	35000	8800	2600	1400	450	83000
12/16/98	5700	3900	1200	6300	410	51000
3/16/99	4100	6400	1000	6100	470	45000
SD	11589	12849	1796	10983	244	98707
Count	10	10	10	10	5	10
T Value	2.262	2.262	2.262	2.262	-	2.262
95% UCL	15148	15639	2498	13433	470	171636
Average	6858	6448	1214	5577	266	101030
Maximum	190000	740000	310000	130000	470	3000000

Appendix C: Groundwater Analytical Results at Well MW-4

Date	Benzene (ppb)	Toluene (ppb)	Ethyl-Benzene (ppb)	Xylenes (ppb)	MTBE (ppb)	TPH-g (ppb)
10/2/95	23	11	10	29	NA	9300
1/3/96	230	110	10	29	NA	9300
4/3/96	12	8	5	14	NA	1900
12/9/96	14	6	4	12	0	4000
4/10/97	0	0	0	0	0	0
12/3/97	410	270	100	1500	NA	2300
6/30/98	780	160	54	200	NA	1700
12/16/98	590	33	28	94	24	1400
9/29/98	910	77	68	200	18	6200
3/16/99	200	35	19	56	11	600
SD	340	87	33	458	11	3445
Count	10	10	10	10	5	10
T Value	2.262	2.262	2.262	2.262	-	2.262
95% UCL	560	133	54	541	24	6135
Average	317	71	30	213	11	3670
Maximum	910	270	100	1500	24	9300

Appendix C: Groundwater Analytical Results at Well MW-5

Date	Benzene (ppb)	Toluene (ppb)	Ethyl-Benzene (ppb)	Xylenes (ppb)	MTBE (ppb)	TPH-g (ppb)
10/2/95	1	1	4	5	NA	1500
1/3/96	1	1	4	5	NA	1500
4/3/96	1	1	5	4	NA	780
12/9/96	NA	NA	NA	NA	NA	NA
4/10/97	NA	NA	NA	NA	NA	NA
12/3/97	82	66	59	160	NA	790
6/30/98	0	0	15	0	NA	400
9/29/98	2	1	3	3	0	270
12/16/98	1	0.6	0	2	0	1400
3/16/99	3	0.6	16	2	9.5	650
SD	29	23	19	56	5	494
Count	8	8	8	8	3	8
T Value	2.365	2.365	2.365	2.365	-	2.365
95% UCL	35	28	29	69	10	1324
Average	11	9	13	23	3	911
Maximum	82	66	59	160	9.5	1500

Appendix C: Groundwater Analytical Results at Well MW-6

Date	Benzene (ppb)	Toluene (ppb)	Ethyl-Benzene (ppb)	Xylenes (ppb)	MTBE (ppb)	TPH-g (ppb)
10/2/95	350	310	200	610	NA	120000
1/3/96	350	310	200	610	NA	120000
4/3/96	140	110	62	170	NA	48000
12/9/96	480	450	160	460	0	57000
4/10/97	60	70	24	71	0	29000
6/30/98	3100	4300	1300	4900	NA	28000
12/16/98	3800	4600	1400	6400	360	54000
3/16/99	3900	4300	1600	7000	180	37000
SD	1741	2153	683	3020	172	37573
Count	8	8	8	8	4	8
T Value	2.365	2.365	2.365	2.365	-	2.365
95% UCL	2978	3607	1189	5053	360	93041
Average	1523	1806	618	2528	135	61625
Maximum	3900	4600	1600	7000	360	120000

Appendix C: Groundwater Analytical Results at Well MW-7

Date	Benzene (ppb)	Toluene (ppb)	Ethyl-Benzene (ppb)	Xylenes (ppb)	MTBE (ppb)	TPH-g (ppb)
10/2/95	10	12	17	NA	NA	3300
1/3/96	9	12	17	45	NA	3300
4/3/96	2	3	5	7	NA	1900
12/3/97	130	98	75	200	NA	1400
6/30/98	4	0	9	0	NA	620
9/29/98	1	0.6	1	2	68	1800
12/16/98	5	10	5	20	160	990
3/16/99	3	0.7	1	1	62	300
SD	44	33	25	73	55	1127
Count	8	8	8	7	3	8
T Value	2.365	2.365	2.365	2.447	-	2.365
95% UCL	58	45	37	106	160	2644
Average	21	17	16	39	97	1701
Maximum	130	98	75	200	160	3300

Appendix C: Groundwater Analytical Results at Well MW-8

Date	Benzene (ppb)	Toluene (ppb)	Ethyl-Benzene (ppb)	Xylenes (ppb)	MTBE (ppb)	TPH-g (ppb)
10/2/95	310	250	180	480	NA	94000
1/3/96	310	250	180	480	NA	94000
4/3/96	250	170	140	330	NA	58000
12/9/96	88	43	44	80	0	27000
4/10/97	86	55	50	100	0	24000
12/3/97	6000	1600	2100	4700	NA	28000
12/16/98	6300	1700	2200	4400	1300	61000
6/30/98	4600	2800	3500	7300	NA	54000
3/16/99	1800	470	2000	2000	820	22000
SD	2670	980	1303	2633	643	28570
Count	9	9	9	9	4	9
T Value	2.306	2.306	2.306	2.306	-	2.306
95% UCL	4246	1569	2157	4232	1300	73294
Average	2194	815	1155	2208	530	51333
Maximum	6300	2800	3500	7300	1300	94000

Appendix C: Groundwater Analytical Results at Well MW-9

Date	Benzene (ppb)	Toluene (ppb)	Ethyl-Benzene (ppb)	Xylenes (ppb)	MTBE (ppb)	TPH-g (ppb)
6/30/98	3700	60	980	420	NA	8900
SD	-	-	-	-	-	-
Count	1	1	1	1	0	1
T Value	-	-	-	-	-	-
95% UCL	3700	60	980	420	-	8900
Average	3700	60	980	420	-	8900

Appendix C: Groundwater Analytical Results at Well MW-10

Date	Benzene (ppb)	Toluene (ppb)	Ethyl-Benzene (ppb)	Xylenes (ppb)	MTBE (ppb)	TPH-g (ppb)
12/9/96	8	2	2	7	0	3000
4/10/97	21	9	3	3	0	1000
12/3/97	5300	76	1100	780	NA	10000
9/29/98	5400	66	970	620	2600	9900
12/16/98	3800	51	790	420	1800	8700
3/16/99	15	28	420	250	2800	4100
SD	2699	30	480	320	1367	3899
Count	6	6	6	6	5	6
T Value	2.571	2.571	2.571	2.571	-	2.571
95% UCL	5257	71	1052	682	2800	10210
Average	2424	39	548	347	1440	6117
Maximum	5400	76	1100	780	2800	10000

Appendix C: Groundwater Analytical Results at Well MW-11

Date	Benzene (ppb)	Toluene (ppb)	Ethyl-Benzene (ppb)	Xylenes (ppb)	MTBE (ppb)	TPH-g (ppb)
12/9/96	2	0.5	0.8	4	0	690
4/10/97	0	0	0	0	0	0
12/3/97	66	97	59	190	NA	710
6/30/98	45	24	71	100	NA	1100
9/29/98	7	0.6	4	9	22	170
12/16/98	27	4	25	33	0	650
3/16/99	30	6	53	84	8	710
SD	24	35	30	70	10	371
Count	7	7	7	7	5	7
T Value	2.447	2.447	2.447	2.447	-	2.447
95% UCL	48	52	58	124	22	919
Average	25	19	30	60	6	576
Maximum	66	97	71	190	22	1100

Appendix C: On-Site Groundwater Concentrations UCL (ppb)

	Benzene (ppb)	Toluene (ppb)	Ethyl-Benzene (ppb)	Xylenes (ppb)	MTBE (ppb)	TPH-g (ppb)
MW-1	3453	3409	1042	4492	175	62350
MW-2	980	998	482	2357	11	30080
MW-3	6858	6448	1214	5577	266	101030
MW-4	317	71	30	213	11	3670
MW-5	11	9	13	23	3	911
MW-6	1523	1806	618	2528	135	61625
MW-7	21	17	16	39	97	1701
MW-8	2194	815	1155	2208	530	51333
MW-9	3700	60	980	420		8900
SD	2250	2164	506	2028	178	35420
Count	9	9	9	9	8	9
T Value	2.228	2.228	2.228	2.228	2.262	2.228
95% UCL	3621	2885	939	3177	293	58712
Average	1951	1278	564	1671	150	32406
Maximum	6858	6448	1214	5577	530	101030

Appendix C: Off-Site Groundwater Concentrations 95% UCL (ppb)

	Benzene (ppb)	Toluene (ppb)	Ethyl-Benzene (ppb)	Xylenes (ppb)	MTBE (ppb)	TPH-g (ppb)
MW-10	2424	39	548	347	1440	6117
MW-11	25	19	30	60	6	576
SD	1696	14	366	203	1014	3918
Count	0	0	0	0	0	0
T Value	-	-	-	-	-	-
95% UCL						
Average	1225	29	289	204	723	3347
Maximum	2424	39	548	347	1440	6117

Appendix C: Soil Boring Analytical Results at On-Site Locations

Well Name	Depth (feet)	Benzene (mg/Kg)	Ethyl-benzene (mg/Kg)	Toluene (mg/Kg)	Xylenes (mg/Kg)	TPH-g (mg/Kg)
B-1	5	0.024	0.076	0.250	0.180	4.000
	10	1.800	5.000	6.000	31.000	1000.000
	15	0.770	1.600	3.100	0.520	110.000
B-2	6	0.000	0.007	0.020	0.000	0.000
	12	0.670	1.400	3.700	0.640	110.000
B-3	5	0.000	0.000	0.000	0.000	0.000
	10	0.390	0.840	3.100	0.560	91.000
	15	2.400	8.200	3.400	17.000	500.000
B-4	5	0.000	0.000	0.000	0.000	0.000
	10	0.024	0.006	0.015	0.190	1.400
	15	0.020	0.000	0.018	0.000	0.000
B-5	5	0.000	0.000	0.000	0.000	0.000
	10	0.007	0.000	0.000	0.000	0.000
	15	0.053	0.016	0.008	0.018	0.000
B-6	5	1.000	2.800	5.000	0.950	160.000
	10	1.700	3.700	1.400	6.900	220.000
	14	11.000	36.000	15.000	73.000	1800.000
B-7	5	0.000	0.000	0.000	0.000	0.000
	10	0.370	0.510	0.210	0.950	18.000
	14	3.200	6.800	2.900	14.000	250.000
B-8	5	0.011	0.000	0.005	0.014	0.000
	10	0.016	0.015	0.013	0.021	1.400
	14	0.520	0.280	0.850	2.400	150.000
B-9	5	0.000	0.000	0.000	0.000	0.000
	10	0.000	0.000	0.000	0.000	0.000
	14	0.000	0.000	0.000	0.000	0.000
B-10	5	0.000	0.000	0.000	0.000	0.000
	10	0.021	0.000	0.000	0.000	0.000
	14	0.009	0.000	0.000	0.000	1.600
B-11	5	0.000	0.000	0.000	0.000	0.000
	10	0.064	0.012	0.100	0.016	0.000
	14	2.000	6.300	4.500	24.000	630.000
B-12	5	0.052	0.015	0.043	0.009	0.000
	10	0.007	0.000	0.000	0.000	0.000
	14	0.008	0.000	0.000	0.000	0.000
B-13	5	0.000	0.000	0.000	0.000	0.000
	10	0.036	0.000	0.000	0.000	0.000
	14	0.051	0.028	0.140	0.046	17.000
SD		1.89	6.06	2.83	13.38	345.01
Count		38	38	38	38	38
T Value		1.96	1.96	1.96	1.96	1.96
95% UCL		1.29	3.86	2.21	8.79	243
Average		0.69	1.94	1.31	4.54	133
Maximum		11	36	15	73	1800

APPENDIX D

SUMMARY OF EDR ENVIRONMENTAL RECORD SEARCH

TONY'S EXPRESS AUTO SERVICES
3609 International Boulevard
Oakland, California 94601

Listed below are the closest potentially hazardous substance sites all located within approximately 1 mile of the subject property. I have also listed each data source and what information has been derived from each database. The following information has been extracted from a radius map report prepared by Environmental Data Resources, Inc.

Database: Cal-Sites – provides both known and potentially hazardous substance sites.

Site Name	Address	Distance/Dir
Clorox Co The	850 42nd Avenue	¼ - ½ SSE
EKOTEK Lube	4200 Alameda Avenue	½ - 1 S
Esposito Plating Corp.	2904-2908 Chapman Street	½ - 1 WSW
Big B Lumberteria	30 1/411 High Street	½ - 1 SSW

Database: State Water Resources Control Board's Proposition 65 – sites that have received notification of any release that could impact drinking water and thereby expose the public to a potential health risk.

Site Name	Address	Distance/Dir
Pacific Bell	2112 Fruitvale Avenue	½ - 1 N
LaLo's Autobody Repair	2801 Foothill Boulevard	½ - 1 NNW
Ed's Auto Wreckers	752 High Street	¼ - ½ SSE
Shell Self Service	630 High Street	½ - 1 S

Database: The California Hazardous Material Incident Report System – sites that have been reported to have had hazardous material incidents, i.e., accidental releases or spills.

Site Name	Address	Distance/Dir
American Electrofinishing	4933 San Leandro Street	½ - 1 SE

Database: Cortese – Listed below are the closest public drinking water wells with detectable levels of contamination, hazardous substance sites selected for remedial action, sites with known toxic material, sites with UST's having a reportable release and all solid waste disposal facilities from known migration.

Site Name	Address	Distance/Dir	
August Manufacturing	1466 36th Avenue	0 – 1/8	N
Motor Partners	1234 40th Avenue	1/8 – ¼	SE
Continental Volvo Inv.	4030 E. 14th Street	¼ - ½	ESE
BP	4250 Foothill Boulevard	¼ - ½	E
Stop N Go Market	2710 Foothill Boulevard	½ - 1	NNW
German Engine Repair DBA	2350 High Street	½ - 1	ENE
Snow Cleaners Inc.	2678 Coolidge	½ - 1	NNE
City of Oakland	2662 Fruitvale Avenue	½ - 1	N
Chevron	3616 San Leandro Street	1/8 – ¼	SSW
Pahlmeyer Property	3132 E. 12th Street	¼ - ½	W
Melrose Ford	3050 E. 14th Street	¼ - ½	WNW
An-Fo Mfg Co	3129 Elmwood Avenue	¼ - ½	WSW
Ed's Auto Wreckers	752 High Street	¼ - ½	SSE
EKO TEK	4200 Alameda Avenue	½ - 1	S
King Petroleum	2001 Versailles Avenue	½ - 1	SW

Database: CORRACTS – This report shows 1 site that has had nationally defined corrective action activity.

Site Name	Address	Distrance/Dir	
American National Can Co	3801 East 8th Street	¼ - ½	SSW

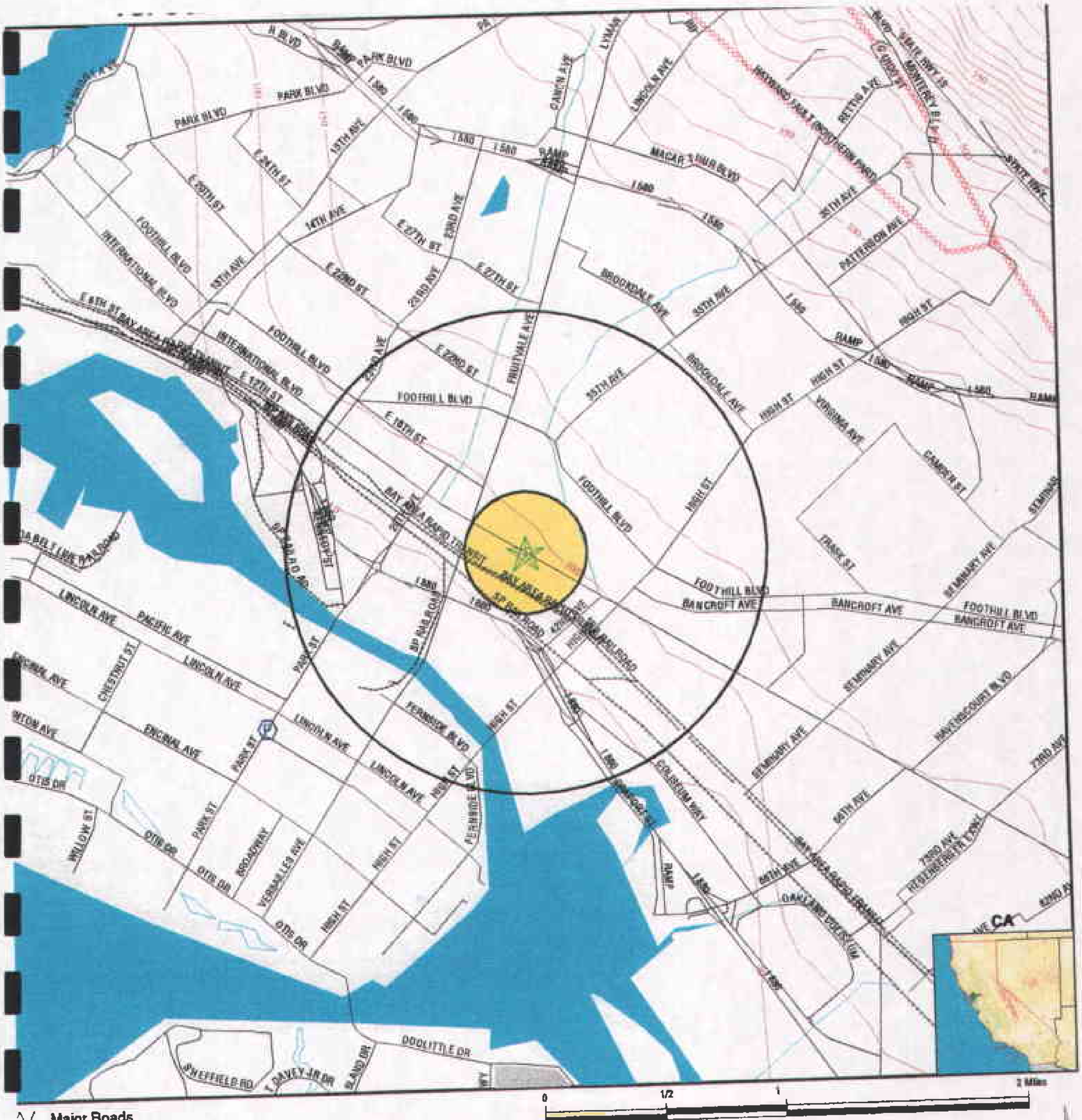
Database: LUST – The Leaking Underground Storage Tank reports contain sites that have reported leaking underground storage tank incidents.

Site Name	Address	Distance/Dir	
August Manufacturing	1466 36th Avenue	0 – 1/8	N
Motor Partners	1234 40th Avenue	1/8 – ¼	SE
Continental Volvo Inv	4030 E. 14th Street	¼ - ½	ESE
BP	4250 Foothill Boulevard	¼ - ½	E

Site Name	Address	Distance/Dir
Chevron	3616 San Leandro Street	1/8 – ¼ SSW
Guy's Service	3820 San Leandro Street	1/8 – ¼ S
State Shingle Company	880 Fruitvale Avenue	¼ - ½ WSW
Melrose Ford	3050 E. 14th Street	¼ - ½ WNW
San Leandro St. Proj RGA	4701 San Leandro Street	¼ - ½ SSE

The closest Public Water Supply (PWS) System is 1 – 2 miles west of 3609 International Boulevard, Oakland, California. The name of the PWS is Camp Cedarbrook. The PWS has currently had no major violations.

Please see the attached Topographic Map.



Major Roads
Contour Lines
Waterways
Earthquake Fault Lines
Airports
Earthquake epicenter, Richter 5 or greater
Closest Federal Well in quadrant
Closest State Well in quadrant
Closest Public Water Supply Well
Closest Hydrogeological Data
Oil, gas or related wells

TARGET PROPERTY:	Tonys Express Auto Services	CUSTOMER:	Soma Environmental Engineering
ADDRESS:	3609 International Blvd	CONTACT:	Mr. Mansour Sepehr
CITY/STATE/ZIP:	Oakland CA 94601	INQUIRY #:	374053.1s
LAT/LONG:	37.7755 / 122.2206	DATE:	May 26, 1999 3:06 pm

APPENDIX E

OUTPUT OF ASTM-RBCA

TIER I, AND TIER II ANALYSIS

RBCA SITE ASSESSMENT

Tier 1 Worksheet 6.3

Site Name: Tony's Express Auto Services
Site Location: 3609 International Blvd. Oakland

Completed By: Mansour Sepehr
Date Completed: 6/11/1999

GROUNDWATER RBSL VALUES

Target Risk (Class A & B) 1.0E-6
Target Risk (Class C) 1.0E-5
Target Hazard Quotient 1.0E+0

☐ MCL exposure limit?
☐ PEL exposure limit?

Calculation Option: 1

RBSL Results For Complete Exposure Pathways ("x" if Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	Groundwater Ingestion			X Groundwater Volatilization to Indoor Air		X Groundwater Volatilization to Outdoor Air		Applicable RBSL	RBSL Exceeded ?	Required CRF
CAS No.	Name	(mg/L)	Residential: (on-site)	Commercial: (on-site)	Regulatory(MCL): (on-site)	Residential: (on-site)	Commercial: (on-site)	Residential (on-site)	Commercial: (on-site)	(mg/L	"■" if yes	Only if "yes" left
71-43-2	Benzene	3.6E+0	NA	NA	NA	NA	7.4E-2	NA	1.8E+1	7.4E-2	■	4.9E+01
100-41-4	Ethylbenzene	9.4E-1	NA	NA	NA	NA	>Sol	NA	>Sol	>Sol	☐	<1
1634-04-4	Methyl t-Butyl Ether	2.9E-1	NA	NA	NA	NA	3.7E+3	NA	>Sol	3.7E+3	☐	<1
108-88-3	Toluene	2.9E+0	NA	NA	NA	NA	8.5E+1	NA	>Sol	8.5E+1	☐	<1
1330-20-7	Xylene (mixed isomers)	3.2E+0	NA	NA	NA	NA	>Sol	NA	>Sol	>Sol	☐	<1

>Sol indicates risk-based target concentration greater than constituent solubility

Software: GSI RBCA Spreadsheet
Version: 1.0.1

Serial: G-335-FXX-770

3.6 / 7.4x10^-2 ... 50

RBCA SITE ASSESSMENT

Site Name: Tony's Express Auto Services
Site Location: 3609 International Blvd. Oakland

Completed By: Mansour Sepehr
Date Completed: 6/11/1999

SUBSURFACE SOIL RBSL VALUES (> 3.3 FT BGS)

Target Risk (Class A & B) 1.0E-6
Target Risk (Class C) 1.0E-5
Target Hazard Quotient 1.0E+0

☐ MCL exposure limit?
☐ PEL exposure limit?

Calculation Option: 1

RBSL Results For Complete Exposure Pathways ("x" if Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	Soil Leaching to Groundwater			X Soil Volatilization to Indoor Air		X Soil Volatilization to Outdoor Air		Applicable RBSL	RBSL Exceeded ?	Required CRF
CAS No.	Name	(mg/kg)	Residential: (on-site)	Commercial: (on-site)	Regulatory(MCL): (on-site)	Residential: (on-site)	Commercial: (on-site)	Residential: (on-site)	Commercial: (on-site)	(mg/kg)	"■" if yes	Only if "yes" left
71-43-2	Benzene	2.2E-1	NA	NA	NA	NA	7.9E-2	NA	3.4E+1	7.9E-2	■	3.0E+00
100-41-4	Ethylbenzene	1.5E+0	NA	NA	NA	NA	>Res	NA	>Res	>Res	☐	<1
1634-04-4	Methyl t-Butyl Ether	0.0E+0	NA	NA	NA	NA	7.0E+2	NA	>Res	7.0E+2	☐	<1
108-88-3	Toluene	4.4E+0	NA	NA	NA	NA	9.3E+1	NA	>Res	9.3E+1	☐	<1
1330-20-7	Xylene (mixed isomers)	4.7E+0	NA	NA	NA	NA	>Res	NA	>Res	>Res	☐	<1

>Res indicates risk-based target concentration greater than constituent residual saturation value

Software: GSI RBCA Spreadsheet
Version: 1.0.1
Serial: G-335-FXX-770

.22 / .08 ≈ 3

RBCA SITE ASSESSMENT | Tier 2 Worksheet 9.2

Site Name: Tony's Express Auto Services
Site Location: 3609 International Blvd. Oakland

Completed By: Mansour Sepehr
Date Completed: 6/11/1999

SUBSURFACE SOIL SSTL VALUES (> 0 FT BGS)

Target Risk (Class A & B) 1.0E-6
Target Risk (Class C) 1.0E-5
Target Hazard Quotient 1.0E+0

☐ MCL exposure limit?
☐ PEL exposure limit?

Calculation Option: 1

SSTL Results For Complete Exposure Pathways ("x" if Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	Soil Leaching to Groundwater			X Soil Volatilization to Indoor Air		X Soil Volatilization to Outdoor Air		Applicable SSTL	SSTL Exceeded ?	Required CRF
CAS No.	Name	(mg/kg)	Residential: (on-site)	Commercial: (on-site)	Regulatory(MCL): (on-site)	Residential: (on-site)	Commercial: (on-site)	Residential: (on-site)	Commercial: (on-site)	(mg/kg)	"■" if yes	Only if "yes" left
71-43-2	Benzene	2.2E-1	NA	NA	NA	NA	1.0E-1	NA	3.7E+1	1.0E-1	■	2.0E+00
100-41-4	Ethylbenzene	1.5E+0	NA	NA	NA	NA	>Res	NA	>Res	>Res	☐	<1
1634-04-4	Methyl t-Butyl Ether	0.0E+0	NA	NA	NA	NA	9.2E+2	NA	>Res	9.2E+2	☐	<1
108-88-3	Toluene	4.4E+0	NA	NA	NA	NA	1.2E+2	NA	>Res	1.2E+2	☐	<1
1330-20-7	Xylene (mixed isomers)	4.7E+0	NA	NA	NA	NA	>Res	NA	>Res	>Res	☐	<1

>Res indicates risk-based target concentration greater than constituent residual saturation value

Software: GSI RBCA Spreadsheet
Version: 1.0.1

Serial: G-335-FXX-770

RBCA SITE ASSESSMENT	Tier 2 Worksheet 9.3

Site Name: Tony's Express Auto Services

Site Location: 3609 International Blvd. Oakland

Completed By: Mansour Sepehr

Date Completed: 6/11/1999

GROUNDWATER SSTL VALUES

Target Risk (Class A & B) 1.0E-6

Target Risk (Class C) 1.0E-5

Target Hazard Quotient 1.0E+0

☐ MCL exposure limit?

☐ PEL exposure limit?

Calculation Option: 1

SSTL Results For Complete Exposure Pathways ("x" if Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	Groundwater Ingestion			X Groundwater Volatilization to Indoor Air		X Groundwater Volatilization to Outdoor Air		Applicable SSTL	SSTL Exceeded ?	Required CRF
CAS No.	Name	(mg/L)	Residential: (on-site)	Commercial: (on-site)	Regulatory(MCL): (on-site)	Residential: (on-site)	Commercial: (on-site)	Residential (on-site)	Commercial: (on-site)	(mg/L	"■" If yes	Only if "yes" left
71-43-2	Benzene	3.6E+0	NA	NA	NA	NA	9.1E-2	NA	2.2E+1	9.1E-2	■	4.0E+01
100-41-4	Ethylbenzene	9.4E-1	NA	NA	NA	NA	>Sol	NA	>Sol	>Sol	☐	<1
1634-04-4	Methyl t-Butyl Ether	2.9E-1	NA	NA	NA	NA	5.4E+3	NA	>Sol	5.4E+3	☐	<1
108-88-3	Toluene	2.9E+0	NA	NA	NA	NA	1.0E+2	NA	>Sol	1.0E+2	☐	<1
1330-20-7	Xylene (mixed isomers)	3.2E+0	NA	NA	NA	NA	>Sol	NA	>Sol	>Sol	☐	<1

>Sol indicates risk-based target concentration greater than constituent solubility

Software: GSI RBCA Spreadsheet
Version: 1.0.1

Serial: G-335-FXX-770

RBCA SITE ASSESSMENT | Tier 1 Worksheet 6.3

Site Name: Tony's Express Auto Services
Site Location: 3609 International Blvd. Oakland

Completed By: Mansour Sepehr
Date Completed: 6/11/1999

GROUNDWATER RBSL VALUES

Target Risk (Class A & B) 1.0E-6
Target Risk (Class C) 1.0E-5
Target Hazard Quotient 1.0E+0

☐ MCL exposure limit?
☐ PEL exposure limit?

Calculation Option: 1

RBSL Results For Complete Exposure Pathways ("x" if Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	Groundwater Ingestion			X Groundwater Volatilization to Indoor Air		X Groundwater Volatilization to Outdoor Air		Applicable RBSL	RBSL Exceeded ?	Required CRF
CAS No.	Name	(mg/L)	Residential: (on-site)	Commercial: (on-site)	Regulatory(MCL): (on-site)	Residential: (on-site)	Commercial: (on-site)	Residential (on-site)	Commercial: (on-site)	(mg/L	"■" if yes	Only if "yes" left
71-43-2	Benzene	2.4E+0	NA	NA	NA	2.4E-2	NA	1.1E+1	NA	2.4E-2	■	1.0E+02
100-41-4	Ethylbenzene	5.5E-1	NA	NA	NA	7.7E+1	NA	>Sol	NA	7.7E+1	☐	<1
1634-04-4	Methyl t-Butyl Ether	1.4E+0	NA	NA	NA	1.4E+3	NA	>Sol	NA	1.4E+3	☐	<1
108-88-3	Toluene	3.9E-2	NA	NA	NA	3.3E+1	NA	>Sol	NA	3.3E+1	☐	<1
1330-20-7	Xylene (mixed isomers)	3.5E-1	NA	NA	NA	>Sol	NA	>Sol	NA	>Sol	☐	<1

>Sol indicates risk-based target concentration greater than constituent solubility

Software: GSI RBCA Spreadsheet
Version: 1.0.1

Serial: G-335-FXX-770

$\frac{2.4}{0.024} = 10^2$

RBCA SITE ASSESSMENT — Tier 2 Worksheet 9.3

Site Name: Tony's Express Auto Services
Site Location: 3609 International Blvd. Oakland

Completed By: Mansour Sepehr
Date Completed: 6/11/1999

GROUNDWATER SSTL VALUES

Target Risk (Class A & B) 1.0E-6
Target Risk (Class C) 1.0E-5
Target Hazard Quotient 1.0E+0

☐ MCL exposure limit?
☐ PEL exposure limit?

Calculation Option: 1

SSTL Results For Complete Exposure Pathways ("x" if Complete)

CONSTITUENTS OF CONCERN		Representative Concentration	Groundwater Ingestion			X Groundwater Volatilization to Indoor Air		X Groundwater Volatilization to Outdoor Air		Applicable SSTL	SSTL Exceeded ?	Required CRF
CAS No.	Name	(mg/L)	Residential: (on-site)	Commercial: (on-site)	Regulatory(MCL): (on-site)	Residential: (on-site)	Commercial: (on-site)	Residential (on-site)	Commercial: (on-site)	(mg/L	"■" if yes	Only if "yes" left
71-43-2	Benzene	2.4E+0	NA	NA	NA	7.6E-2	NA	3.7E+1	NA	7.6E-2	■	3.2E+01
100-41-4	Ethylbenzene	5.5E-1	NA	NA	NA	>Sol	NA	>Sol	NA	>Sol	☐	<1
1634-04-4	Methyl t-Butyl Ether	1.4E+0	NA	NA	NA	5.2E+3	NA	>Sol	NA	5.2E+3	☐	<1
108-88-3	Toluene	3.9E-2	NA	NA	NA	1.0E+2	NA	>Sol	NA	1.0E+2	☐	<1
1330-20-7	Xylene (mixed isomers)	3.5E-1	NA	NA	NA	>Sol	NA	>Sol	NA	>Sol	☐	<1

>Sol indicates risk-based target concentration greater than constituent solubility

Software: GSI RBCA Spreadsheet
Version: 1.0.1
Serial: G-335-FXX-770

24 ≈ 30
.076

APPENDIX F

ESTIMATION OF TOTAL MASS OF HYDROCARBONS & MTBE IN GROUNDWATER

0	0	37	94	137	210	287	331	302	172
0	46	222	415	493	695	946	940	723	408
1	144	583	1131	1425	1679	1914	1717	1186	601
1	151	841	2105	2869	2967	3009	2504	1535	652
1	89	782	2272	3276	3377	3269	2622	1551	618
69	231	716	1698	2507	2668	2428	1893	1182	519
224	676	1078	1477	1781	1686	1285	927	645	303
362	989	1400	1431	1303	986	526	282	221	99
380	876	1188	1168	959	639	293	92	35	11
269	599	811	824	680	453	220	57	1	0
146	370	515	538	456	314	160	43	0	0
79	214	303	322	280	200	105	29	0	0
40	110	155	161	143	110	61	17	0	0
12	37	54	51	48	48	33	11	0	0
0	4	8	5	7	15	20	16	6	0
0	0	0	0	0	4	12	18	9	0
0	0	0	0	0	1	4	7	3	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

Appendix F: Average Grid Values for the Benzene Plume in the Groundwater

0	25	505	1124	1441	2052	2728	3099	2794	1587
0	589	2644	4684	5197	6861	9086	8889	6760	3787
0	1613	6539	12444	15125	16894	18517	16245	11095	5579
0	1635	9586	23527	30927	30351	29208	23630	14320	6039
472	2341	11300	27645	36623	35243	31993	24723	14370	5657
2146	3508	11500	24552	30019	28747	24074	17729	10739	4620
3951	8393	15260	22129	22627	18916	12633	8109	5478	2546
4761	12865	18570	19284	16792	11599	5099	1866	1462	677
4548	10713	14865	15068	12427	7995	3283	637	56	0
3256	7507	10419	10900	9213	6225	3081	869	45	0
1936	5038	7221	7833	6929	5039	2889	1085	162	0
1280	3489	5163	5820	5397	4187	2665	1230	286	0
911	2566	3911	4601	4434	3578	2436	1283	365	0
661	1956	3079	3779	3742	3075	2187	1260	410	10
488	1476	2376	2965	3004	2553	1896	1170	439	38
330	1051	1741	2180	2265	2020	1569	1020	425	59
183	675	1216	1564	1671	1544	1242	830	353	52
57	360	794	1086	1203	1147	946	639	262	30
0	148	455	711	835	825	696	470	176	9
0	40	201	415	544	567	491	327	113	0
0	0	49	181	312	362	328	214	69	0
0	0	0	40	128	196	199	128	37	0
0	0	0	0	24	68	93	65	17	0
0	0	0	0	0	7	22	19	5	0

Appendix F: Average Grid Values for the TPH-g Plume in the Groundwater

0	0	6	12	10	10	13	13	10	5
0	7	31	49	41	39	46	41	28	5
1	23	78	131	136	117	101	75	46	20
6	38	123	253	297	232	166	107	56	21
22	65	151	305	370	291	192	111	51	15
62	153	229	324	363	283	165	78	31	7
125	339	460	476	430	297	129	40	24	8
191	507	698	686	576	404	206	100	74	43
232	562	795	847	769	611	424	281	191	119
232	591	880	1020	1003	869	677	488	331	208
251	672	1044	1265	1292	1151	917	668	451	279
301	797	1280	1599	1643	1439	1119	793	518	309
332	919	1537	2004	2038	1684	1237	828	506	281
370	964	1643	2222	2239	1749	1208	737	395	189
355	849	1431	1919	1944	1530	1015	519	193	67
214	573	997	1329	1383	1149	757	326	60	3
58	243	549	812	894	789	536	245	51	0
0	49	239	449	541	510	368	192	52	0
0	7	92	232	314	310	239	137	42	0
0	0	23	92	158	173	144	88	28	0
0	0	0	19	57	81	76	49	16	0
0	0	0	0	9	23	29	21	7	0
0	0	0	0	0	2	5	5	2	0
0	0	0	0	0	0	0	0	0	0

Appendix F: Average Grid Values for the MTBE Plume in the Groundwater