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# ASSESSMENT OF EXPOSURE AND PUBLIC HEALTH RISKS DURING THE EXCAVATION OF A REFINERY WASTES CONTAMINATED SITE


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## I. INTRODUCTION

Med-Tox Associates, Inc. (MED-TOX) was retained by Company X (unnamed) to develop and implement a health and safety plan designed to protect on-site workers and the public in surrounding communities from exposure to hazardous materials during remedial excavation of a hazardous waste site located at an abandoned oil refinery. The site-specific health and safety plan developed by MED-TOX covered the following topics: site characterization, chemical hazards, perimeter and on-site pollutant monitoring networks, work zone delineation, personal protective equipment, standard operation procedures, emergency response procedures, health and safety training, medical surveillance program, decontamination and documentation. Through implementation of this site health and safety plan, air pollutant emissions from site related remedial excavation activities were substantially reduced along with public exposure to these hazardous materials. However, it is inevitable that this site was considered as a point source of hazardous pollutants during the excavation period due to the nature of the waste, extent of disruption of soil cover and potential release of volatile contaminants from on-site soils.

Presented in this paper are estimates of human health risk from potential exposure to hazardous materials during each distinct phase of the project: pre-excavation, concurrent excavation and post excavation. The key components of this risk assessment are as follows:

- Site Characterization
- Evaluation of Field Monitoring Results
- Selection of Indicator Chemicals
- Chemical Hazard Assessment
- Theoretical and Monitored Assessment of Chemical Emission Rates, Environmental Fate and Exposure Concentrations.
- Population Characterization
- Human Intake and Risk Assessment
- Critical Evaluation.





Potential health risks for each phase are calculated using the results of field monitored pollutant concentrations and/or predicted pollutant concentrations derived from best estimated theoretical site scenarios. U.S. Environmental Protection Agency (EPA) guidelines were followed in the determination of public health risks.

## II. SITE CHARACTERIZATION

### 2.1 Site History

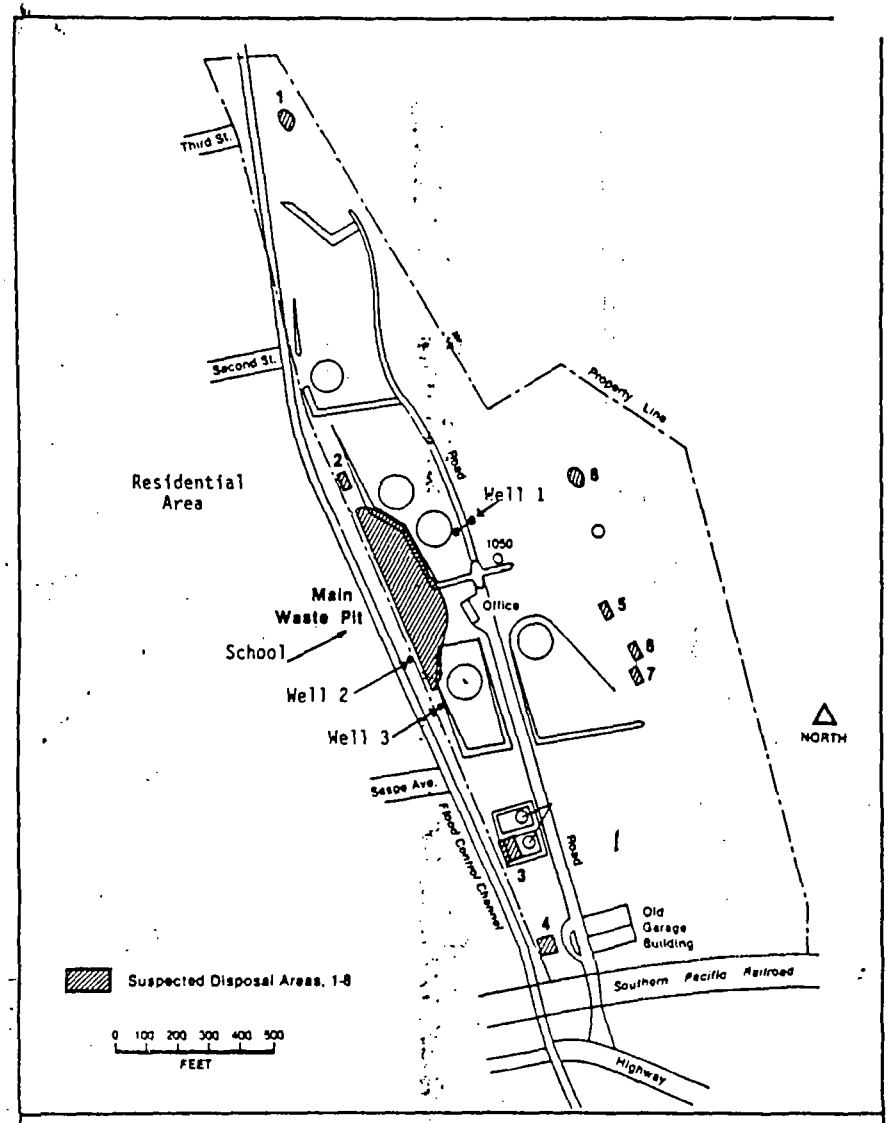
Based on available records and activity logs, it is known that Company X operated a small oil refinery at the site from the year 1920 to 1950. During these years, miscellaneous refinery wastes were disposed on site in a large 600' by 100' pit which was located on the western border of the property. In addition, wastes were also disposed of in eight identified smaller pits located throughout the property. (Figure 1).

Such waste disposal practices were considered acceptable during this time period. Following the closure of the refinery in 1950, a majority of the facility was dismantled. Since closure of the refinery to present time, the facility has operated only as a crude oil pumping station. It is believed that the waste disposal areas on site have not been active since 1950.

Company X initiated a remedial investigation/feasibility study (RI/FS) and subsequent mitigative measures at the site after considering: 1) the potential extent of and liability for environmental contamination and associated health hazards posed by the site; 2) that with anticipated Federal and/or State hazardous waste mitigative requirements, it would presently be more economical to perform remedial action than in the future because of escalating clean up costs; and 3) recent encroachment of surrounding populations has escalated property values to the point that development of the land is more economically feasible than are its industrial applications.

Remedial investigations and mitigative measures performed by Company X to date are:

1. A site investigation to characterize the nature and extent of contamination at the site and determine appropriate remedial alternatives (July 1983 to August 1983);
2. Selection of soil excavation as the most appropriate remedial alternative and implementation of such remedial action (January 1986 to August 1986); and
3. Post remedial investigation to characterize the nature and extent of contamination remaining at the site after remedial action (September 1986 to October 1986).




Site Map





Excavation operation was temporarily halted in August 1986 due to the unexpected cost overrun.

### 2.2 Site and Population Description

Regionally, the site is located in the coastal range mountains of Southern California, approximately 20 miles inland from the Pacific Ocean. Topographically, the site is located on a river alluvial fan within a small valley of the coastal range mountains. Bordering the facility to the north and east are steep hills. South of the site is a river which flows intermittently depending on rainfall levels. West of the site is a small rural city.

The main waste pit at the oil refinery is located adjacent to the western border of the site. A small canal separates the waste pit from an adjacent residential area of the city.

Populations which may be maximally impacted by air contaminant emissions originating from the site include this residential area and a local school also bordering the west side of the main waste pit. Possible sensitive individuals within this area include infants, children and pregnant women, as well as elderly people and the chronically ill.

### 2.3 Soils and Groundwater Description

As reported in remedial studies, the site and nearby city are located on a large alluvial fan. Soils consist of erosional materials which include quarternary clays, sands and gravel. Groundwater underneath the site is found at approximately 85 feet below the existing ground surface. Flow is estimated to be southwesterly. Water levels fluctuate significantly year to year depending on climatic conditions.

Water supply for the city is derived from two water wells located in the northwest section of the city. As reported, these wells are not considered downgradient of the oil refinery, therefore, are not believed to be impacted by site contaminants. Prior to the installation of these wells, the city obtained water from three wells located 1/2 to 2/3 of a mile southwest of the facility; which is considered downgradient. These wells were reported not to be used as a water source except in extreme emergencies. Records indicate an irrigation well located 1400 feet southwest of the waste pit. The current status of this well was not established.

Water for the present crude oil pumping facility is supplied by an on-site production well located southeast of the main waste pit. Records indicate that this well derives water from deep zones that are hydraulically isolated from upper shallow groundwater aquifers. As reported, this well was not considered endangered by contaminants in the upper groundwater table aquifer and was not sampled for analysis.

Three water wells were drilled on-site during remedial investigation activities to establish whether contaminants from the waste pit had impacted underlying groundwater.

### 2.4 Climatology

The study area is subject to hot summers and mild winters. Precipitation is approximately 20" per year, occurring primarily during the winter months. Winds were reported to be predominantly from the west and southwest.

## III. FIELD MONITORING RESULTS

Accurate quantification of pollutant concentrations at a hazardous waste site is essential and critical in: (1) protecting the health and safety of on site workers and the public at large during mitigative actions; (2) providing immediate valuable information for taking emergency action should it become necessary; (3) providing a data base for assessing human health risks from exposure to site hazardous pollutant emissions; and (3) evaluating the feasibility and effectiveness of mitigative measures.

### 1.0 Pre Remedial Excavation

Company Y (unnamed) was retained by Company X to conduct an initial remedial investigation/feasibility study of the site. A comprehensive monitoring program was initiated by Company Y to characterize the nature and extent of contamination in potentially impacted air, soil and groundwater. Monitoring methodologies employed included real time field monitoring for organics, $SO_2$ and $H_2S$ as well as an intensive air, soil and groundwater sampling and laboratory analysis program to qualify and quantify organic and inorganic chemical contaminant levels. The results of this investigation as reported by Company Y are as follows:

- Air Monitoring

An initial study was conducted to determine the emission rates of volatile compounds from undisturbed surface soils. Emission rates for $SO_2$, total hydrocarbons (THC) and organics were found to be low (Table 1). Under steady state conditions, $SO_2$ emission rates ranged from background (0.14 $ug/m^2/min.$) to 5.6 $ug/m^2/min.$, and THC emission rates ranged from background (7.3 $ug/m^3/min.$) to 120 $ug/m^3$ min. Emissions exhibited a high dependence on diurnal temperature fluctuations with increased emissions observed during higher mean temperature periods, as expected. Air canisters sampled during this survey allowed qualification and quantification of volatile organic emission from undisturbed surface soils (Table 2). Air canister sampling results are used in this paper for estimating pre-excavation soil volatile organic emission rates.





- Soil Monitoring

A soil monitoring program was conducted by Company Y to characterize the concentration of organic and inorganic in soils as well as the emission potential of $SO_2$ and THC in soil boring samples and downhole samples. Seven boreholes were drilled in the main waste pit with depths ranging from 2' to 50' below the soil surface.

High concentrations of $SO_2$ and THC were detected in both downhole and soil boring samples (Table 1). Peak concentrations for $SO_2$ and THC downhole were $>1.9x10^4$ and $>3.8x10^4$ ppm, respectively. In soil samples the peak THC concentration was 2500 ppm. Significant concentrations of $SO_2$ and THC were also detected in the vicinity of bore drilling activities but decreased rapidly at downwind border monitoring locations (Table 1). Peak concentrations for $SO_2$ and THC for vicinity monitoring were <20 and 500 ppm, respectively, for border monitoring the peak $SO_2$ concentration was 0.12 ppm.

All soil samples were found to be significantly impacted by both organic and inorganic contaminants (Tables 3 and 4) with the top 6' of soil being reported as the the most severely contaminated. This includes homogeneous wastes in the southern section of the main pit and soil/waste mixtures in both the northern and southern sections. In the northern section, wastes (neutral pH) were found to be covered with 3' of soil fill whereas in areas of the southern section wastes (pH 2.0) were exposed at the surface and had a consistency typical of refinery sludges.

Soils below the wastes are predominantly alluvial gravels mixed with sand and silt. Soil monitoring and sampling efforts indicated significant yet lower levels of organic chemical contamination to maximum depths sampled of -40'.

- Groundwater Monitoring

Three monitoring wells were installed to assess the degree of migration of contaminants from the site to underlying groundwater. One well was installed upgradient and two downgradient of the main waste pit (Figure 1). Well #1 was reported to be located in a perched water aquifer hydrogeologically disconnected from wells #2 and #3.

The two downgradient wells were found to be impacted by volatile organics (Table 5). Benzene was detected at 800 ppb. Groundwater analysis performed did not include semi volatile organic analysis, thus impacts from these chemicals were not evaluated. Groundwater was not found to be impacted by inorganic contaminants.

2.0 Remedial Excavation

MED-TOX established and conducted an on-site monitoring program for $SO_2$, $H_2S$, THC (Table 1) and Organics (Table 2) during site remedial excavation activities. Monitoring of hazardous waste emissions was performed to provide actual pollutant concentrations; (1) for responding to emergency situations should they occur; (2) to aid in the assessment of worker and public health and safety during excavation activities; and (3) to provide contaminant emission rate information required in this health risk assessment. The Monitoring Program included excavated soil headspace sampling (Table 2) to aid in the calculation of contaminant emission rates used in this paper in evaluating public health risks posed by volatile organic emissions during remedial excavation activities.

Along with MED-TOX's on-site, hot zone monitoring, Company Y also provided boundary monitoring during excavation activities. $SO_2$, THC as well as meteorological conditions were monitored (Table 1).

Due to the nature of oil refinery wastes organics, $SO_2$, $H_2S$ and associated biodegration by-products were frequently detected at high levels during excavation activities (Tables 1 and 2). Due to peak concentrations monitored for $SO_2$, THC and $H_2S$ immediate downwind were 2000, 10 and 40 ppm, respectively, border monitored peak concentrations for $SO_2$ and THC were 9.2 and 52 ppm, respectively, the proximity of a residential area immediately west of the main pit, strict precautions and regulations were imposed on excavation activities. Excavation was only allowed under favorable winds and conditions. Strong odors typical of petroleum waste were a significant problem during excavation activities. Extensive temporary/permanent foams were used to control odorous emissions. Other abatement measures including backfill, heavy plastic tarping, and air dispersion with a large agricultural fan were also taken.

3.0 Post Remedial Excavation

Company Y collected soil borings and performed soil analyses and real time organic field monitoring for $SO_2$ and THC to determine the nature and extent of soil contamination remaining in the main waste pit post remedial excavation. This study was performed before soil excavation activities had been completed so was confined to the northern section of the waste pit. Excavation of the main waste pit was completed to approximately 15-20 feet below the original land surface. On-site visual evaluations and organolead analyses performed during excavation indicated the presence of potentially contaminated material below excavated levels.





High levels of THC were detected in the vicinity of soil borehole drilling activities (Table 1). The peak concentration was 270 ppm. High levels of THC were also detected in soil samples indicating the presence of organics in the soils below excavated surface levels. (Table 1). The peak concentration was 500 ppm.

Various species of volatile and semivolatile organics similar to those detected prior to excavation were found at different concentrations in all samples collected (Table 3).

Organolead was not detected in soil samples. Due to the limitation of post excavation sampling to the northern main pit and the likely spatial variability of contaminated areas, these results did not preclude that remaining unsampled areas contain lead.

## IV SELECTION OF INDICATOR CHEMICALS

As anticipated, hazardous waste sites like the one under study contains a large number of potentially harmful contaminants. To include all identified chemicals and evaluate the total potential impacts of these chemicals in this public health evaluation is both impractical and unrealistic. EPA, in its guidelines, has recommended that contaminants which pose the greatest potential health risk shall be selected as indicator chemicals and received a thorough review in order to determine the magnitude and significance of health risks posed by the site. Two important factors for selecting indicator chemicals are their measured and/or predicted concentrations at the site and their toxicity. Other factors such as physical and chemical parameters related to environmental mobility and persistence of the chemical are also considered in the selection process.

Benzene, toluene, total xylenes, ethyl benzene, hexane, methylene chloride, acetone, and napthalene were selected as indicator chemicals for evaluating site hazards following EPA's guidelines, criteria and methodology.

## V TOXICITY ASSESSMENT

Toxicity assessment is used to generate chemical-specific critical toxicity values to be used in conjunction with results of the exposure assessment to characterize health risk associated with that chemical. Toxicity information for a chemical is commonly obtained from clinical studies, epidemiological studies, animal studies, in vitro studies, or structure activity relationships. The most accurate and strongest evidence of human toxicity is believed to be from clinical studies, unfortunately, for most chemicals human health data are not readily available. Most researchers and regulatory agencies therefore have to extrapolate non-human experimental results to estimate the toxicity of a chemical to humans.

Noncarcinogens are currently believed to act primarily via threshold mechanisms. This means that adverse health effects will result only after the levels of exposure exceed this threshold level. Because of this threshold effect, acceptable daily intake (ADI) or exposure levels can be computed. The toxicity of a noncarcinogen chemical is further determined by considering ADI. Available ADIs for noncarcinogenic indicator chemicals are presented in Table 6.

Unlike noncarcinogens, carcinogens are currently believed to act primarily via nonthreshold mechanisms. This means that there is a health risk associated with exposure to all levels of a carcinogen. The EPA's Carcinogen Assessment Group has prepared quantitative estimates of cancer risks per unit dose and potency factor, for human and suspected human carcinogens, based on nonthreshold dose response models. Potency factors for the two identified carcinogenic indicator chemicals, benzene and methylene chloride are $2.9 \times 10^{-2}$ and $1.4 \times 10^{-2}$ respectively (U.S. EPA 1986). Carcinogenic potency factors expressed as a lifetime cancer risk in the unit of mg chemical per kg of body weight per day were used as an indicator of a chemical's toxicity to assess human cancer risk. This factor represents an estimate of upper 95% confidence limit of a chemical's carcinogenic potency.

## VI. THEORETICAL AND MONITORED EXPOSURE ASSESSMENT

In order to fully characterize the extent and significance of health impacts from hazardous waste sites, complete and accurate estimations of human exposure are needed. Discussed in this section are the results of and methodology for assessing the extent and duration of human exposure to toxic chemicals released from the site.

Since contaminants in our study site have potentially migrated offsite, a quantitative exposure assessment is required and initiated to identify all exposure pathways and estimate environmental concentrations of each indicator chemical in each pathway. An exposure pathway is considered complete if it consists of the following four elements: 1) source of contaminant, 2) contaminant release mechanisms; 3) transport medium and transport of the released chemical; and 4) human exposure points.

Identified major exposure pathways of contaminants from the site to surrounding human receptors include: 1) ambient air exposure to volatile surface wastes; 2) ambient air exposure to resuspended contaminated soil particulates; and 3) exposure to contaminated groundwater.

Exposure point concentrations of contaminants, via these environmental pathways, are quantitated below. Both monitored data and modeling estimates were used to fully assess contaminant exposure levels. Considerable uncertainties exist with both sets of data.





In order to keep a perspective as to the range of risk being estimated, both best and worst estimates of all exposure point concentrations were calculated and are presented in subsequent cancer risk estimates.

### 1.0 Emission Rate Estimates

As stated previously, both volatilization and fugitive dust generation were identified in this case as possible release routes of contaminants along with contaminant leaching to groundwater. Where available, monitored emission rate data is used to extrapolate site emission rates. Unfortunately monitoring data was either deficient, nonapplicable, or not available to assess emission rates for all scenarios essential in evaluating human health risk.

Fugitive dust (resuspended soil) levels were estimated to be negligible and were not included in subsequent exposure level calculations. Monitored concentrations of contaminants in groundwater were used in estimating risk levels from ingestion of drinking water and for comparison to drinking water standards, whereas ambient concentrations of contaminants required supplemental modeling of monitored data to adequately characterize emission rates, exposure levels, and associated health risks.

Theoretical emission rate estimates of volatile chemicals from soil are calculated using mathematical emission rate modeling equations derived from Fick's Law Of Diffusion (Hwang 1982). Input for these equations includes a number of chemical specific physical constants for characterizing a chemical's behavior in soil and vapor phases and may site specific parameters such as monitored concentration of contaminants in soil and soil properties.

Pre-excavation monitored emission rates of volatile organics from undisturbed surface soils are used to assess site emission rates for these contaminants. Unfortunately, sampling efforts were confined to the south end of the main pit where waste materials are exposed at the surface and could not be extrapolated to the north end of the main pit which had 3' of soil cover. Therefore, theoretical models applicable to estimating emission rates from waste with a soil cover were employed (Farino, 1983).

Similarly, during remedial activities monitored data from soil headspace samples are used to estimate emission rates from exposed excavated soils. Unfortunately, all indicator chemicals were not detected during limited soil headspace sampling. Therefore, theoretical models applicable for estimating emission rates of volatile chemicals from exposed excavated soils were employed (Hwang, 1982).

Due to the lack of post excavation monitoring data, theoretical models were also used to estimate emission from soils with 1' of soil cover (Farino 1983).

### 2.0 Environmental Transport, Fate, and Exposure Point Concentrations

After release rates of volatile air contaminants are determined, theoretical methods (Turner 1970) for describing the ambient concentrations of a chemical at a specified downwind distance from the site were used to derive an upperbound conservative estimate of maximum contaminant exposure concentrations. Theoretical models for calculating ambient air dispersion model estimates are derived using established dispersion coefficients as a function of downwind distance and Pasquill stability classes as well as other site specific variables such as monitored pollutant emission rates, wind speed and wind direction. These models provide conservative upper bound downwind ambient air pollutant concentration estimates. Conservatively, environmental degradation processes were not accounted for in these estimates.

Results of estimated exposure point concentration for volatilization of soil contaminants are presented in Table 7, the maximally impacted receptors were determined from modeling efforts to be the closest downwind populations and were calculated for a point 0.1 kilometers downwind form the site.

## VII. COMPARISON TO ENVIRONMENTAL CRITERIA, STANDARDS, AND REQUIREMENTS

Where appropriate environmental criteria, standards and requirements exist, a comparison was made to establish whether environmental levels fall within these prescribed acceptable limits. Contaminant levels monitored in groundwater were found to exceed acceptable levels and the results of this evaluation are presented in Table 5.

## VIII. HUMAN INTAKE

Human exposure to contaminants is expressed in terms of intake, which is the amount of substance taken intq the body per unit body weight per unit time (mg/kg/day). The term intake is used instead of dose because information indicating the amount of chemical that may be absorbed and subsequently distributed to target organs or tissues would be needed.

Inhalation intake of volatile contaminants are calculated assuming that the average adult weighs 70 kg and breathes 20 cubic meters of air per day. The results of inhalation intake estimates are presented in Table 8. Groundwater intake is calculated assuming the average adult consumes 2 liters of water per day. Benzene was the only carcinogenic indicator chemical detected in drinking water. At a concentration of 0.8 mg/l in the groundwater, the drinking water lifetime ingestion rate for benzene is therefore $2.29 \times 10^{-2}$ mg/kg/day.





## IX. RISK ASSESSMENT

In order to evaluate risk, a comparison is made between projected intakes and acceptable intakes for noncarcinogens and between calculated risks and acceptable risks for carcinogens.

### 9.1 Noncarcinogens

As stated, noncarcinogenic risk is assessed by comparing projected intake levels to calculated acceptable daily intakes. A hazard index approach is conservatively used to assess risk and is expressed as the sum of the projected exposures over the acceptable exposures. Exposure concentration estimates for noncarcinogens were found not exceed acceptable intake levels therefore are not considered a health risk.

### 9.2 Carcinogens

For carcinogens, risk is estimated as a probability. The carcinogenic potency factor, which is an upper 95% confidence limit on the probability of response per unit intake of a chemical over a lifetime, converts estimated intakes directly to incremental risk.

Conservative assumptions incorporated into both emission rate and air dispersion modeling estimates are accounted for in best estimate inhalation cancer risk calculations by applying a 10 fold reduction in risk for each respective estimate. For further discussion on uncertainties and assumptions refer to critical evaluation discussions (Section X). The total best estimate cancer risks from lifetime inhalation exposure to carcinogenic volatile organic indicator chemical originating from the main waste pit are $1.49 \times 10^{-8}$, $7.27 \times 10^{-7}$ and $5.16 \times 10^{-2}$ for pre-excavation, concurrent excavation and post excavation operations, respectively (Table 9). These cancer risk level fall below the cancer risk levels of one in a million ($1.0 \times 10^{-6}$) currently considered as significant.

Pre-excavation worst case inhalation cancer risk estimates ($1.49 \times 10^{-6}$ - Table 9) based on monitored data exceeds risk levels considered as significant suggesting that a significant cancer risk may have been present due to exposure to site-related pollutants. In addition, concurrent excavation worst case inhalation cancer risk estimates ($9.77 \times 10^{-6}$ - Table 9) derived from theoretical models also exceeds $1 \times 10^{-6}$ risk level. Post excavation worst case inhalation cancer risk was estimated to be $5.16 \times 10^{-10}$ (Table 9) well below the level considered to be significant.

Benzene was the only carcinogenic indicator chemical detected in groundwater during remedial investigations. Lifetime cancer risk form ingestion of benzene contaminated drinking water is calculated to be $6.64 \times 10^{-4}$, clearly exceeding acceptable risk levels. It is believed that this groundwater is not currently consumed by the city and the surrounding community.

## X CRITICAL EVALUATION

### 10.1 Estimating Risk - Uncertanties and Assumptions

Health risks posed by contaminants from the site have been quantified to a representative number. This estimate of probable carcinogenic risk and hazard index for noncarcinogenic risks are dependent on numerous assumptions and uncertainties inherent in the risk assessment process. In reality, actual risk could be more than 100 times greater or smaller. Despite these limitations, quantification of risk is important in guiding decisions to prevent harmful chemical exposures.

Areas of uncertainties and assumptions employed in estimating health risk include:

- Exposure Assessment
  - o Monitoring, sampling and analysis techniques
  - o Time and spatial variability in monitored data: monitored data may not represent actual contaminant levels, past current or post monitoring.
  - o Exposure modeling: in addition to inherent uncertainties and assumptions in theoretical models, site specific conservative assumptions, such as considering the main waste pit as a point source to immediately adjacent receptors, may significantly over estimate exposure levels.
  - o Prior exposure to other pollutants.
  - o Extrapolation of subchronic exposure to lifetime exposure to evaluate lifetime cancer risk.
- Toxicity Assessment
  - o Inter and intraspecies extrapolation
  - o High to low dose extrapolation: the shape of the dose response curve at exposure levels encountered in the environment is unknown.
  - o Threshold, nonthreshold effects: all carcinogens are conservatively assumed to act via nonthreshold genotoxic mechanisms.
  - o Synergism/antagonism
  - o Chemical absorption, distribution and endpoint target tissue levels.





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TABLE 1: FIELD MONITORING RESULTS OF SULFER DIOXIDE ($SO_2$), TOTAL HYDROCARBON (THC) AND HYDROGEN SULFIDE ($H_2S$)

| PROJECT PHASE | SITE LOCATION | MONITORING LOCATION | LEVELS DETECTED (PPM) $SO_2$ PEAK | $SO_2$ MEAN | THC PEAK | THC MEAN | $H_2S$ PEAK | $H_2S$ MEAN |
|---|---|---|---|---|---|---|---|---|
| Pre-excavation | South main pit | Undisturbed surface flux | 5.6* | ND | $1.4 \times 10^2$* | 7.3 | NA | NA |
| Pre-excavation | Main pit | Soil Samples | NA | NA | 2500.0 | 700.0 | NA | NA |
| Pre-excavation | Main pit | Soil borehole downhole | $>1.9 \times 10^4$* | $7.2 \times 10^3$* | $>3.8 \times 10^4$* | $>3.8 \times 10^4$* | NA | NA |
| Pre-excavation | Main pit | Downwind border during drilling | 0.12 | not provided | NA | NA | NA | NA |
| Pre-excavation | Main pit | Immediate downwind during drilling | <20.0 | >1.0 | 500.0 | 10.0 | NA | NA |
| Concurrent excavation | Main pit | Immediate downwind during excavation | 2000 | <0.5 | 10.0 | 1.0 | 40 | <0.5 |
| Concurrent excavation | Main pit | Downwind border during excavation | 9.2 | <0.5 | 52.0 | <1.0 | NA | NA |
| Post excavation | North main pit | Immediate downwind during drilling | NA | NA | 270.0 | 70.0 | NA | NA |
| Post excavation | North main pit | Soil Sample | NA | NA | 500.0 | 50.0 | NA | NA |

* = $ug/m^2$ min.
ND = Not Detected
NA = Not Analyzed





TABLE 2: RESULTS OF MONITORED AMBIENT AIR CONCENTRATIONS OF ORGANICS (PPMV)

| CHEMICAL | PRE-EXCAVATION AIR CANISTER SURFACE SAMPLE SOUTH MAIN PIT(1) | PRE-EXCAVATION AIR CANISTER DOWNHOLE SAMPLING MAIN PIT MAXIMUM | MEAN | CONCURRENT EXCAVATION HEADSPACE SAMPLING EXCAVATED SOIL MAXIMUM | MEAN |
|---|---|---|---|---|---|
| BENZENE | 0.22 | 598.8 | 207.4 | $2.9 \times 10^{-2}$ | ND |
| TOLUENE | 0.60 | 321.8 | 17.1 | $2.7 \times 10^{-2}$ | $7.8 \times 10^{-4}$ |
| TOTAL XYLENES | 1.58 | 358.0 | 52.3 | $3.0 \times 10^{-2}$ | ND |
| ETHYL BENZENE | 0.46 | 142.1 | 31.8 | $4.9 \times 10^{-3}$ | ND |
| HEXANE | 0.80 | 4478.4 | 957.1 | $2.1 \times 10^{-1}$ | $1.9 \times 10^{-2}$ |
| METHYLENE CHLORIDE | ND | 0.11 | ND | $3.2 \times 10^{-1}$ | ND |
| ACETONE | ND | ND | ND | 11.0 | $5.9 \times 10^{-1}$ |
| NAPTHALENE | 0.30 | 5.0 | 0.6 | NA | NA |

(1) - One Sample Collected
ND = Not Detected
NA = Not Analyzed

TABLE 3: RESULTS OF ORGANICS ANALYSIS IN SOIL (mg/kg)[1]

| CHEMICAL | PRE-EXCAVATION MAIN PIT MAXIMUM | PRE-EXCAVATION MAIN PIT MEAN | POST EXCAVATION MAIN PIT MAXIMUM | POST EXCAVATION MAIN PIT MEAN |
|---|---|---|---|---|
| BENZENE | 9.3 | 1.0 | 0.61 | ND |
| TOLUENE | 16.0 | 1.6 | 13.0 | 0.25 |
| TOTAL XYLENES | 61.0 | 7.9 | ND | ND |
| ETHYL BENZENE | 10.0 | 3.3 | 18.0 | ND |
| HEXANE | 33.0 | ND | ND | ND |
| METHYLENE CHLORIDE | ND | ND | ND | ND |
| ACETONE | ND | ND | ND | ND |
| NAPTHALENE | 0.13 | NA[2] | 110.0 | ND |

ND = Not Detected
NA = Not Analyzed

(1) EPA recommended volatile and semivolatile organic analysis methods.

(2) 2 of 14 pre-excavation soil samples underwent semivolatile chemical analysis and were positive.





TABLE 4: SOIL CONCENTRATIONS (mg/kg) OF INORGANICS DETECTED IN THE MAIN WASTE PIT PRIOR TO EXCAVATION

| CHEMICAL | MAXIMUM | MEAN | TTLC[1] |
|---|---|---|---|
| Ag | ND | ND | 20 |
| As | 14.0 | 5.4 | 500 |
| Ba | 150.0 | 73.0 | 10,000 |
| Be | NA | NA | 75 |
| Cd | 11.0 | 2.6 | 100 |
| Cr | 120.0 | 24.0 | 2,500 |
| Hg | ND | ND | 500 |
| Ni | NA | NA | 2,000 |
| Pb | 3700 | 9.8 | 1,000 |
| Se | 1.2 | 0.51 | 100 |

(1) - Total threshold limit concentration established in Section 66699 of Title 22, CAC.
ND = Not Detected.
NA = Not Analyzed.

TABLE 5: RESULTS OF ORGANIC ANALYSIS IN GROUND WATER(1)

| CHEMICAL | PRE-EXCAVATION UG/L | EPA DRINKING WATER HEALTH ADVISORIES LIFETIME - (UG/L) |
|---|---|---|
| BENZENE | 800 | CARCINOGEN(2) |
| TOLUENE | ND | 10100 |
| ETHYL BENZENE | 14 | 3400 |
| o,p,m-DICHLOROBENZENE | ND | 3125 |

(1) - EPA Method 602 Volatile Organics - Not all peaks are identified under this method. Semi volatile organics analysis was not performed.
(2) - CAG estimates a 13 ug/l benzene in drinking water equalling to $1 \times 10^{-6}$ cancer risk.
ND = Not Detected.

NOTE TO EDITORS

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TABLE 6: ACCEPTABLE DAILY INTAKE (mg/kg/DAY) OF NONCARCINOGENS USED IN RISK ASSESSMENT

| | ORAL INTAKE | | INHALATION INTAKE | |
|---|---|---|---|---|
| CHEMICAL | AIS(1) | AIC(2) | AIS | AIC |
| TOLUENE | $4.3 \times 10^{-1}$ | $2.9 \times 10^{-1}$ | N/A | N/A |
| O-XYLENE | $1 \times 10^{-1}$ | $1 \times 10^{-2}$ | $9.6 \times 10^{-1}$T(3) | $2 \times 10^{-1}$ |
| P-XYLENE | $1 \times 10^{-1}$ | $1 \times 10^{-2}$ | 1.0 | $2 \times 10^{-1}$ |
| M-XYLENE | N/A | N/A | N/A | N/A |
| TOTAL XYLENES | $1 \times 10^{-1}$ | $1 \times 10^{-2}$ | $6.9 \times 10^{-1}$T(3) | $4 \times 10^{-7}$ |
| ETHYL BENZENE | 0.97 | 0.097 | N/A | N/A |
| HEXANE | N/A | N/A | N/A | N/A |
| ACETONE | N/A | N/A | 30.0 | 3.0 |
| NAPTHALENE | N/A | N/A | N/A | N/A |
| HYDROGEN SULFIDE | N/A | $2.0 \times 10^{-3}$ | N/A | N/A |

N/A = Not Available

(1) - AIS = Acceptable Daily Intake Subchronic exposure.
(2) - AIC = Acceptable Daily Intake Chronic exposure.
(3) - T = Teratogen.
Source: ECAO, U.S. EPA 1984, Summary Data Tables for Chronic Noncarcinogenic Effects.

TABLE 7: ESTIMATES OF WORST CASE AMBIENT EXPOSURE CONCENTRATIONS (0.1 KILOMETER DOWNWIND FROM THE SOURCE) ($MG/M^3$)

| CHEMICAL | PRE-EXCAVATION | | CONCURRENT EXCAVATION | | POST EXCAVATION |
|---|---|---|---|---|---|
| | NORTH(1) MAIN PIT | SOUTH(2) MAIN PIT | EXCAVATED(3) SOIL | EXCAVATED(3) SOIL | MAIN(4) PIT |
| BENEZENE | $2.40 \times 10^{-6}$ | $1.80 \times 10^{-4}$ | $3.30 \times 10^{-1}$ | $3.65 \times 10^{-4}$ | $6.23 \times 10^{-8}$ |
| TOLUENE | $2.02 \times 10^{-6}$ | $5.84 \times 10^{-4}$ | $3.04 \times 10^{-1}$ | $3.92 \times 10^{-4}$ | $7.99 \times 10^{-6}$ |
| TOTAL XYLENES | $3.71 \times 10^{-5}$ | $1.78 \times 10^{-3}$ | 1.30 | $5.10 \times 10^{-4}$ | ND |
| ETHYL BENZENE | $1.85 \times 10^{-7}$ | $5.25 \times 10^{-4}$ | $9.17 \times 10^{-2}$ | $8.25 \times 10^{-5}$ | $3.60 \times 10^{-6}$ |
| HEXANE | $8.99 \times 10^{-5}$ | $7.22 \times 10^{-4}$ | 2.02 | $2.95 \times 10^{-3}$ | ND |
| METHYLENE CHLORIDE | $6.19 \times 10^{-13}$ | ND | $1.67 \times 10^{-4}$ | $4.36 \times 10^{-1}$ | ND |
| ACETONE | $9.08 \times 10^{-9}$ | ND | $2.03 \times 10^{-2}$ | $1.07 \times 10^{-1}$ | ND |
| NAPTHALENE | NA | $4.01 \times 10^{-4}$ | NA | NA | NA |

(1) North Main Pit, 3' soil cover, 300' x 100' area.
(2) South Main Pit, exposed surface waste, 200' x 100' area.
(3) Main Pit, exposed excavated soil, 30' x 30' area.
(4) Main Pit, 1' soil cover, 600' x 100' area.

ND = Not Detected.
NA = Not Available.





TABLE 8: ESTIMATES OF WORST CASE INHALATION INTAKE (mg/kg/DAY)

| CHEMICAL | PRE-EXCAVATION | | CONCURRENT EXCAVATION | | POST EXCAVATION |
|---|---|---|---|---|---|
| | NORTH(1) MAIN PIT | SOUTH(2) MAIN PIT | EXCAVATED(3) SOIL | EXCAVATED(3) SOIL | MAIN(4) PIT |
| BENZENE | $6.86 \times 10^{-7}$ | $5.14 \times 10^{-5}$ | $9.43 \times 10^{-2}$ | $1.04 \times 10^{-4}$ | $1.78 \times 10^{-8}$ |
| TOLUENE | $5.77 \times 10^{-7}$ | $1.67 \times 10^{-4}$ | $8.69 \times 10^{-2}$ | $1.12 \times 10^{-4}$ | $2.28 \times 10^{-6}$ |
| TOTAL XYLENES | $1.06 \times 10^{-5}$ | $5.09 \times 10^{-4}$ | $3.71 \times 10^{-1}$ | $1.46 \times 10^{-4}$ | ND |
| ETHYL BENZENE | $5.29 \times 10^{-8}$ | $1.50 \times 10^{-4}$ | $2.62 \times 10^{-2}$ | $2.36 \times 10^{-5}$ | $1.03 \times 10^{-6}$ |
| HEXANE | $2.57 \times 10^{-5}$ | $2.06 \times 10^{-4}$ | $5.77 \times 10^{-1}$ | $8.43 \times 10^{-4}$ | ND |
| METHYLENE CHLORIDE | $1.77 \times 10^{-13}$ | ND | $4.77 \times 10^{-5}$ | $1.25 \times 10^{-3}$ | ND |
| ACETONE | $2.59 \times 10^{-9}$ | ND | $5.80 \times 10^{-3}$ | $3.06 \times 10^{-2}$ | ND |
| NAPTHALENE | NA | $1.15 \times 10^{-4}$ | NA | NA | NA |

(1) North Main Pit, 3' soil cover, 300' x 100' area.
(2) South Main Pit, exposed surface waste, 200' x 100' area.
(3) Main Pit, exposed excavation soil, 30' x 30' area.
(4) Main Pit, 1' soil cover, 600' x 100' area.

ND = Not Detected.
NA = Not Available.

TABLE 9: ESTIMATES OF CANCER RISKS FROM INHALATION EXPOSURE TO VOLATILE ORGANICS IN CONTAMINATED SOILS

| CHEMICAL | PROJECT PHASE | SOURCE OF DATA FOR EMISSION ESTIMATE | BEST ESTIMATE | WORST CASE ESTIMATE |
|---|---|---|---|---|
| BENZENE | PRE-EXCAVATION(1) | MAXIMUM CONCENTRATION IN SOIL | $1.99 \times 10^{-10}$ | $1.99 \times 10^{-8}$ |
| METHYLENE CHLORIDE | | | $2.47 \times 10^{-17}$ | $2.47 \times 10^{-15}$ |
| BENZENE | PRE-EXCAVATION(2) | SOIL SURFACE FLUX | $1.49 \times 10^{-8}$ | $1.49 \times 10^{-6}$ |
| METHYLENE CHLORIDE | | | ND | ND |
| BENZENE | CONCURRENT(3) EXCAVATION | MAXIMUM CONCENTRATION IN SOIL | $9.77 \times 10^{-7}$ | $9.77 \times 10^{-6}$ |
| METHYLENE CHLORIDE | | | $2.39 \times 10^{-10}$ | $2.39 \times 10^{-9}$ |
| BENZENE | CONCURRENT(3) EXCAVATION | SOIL HEADSPACE FLUX | $1.07 \times 10^{-9}$ | $1.07 \times 10^{-8}$ |
| METHYLENE CHLORIDE | | | $6.25 \times 10^{-7}$ | $6.25 \times 10^{-8}$ |
| BENZENE | POST EXCAVATION(4) | MAXIMUM CONCENTRATION IN SOIL | $5.16 \times 10^{-12}$ | $5.16 \times 10^{-10}$ |
| METHYLENE CHLORIDE | | | ND | ND |

(1) North Main Pit, 3' soil cover, 300' x 100' area.
(2) South Main Pit, exposed surface waste, 200' x 100' area.
(3) Main Pit, exposed excavated soil, 30' x 30' area.
(4) Main Pit, 1' soil cover, 600' x 100' area.
ND = Not Detected.