



Mill Cove Air Quality Study



Project # NSD16203



Jacques Whitford
Environment Limited

**HALIFAX REGIONAL MUNICIPALITY
AIR QUALITY RISK ASSESSMENT
MILL COVE POLLUTION CONTROL PLANT**

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REPORT TO

HALIFAX REGIONAL MUNICIPALITY

ON

**AIR QUALITY RISK ASSESSMENT
MILL COVE POLLUTION CONTROL PLANT
BEDFORD, NOVA SCOTIA**

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EXECUTIVE SUMMARY

The air emissions from the Mill Cove Pollution Control Plant (the plant) in the Halifax Regional Municipality (HRM) were measured to determine if they contained substances which presented a potential risk that might warrant further investigation. The plant treats municipal sewage with the treated effluent discharged to Bedford Basin.

The study was primarily directed at assessment of potential risk to the community; however, exposures to the workers at the plant were also measured as part of the field program. These results, together with the results of analysis of intake effluent samples and literature reviews were used to help focus the air testing program. Worker exposure was found to be well within the limits as set by the Nova Scotia Department of Environment and Labour (NSDEL).

The emissions from the plant were determined to result primarily from the rooftop vent emitting the ventilation air from the headworks area, the volatilization of substances from the primary clarifier, and the volatilization from the secondary clarifier. The substances emitted from these sources are primarily volatile organic compounds (VOCs) that enter the plant with the wastewater.

There are two methods available in the assessment of community exposure. The most obvious is to conduct measurements where the population is exposed. This approach is generally not feasible: firstly because the resource requirements are enormous to cover the area, and to sample throughout a representative range of weather conditions; and, secondly, because the ability to sample the substances of concern is severely compromised by the laboratory detection limit. A better approach is the use of dispersion modelling to link the source emission characteristics to the exposure concentration in the town. This allows the use of long-term meteorological observations and survey information to accurately determine the long term exposure patterns. It also allows the determination of emissions to a much higher degree of accuracy at the source, where the concentrations are higher and detection limits are much less of a problem. In this study, many of the target compounds at the sources were still below the detection limit.

Based on the results of this study, it is concluded that the potential risk to the community population is extremely low, and is below the critical values used for both carcinogenic and non-carcinogenic substances detected in this study. These risk estimates are conservative; that is, likely to err on the high side, because:

- the dispersion model errs on the high side, particularly in areas with complex terrain, such as Bedford;
- the carbon filtration system in the air scrubber is scheduled for renewal, and emissions will drop substantially with the new filter; and
- scrubbing systems have been installed to prevent the release of substances from the clarifiers further reducing future emissions.

1.0 INTRODUCTION

Jacques Whitford Environment Limited (JWEL) was retained by Halifax Regional Municipality (HRM) to assess the potential risks to the community from atmospheric emissions from the Mill Cove Pollution Control Plant (PCP) (the plant). This is the final report on this project.

2.0 BACKGROUND

HRM had made a commitment to a review of potential health risk due to atmospheric emissions from the Mill Cove PCP. Initial site survey work was conducted in late summer of 2001, and meetings were held on-site to determine the best strategies for sampling emissions from the facility.

The main purpose of the work was to determine risk to the community, that is, to persons off-site; however, it was also considered appropriate to evaluate the potential exposures of persons on-site to air contaminants at the facility. The work plan was designed to address both the on-site (occupational) exposure issues and the off-site (community) exposures. The occupational exposure measurements helped determine the potential off-site emissions and allowed the project resources to be focused on the contaminants of greatest concern.

This report presents the results of both components of the study.

3.0 MILL COVE

3.1 Location of Plant

The Mill Cove PCP is located at the northwestern Side of the Bedford Basin in the former Town of Bedford, which is part of the HRM. The Sackville River and Parkers Brook discharge into Bedford Bay, which is the northern extension of the Bedford Basin. The plant is in a prominent location immediately adjacent to the deWolfe Park, the site of community events such as Canada Day celebrations. A significant part of the residential areas of Bedford are within a few hundred meters of the plant, and further condominium development is occurring immediately to the east of the plant.

3.2 Plant Processes

The Mill Cove Sewage Treatment facility was constructed in 1969 and became operational in 1970. Upgrades were done in 1981 and 1994. It has the operational capacity to treat 7.5 million gallons a day (34,095 m³/day) and at peak flows 16.5 million gallons a day (75,010 m³/day) of wastewater. It treats wastewater from the communities of Bedford and Sackville. It is the largest secondary treatment facility in Atlantic Canada.

The facility treats sewage to a level of secondary treatment. The secondary treatment process consists of preliminary treatment, primary treatment, activated sludge treatment, secondary settling and disinfection.

As wastewater is introduced to the plant, it follows the treatment process by first undergoing preliminary treatment, which consists of screening, and grit removal. At the entry of the wastewater into the plant, in the headworks area, odours are relatively strong, and ventilation air is scrubbed to remove odours before discharge at the roof level.

Primary treatment is next and consists of sedimentation and flotation. There is a pure oxygen activated sludge process that enables the sludge to become microbiologically active. Secondary treatment consists of removing suspended and dissolved solids by biological, chemical and physical processes. This is achieved by utilizing two sets of secondary clarifiers (the north and the south clarifiers) along with an anaerobic digester that treats and stabilizes the biosolids by means of anaerobic digestion. An ultraviolet light process has been installed, rather than chlorination, for disinfection to destroy pathogenic organisms. A surge or overflow equalization tank is located under the parking lot. This surge tank is used to allow overflow, to be retained during times of extreme or high flow and eventually pumped to the treatment facility when it can be properly treated.

3.3 Sources of Wastewater

The main source of wastewater entering the plant is from sanitary wastes produced by the residences and businesses of Bedford and Sackville. On an occasional basis, leachate from New Era and Otter Lake composting facilities has been treated at the plant. The community has little industry and there was no indication of specific industrial contaminants of concern.

4.0 OCCUPATIONAL EXPOSURES TO AIR CONTAMINANTS

Although the main purpose of this study was the assessment of community exposure, it was determined that a component to address the workplace environment would assist in determining the contaminants of concern on the plant site, and would also be useful in characterizing worker exposures. This section reports those results.

4.1 Design and Implementation of Test Program

Following a literature review and site inspection, it was determined that employees are most likely to be exposed to volatile organic compounds (VOCs). Daily exposure concentrations of four employees

working in three different job areas were sampled. Personal passive monitor dosimeters¹, were worn by the employees during a full working day (approximately 8 hours). The dosimeter badge was worn on the employee's shirt or work coveralls collar. Formaldehyde was sampled as an additional personal monitor badge.

On August 9, and August 15, 2001, a VOC dosimeter and a formaldehyde dosimeter were placed prior to the start of the work day on a lab technician, an operator and a maintenance worker. At the end of the workday the badges were removed and sent to the Philips Analytical for analysis. Philip Analytical is a certified industrial hygiene laboratory. Normal work activities were underway during the test period.

Passive sampling devices have been long recognized as relatively low cost, light weight, and unobtrusive means for monitoring time-weighted average concentrations of airborne chemicals. They require no external sources of power, but rather rely on diffusion of the contaminants from a bulk air stream to a collection surface. They are therefore ideal samplers for survey applications either in remote areas or in assessment of personal exposure.

4.2 Results of Occupational Monitoring

The results of the personal passive monitors are shown in Table A1 in Appendix A. Except for small quantities of formaldehyde and acetone, no other chemicals were detected. The detected concentrations of these VOC's were well below the TLV² and STEL³ values.

The values are so low that even though the worker exposure was not specifically done for 15 minute exposure (STEL), it is concluded that the 15-minute limit could not have been exceeded.

4.3 Worker Exposures

4.3.1 Volatile Organic Compounds

Employees are only exposed to very low limits of VOCs, in most cases the concentrations were below the detection limits.

The exposures measured were all significantly below the regulated exposure limits and, with the exception of acetone and formaldehyde, none of the materials tested were detected in the samples.

¹ Passive dosimeter: These are small devices that contain an absorbing media to which organics in the air come into contact. The organics are held by this media and the compounds are later extracted in the laboratory and measured using gas chromatography.

² TLV- Threshold Limit Value – Regulated exposure limits in Nova Scotia for an 8-hour working day exposure.

4.3.2 Hydrogen Sulphide

Hydrogen sulphide (H₂S) readings are taken on a daily basis by plant staff using hand held units within the plant and outside the plant. Sampling locations are indicated on Figure 1. H₂S is a concern for worker health and safety (e.g., in confined spaces at the plant) and for potentially odourous conditions offsite. The sampling data were provided to Jacques Whitford for the purposes of this study.

The H₂S data indicate that employees are typically exposed to an average concentration of 1 ppm while conducting routine maintenance or collecting wastewater samples from the two sets of primary clarifiers and from the headworks building. The TLV for H₂S is 10 ppm, and the STEL is 15 ppm. Although levels of 6 – 9 ppm are occasionally detected in the areas onsite indicated above, employees do not spend significant time on a regular basis in these areas. Ventilation is provided on all of the primary clarifiers by numerous openable hatches.

5.0 EMISSIONS MEASUREMENTS

5.1 Emission Sources

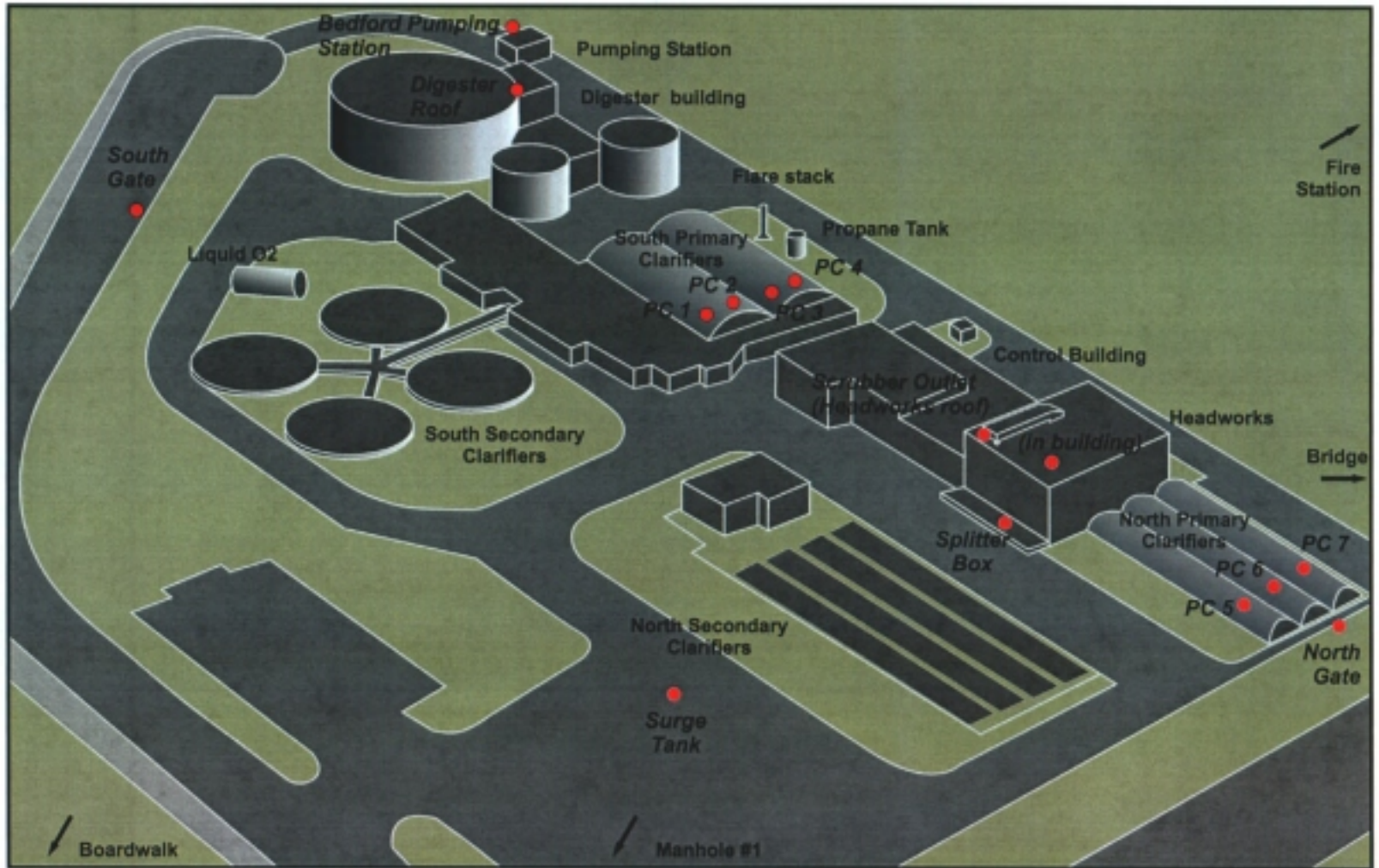
JWEL designed the sample program at the Mill Cove facility based on the requirements of the study and literature review of sewage treatment plants (Bishop *et al.* 1992; Card and Corsi 1992; Leonardos 1999; McDonald *et al.* 1992; Vasconcelos *et al.* 1991). Mill Cove and other plants are expected to operate with minimal impact to their surroundings; however, low levels of VOCs have been reported and were targeted for sampling and analysis. The following areas were identified as potential sources for VOC emissions:

- ventilation air from the headworks where influent enters the plant;
- headworks scrubber exhaust;
- volatilization from the primary clarifier; and
- volatilization from the secondary clarifier.

Figure 2 shows the sample locations at the plant.

5.2 Sampling Program

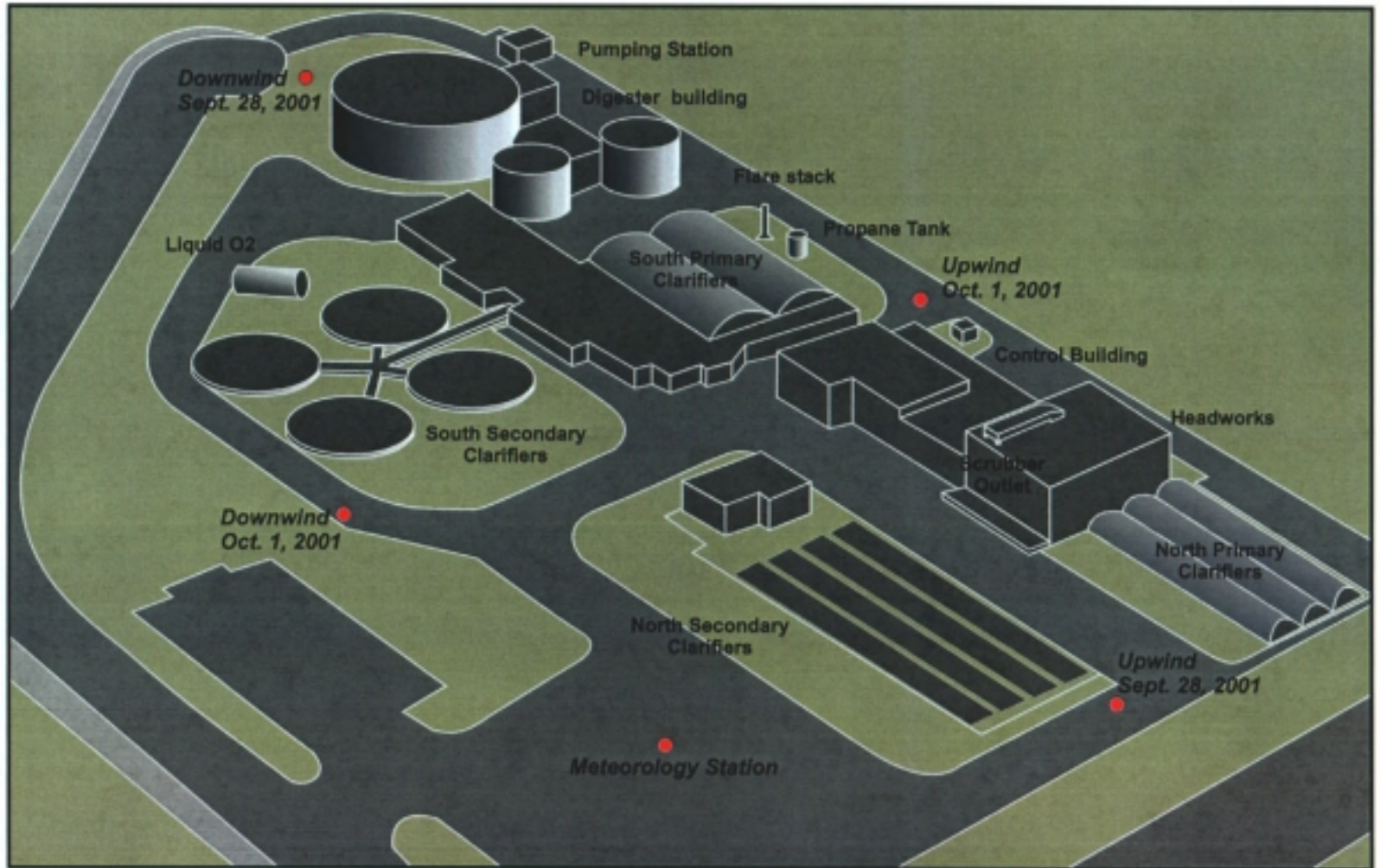
The sampling program consisted of three parts. In the first part, samples of influents and effluents of the plant were taken to determine what substances were present in the liquid phase that might be released to the air. These results helped in the selection of a suitable air sampling methodology to provide a sufficient minimum detection limit and to encompass the compounds determined in the water.



● Sample Location

↖ Indicates where samples are taken outside diagram boundary

Figure 1
H2S Sampling Locations



● Sample Location

Figure 2
Sampling Locations

In the second part, samples of VOCs from the primary clarifier, the secondary clarifier, and the headworks scrubber were taken to determine individual source strengths. Additional samples to help assess the headworks scrubber efficiency were obtained by sampling the scrubber intake and outlet at the same time.

The third part comprised ambient air measurements up and downwind of the plant to determine the overall impact of the facility. It was recognized that these samples could include the background concentrations of contaminants from sources in the airshed other than the plant, but was still considered useful for comparison purposes.

EPA methodology TO-1 for VOST-tube sampling and EPA 5040 GCMS for VOST-tube analysis were chosen after review of the results of the water samples (Table D1 in Appendix D). This methodology provided the lowest detection limit available from a commercial operating laboratory. Philip Analytical Services in Burlington conducted the analytical work. The list of 68 chemical substance which the lab could detect with the VOST-tube methodology and their Threshold Limit Values are shown in Appendix A. Note that ambient air standards do not exist in Nova Scotia for the listed chemical substances.

During air sampling all VOST-tubes were mounted to the top of a tripod and the outlet connected to a high volume air pump. The sample inlet for a VOST-tube was at approximately 1.2 m height to measure air that typically would be breathed by humans. Prior to sampling, flow rates through the VOST-tubes were measured with a Bios DryCal DC-Lite.

Air in the Headworks

The interior air in the headworks entering the scrubber was sampled for 60 minutes at a sample flow of 9.2 litres per minute.

Headworks Scrubber Outlet

The exhaust air from the scrubber outlet was sampled for 61 minutes at 9.5 litres per minute at the centre of the outlet at approximately 1 m height and 0.5 m away from the exit screen. The airflow of the discharge scrubber air was reported to be 4 m³/sec (8,000 cfm).

Primary and Secondary Clarifier

Emissions from the primary and secondary clarifiers were sampled with a floating flux chamber. Air inside the flux chamber was mixed with a fan. Sample air was drawn from the chamber into a VOST tube and filtered air was supplied to the chamber to avoid drawing a vacuum. The sample area was approximately 0.022 m². Samples were taken for approximately 1 hour at a rate of approximately 9.5 litres per minute. Flux chambers are used to determine the emission rate of a substance from a surface. The quantity of pollutant trapped in the sample corresponds to the emission from the enclosed

surface area during the time of sampling. Thus the results are usually expressed in terms of grams per square metre per second ($\text{g}/\text{m}^2\text{s}$).

Measurement of Air Emissions at Fence Line (Ambient Measurements)

The overall source effect of the plant was determined by measuring up and downwind at the same time. An anemometer and a datalogger were set up adjacent to the plant to determine wind direction and wind speed. Based on the averaged half-hour wind direction measurements at site prior to sampling, and the hourly reports from Environment Canada, an up- and downwind sample location was determined. Samples were taken on two different days. Sample locations at September 28, 2001 were in 20 minute intervals adjusted to the wind direction (Figure 1 Up- and Downwind). Due to restrictions on site sample locations on October 1, 2001, these locations could not be adjusted to the wind direction.

Hydrogen Sulphide

The hydrogen sulphide readings from the daily observations by the Mill Cove staff were used to review hydrogen sulphide exposures to the public. These readings are obtained both inside and outside the plant perimeter. The readings taken outside the plant are done to ensure the plant is working effectively and efficiently along with ensuring the public is at no risk associated with hydrogen sulphide gas.

5.3 Results of Analytical Work

The results of the water measurements are shown in Appendix D and the results of the air measurements are shown in Appendix E. Example calculations for ambient air concentrations and emission rates are shown in Appendix F.

Water Samples

Except for benzene, chloroform and toluene no other chemicals were detected in the water samples. The results are shown in Table D1 in Appendix D.

Air Samples

Most chemical substances that were analysed were not detected. 1,1 Dichloroethane, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, 1,4-dichlorobenzene, 2-butanone, 2-propanone, 4-methyl-2-pentanone, benzene, bromodichloromethane, carbon tetrachloride, chloroform, cis-1,2-dichloroethene, cis-1,2-dichloroethylene, dibromochloromethane, dichlorodifluoromethane, ethylbenzene, isopropylbenzene, m&p-xylene, methylene chloride, n-propylbenzene, o-xylene, styrene, tetrachloroethane, toluene and trichloroethylene were detected in the air samples in orders of magnitudes smaller than the TLV-limits. Most detected chemical substances were found close or at the lower range

of the detection limit of the methodology. Results are shown in Appendix E. The overall low concentrations and emissions confirm that the facility does not generally receive industrial wastewater.

Air in the Headworks Scrubber (In- and Outlet)

The minimum detectable limit within the group of compounds detected for the scrubber inlet was $0.794 \mu\text{g}/\text{m}^3$, and $0.017 \mu\text{g}/\text{m}^3$ for the scrubber outlet respectively. Fourteen chemicals were detected at the scrubber outlet and 7 at the scrubber inlet. The results are shown in Table E1 in Appendix E. Ethylbenzene, m&p-xylene, and o-xylene occurred in higher concentrations in the scrubber outlet air than in the inlet air. These results could be due to short-term fluctuations of VOC in the influent stream, which could probably be observed due to the overall low VOC load. Secondly, the sampled air at the scrubber intake and outlet is different due to the time delay for air to pass through the scrubber system.

Primary and Secondary Clarifier

Twenty-three chemical substances were detected in the primary clarifier and 9 in the secondary clarifier. The results are shown in Table E3 in Appendix E. The minimum detectable limit within the group of compounds detected for the primary clarifier was $0.1 \mu\text{g}/\text{sec}$ and $0.18 \mu\text{g}/\text{sec}$ for the secondary clarifier respectively. Emission rates are in general higher at the primary clarifiers. 1,4-dichlorobenzene, bromodichloromethane and dibromochloromethane have higher emission rates in the secondary clarifier. It is expected that these differences are due to the different sampling days.

Measurement of Air Emissions at Fence Line (Ambient Measurements)

Nineteen different chemicals were detected at the fence line. The results are shown in Table E2 in Appendix E. In general, downwind ambient air concentrations were higher than the upwind concentrations, which was expected. Site constraints (railway, ocean) made it impossible to get true upwind-downwind measurement plant.

Hydrogen Sulphide

Plant records indicate that H_2S concentrations are generally lower than 0.008 ppm for all the sampling locations outside the plant boundary (shown in Figure 1). Concentrations on the railroad overpass (designated as the causeway in the plant records) are about 0.003 ppm.

6.0 EFFECTS ON COMMUNITY AIR QUALITY

6.1 Dispersion Modelling

Dispersion modelling is an analysis method that uses mathematical models of pollutant dispersion in the atmosphere to relate emissions from pollution sources to exposures of those pollutants at locations downwind of the source. This approach was used in this study to predict the exposure of persons in Bedford to emissions of trace organic pollutants from the Mill Cove PCP. The use of dispersion models is a preferable method to the direct measurement of pollutants. The resources required to monitor pollutants across the town over a representative time period would not be economically feasible. Also, measurement at the receptors (i.e. the persons or places exposed to the air contaminants) would be at concentrations below the standard detection limits available from analytical laboratories. These concentrations are highest at the source, and can be more accurately quantified at that point. The use of dispersion models allows for accurate prediction of short-term and long-term exposures to concentrations of pollutants that cannot be measured.

The most common class of models in use for applications such as this are the "Gaussian" dispersion models. The name arises from the observations that concentrations in contaminant plumes exhibit the form of the statistical normal, or Gaussian, distribution in the horizontal and vertical when viewed in cross section. Most models are computerized because of the very large number of computations involved. The concentrations at each point in space are computed for each source, and for each hour of a statistically stable period of time.

Model

For this project, the US EPA model ISC-PRIME was used. This is a form of the Industrial Source Complex, Version 3 (ISC3) that has been enhanced in its abilities to predict the effects of building downwash in influencing the results near buildings or other structures. The model is approved by the US EPA, and recommended for use by many provinces, including Nova Scotia.

Meteorological Data

Weather data for this study were obtained from the Meteorological Service of Canada (MSC), and comprised a five year record of hourly observations at the MSC station at Halifax International Airport processed by MSC staff to meet the input requirements of ISC-PRIME.

Emissions Information

The sources identified as potential sources of contaminant release at the treatment plant are:

Scrubber exhaust – Air from ventilation of the headworks and plant areas is scrubbed and exhausted from the roof of the main building. This type of source is treated as a “volume source” in the model terminology. The characterization of the source included the rate of contaminant release, the height of the release, and the physical dimensions of the building from which it is exhausted.

Primary clarifiers – The treated effluent from the plant first is exposed to the atmosphere at the primary clarifiers. These holding basins have a large surface area, thus even low concentrations of materials have a ready opportunity to volatilize and be dispersed in the atmosphere. They are treated in the model as “area sources”.

Secondary clarifiers – The effluent moves from the primary to the secondary clarifiers. As with the primary clarifiers, they have a large surface area open to the atmosphere – they are a potential source of emissions.

Building Downwash Considerations

Building downwash is a recognized phenomenon that occurs when relatively short exhaust stacks are mounted on buildings that, by virtue of their size, create a wake that may entrain the stack exhaust and bring it to ground level in the immediate vicinity of the building. This phenomenon may be intermittent, and may depend on wind direction and wind speed. If downwash does not occur, elevated stack exhaust plumes generally stay elevated and disperse without affecting the nearby area. Whether this is a problem, or not, depends on the strength of the source. If the characteristics of the exhaust do not require large stacks that are potentially costly and visually objectionable, the exhaust is generally released from a low rooftop vent.

The exhaust from the scrubber at the plant is susceptible to some degree of downwash. Accordingly, the dimensions of the building were used in the dispersion model to enable the model to predict the effect of this on dispersion. Generally, the downwash effect will be to increase the concentration at ground level in the immediate vicinity of the source, and to decrease the concentration at ground level farther from the source.

6.2 Spatial Distribution of Contaminants

Results of the dispersion model include short-term and long-term averages. For the purposes of this study, the long-term averages are most important, as they are used to determine the exposures that may present a hazard and risk to the community.

Appendix 2 contains the long-term results presented as concentrations of the contaminants detected in the source sampling program. The spatial pattern is virtually identical for all contaminants. The clarifiers, in part because of the very large surface area, are greater emission sources than the scrubber exhaust.

The pattern reflects the average wind distribution of the area. Western winds⁴ are dominant, but other directions are also common. In addition to the wind direction, the wind speed and the atmospheric stability (a measure of turbulent mixing) are important in determining the pattern. The results show that the concentrations of all pollutants drop by a factor of about ten between the receptors immediately outside the plant property (e.g., deWolfe Park), and receptors about 500 m farther away. None of the contaminants of concern modelled (e.g., VOCs) is regulated in Nova Scotia.

7.0 RISK ANALYSIS

7.1 Risk Assessment Methodology

The risk evaluation based on atmospheric exposures from the plan has followed standard risk assessment procedures that have been established and accepted by regulatory agencies throughout Canada and the United States. The risk evaluation has incorporated all of the essential risk assessment components:

- Hazard Identification
- Toxicity Assessment
- Exposure Assessment
- Risk Characterization

Further details on these aspects of the risk assessment are presented in the following sections.

7.2 Hazard Identification

Hazard identification is the first step in the human health risk assessment. It is used to identify potential hazards associated with exposures to specific substances. The process used in this study followed standards and procedures for the prediction of contaminant concentrations in ambient air at various distances from the facility. To assess the greatest hazard, the location of exposure was chosen at the perimeter of the plant boundary where the predicted average concentrations were highest. If the public is protected at this location, they are protected at all other locations. The identification of hazards was based on results from the field sampling program that was completed by JWEL throughout the fall of 2001. JWEL designed the sample program based on the requirements of the study and literature review of other sewage treatment plants.

Field Program

Samples of influents and effluents of the sewage treatment plant were first collected and sampled to determine what substances were present in the wastewater which could potentially be released to the air and present an exposure to the surrounding community. These results helped in the selection of a suitable air sampling program. EPA method TO-1 and EPA 5040 GCMS were chosen after review of the results of the water sampling program. VOC samples were then collected and analyzed by these methods from the primary clarifier, the secondary clarifier, and the headworks scrubber to determine individual source strengths and emission rates. Additional samples were also collected at the headworks scrubber intake and outlet.

A total of 68 chemical substances were evaluated in the air study. A complete list of the 68 substances is provided in Appendix A. This study is based on an evaluation of the substances for which there were detectable concentrations in the air samples. Specific details of the field-sampling program are provided in Section 5 of this report.

Establishing Exposure Point Concentrations

The dispersion modeling results were used to establish the long-term average concentrations of each substance of concern in the Town of Bedford. They represent the exposures that may present a hazard and risk to the surrounding community. These predicted concentrations are known as Exposure Point Concentrations (EPC) and were used for the determination of potential risks. Note that ambient air standards do not exist in Nova Scotia for the chemical substances evaluated in this study.

7.3 Toxicity Assessment

An essential part of the risk assessment process is the identification of toxicity values against which exposures can be compared. These values are based on scientifically reviewed, published toxicological assessments from various sources. Toxicity values have been established by several regulatory agencies including: Health Canada; the United States Environmental Protection Agency (US EPA); the World Health Organization (WHO); and the Agency for Toxic Substances and Disease Registry (ATSDR). In the selection of toxicity values, preference has been given to the most recently developed values because these incorporate the most recent scientific information and would provide the best basis upon which to assess potential health hazards/risks.

The potential hazards associated with exposures to non-carcinogenic substances are assessed differently than the potential risks associated with exposures to carcinogenic substances. The toxicity values for each type of substance are defined differently. Non-carcinogenic toxicity is defined using a tolerable daily intake (TDI), also called a reference dose RfD or Reference Concentration RfC.

⁴ Wind direction is named for the direction from which the wind blows. Western winds blow from the west to the east.

Carcinogenic toxicity is defined using a cancer slope factor (SF) or unit risk (UR) value. Because the two classes of toxicity are considered differently in the assessment, the substances of concern have been grouped into carcinogenic and non-carcinogenic categories.

Summaries of the toxicity values selected for each substance included in the risk assessment are provided in Table 1 and Table 2. Inhalation toxicity values are provided for each of the substances of concern. Where inhalation Reference Concentrations were not available, toxicity values were calculated through extrapolation from Oral Reference Doses (RfDs).

Substance	Route	Toxicity Value RfC (mg/m ³)	Agency
1,1 Dichloroethane	Inhalation	5.00E-01	US EPA
1,2,4-Trimethylbenzene	Inhalation	6.00E-03	US EPA
1,3,5-Trimethylbenzene	Inhalation	6.00E-03	US EPA
2-Butanone (MEK)	Inhalation	1.00E+00	US EPA
2-Propanone (Acetone)	Inhalation	3.50E-01*	US EPA
4-Methyl-2-Pentanone (MIBK)	Inhalation	8.00E-02	US EPA
cis-1,2-Dichloroethylene	Inhalation	3.50E-02*	US EPA
Dichlorodifluoromethane	Inhalation	7.00E-01*	US EPA
Ethylbenzene	Inhalation	1.00E+00	US EPA
Isopropylbenzene (Cumene)	Inhalation	4.00E-01	US EPA
m&p-Xylene	Inhalation	7.00E+00*	US EPA
o-Xylene	Inhalation	7.00E+00*	US EPA
Styrene	Inhalation	1.00E+00	US EPA
Toluene	Inhalation	4.00E-01	US EPA

*Extrapolated from Oral Reference Dose

Substance	Route	Slope Factor/ Unit Risk [1/(mg/m ³)]	Agency
1,4-Dichlorobenzene	Inhalation	6.86E-03	US EPA
Benzene	Inhalation	7.80E-03	US EPA
Bromodichloromethane	Inhalation	1.77E-02	US EPA
Carbon Tetrachloride	Inhalation	1.5E-02	
Chloroform	Inhalation	2.30E-02	US EPA
Dibromochloromethane	Inhalation	2.4E-02	US EPA
Methylene chloride	Inhalation	4.70E-04	US EPA
Tetrachloroethene (Perc)	Inhalation	5.8E-04	US EPA
Trichloroethylene	Inhalation	1.7E-03	US EPA

* Extrapolated from Oral Slope Factor

For each substance, the predicted Maximum Ground Level Concentration (MGLC) is used to represent the Exposure Point Concentration (EPC) from facility related sources. The risks that result from exposures from other sources are not considered in this assessment.

7.4 Exposure Assessment

The exposure assessment portion of the study includes the identification of:

- the receptors of interest;
- the relevant exposure pathways; and
- the methods used to quantify the exposures.

The plant is in a prominent location immediately adjacent to deWolfe Park. A significant part of the residential areas of Bedford are within a few hundred meters of the plant, and further condominium development is occurring to the east of the plant. Based on the current and assumed future land use in the area surrounding the plant, the human receptors of interest are the nearby residents. For the purposes of this assessment, it has been conservatively assumed that the maximum amount of time a person could spend on a residential property is 24 hours per day over an entire lifetime

Exposure Pathways

An exposure pathway is the route by which a receptor can come into contact with a substance. Exposure pathways can include both site-related and non-site related sources. For example, the inhalation of substances from the plant represents a site-related exposure pathway for substances present in the air. However, the inhalation of the same substances from ambient air represents exposure pathways that are not facility related. Both types of pathways can contribute to the total daily exposure. The calculation of potential risk for the purposes of this assessment has assumed the total exposure is from emissions from the plant only.

7.5 Risk Characterization

The risk characterization stage of the risk assessment process compares the estimated exposures with the identified toxicity values for each substance. The characterization of potential hazards associated with exposures to non-carcinogenic substances is assessed separately from the potential risks associated with exposures to carcinogenic substances. These differences are based on the difference in the way these two types of substances may produce effects in the body.

7.5.1 Characterizing Hazards for Non-Carcinogenic Substances

Non-carcinogenic substances are generally considered to act on the body through threshold mechanisms. This means that at low doses the body is able to remove the substances from the body without the substance causing an adverse or toxic effect. As the dose or exposure increases, the body's ability to clear the substances is reduced. When the exposure to a substance exceeds the body's ability to process and excrete the substance, it can cause adverse or toxic effects. The point at which this occurs is called the threshold. The threshold is different for every substance. The toxicity values developed for each substance reflect the threshold for each substance.

Toxicity values, referred to as *Reference Doses* RfDs (*Reference Concentration (RfCs) for inhalation exposures*) by the US EPA, are developed from toxicological studies of human or animal populations and are set to ensure that adverse human health effects will not occur over a lifetime of exposure. Toxicity values for non-carcinogenic substances are defined as;

A quantitative estimate (with uncertainty spanning perhaps and order of magnitude (ten-fold)) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of non-carcinogenic; deleterious effects during a life-time.

Toxicity values are based on lifetime averaged exposures. This means that limited or short-term exposures to a substance that exceed a toxicity value will not result in adverse effects, provided that, over a life-time, the averaged daily dose does not exceed the toxicity value. The toxicity value is set to prevent the accumulation of the substance in the body at levels that exceed the threshold and therefore limit the possibility of adverse health effects occurring.

Toxicity values are intended to be used as lifetime averaged daily exposures and therefore, in assessing potential risks for an exposed individual or population. The US EPA recommends that in the assessment of risks associated with exposure to non-carcinogenic substances that life-time averaged exposures be used to assess risks when exposures occur over a lifetime.

In determining the potential for adverse health effects to occur, the EPC for each of the non-carcinogenic substances of concern is compared to the identified toxicity value to determine if the estimated exposures exceed these limits. The potential for adverse effect, is called a *Hazard Index (HI)*, and is calculated as shown in Equation 1. The HI provides an indication of whether estimated exposures are large enough to be of concern for human health.

A HI of less than 1 indicates that exposures are below the toxicity value and would not be expected to result in adverse human health effects. Because of the conservative assumptions used by regulatory agencies in the development of toxicity values, HI values greater than 1.0 do not mean that adverse

human health effects will occur, but the likelihood that an adverse health effect will occur increases as the HI value rises above 1.0.

Equation 1:
$$HI = \frac{EPC}{RfC}$$

Where:

HI	= Hazard Index	(Unitless)
EPC	= Exposure Point Concentration (based on the maximum predicted ambient air concentrations)	(mg/m ³)
RfC	= Reference Concentration or Toxicity value	(mg/m ³)

7.5.2 Characterizing Potential Risk for Carcinogenic Substances

Carcinogenic substances are generally considered to work through a non-threshold mechanism. This means that there is no dose below which and adverse effect will not occur. Any exposure to a carcinogen is considered to be associated with some level of risk. At very low doses the probability that an adverse effect (cancer) will occur is extremely small. The probability of developing cancer increases as the dose increases. The probability of developing cancer as a result of environmental exposure to a carcinogenic substance is expressed as the *Incremental Increase in Life-Time Cancer Risk (IILCR)* and are calculated as shown in Equation 2.

Equation 2:
$$IILCR = C * U.R$$

Where:

IILCR	= Incremental Increase in Life-Time Cancer Risk	Unitless
C	= Concentration of Substance in air	(mg/m ³)
UR	= Unit Risk	(mg/m ³) ⁻¹

The US EPA expresses carcinogenic potencies as *Cancer Slope Factors (CSFs)* or as *Unit Risks (URs)*.

The UR is defined as; the upper-level increased likelihood that an individual will develop cancer when exposed to a substance over a life-time at a concentration of 1 mg/m³ in air of a continuous inhalation exposure. Unit risks are expressed as risk per mg/m³ in air (mg/m³)⁻¹.

The characterization of potential IILCR was undertaken for each of the carcinogenic substances of concern identified. The risk assessment has assessed the potential risks using a target risk benchmark established by Nova Scotia, and Health Canada. The value is 1×10^{-5} for incremental excess lifetime cancer risk (theoretically one additional cancer per 100,000 population).

The results of these comparisons are provided as *Risk Quotients* (RQ) calculated as shown in Equation 3. The RQ is intended to simplify the interpretation of the IILCR values. Estimated IILCR values are compared to the benchmark value of 1×10^{-5} . The magnitude of the RQ provides an indication of the acceptability of the potential risk.

Equation 3

$$RQ = \frac{IILCR}{1 \times 10^{-5}}$$

Where:

RQ = Risk Quotient

Unitless

RQ values greater than 1 indicate that potentially unacceptable risks may exist. RQ values less than one indicates that exposures would not be expected to result in increases in lifetime cancer risk beyond benchmarks of acceptability.

7.5.3 Sources of Uncertainty

The uncertainty associated with this type of analysis includes errors in the emissions information, modelling results, and the criteria used. In this study, the analysis has been conducted to err on the high side; therefore:

- the nearest, therefore highest concentrations have been used;
- the dispersion model tends to overpredict, particularly where, as in this case, downwash may occur; and
- the emissions are high relative to probable future emissions because the plant is due for replacement of the carbon scrubber bed, and scrubbers are being installed on the exhaust air from the north primary clarifier.

7.6 Results

7.6.1 Non-carcinogenic Substances

The result of the evaluation for non-carcinogenic substances is presented in Table 3. The individual Hazard Quotients for each substance assessed ranged from 2.42 E^{-08} to 6.47 E^{-05} . The cumulative Hazard Index (the sum of all individual risks) is 0.00011 which is significantly less than 1.0 This suggests no unacceptable risk is anticipated from exposure to the highest predicted air concentrations of non-carcinogenic substances in the community adjacent to the plant.

Substance	Maximum GLC [mg/m ³]	Inhalation Chronic RfC [mg/m ³]	Individual Hazard Quotient
1,1 Dichloroethane	1.20E-08	5.00E-01	2.41E-08
1,2,4-Trimethylbenzene	3.88E-07	6.00E-03	6.47E-05
1,3,5-Trimethylbenzene	1.95E-07	6.00E-03	3.25E-05
2-Butanone (MEK)	1.04E-07	1.00E+00	1.04E-07
2-Propanone (Acetone)	2.49E-07	3.50E-01*	7.11E-07
4-Methyl-2-Pentanone (MIBK)	3.06E-08	8.00E-02	3.83E-07
cis-1,2-Dichloroethylene	3.72E-08	3.50E-02*	1.06E-06
Dichlorodifluoromethane	2.89E-07	7.00E-01*	4.13E-07
Ethylbenzene	3.50E-06	1.00E+00	3.50E-06
Isopropylbenzene (Cumene)	1.53E-08	4.00E-01	3.83E-08
m&p-Xylene	1.01E-05	7.00E+00*	1.44E-06
o-Xylene	4.49E-06	7.00E+00*	6.41E-07
Styrene	1.86E-07	1.00E+00	1.86E-07
Toluene	1.57E-06	4.00E-01	3.93E-06
Cumulative Hazard Index			0.00011

*Extrapolated from Oral Reference Dose

7.6.2 Carcinogenic Substances

The result of the evaluation for carcinogenic substances is presented in Table 7.4. The Incremental Increase in Life time Cancer Risk (IILCR) for each substance assessed ranged from 2.23 E^{-11} to 1.21 E^{-08} . The cumulative Risk Quotient (the sum of all individual risks) is 1.1 E^{-07} which is less than 1.0 This suggests no unacceptable risk are anticipated from exposure to the highest predicted air concentrations of carcinogenic substances in the community adjacent to the plant.

Substance	Maximum GLC [mg/m³]	Inhalation Unit Risk [1/(mg/m³)]	Incremental Increase in Lifetime Cancer Risk (IILCR)
1,4-Dichlorobenzene	6.03978E-07	6.86E-03	4.14E-09
Benzene	1.01773E-07	7.80E-03	7.94E-10
Bromodichloromethane	6.84416E-07	1.77E-02	1.21E-08
Carbon Tetrachloride	1.53155E-08	1.5E-02	2.30E-10
Chloroform	3.77968E-06	2.30E-02	8.69E-08
Dibromochloromethane	7.67322E-08	2.4E-02	1.84E-09
Methylene chloride	2.09678E-07	4.70E-04	9.85E-11
Tetrachloroethene (Perc)	3.03123E-07	5.8E-04	1.76E-10
Trichloroethylene	1.31276E-08	1.7E-03	2.23E-11
Risk Quotient			1.1E-07

*Extrapolated from Oral Slope factor.

7.6.3 Hydrogen Sulphide

The odour detection limit for H₂S is approximately 0.010 ppm. As noted in Section 5.3 offsite H₂S concentrations are measured as generally lower than 0.008. At these low observed concentrations, a nuisance odour may be detected on occasion by sensitive persons; however the exposure has no direct health risk. The Agency for Toxic Substances and Disease Registry, a part of the US Center for Disease Control, published Minimal Risk-Levels (MRLs) which are “estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specific duration of exposure”. For H₂S, the MRLs are 0.07 ppm for acute (1-14 days) exposure, and 0.03 ppm for intermediate (15-364 day) exposure. These MRLs include a substantial factor of safety. All observed off-site concentrations are well below the MRL for H₂S.

The H₂S monitoring program is an ongoing operating procedure; readings are taken routinely as well as in prompt response to any complaints from the public. It is fully anticipated that any significant change in H₂S emissions from the plant would be rapidly detected and responded to by plant staff.

8.0 CONCLUSIONS AND RECOMMENDATIONS

The Mill Cove PCP has been a compatible component of the Bedford community since its construction. The effects of the air emissions on the community are not a cause for concern, as the total risk of non-carcinogenic and carcinogenic risks is well within accepted standards. The plant has undergone several expansions and process improvements since the original construction, and continues to improve.

Scrubbers have been recently installed to treat the air from the north primary clarifiers. The primary clarifiers are the largest source areas in the plant. Consideration should be given to similar filters on the south clarifiers. Although this improvement is not required on the basis of risk, the increasing development near the plant may increase the potential for occasional nuisance odours. Treatment of that air stream would reduce the potential of such episodes.

The carbon bed in the main scrubber system will be changed over in the next several months, resulting in a significant reduction in emissions that are already low. This scrubber system is tested on an annual basis; it is recommended that this testing continue. The air at the exhaust has a perceptible odour on the roof and near the unit, although off-site complaints are rare. The discharge of this air at the roof level results in some degree of downwash of the exhaust near the plant. If the expanding load at the plant does result in perceptible emissions (i.e., odour), the two options available are a more aggressive replacement cycle for the carbon beds, and an extension of the exhaust stack to provide greater dispersion of the emissions.

The results indicate that the workers at the plant are not exposed to adverse levels of contaminants. Although this study was restricted to air emissions and exposures, and was focused on off-site issues rather than worker health, it was clear to the investigators that an excellent level of training and industrial hygiene practices exists at the plant and contributes to its safe operation.

9.0 LITERATURE CITED

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APPENDIX A

MAPS OF GROUND LEVEL CONCENTRATIONS

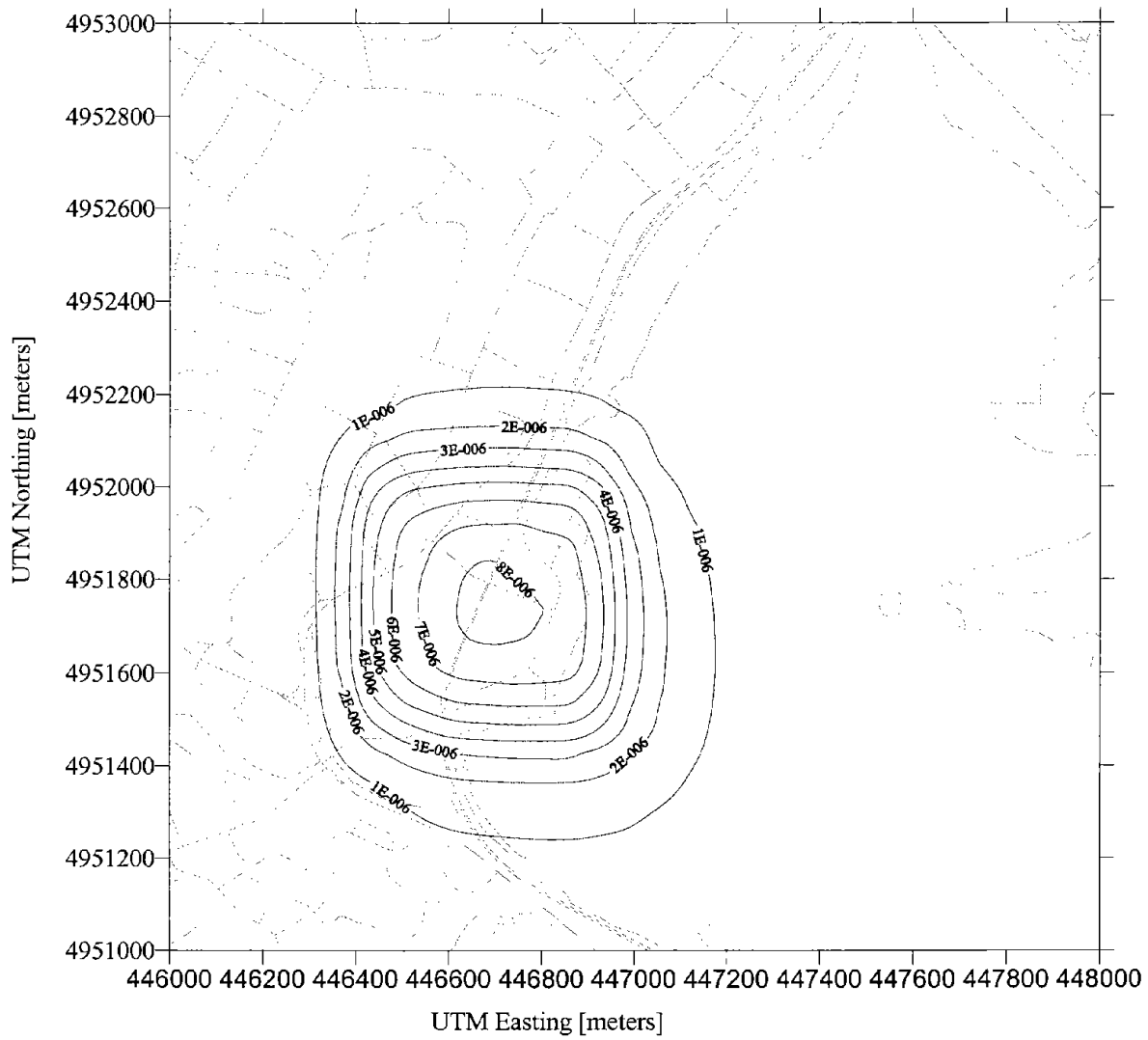


Figure 1 Annual Average Ground Level Concentrations of 1,2 Dichloroethane [$\mu\text{g}/\text{m}^3$]

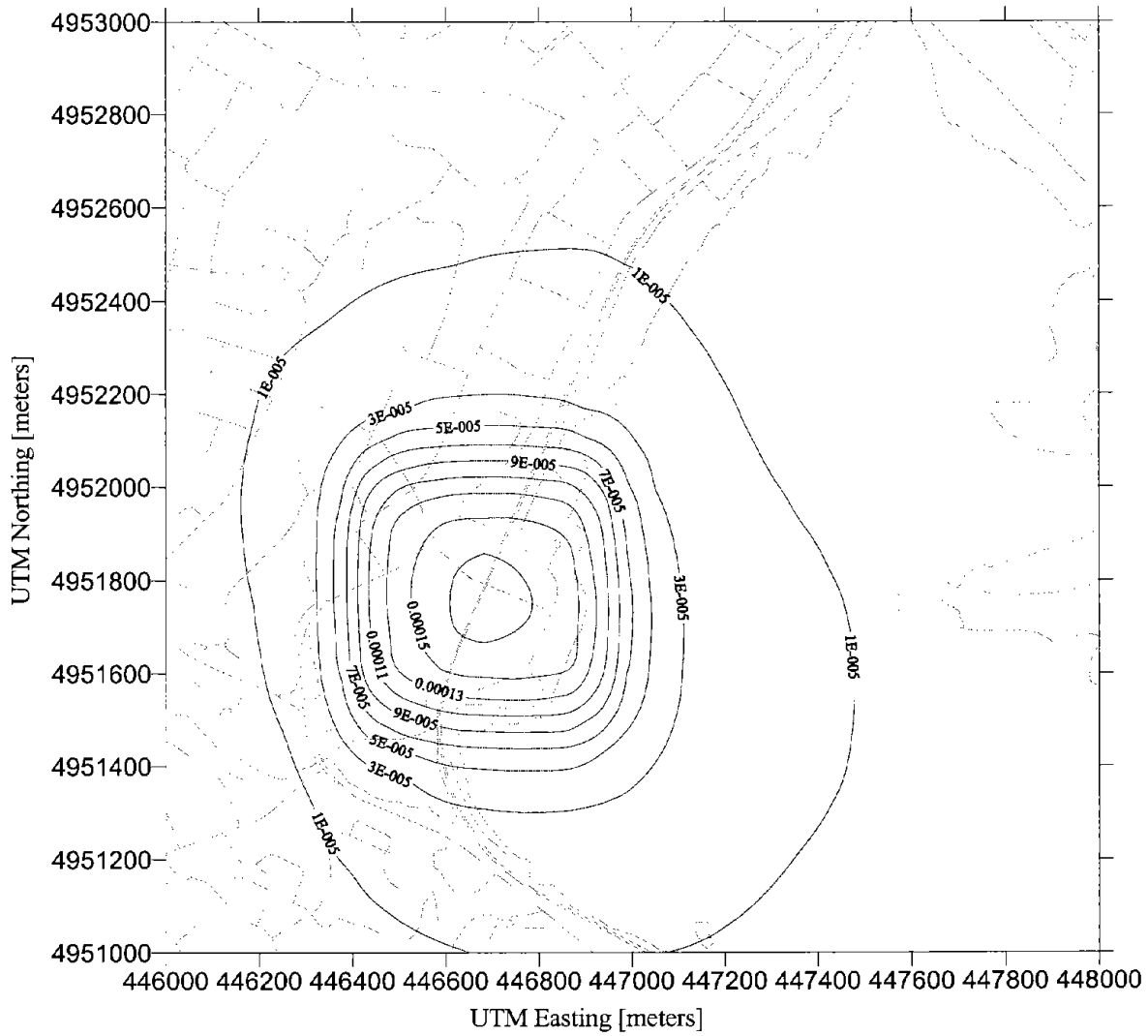


Figure 2 Annual Average Ground Level Concentration of 1,2,4 Trimethylbenzene [$\mu\text{g}/\text{m}^3$]

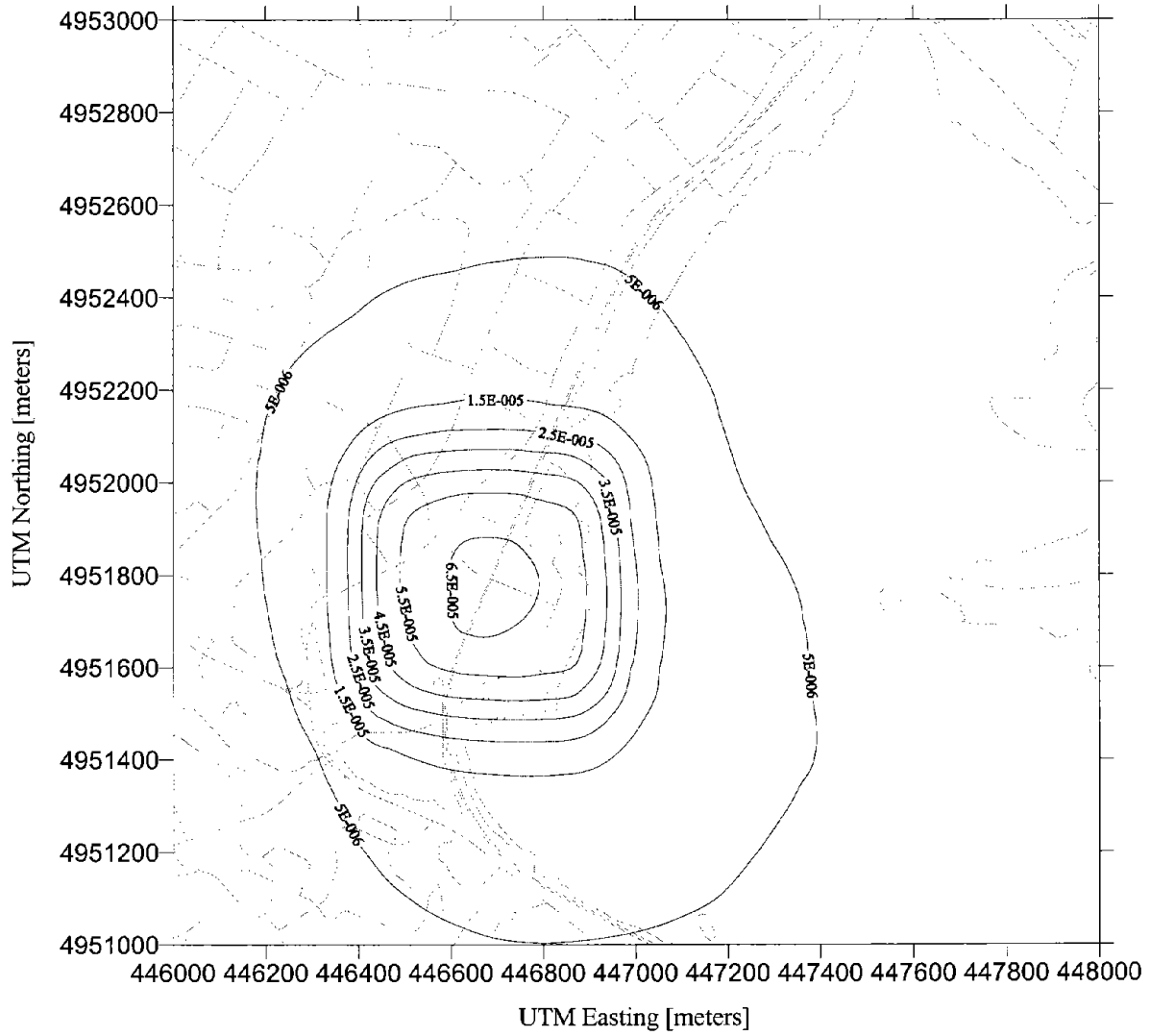


Figure 3 Annual Average Ground Level Concentrations of 1,3,5-Trimethylbenzene [$\mu\text{g}/\text{m}^3$]

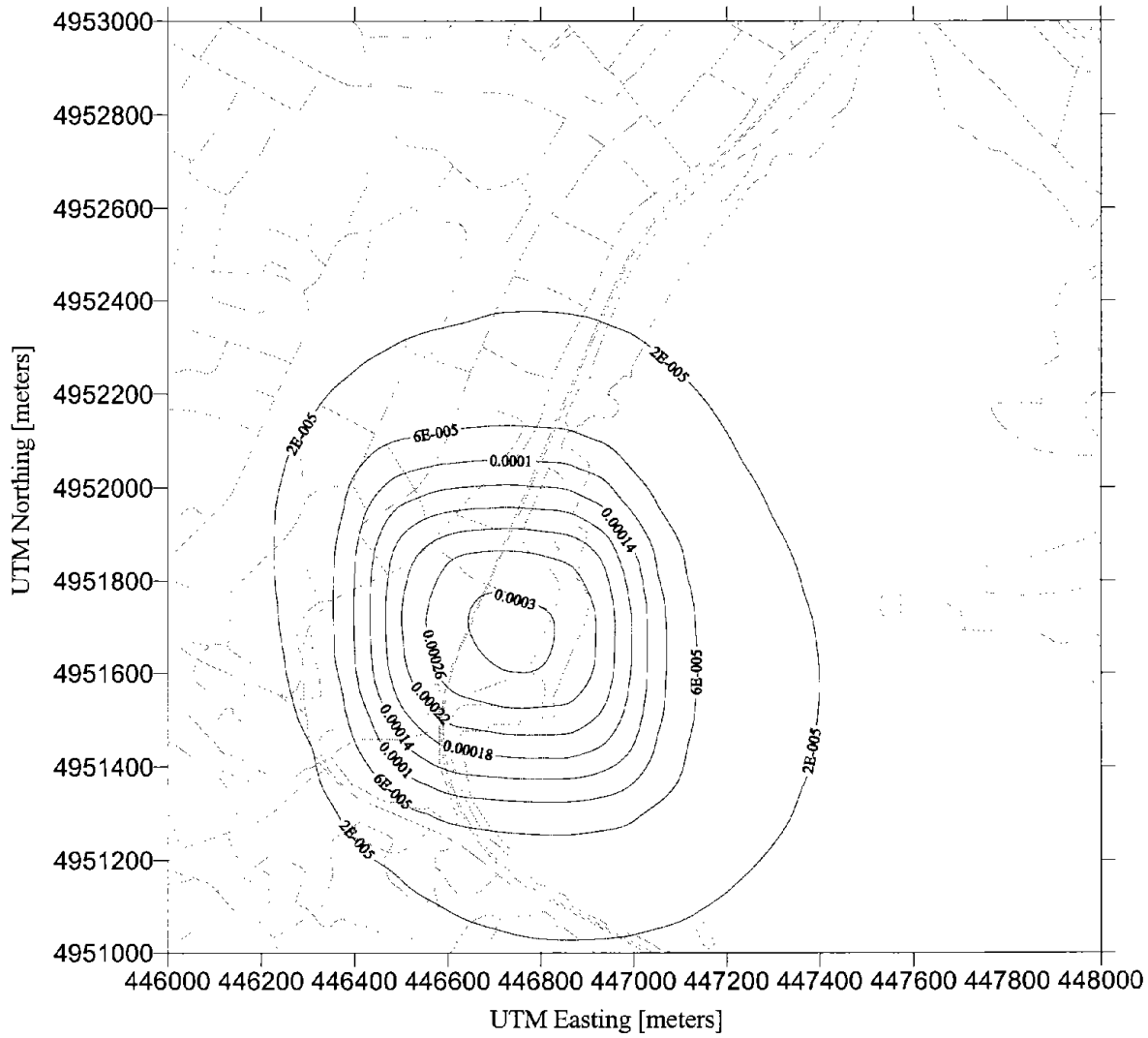


Figure 4 Annual Average Ground Level Concentration of 1,4-Dichlorobenzene [µg/m³]

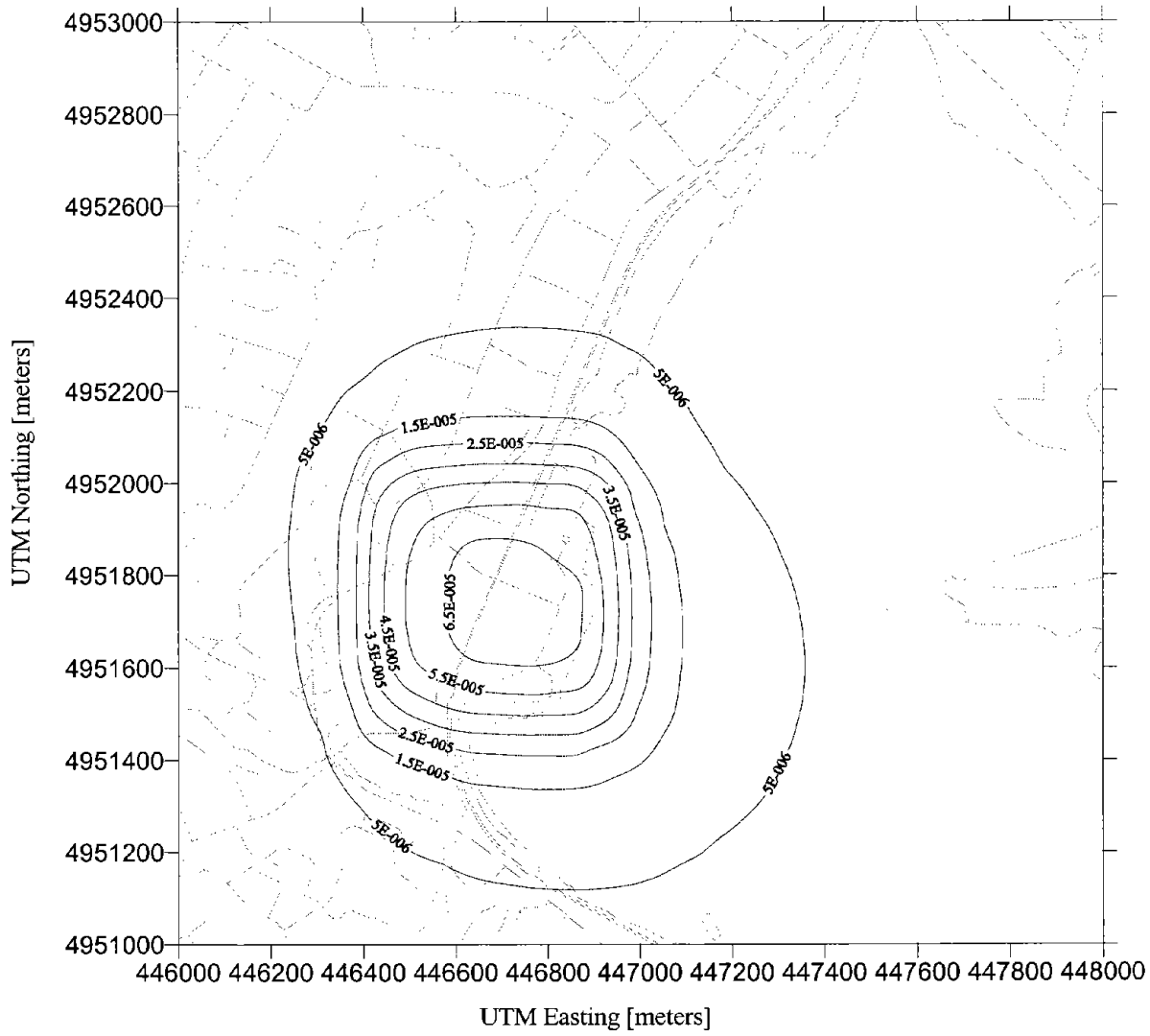


Figure 5 Annual Average Ground Level Concentrations of 2-Butanone [$\mu\text{g}/\text{m}^3$]

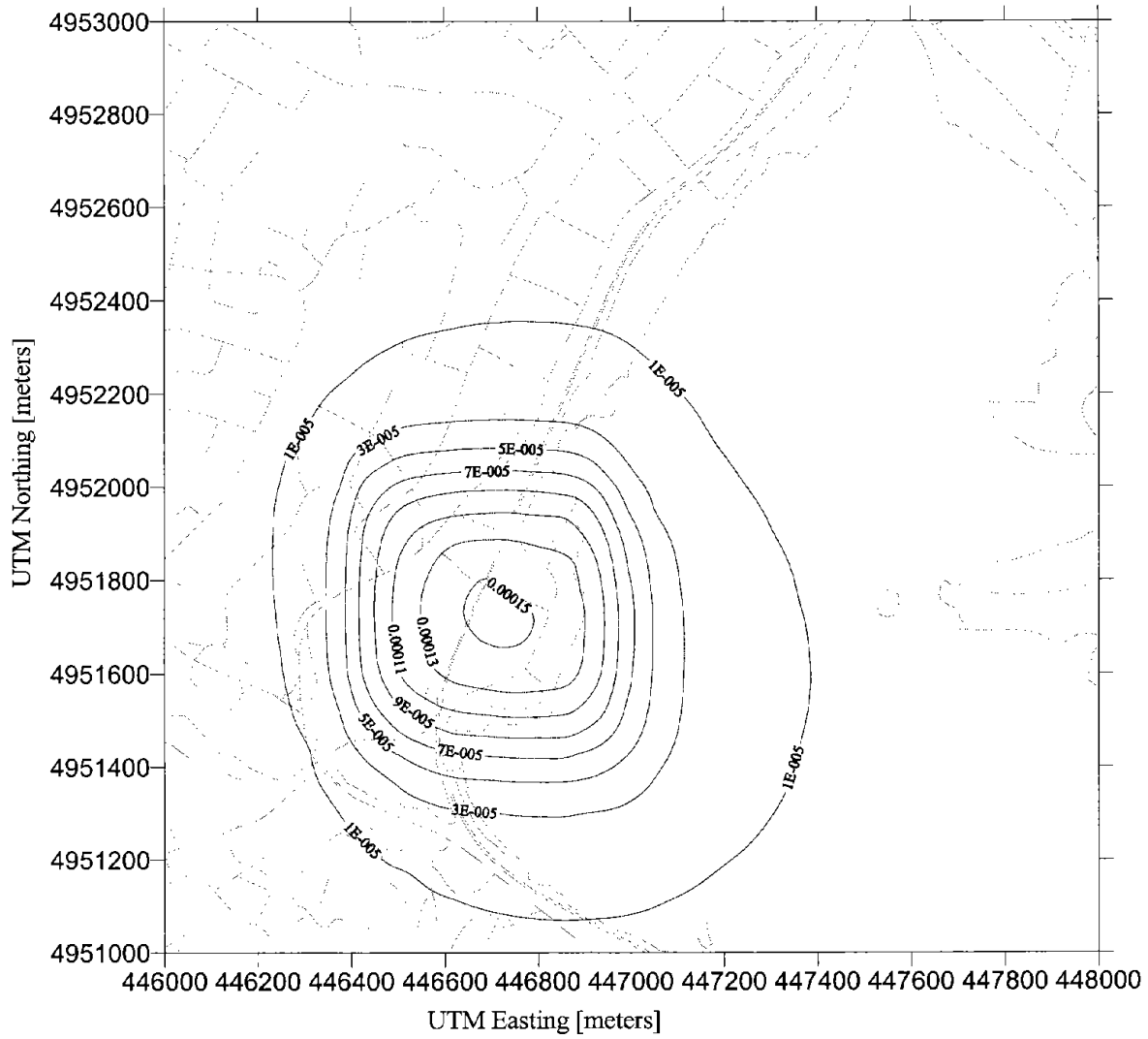


Figure 6

Annual Average Ground Level Concentration of 2-Propanone [$\mu\text{g}/\text{m}^3$]

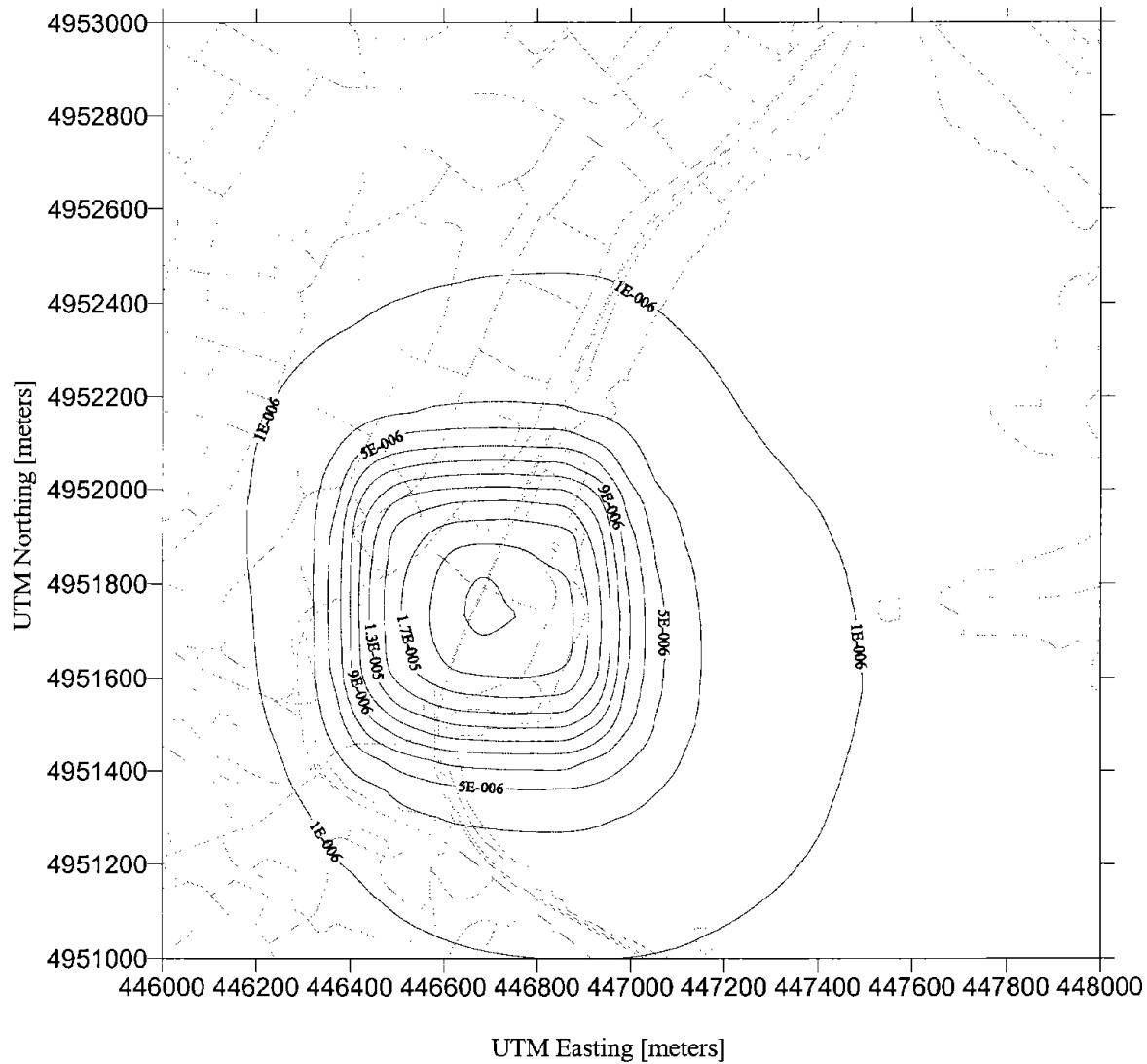


Figure 7 Annual Average Ground Level Concentrations of 4-Methyl-2-Pentanone [$\mu\text{g}/\text{m}^3$]

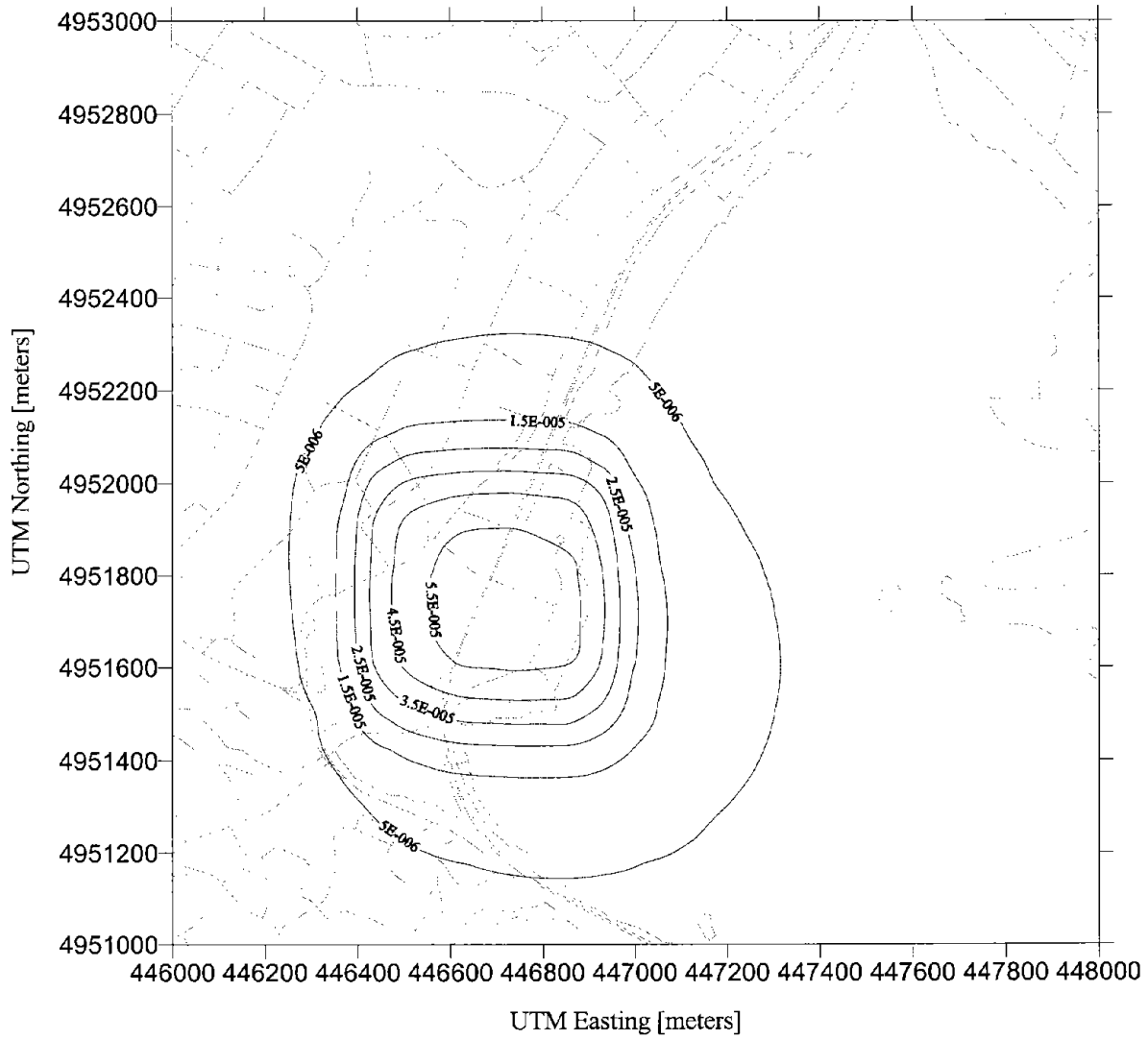


Figure 8

Annual Average Ground Level Concentrations of Benzene [$\mu\text{g}/\text{m}^3$]

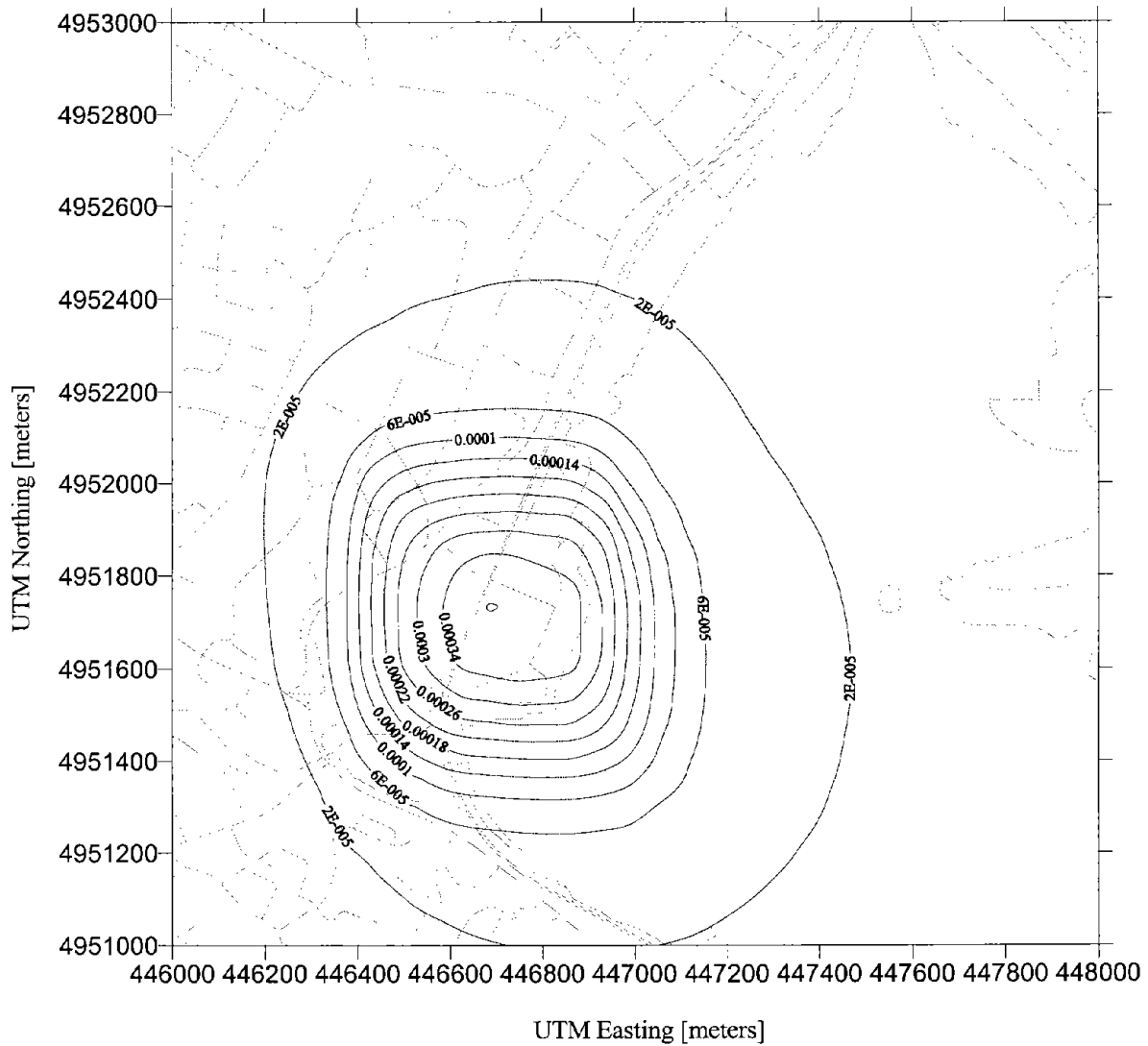


Figure 9 Annual Average Ground Level Concentrations of Bromodichloromethane [$\mu\text{g}/\text{m}^3$]

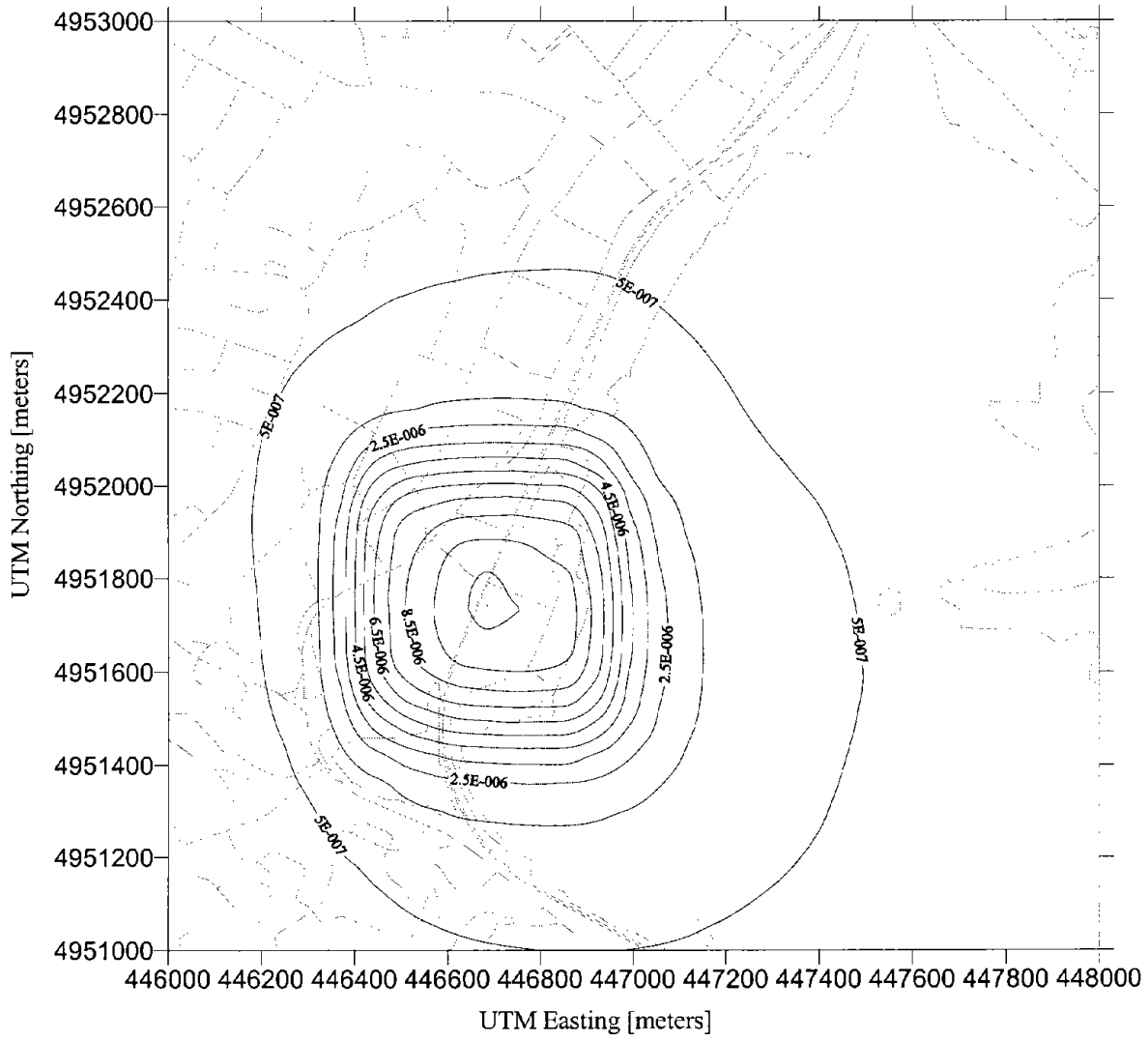


Figure 10 Annual Average Ground Level Concentrations of Carbon Tetrachloride [$\mu\text{g}/\text{m}^3$]

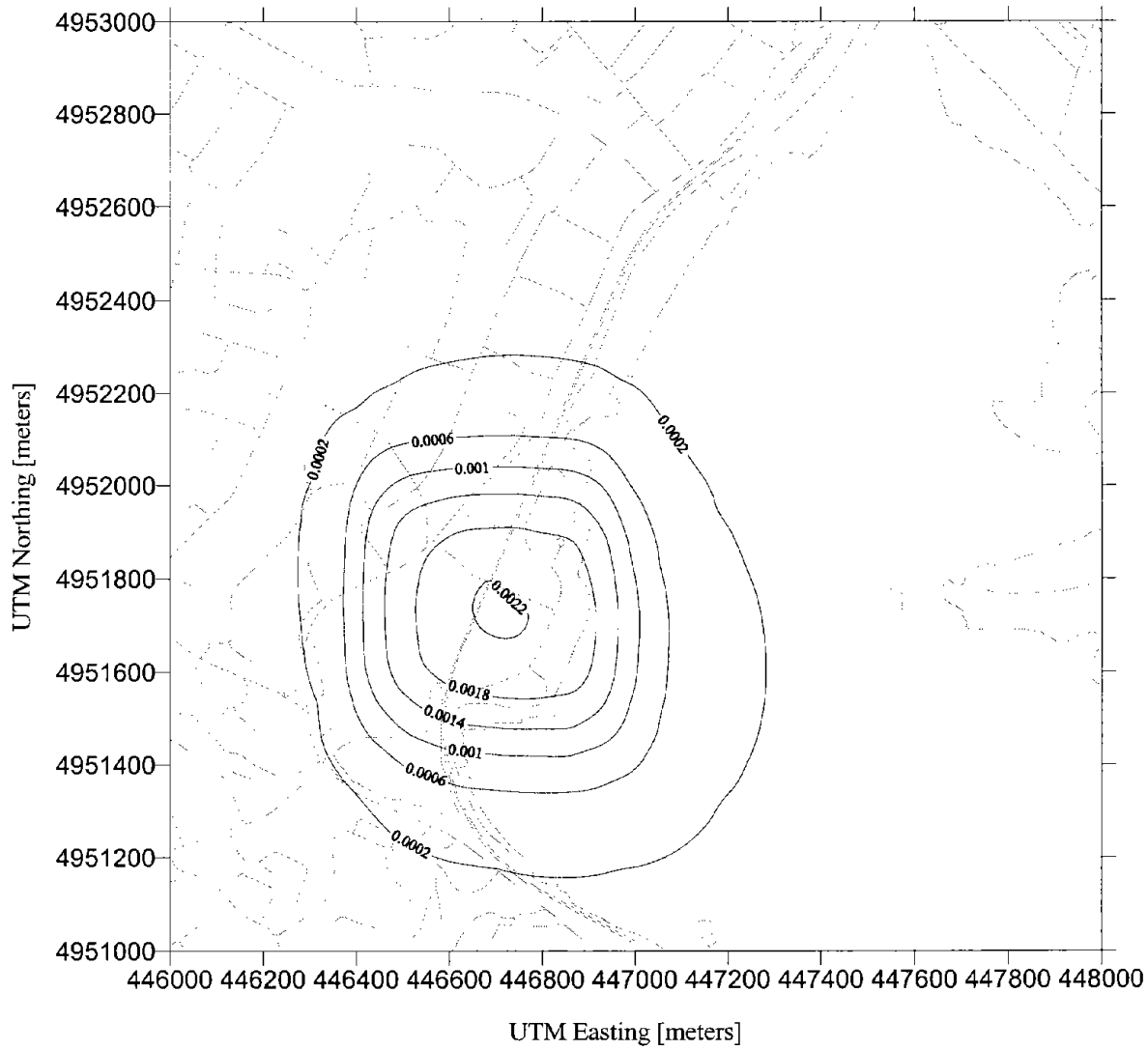


Figure 11

Annual Average Ground Level Concentrations of Chloroform [$\mu\text{g}/\text{m}^3$]

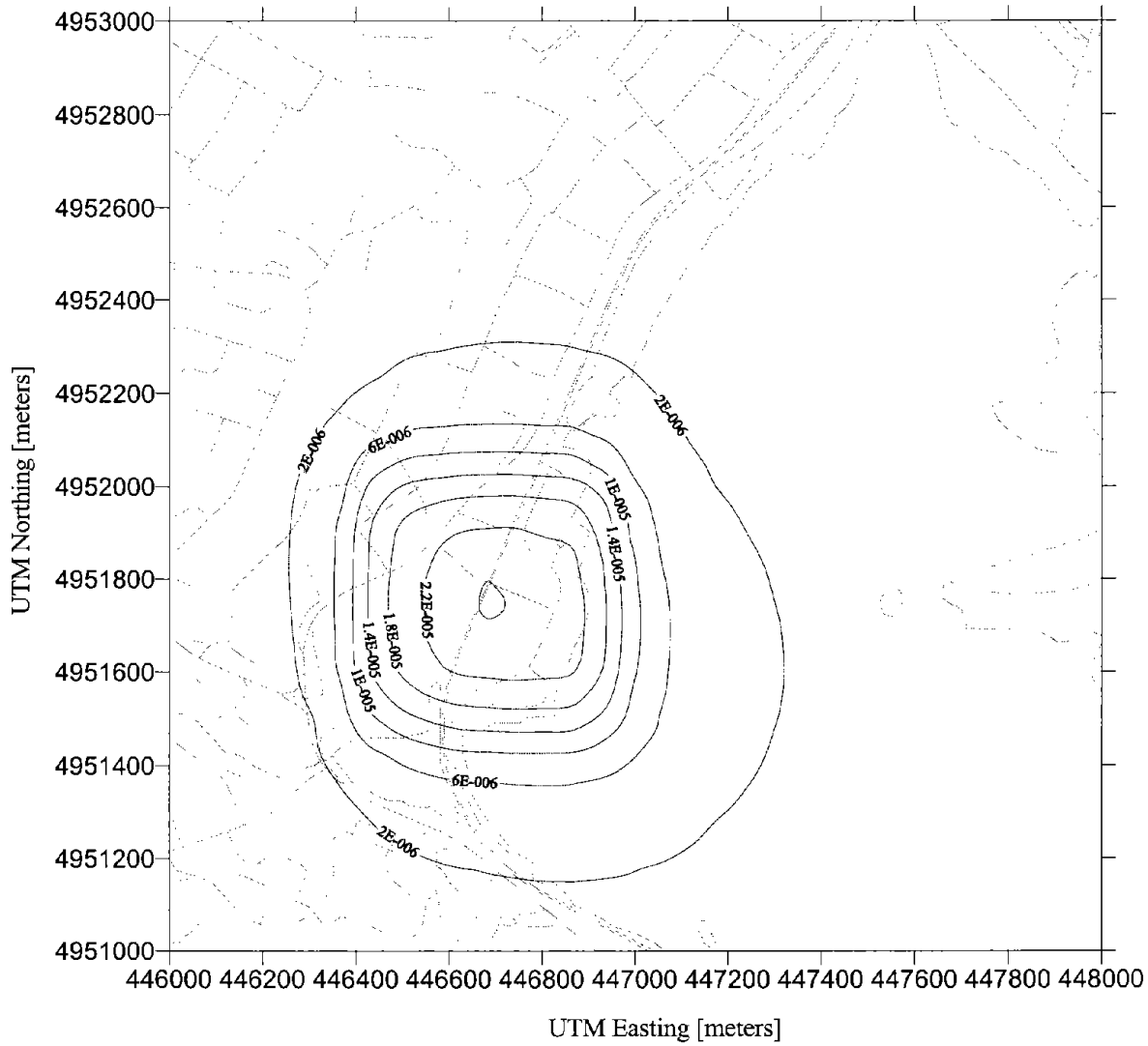


Figure 12 Annual Average Ground Level Concentrations of Cis-1,2-Dichloroethylene [$\mu\text{g}/\text{m}^3$]

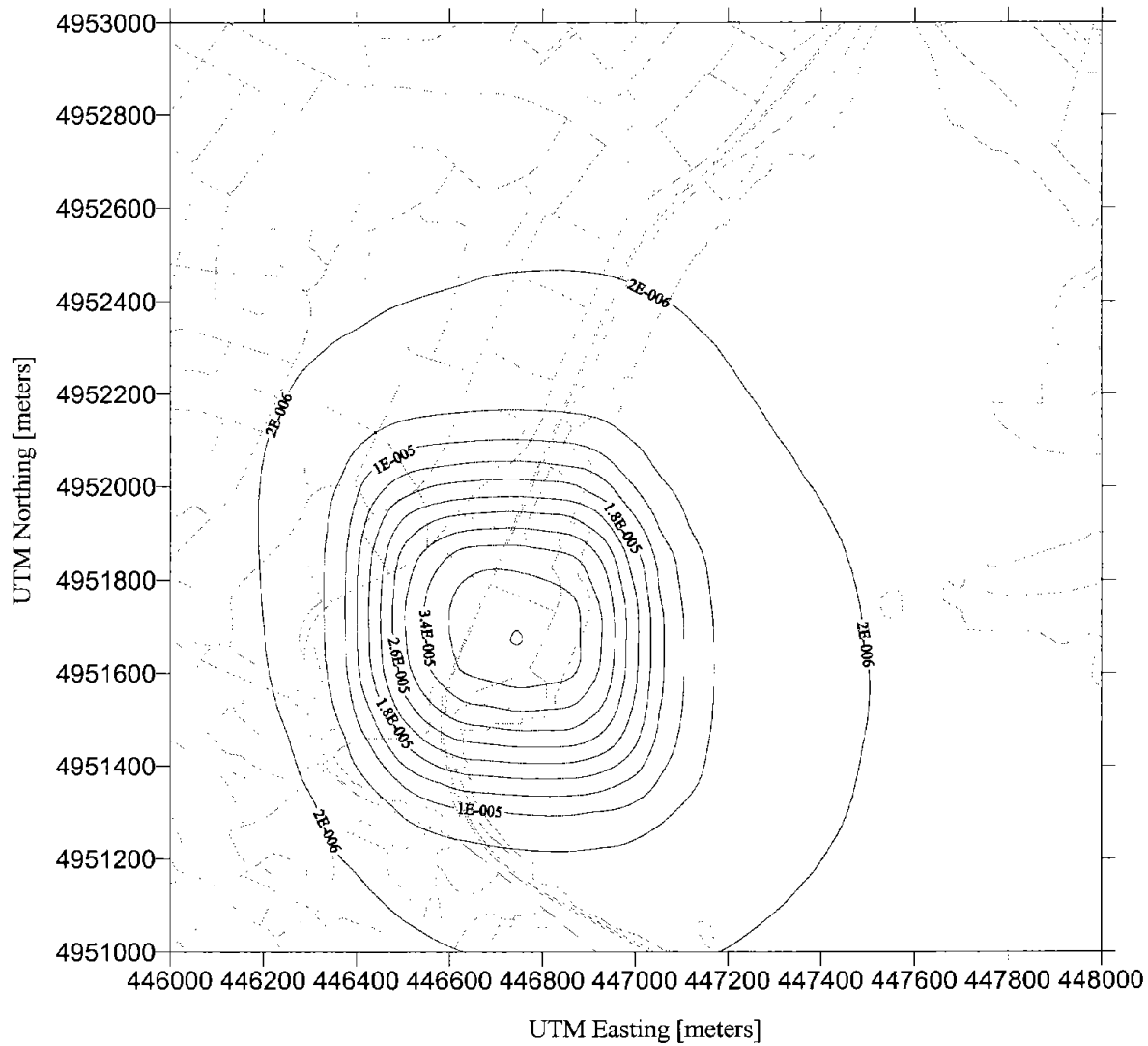


Figure 13 Annual Average Ground Level Concentrations of Dibromochloromethane [µg/m³]

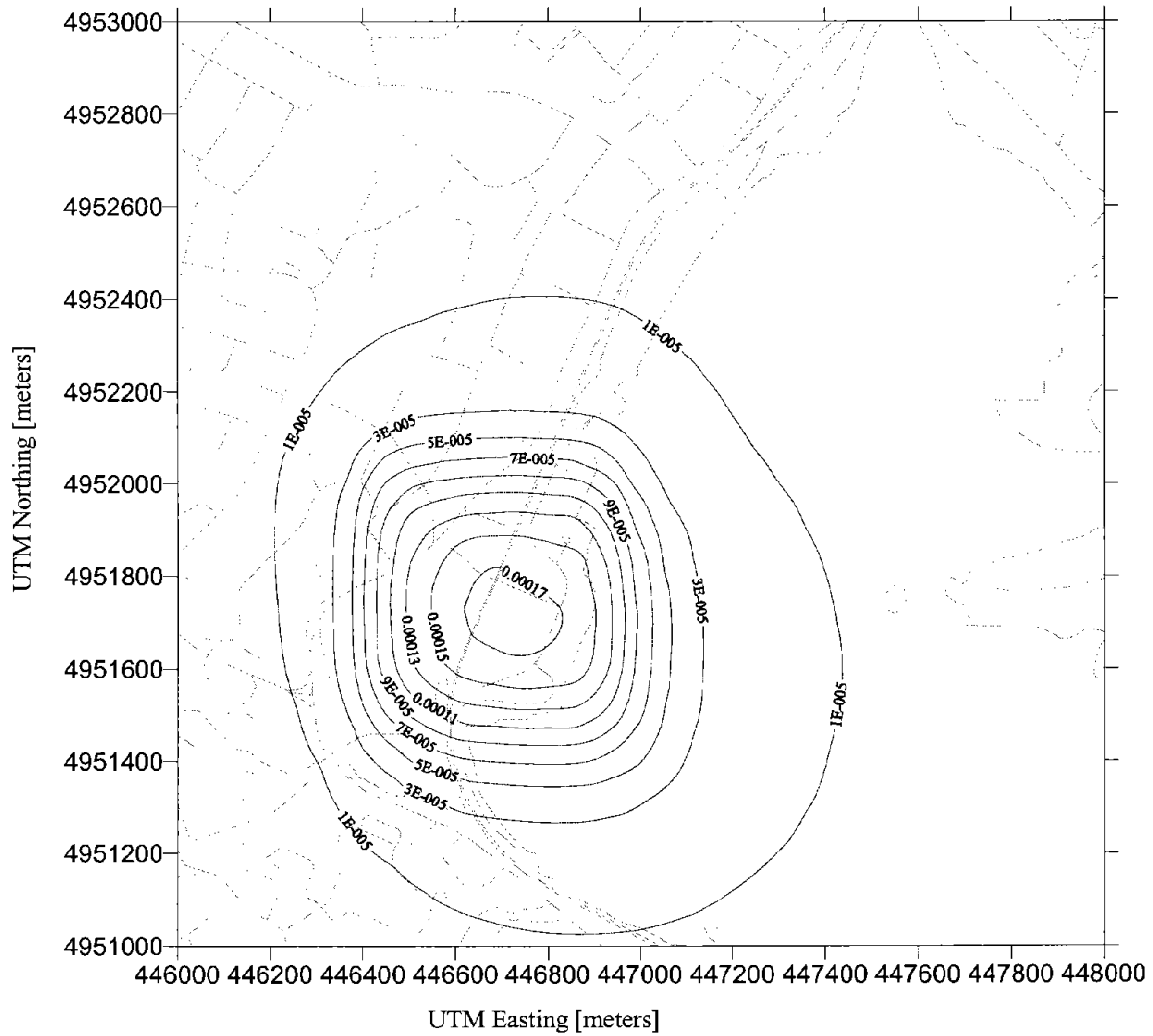


Figure 14 Annual Average Ground Level Concentrations of Dichlorodifluoromethane [$\mu\text{g}/\text{m}^3$]

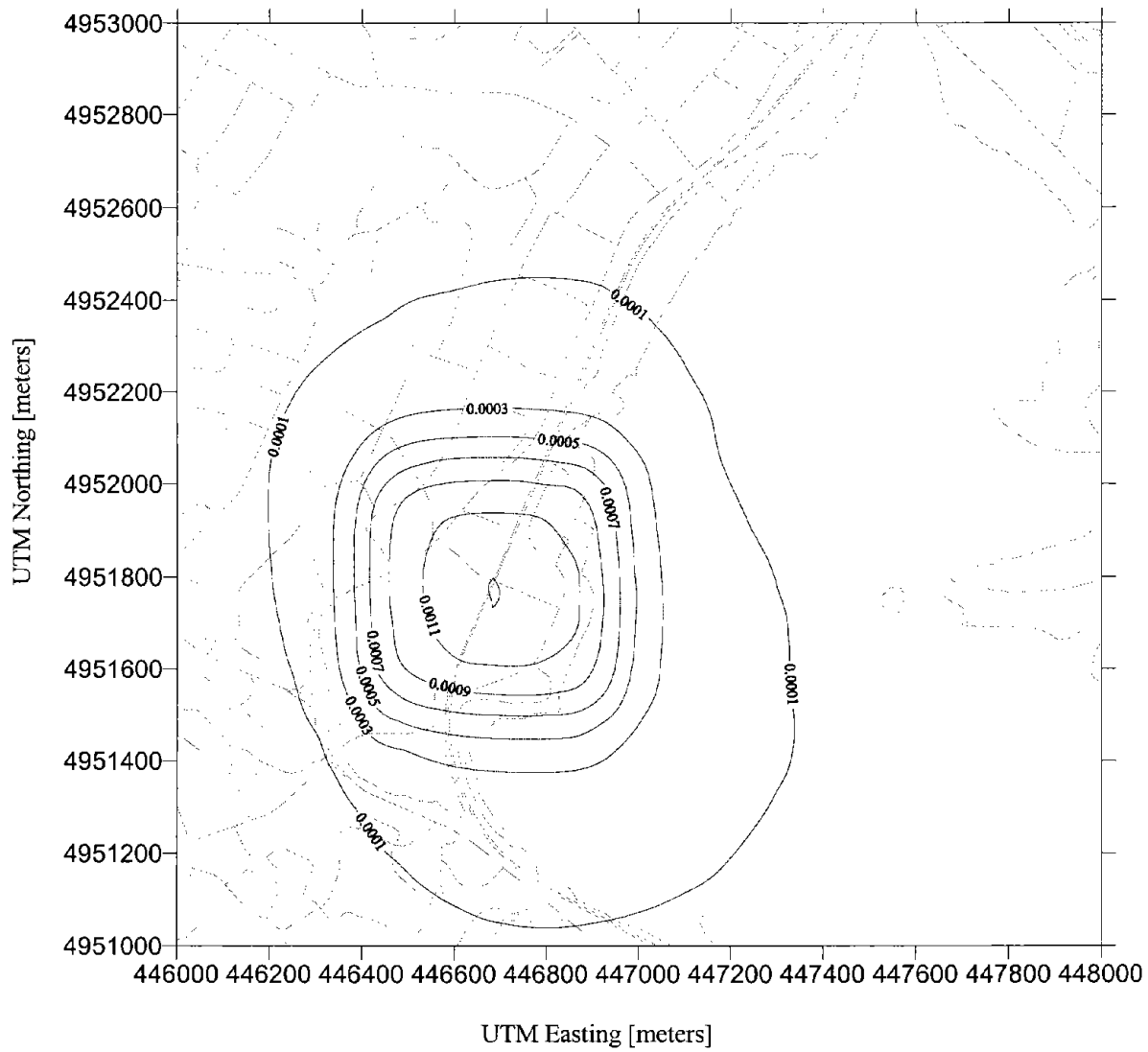


Figure 15 Annual Average Ground Level Concentrations of Ethylbenzene [$\mu\text{g}/\text{m}^3$]

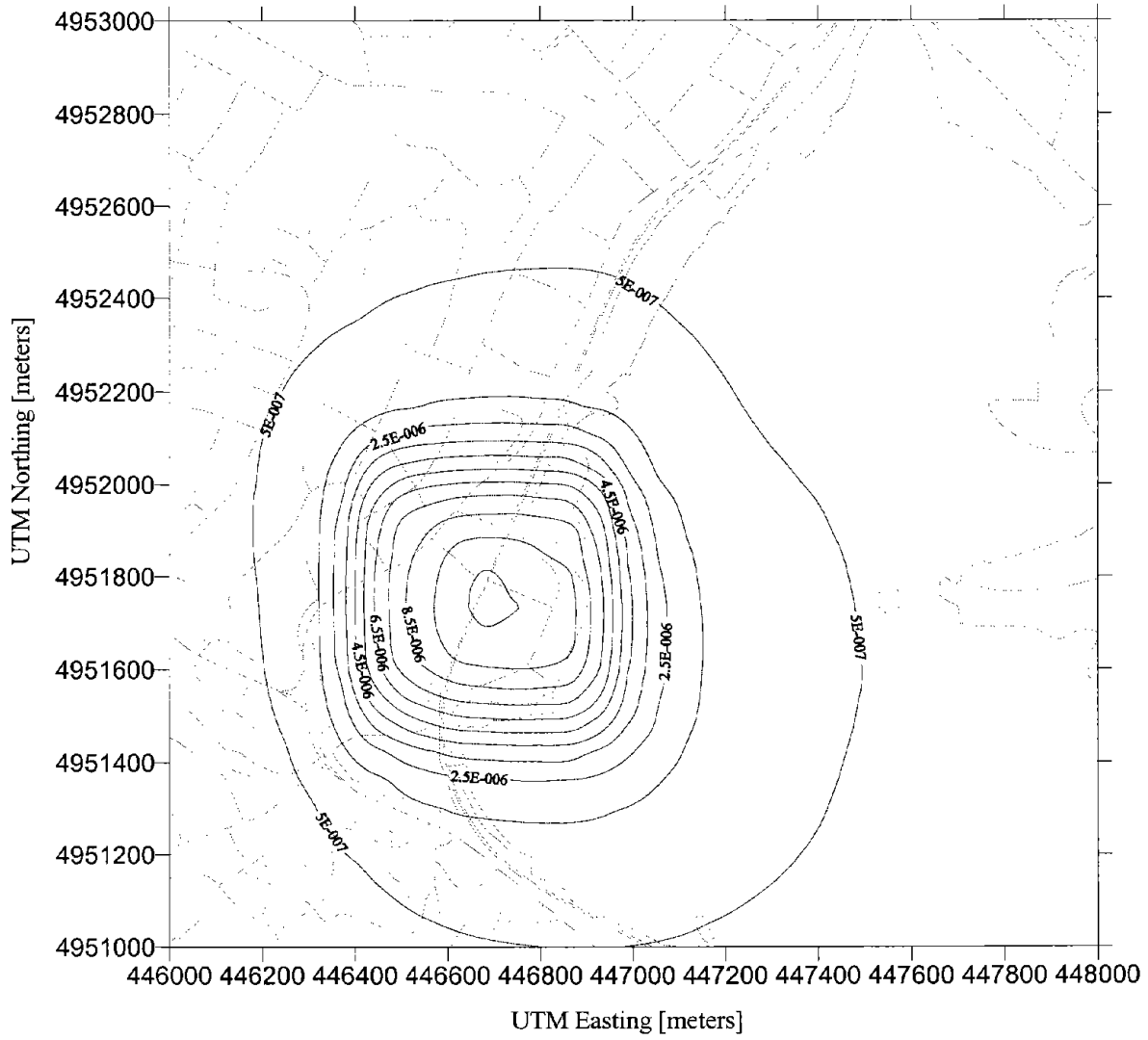


Figure 16 Annual Average Ground Level Concentrations of Isopropylbenzene [$\mu\text{g}/\text{m}^3$]

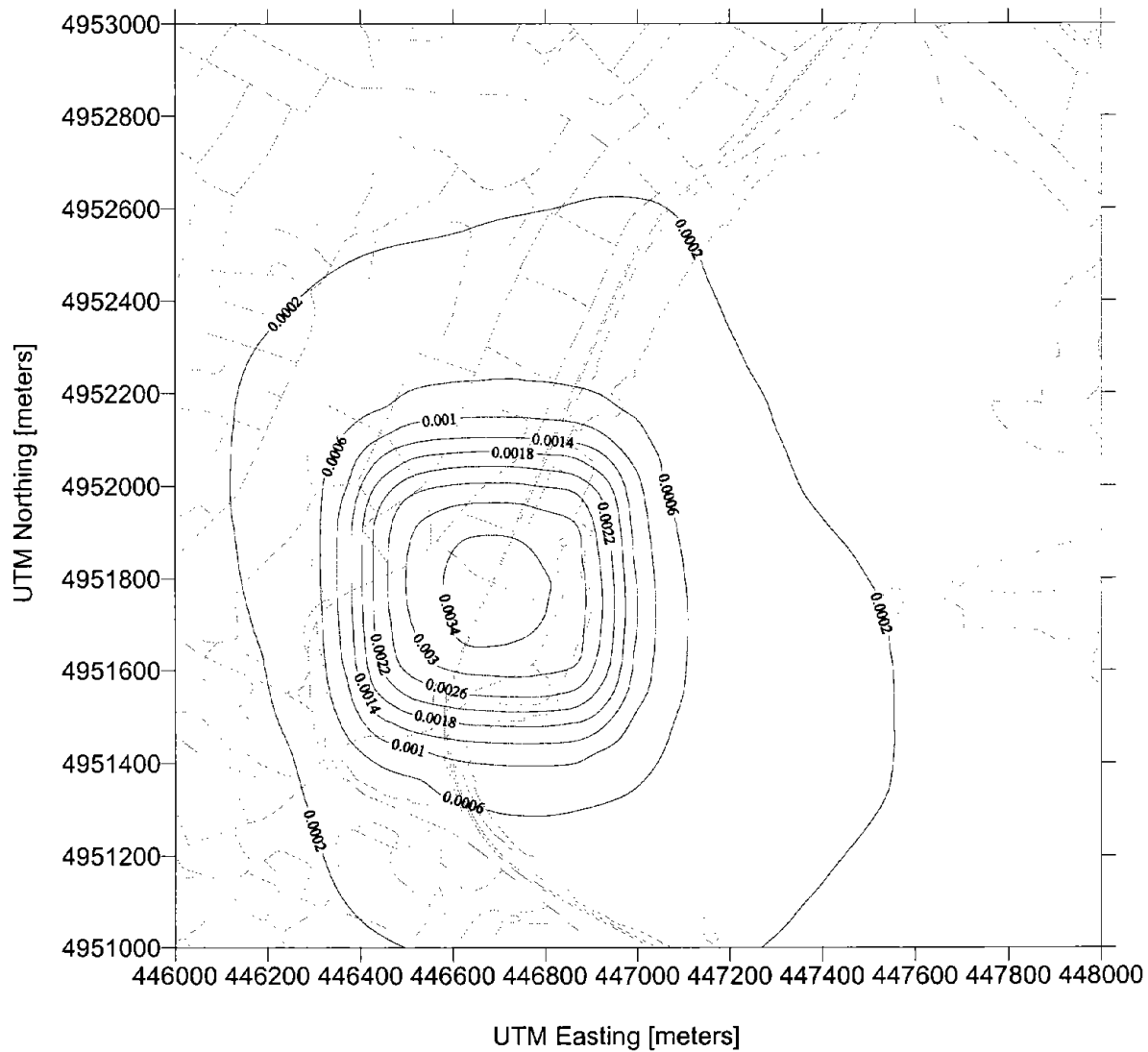


Figure 17 Annual Average Ground Level Concentrations of m&p-Xylene [$\mu\text{g}/\text{m}^3$]

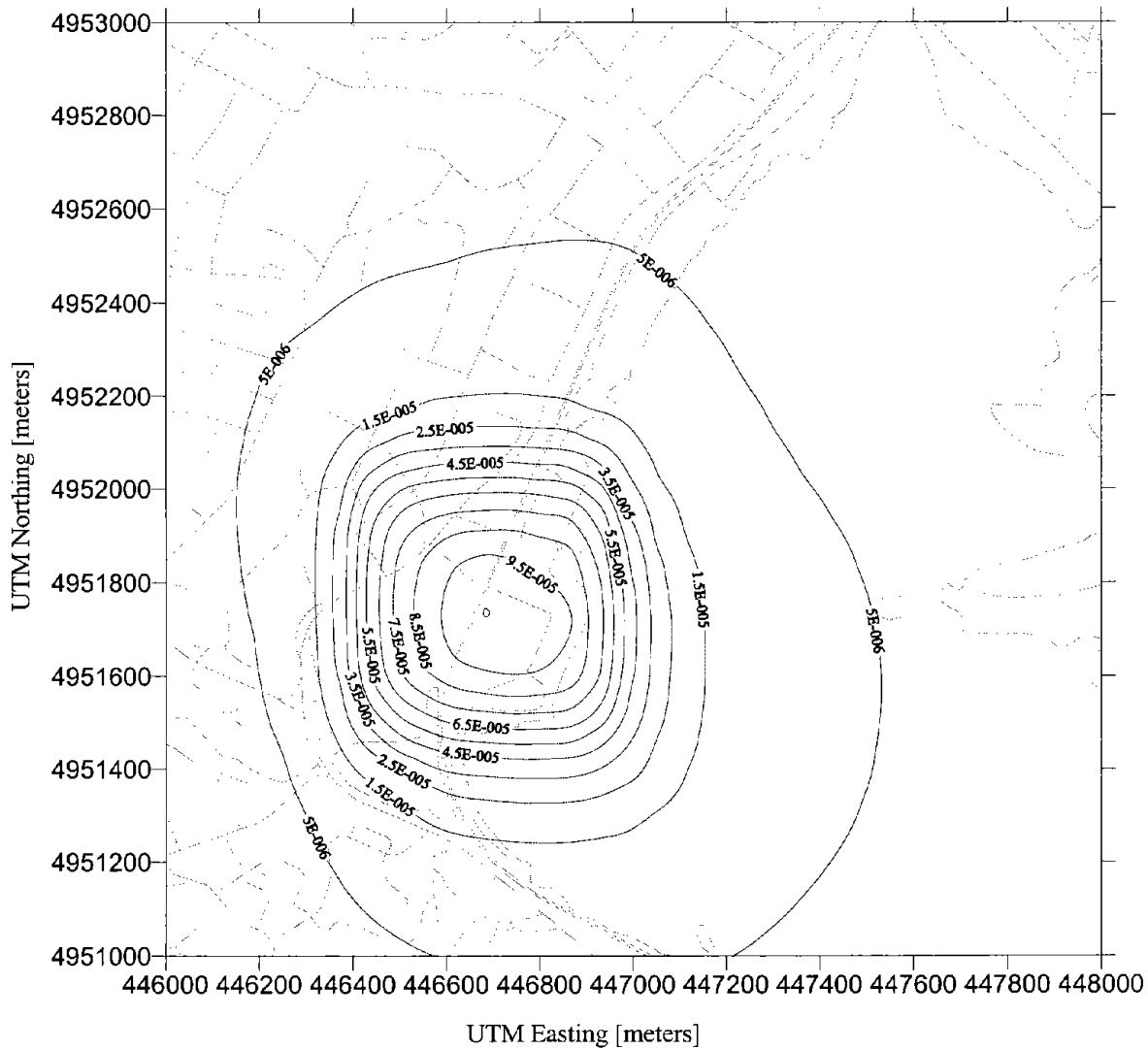


Figure 18 Annual Average Ground Level Concentrations Methylene Chloride [$\mu\text{g}/\text{m}^3$]

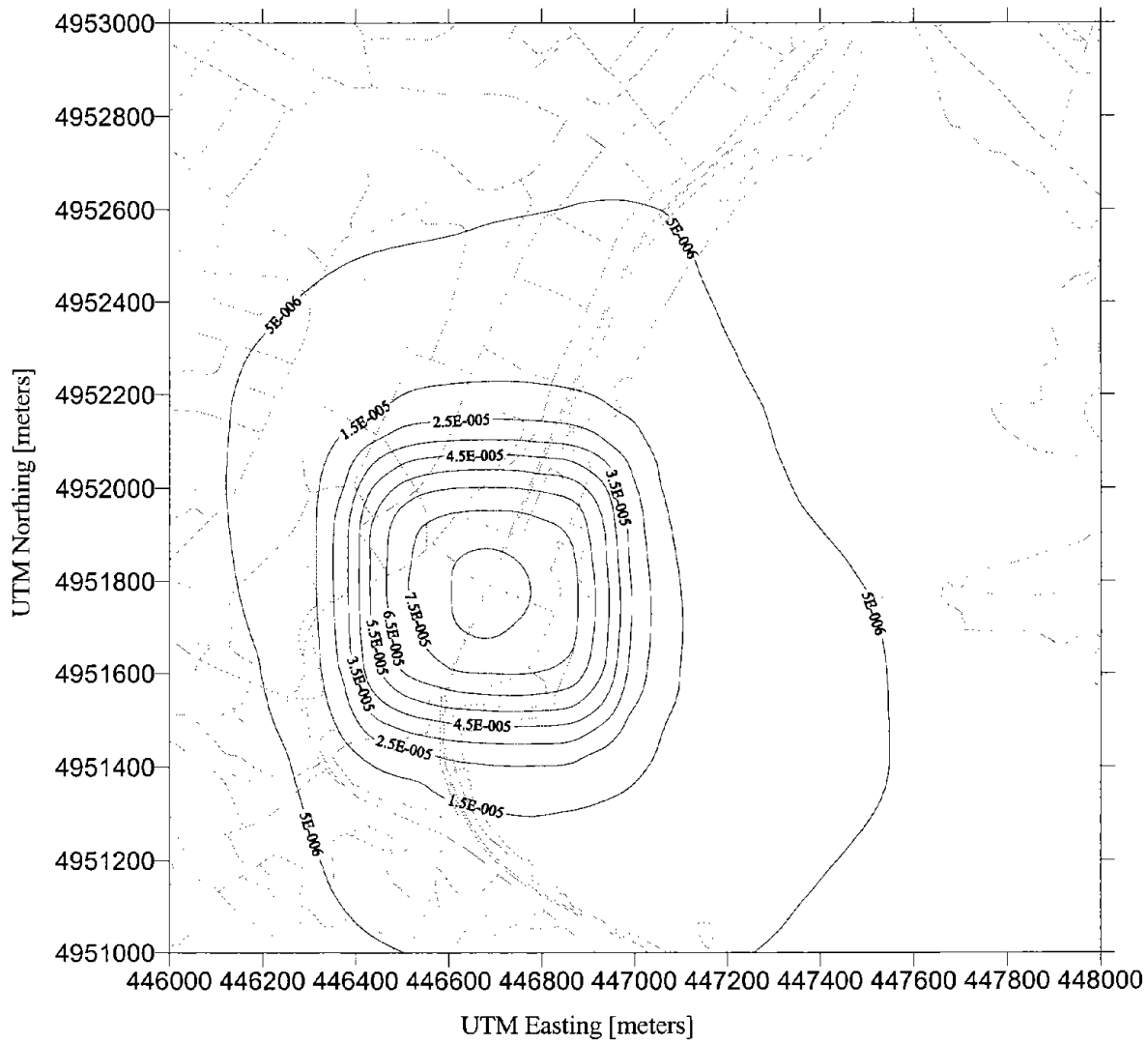


Figure 19 Annual Average Ground Level Concentrations of n-Propylbenzene [µg/m³]

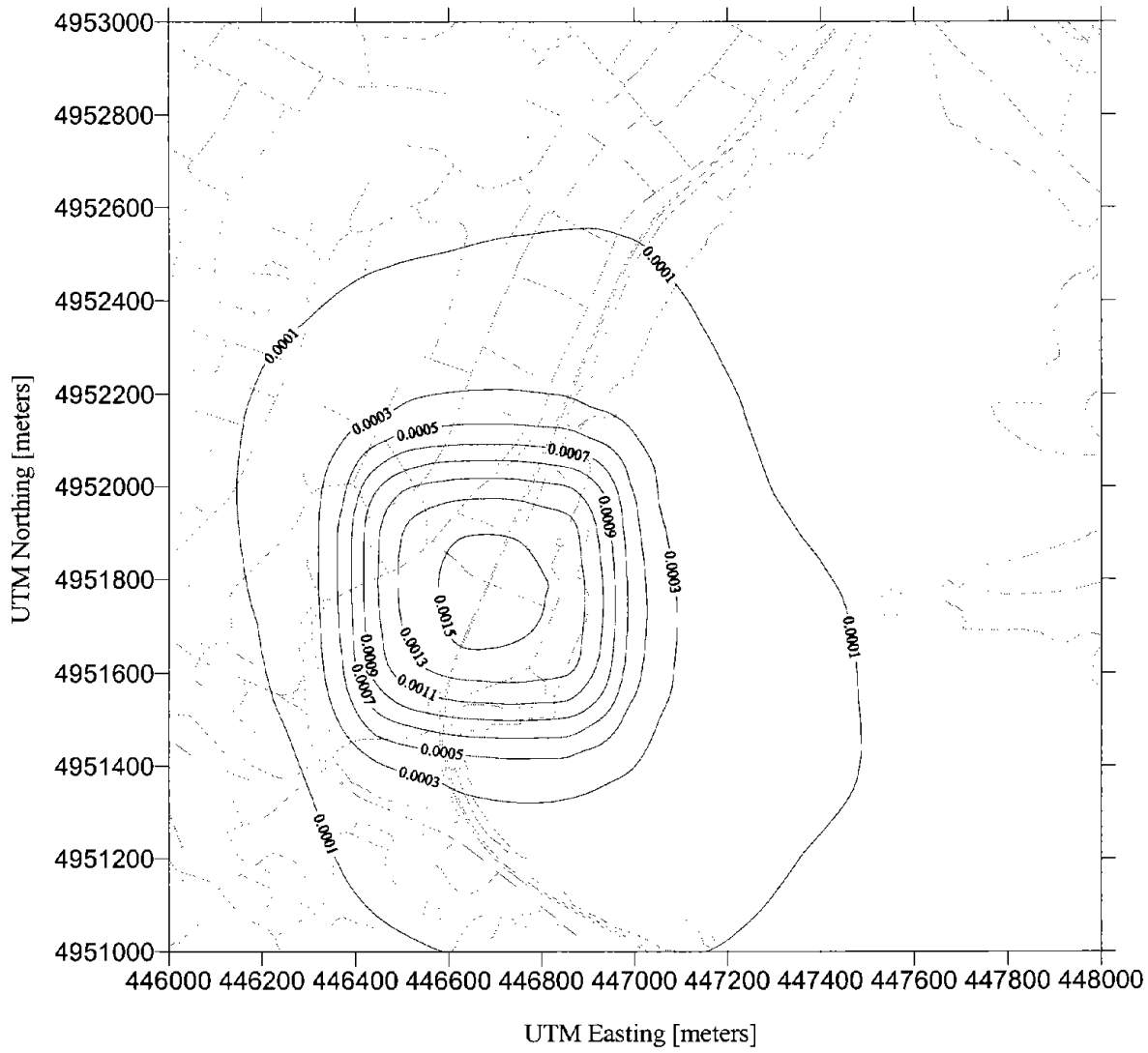


Figure 20

Annual Average Ground Level Concentrations of o-Xylene [$\mu\text{g}/\text{m}^3$]

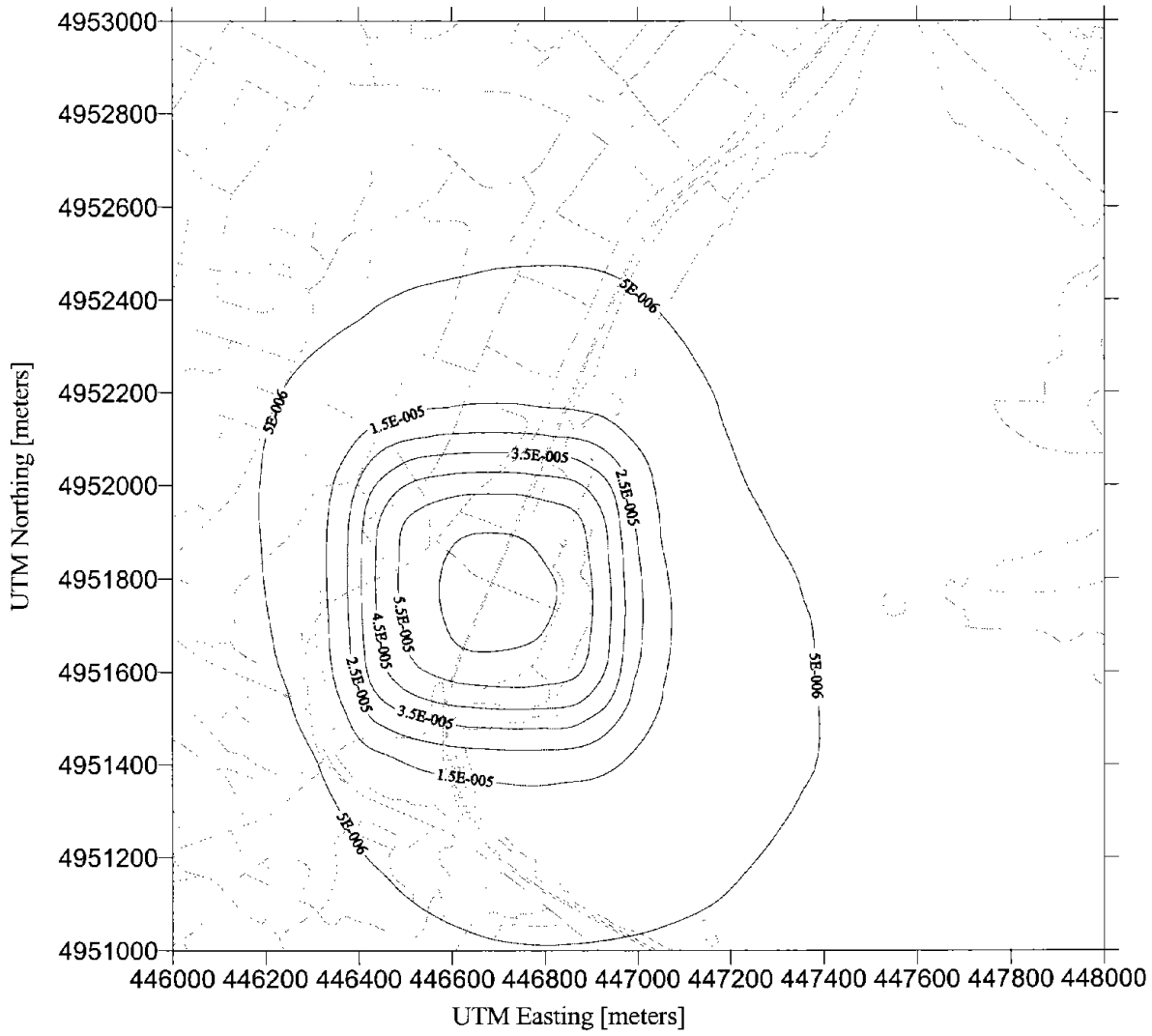


Figure 21 Annual Average Ground Level Concentrations of Styrene [$\mu\text{g}/\text{m}^3$]

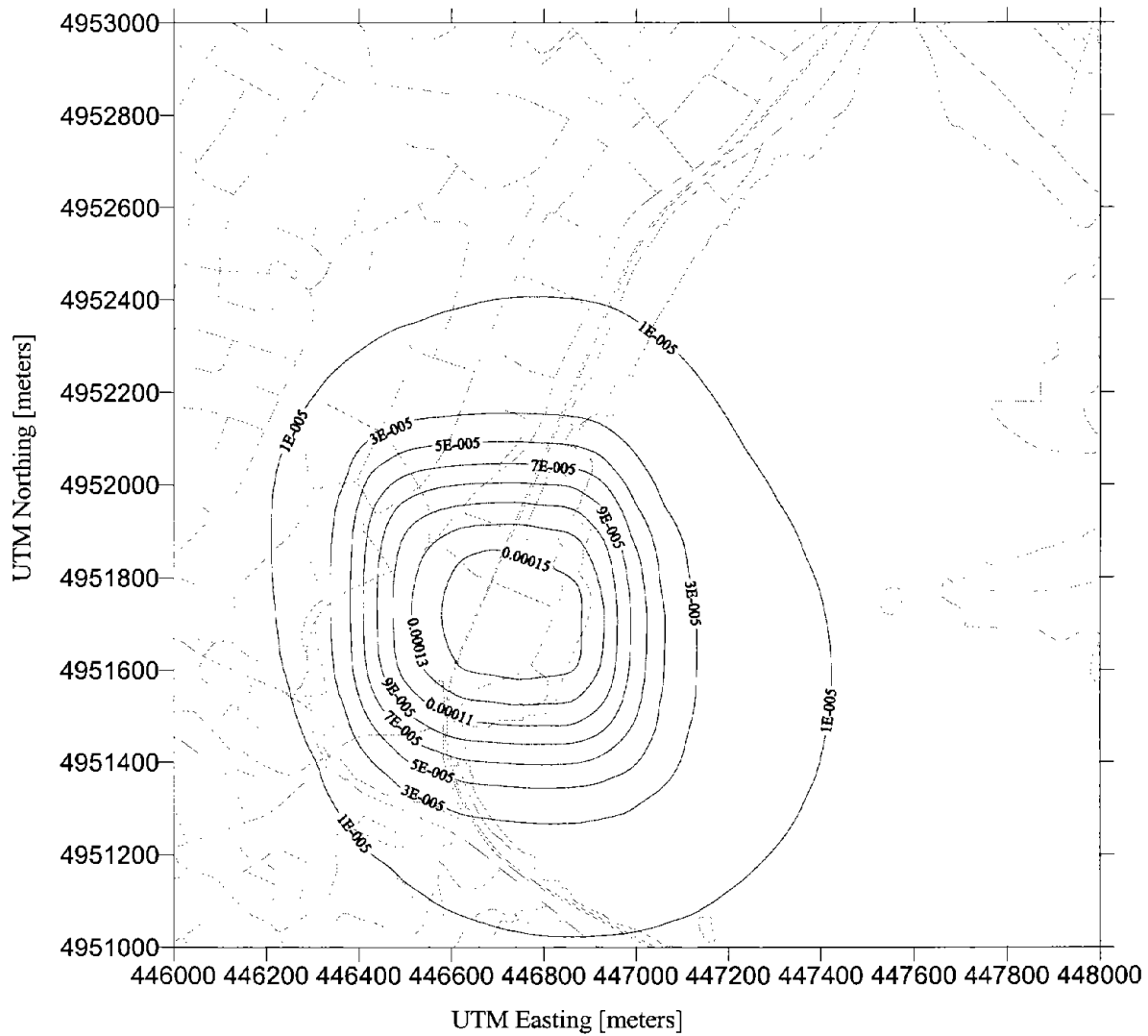


Figure 22 Annual Average Ground Level Concentrations of Tetrachloroethane [$\mu\text{g}/\text{m}^3$]

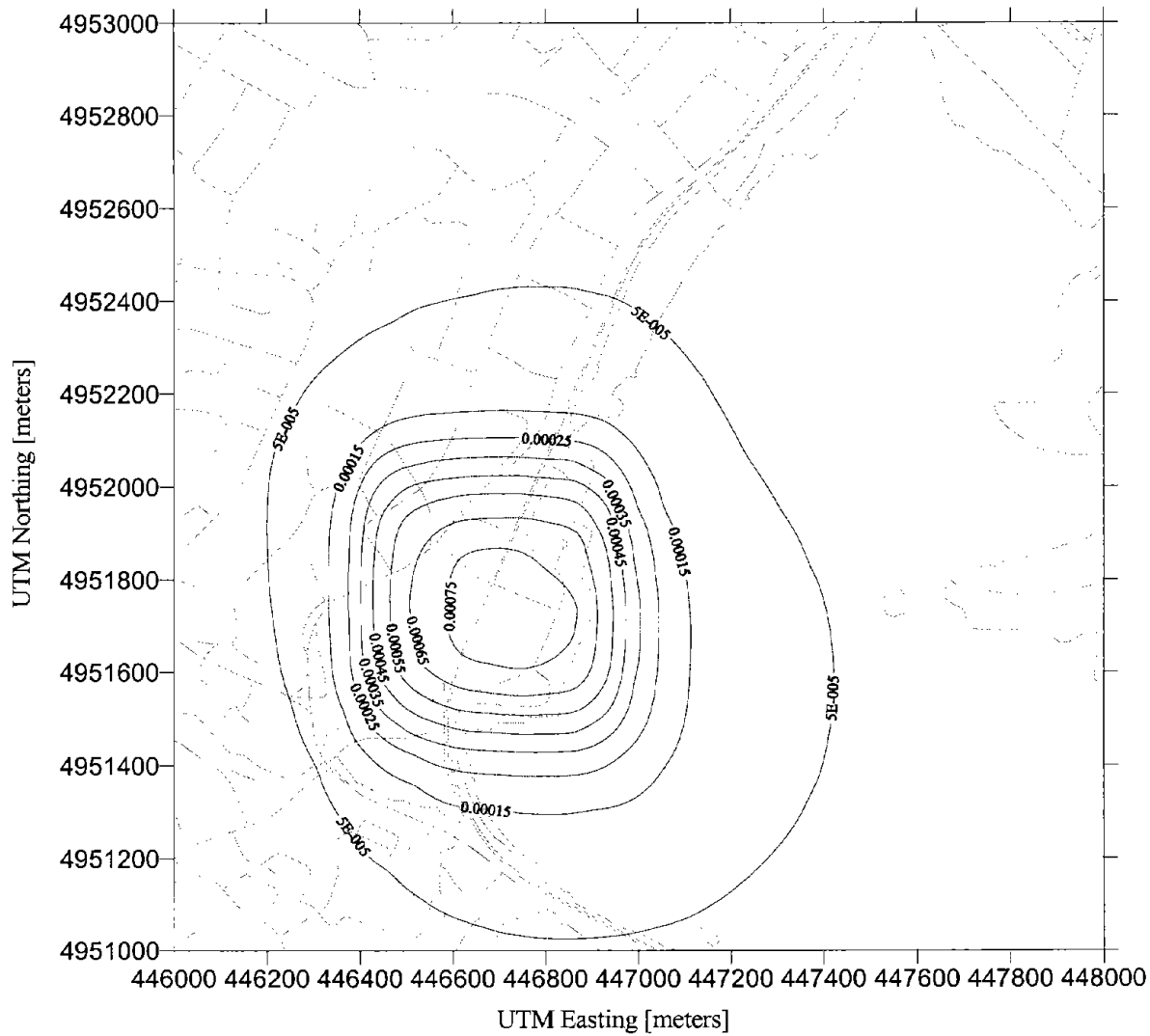


Figure 23 Annual Average Ground Level Concentrations of Toluene [$\mu\text{g}/\text{m}^3$]

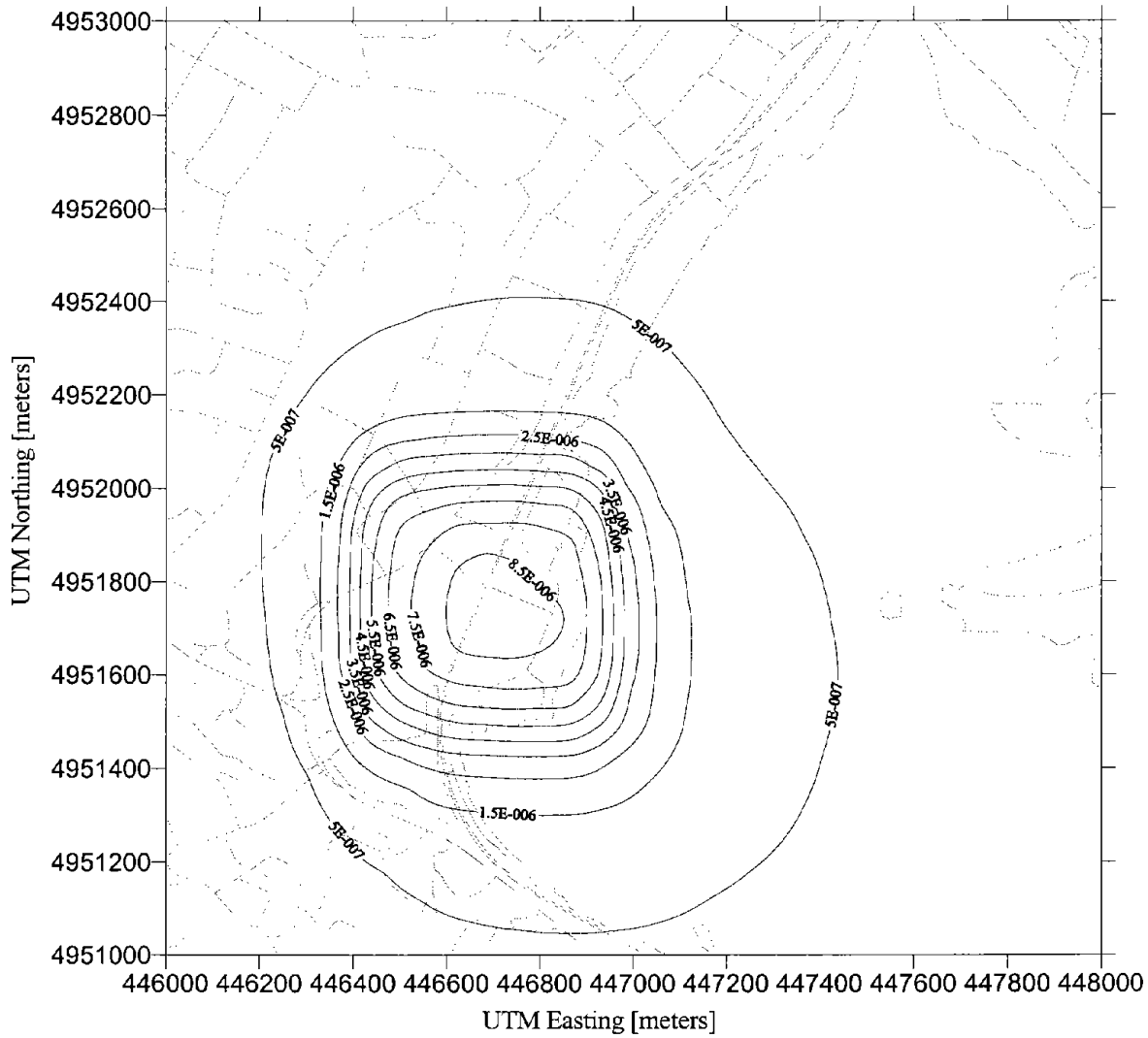


Figure 24 Annual Average Ground Level Concentrations of Trichloroethylene [$\mu\text{g}/\text{m}^3$]

APPENDIX B
OCCUPATIONAL EXPOSURE MEASUREMENTS

Table B1 Occupational Health and Safety Monitoring

Analyte	Dave Operator August 9, 2001	Sean Lab Technician August 9, 2001	Tim Maintenance Worker August 9, 2001	Dave Operator August 15, 2001	*Sean/Joe Lab Technician August 15, 2001	Tim Maintenace Worker August 15, 2001	TLV [ppm]	STEL [ppm]
	Concentration [ppm]	Concentration [ppm]	Concentration [ppm]	Concentration [ppm]	Concentration [ppm]	Concentration [ppm]		
Acetone	<0.41	<0.43	0.60	<0.42	<0.43	<0.41	500	750
Benzene	<0.35	<0.36	<0.34	<0.35	<0.36	<0.34	0.5	2.5
Carbon Tetrachloride	<0.21	<0.21	<0.20	<0.21	<0.21	<0.20	5	10
Chlorobenzene	<0.29	<0.30	<0.29	<0.30	<0.30	<0.29	10	NA
Chloroform	<0.24	<0.25	<0.24	<0.24	<0.25	<0.24	10	NA
1,4 - Dichlorobenzene	<0.24	<0.25	<0.24	<0.24	<0.25	<0.24	10	NA
1,1 - Dichloroethene	<0.29	<0.30	<0.28	<0.29	<0.30	<0.28	NA	NA
Dichloromethane	<0.31	<0.32	<0.30	<0.31	<0.32	<0.30	50	NA
Napthalene	<0.62	<0.64	<0.60	<0.62	<0.64	<0.60	10	15
PCE (Tetrachloroethene)	<0.21	<0.21	<0.20	<0.21	<0.21	<0.20	NA	NA
Styrene	<0.35	<0.36	<0.34	<0.35	<0.36	<0.34	20	40
Toluene	<0.33	<0.34	<0.33	NA	NA	NA	50	NA
1,1,1 - Trichloroethane	<0.23	<0.24	<0.23	<0.24	<0.24	<0.23	350	450
1,1,2 - Trichloroethane	<0.24	<0.25	<0.24	<0.25	<0.25	<0.24	10	NA
Trichloroethylene	<0.24	<0.24	<0.23	<0.24	<0.24	<0.23	50	100
Vinyl Chloride	<0.039	<0.040	<0.038	<0.039	<0.040	<0.038	1	NA
Xylene	<0.33	<0.34	<0.33	<0.34	<0.34	<0.33	100	150
Formaldehyde	0.03	<0.03	<0.03	0.03	<0.03	<0.03		C 0.3

TWA: Threshold Limit Value: Time Weighted Average (TLV-TWA) the time-weighted average concentration for a conventional 8-hour workday and a 40-hour workweek, to which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse effect.

STEL: Threshold Limit Value - Short Term Exposure Limit (TLV-STEL) is defined as a 15-minute Time Weighted Average exposure which should not be exceeded at any time during the work day. The "C" or the ceiling value indicates that the concentration should not be exceeded during any part of working exposure.

*Sean left work early and Joe covered for him in the lab

APPENDIX C
THRESHOLD LIMIT VALUES

Table C1 Threshold Limit Values of the American Conference of Governmental Industrial Hygienists.

	Compound	TLV [mg/m3]
1	1,1 Dichloroethane	404.8
2	1,1,1,2-Tetrachloroethane	6.9
3	1,1,1-Trichloroethane	1909.9
4	1,1,2,2-Tetrachloroethane	6.9
5	1,1,2-Trichloroethane	54.6
6	1,1-Dichloroethylene	19.8
7	1,1-Dichloropropylene	NA
8	1,1-Dimethyl Ethylbenzene	NA
9	1,2 Dichloroethane	40.5
10	1,2,3-Trichlorobenzene	NA
11	1,2,3-Trichloropropane	60.3
12	1,2,4 Trichlorobenzene	NA
13	1,2,4-Trimethylbenzene	122.9
14	1,2-Dibromo-3-Chloropropane	NA
15	1,2-Dichlorobenzene	150.3
16	1,2-Dichloropropane	346.6
17	1,3,5-Trimethylbenzene	122.9
18	1,3-Dichlorobenzene	150.3
19	1,3-Dichloropropane	346.6
20	1,4-Dichlorobenzene	150.3
21	1-Chloro-2-Methylbenzene	NA
22	1-Chloro-4-Methylbenzene	NA
23	2-Butanone	589.8
24	2-Hexanone	20.5
25	2-Propanone	NA
26	4-Methyl-2-Pentanone	NA
27	Benzene	1.6
28	Bromobenzene	NA
29	Bromodichloromethane	NA
30	Bromoform	5.2
31	Bromomethane	NA
32	Carbon Disulfide	31.1
33	Carbon Tetrachloride	31.5
34	Chlorobenzene	46.0
35	Chloroethane	NA
36	Chloroform	48.8
37	Chloromethane	NA
38	cis-1,2-Dichloroethylene	19.8
39	cis-1,3-Dichloropropylene	NA
40	Dibromomethane	NA
41	Dibromochloromethane	NA
42	Dichlorodifluoromethane	4047.9

	Compound	TLV [mg/m3]
43	Ethyl Acetate	1441.3
44	Ethylbenzene	434.2
45	Ethylene Dibromide	NA
46	Hexachlorobutadiene	0.2
47	Iodomethane	NA
48	Isopropylbenzene	NA
49	m&p-Xylene	434.2
50	Methylene chloride	173.7
51	Napthalene	52.4
52	n-Butylbenzene	NA
53	n-Propylbenzene	NA
54	o-Xylene	434.2
55	p-Isopropyltoluene	NA
56	scc-Butylbenzene	NA
57	Styrene	85.2
58	tert-Butylbenzene	NA
59	Tetrachloroethene	NA
60	Toluene	188.4
61	Trans-1,2-Dichloroethene	NA
62	trans-1,2-Dichloroethylene	NA
63	trans-1,3-Dichloropropylene	NA
64	Trichloroethylene	268.7
65	Trichlorofluoromethane	NA
66	Vinyl Acetate	35.5
67	Vinyl Chloride	2.6

NA: not available

TWA: Threshold Limit Value: Time Weighted Average (TLV-TWA) the time-weighted average concentration for a conventional 8-hour workday and a 40-hour workweek, to which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse effect..

STEL: Threshold Limit Value – Short Term Exposure Limit (TLV-STEL) is defined as a 15-minute Time Weighted Average exposure which should not be exceeded at any time during the work day. The “C” or the ceiling value indicates that the concentration should not be exceeded during any part of working exposure.

APPENDIX D
WATER MEASUREMENTS

TableD1 Analytical Results of Water Samples from August 3, 2001

Compound	EQL [µg/L]	Influent [µg/L]	Effluent [µg/L]	Otter Lake [µg/L]	New Aera [µg/L]
Benzene 624	1.0	<EQL	<EQL	1.0	<EQL
Bromodichloromethane	1.0	<EQL	<EQL	<EQL	<EQL
Bromoform	1.0	<EQL	<EQL	<EQL	<EQL
Bromomethane	8	<EQL	<EQL	<EQL	<EQL
Carbon Tetrachloride	1.0	<EQL	<EQL	<EQL	<EQL
Chlorobenzene	1.0	<EQL	<EQL	<EQL	<EQL
Chloroethane	8	<EQL	<EQL	<EQL	<EQL
Chloroform	1.0	8.6	8.7	<EQL	<EQL
Chloromethane	8	<EQL	<EQL	<EQL	<EQL
1,2 Dibromoethane	1.0	<EQL	<EQL	<EQL	<EQL
Dibromochloromethane	1.0	<EQL	<EQL	<EQL	<EQL
1,2 Dichlorobenzene	1.0	<EQL	<EQL	<EQL	<EQL
1,3 Dichlorobenzene	1.0	<EQL	<EQL	<EQL	<EQL
1,4 Dichloroenezene	1.0	<EQL	<EQL	<EQL	<EQL
1,1 Dichloroethane	2.0	<EQL	<EQL	<EQL	<EQL
1,2 Dichloroethane	1.0	<EQL	<EQL	<EQL	<EQL
1,1 Dichloroethane	2.0	<EQL	<EQL	<EQL	<EQL
Cis 1,2 Dichloroethane	2.0	<EQL	<EQL	<EQL	<EQL
Trans 1,2 Dichloroethane	2.0	<EQL	<EQL	<EQL	<EQL
Dichloromethane	3.0	<EQL	<EQL	<EQL	<EQL
1,2 Dichloropropane	1.0	<EQL	<EQL	<EQL	<EQL
Cis 1,3 Dichloropropene	2.0	<EQL	<EQL	<EQL	<EQL
Trans 1,3 Dichloropropene	1.0	<EQL	<EQL	<EQL	<EQL
Ethylbenzene	1.0	<EQL	<EQL	<EQL	<EQL
Styrene	1.0	<EQL	<EQL	<EQL	<EQL
Tetrachloroethene	1.0	<EQL	<EQL	<EQL	<EQL
1,1,2,2 Tetrachloroethane	1.0	<EQL	<EQL	<EQL	<EQL
Toluene	1.0	1.7	<EQL	130	84
1,1,1 Trichloroethane	-	<EQL	<EQL	<EQL	<EQL
1,1,2 Trichloroethane	1.0	<EQL	<EQL	<EQL	<EQL
Trichloroethane	1.0	<EQL	<EQL	<EQL	<EQL
Trichlorofluoromethan	8	<EQL	<EQL	<EQL	<EQL
M&p-Xylenes	2.0	<EQL	<EQL	<EQL	<EQL
o-Xylene	1.0	<EQL	<EQL	<EQL	<EQL
Vinyl Chloride	1.0	<EQL	<EQL	<EQL	<EQL

(EQL): The lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The EQL is generally 5 to 10 times the Method Detection Limit (MDL)".

APPENDIX E
AIR SOURCE EMISSION MEASUREMENTS

Table E1 Headworks Scrubber In- and Outlet Air Concentrations

Compound	Scrubber Outlet	Scrubber Inlet
	September 20, 2001	September 20, 2001
	[$\mu\text{g}/\text{m}^3$]	[$\mu\text{g}/\text{m}^3$]
Minimum Detectable Limit	0.017	0.794
1 1,1 Dichloroethane	ND	ND
2 1,1,1,2-Tetrachloroethane	ND	ND
3 1,1,1-Trichloroethane	ND	ND
4 1,1,2,2-Tetrachloroethane	ND	ND
5 1,1,2-Trichloroethane	ND	ND
6 1,1-Dichloroethylene	ND	ND
7 1,1-Dichloropropylene	ND	NA
8 1,1-Dimethyl Ethylbenzene	ND	NA
9 1,2 Dichloroethane	ND	ND
10 1,2,3-Trichlorobenzene	ND	NA
11 1,2,3-Trichloropropane	ND	NA
12 1,2,4 Trichlorobenzene	ND	NA
13 1,2,4-Trimethylbenzene	0.569	ND
14 1,2-Dibromo-3-Chloropropane	ND	NA
15 1,2-Dichlorobenzene	ND	ND
16 1,2-Dichloropropane	ND	ND
17 1,3,5-Trimethylbenzene	0.414	ND
18 1,3-Dichlorobenzene	ND	ND
19 1,3-Dichloropropane	ND	ND
20 1,4-Dichlorobenzene	0.095	ND
21 1-Chloro-2-Methylbenzene	ND	NA
22 1-Chloro-4-Methylbenzene	ND	NA
23 2-Butanone	ND	ND
24 2-Hexanone	ND	ND
25 2-Propanone	ND	2.526
26 4-Methyl-2-Pentanone	ND	ND
27 Benzene	0.047	ND
28 Bromobenzene	ND	NA
29 Bromodichloromethane	0.095	ND
30 Bromoform	ND	ND
31 Bromomethane	ND	ND
32 Carbon Disulfide	ND	ND
33 Carbon Tetrachloride	ND	ND
34 Chlorobenzene	ND	ND
35 Chloroethane	ND	ND
36 Chloroform	0.759	2.526
37 Chloromethane	ND	ND
38 cis-1,2-Dichloroethylene	ND	ND
39 cis-1,3-Dichloropropylene	ND	ND
40 Dibromomethane	ND	ND

Compound	Scrubber Outlet	Scrubber Inlet
	September 20, 2001	September 20, 2001
	[$\mu\text{g}/\text{m}^3$]	[$\mu\text{g}/\text{m}^3$]
Minimum Detectable Limit	0.017	0.794
41 Dibromochloromethane	ND	ND
42 Dichlorodifluoromethane	ND	ND
43 Ethyl Acetate	ND	NA
44 Ethylbenzene	7.248	2.707
45 Ethylene Dibromide	ND	ND
46 Hexachlorobutadiene	ND	NA
47 Iodomethane	ND	NA
48 Isopropylbenzene	ND	ND
49 m&p-Xylene	20.708	11.369
50 Methylene chloride	0.190	2.165
51 Napthalene	ND	NA
52 n-Butylbenzene	ND	NA
53 n-Propylbenzene	0.535	NA
54 o-Xylene	9.318	4.331
55 p-Isopropyltoulene	ND	NA
56 scc-Butylbenzene	ND	NA
57 Styrene	0.362	ND
58 tert-Butylbenzene	ND	NA
59 Tetrachloroethene	0.093	ND
60 Toluene	1.346	3.970
61 trans-1,2-Dichloroethene	ND	ND
62 trans-1,2-Dichloroethylene	ND	ND
63 trans-1,3-Dichloropropylene	ND	ND
64 Trichloroethylene	ND	ND
65 Trichlorofluoromethane	ND	ND
66 Vinyl Acetate	ND	NA
67 Vinyl Chloride	ND	ND

NA: not available

ND: not detectable

TableE2 Up- and Downwind Sample Results

Compound	September 28, 2001 3-4pm		September 28, 2001 4-5pm		October 1, 2001 3-4pm	
	Windspeed: ~1m/sec Winddirection: NE		Windspeed: 0.8m/sec Winddirection: N		Windspeed: 1.9m/sec Winddirection: ESE	
	Downwind (ID:4)	Upwind (ID:5)	Downwind (ID:6)	Upwind (ID:7)	Downwind (ID:10)	Upwind (ID:11)
	[µg/m ³]	[µg/m ³]	[µg/m ³]	[µg/m ³]	[µg/m ³]	[µg/m ³]
Minimum Detectable Limit	0.015	0.051	0.015	0.015	0.018	0.017
1 1,1 Dichloroethane	ND	ND	ND	ND	ND	ND
2 1,1,1,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND
3 1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND
4 1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND
5 1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND
6 1,1-Dichloroethylene	ND	ND	0.039	0.042	0.131	0.185
7 1,1-Dichloropropylene	NA	NA	NA	NA	NA	NA
8 1,1-Dimethyl Ethylbenzene	NA	NA	NA	NA	NA	NA
9 1,2 Dichloroethane	ND	ND	ND	ND	ND	ND
10 1,2,3-Trichlorobenzene	NA	NA	NA	NA	NA	NA
11 1,2,3-Trichloropropane	NA	NA	NA	NA	NA	NA
12 1,2,4 Trichlorobenzene	NA	NA	NA	NA	NA	NA
13 1,2,4-Trimethylbenzene	0.152	10.769	0.053	0.032	0.087	0.059
14 1,2-Dibromo-3-Chloropropane	NA	NA	NA	NA	NA	NA
15 1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND
16 1,2-Dichloropropane	ND	ND	ND	ND	ND	ND
17 1,3,5-Trimethylbenzene	0.056	2.821	0.023	0.015	0.040	0.024
18 1,3-Dichlorobenzene	ND	ND	ND	ND	ND	ND
19 1,3-Dichloropropane	ND	ND	ND	ND	ND	ND
20 1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND
21 1-Chloro-2-Methylbenzene	NA	NA	NA	NA	NA	NA
22 1-Chloro-4-Methylbenzene	NA	NA	NA	NA	NA	NA
23 2-Butanone	ND	ND	0.033	0.025	0.057	ND
24 2-Hexanone	ND	ND	ND	ND	ND	ND
25 2-Propanone	ND	ND	1.002	ND	ND	ND
26 4-Methyl-2-Pentanone	ND	ND	ND	ND	ND	ND
27 Benzene	0.015	0.051	0.079	0.081	0.064	0.185
28 Bromobenzene	NA	NA	NA	NA	NA	NA
29 Bromodichloromethane	ND	ND	0.020	ND	ND	ND
30 Bromoform	ND	ND	ND	ND	ND	ND
31 Bromomethane	ND	ND	ND	ND	ND	ND
32 Carbon Disulfide	ND	ND	ND	ND	0.096	ND
33 Carbon Tetrachloride	0.024	0.051	0.026	0.029	0.028	0.029
34 Chlorobenzene	ND	ND	ND	ND	ND	ND
35 Chloroethane	ND	ND	ND	ND	ND	ND
36 Chloroform	0.015	ND	0.213	0.028	0.028	ND

	Compound	September 28, 2001 3-4pm		September 28, 2001 4-5pm		October 1, 2001 3-4pm	
		Windspeed: ~1m/sec Winddirection: NE		Windspeed: 0.8m/sec Winddirection: N		Windspeed: 1.9m/sec Winddirection: ESE	
		Downwind (ID:4)	Upwind (ID:5)	Downwind (ID:6)	Upwind (ID:7)	Downwind (ID:10)	Upwind (ID:11)
		[µg/m ³]	[µg/m ³]	[µg/m ³]	[µg/m ³]	[µg/m ³]	[µg/m ³]
37	Chloromethane	ND	ND	ND	ND	ND	ND
38	cis-1,2-Dichloroethylene	ND	ND	ND	ND	ND	ND
39	cis-1,3-Dichloropropylene	ND	ND	ND	ND	ND	ND
40	Dibromomethane	ND	ND	ND	ND	ND	ND
41	Dibromochloromethane	ND	ND	ND	ND	ND	ND
42	Dichlorodifluoromethane	0.319	0.821	0.258	0.305	0.368	0.489
43	Ethyl Acetate	NA	NA	NA	NA	NA	NA
44	Ethylbenzene	0.026	0.128	0.033	0.036	0.109	0.071
45	Ethylene Dibromide	ND	ND	ND	ND	ND	ND
46	Hexachlorobutadiene	NA	NA	NA	NA	NA	NA
47	Iodomethane	NA	NA	NA	NA	NA	NA
48	Isopropylbenzene	ND	0.821	ND	ND	ND	ND
49	m&p-Xylene	0.088	0.477	0.129	0.134	0.405	0.236
50	Methylene chloride	1.169	ND	0.137	0.160	1.289	0.354
51	Napthalene	NA	NA	NA	NA	NA	NA
52	n-Butylbenzene	NA	NA	NA	NA	NA	NA
53	n-Propylbenzene	NA	NA	NA	NA	NA	NA
54	o-Xylene	0.058	1.436	0.046	0.044	0.112	0.072
55	p-Isopropyltoulene	NA	NA	NA	NA	NA	NA
56	scc-Butylbenzene	NA	NA	NA	NA	NA	NA
57	Styrene	ND	ND	ND	0.015	0.026	0.037
58	tert-Butylbenzene	NA	NA	NA	NA	NA	NA
59	Tetrachloroethene	ND	ND	ND	ND	ND	ND
60	Toluene	0.258	1.282	0.197	0.233	2.393	0.438
61	Trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND
62	Trans-1,2-Dichloroethylene	ND	ND	ND	ND	ND	ND
63	Trans-1,3-Dichloropropylene	ND	ND	ND	ND	ND	ND
64	Trichloroethylene	ND	ND	ND	ND	ND	ND
65	Trichlorofluoromethane	0.073	0.323	0.105	0.108	0.202	0.133
66	Vinyl Acetate	NA	NA	NA	NA	NA	NA
67	Vinyl Chloride	ND	ND	ND	ND	ND	ND

NA: not available

ND: not detectable

TableE3 Emissions from Clarifier

	Compound	Primary Clarifier December 3, 2001	Secondary Clarifier November 30, 2001
		Total: 1017.2 m ²	Total: 1422.9 m ²
		[µg/sec]	[µg/sec]
Minimum Detectable Limit		0.1	0.18
1	1,1 Dichloroethane	0.12	ND
2	1,1,1,2-Tetrachloroethane	ND	ND
3	1,1,1-Trichloroethane	ND	ND
4	1,1,2,2-Tetrachloroethane	ND	ND
5	1,1,2-Trichloroethane	ND	ND
6	1,1-Dichloroethylene	ND	ND
7	1,1-Dichloropropylene	ND	ND
8	1,1-Dimethyl Ethylbenzene	ND	ND
9	1,2 Dichloroethane	ND	ND
10	1,2,3-Trichlorobenzene	ND	ND
11	1,2,3-Trichloropropane	ND	ND
12	1,2,4 Trichlorobenzene	ND	ND
13	1,2,4-Trimethylbenzene	1.20	ND
14	1,2-Dibromo-3-Chloropropane	ND	ND
15	1,2-Dichlorobenzene	ND	ND
16	1,2-Dichloropropane	ND	ND
17	1,3,5-Trimethylbenzene	ND	ND
18	1,3-Dichlorobenzene	ND	ND
19	1,3-Dichloropropane	ND	ND
20	1,4-Dichlorobenzene	0.80	3.79
21	1-Chloro-2-Methylbenzene	ND	ND
22	1-Chloro-4-Methylbenzene	ND	ND
23	2-Butanone	1.03	ND
24	2-Hexanone	ND	ND
25	2-Propanone	1.52	0.76
26	4-Methyl-2-Pentanone	0.30	ND
27	Benzene	0.79	ND
28	Bromobenzene	ND	ND
29	Bromodichloromethane	2.28	3.25
30	Bromoform	ND	ND
31	Bromomethane	ND	ND
32	Carbon Disulfide	ND	ND
33	Carbon Tetrachloride	0.15	ND
34	Chlorobenzene	ND	ND
35	Chloroethane	ND	ND
36	Chloroform	20.65	10.65
37	Chloromethane	ND	ND
38	cis-1,2-Dichloroethylene	0.37	ND
39	cis-1,3-Dichloropropylene	ND	ND
40	Dibromomethane	ND	ND
41	Dibromochloromethane	0.17	0.47
42	Dichlorodifluoromethane	1.74	0.90
43	Ethyl Acetate	ND	ND
44	Ethylbenzene	0.95	ND
45	Ethylene Dibromide	ND	ND
46	Hexachlorobutadiene	ND	ND
47	Iodomethane	ND	ND

	Compound	Primary Clarifier December 3, 2001	Secondary Clarifier November 30, 2001
		Total: 1017.2 m ²	Total: 1422.9 m ²
		[µg/sec]	[µg/sec]
Minimum Detectable Limit		0.1	0.18
48	Isopropylbenzene	0.15	ND
49	m&p-Xylene	3.04	0.27
50	Methylene chloride	0.63	0.45
51	Napthalene	ND	ND
52	n-Butylbenzene	ND	ND
53	n-Propylbenzene	ND	ND
54	o-Xylene	1.03	ND
55	p-Isopropyltoluene	ND	ND
56	scc-Butylbenzene	ND	ND
57	Styrene	0.15	ND
58	tert-Butylbenzene	ND	ND
59	Tetrachloroethene	1.20	1.10
60	Toluene	6.63	2.17
61	trans-1,2-Dichloroethene	ND	ND
62	trans-1,2-Dichloroethylene	ND	ND
63	trans-1,3-Dichloropropylene	ND	ND
64	Trichloroethylene	0.13	ND
65	Trichlorofluoromethane	ND	ND
66	Vinyl Acetate	ND	ND
67	Vinyl Chloride	ND	ND

NA: not available

ND: not detectable

APPENDIX F

SAMPLE AIR CALCULATIONS

Calculation of air concentration:

e.g. Benzene concentration at scrubber outlet

Given: Mass of Benzene sampled with VOST-Tube: 0.027 μg
 Sample time per VOST-Tube: 61 min
 Sample Rate: 9.5 liters / minute

Total Air Sample Volume Per Tube:

$$\frac{61 \text{ min}}{\text{VOST-tube}} \times \frac{9.5 \text{ liters}}{\text{min}} \times \frac{1 \text{ m}^3}{1000 \text{ liters}} = \frac{0.5795 \text{ m}^3}{\text{VOST-tube}}$$

Benzene concentration at scrubber outlet:

$$\frac{0.027 \frac{\mu\text{g}}{\text{VOST-tube}}}{0.5795 \frac{\text{m}^3}{\text{VOST-tube}}} = \frac{0.047 \mu\text{g}}{\text{m}^3}$$

Calculation of scrubber emission rate:

e.g. Benzene concentration at scrubber outlet

Given: Benzene concentration at scrubber outlet: 0.047 $\mu\text{g}/\text{m}^3$
 Scrubber air flow: 8500 ft^3 / min

$$\frac{0.047 \mu\text{g}}{\text{m}^3} \times \frac{1 \text{ g}}{1000000 \mu\text{g}} \times \frac{8500 \text{ ft}^3}{\text{min}} \times \frac{1 \text{ m}^3}{35.31 \text{ ft}^3} \times \frac{1 \text{ min}}{60 \text{ sec}} = 1.89 \times 10^{-7} \frac{\text{g}}{\text{sec}}$$

Calculation of emission rate from primary clarifier:

Given: Mass of Benzene sampled with VOST-Tube: 0.073 μg
 Sample time per VOST-Tube: 75 min
 Radius of Sample Container: 0.0835 m
 Area of new clarifier: 1710 ft^2
 Area of old clarifier: 1600 ft^2
 Number of old clarifiers: 3
 Number of new clarifiers: 4

Sample Area:

$$(0.0835 \text{ m})^2 \times \pi = 0.022 \text{ m}^2$$

Emission rate per square meter per second:

$$\frac{0.073 \mu\text{g}}{\text{VOST - Tube}} \times \frac{1 \text{ g}}{1000000 \mu\text{g}} = \frac{7.41 \times 10^{-10} \text{ g}}{\text{sec} \times \text{m}^2}$$

$$75 \text{ min} \times \frac{1 \text{ min}}{60 \text{ sec}} \times 0.022 \text{ m}^2$$

Emission rate from primary clarifiers:

$$(3 \times 1710 \text{ ft}^2 + 4 \times 1600 \text{ ft}^2) \times \frac{1 \text{ m}^2}{10.76 \text{ ft}^2} \times \frac{7.41 \times 10^{-10} \text{ g}}{\text{sec} \times \text{m}^2} = \frac{3.53 \times 10^{-7} \text{ g}}{\text{sec}}$$

APPENDIX G
EMISSION RATES

Table G1 Emission Rates

	Compound	Secondary Clarifiers Emission Rates [µg/sec]	Primary Clarifiers Emission Rates [µg/sec]	Scrubber Outlet Emissions Rates [µg/sec]
1	1,1 Dichloroethane	ND	0.12	ND
2	1,1,1,2-Tetrachloroethane	ND	ND	ND
3	1,1,1-Trichloroethane	ND	ND	ND
4	1,1,2,2-Tetrachloroethane	ND	ND	ND
5	1,1,2-Trichloroethane	ND	ND	ND
6	1,1-Dichloroethylene	ND	ND	ND
7	1,1-Dichloropropylene	ND	ND	ND
8	1,1-Dimethyl Ethylbenzene	ND	ND	ND
9	1,2 Dichloroethane	ND	ND	ND
10	1,2,3-Trichlorobenzene	ND	ND	ND
11	1,2,3-Trichloropropane	ND	ND	ND
12	1,2,4 Trichlorobenzene	ND	ND	ND
13	1,2,4-Trimethylbenzene	ND	1.20	2.28
14	1,2-Dibromo-3-Chloropropane	ND	ND	ND
15	1,2-Dichlorobenzene	ND	ND	ND
16	1,2-Dichloropropane	ND	ND	ND
17	1,3,5-Trimethylbenzene	ND	ND	1.66
18	1,3-Dichlorobenzene	ND	ND	ND
19	1,3-Dichloropropane	ND	ND	ND
20	1,4-Dichlorobenzene	3.79	0.80	0.38
21	1-Chloro-2-Methylbenzene	ND	ND	ND
22	1-Chloro-4-Methylbenzene	ND	ND	ND
23	2-Butanone	ND	1.03	ND
24	2-Hexanone	ND	ND	ND
25	2-Propanone	0.76	1.52	ND
26	4-Methyl-2-Pentanone	ND	0.30	ND
27	Benzene	ND	0.79	0.19
28	Bromobenzene	ND	ND	ND
29	Bromodichloromethane	3.25	2.28	0.38
30	Bromoform	ND	ND	ND
31	Bromomethane	ND	ND	ND
32	Carbon Disulfide	ND	ND	ND
33	Carbon Tetrachloride	ND	0.15	ND
34	Chlorobenzene	ND	ND	ND
35	Chloroethane	ND	ND	ND
36	Chloroform	10.65	20.65	3.04
37	Chloromethane	ND	ND	ND
38	cis-1,2-Dichloroethylene	ND	0.37	ND
39	cis-1,3-Dichloropropylene	ND	ND	ND
40	Dibromomethane	ND	ND	ND
41	Dibromochloromethane	0.47	0.17	ND
42	Dichlorodifluoromethane	0.90	1.74	ND
43	Ethyl Acetate	ND	ND	ND
44	Ethylbenzene	ND	0.95	28.99
45	Ethylene Dibromide	ND	ND	ND

	Compound	Secondary Clarifiers Emission Rates [µg/sec]	Primary Clarifiers Emission Rates [µg/sec]	Scrubber Outlet Emissions Rates [µg/sec]
46	Hexachlorobutadiene	ND	ND	ND
47	Iodomethane	ND	ND	ND
48	Isopropylbenzene	ND	0.15	ND
49	m&p-Xylene	0.27	3.04	82.83
50	Methylene chloride	0.45	0.63	0.76
51	Napthalene	ND	ND	ND
52	n-Butylbenzene	ND	ND	ND
53	n-Propylbenzene	ND	ND	2.14
54	o-Xylene	ND	1.03	37.27
55	p-Isopropyltoulene	ND	ND	ND
56	scc-Butylbenzene	ND	ND	ND
57	Styrene	ND	0.15	1.45
58	tert-Butylbenzene	ND	ND	ND
59	Tetrachloroethene	1.10	1.20	0.37
60	Toluene	2.17	6.63	5.38
61	trans-1,2-Dichloroethene	ND	ND	ND
62	trans-1,2-Dichloroethylene	ND	ND	ND
63	trans-1,3-Dichloropropylene	ND	ND	ND
64	Trichloroethylene	ND	0.13	ND
65	Trichlorofluoromethane	ND	ND	ND
66	Vinyl Acetate	ND	ND	ND
67	Vinyl Chloride	ND	ND	ND