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KYLEMORE ROAD
DUBLIN 12
TEL +353-1-450 4922
FAX +353-1-450 4929

THE MODELLING OF PROCESS EMISSIONS FROM ATLAS OILS LTD

FOR:

ATLAS OILS LTD,
CLONMINAM INDUSTRIAL ESTATE,
PORTLAOISE,
COUNTY LAOIS.

Report prepared by: **Edward Porter,** B.Sc.,P.hD., GRSC
Senior Environmental Consultant

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1.0 BRIEF FOR CONSULTANCY

1.1 NES have been commissioned by Martin Hogan (Technical & Environmental Manager, Atlas Oil Ltd) to carry out the modelling of process emissions from the processing plant in Portlaoise, Co. Laois. The modelling has been requested by the Environmental Protection Agency as part of Atlas Oils's Integrated Pollution Control Licence Application (IPCLA). The prediction of ground level concentrations (GLC's) as 98th & 99thpercentiles of hourly values and annual averages has been carried out and comparisons made with the TA Luft Imission limits, Danish C-values and other relevant standards, where appropriate.

The following report details the dispersion modelling study undertaken to identify the ground level concentration (GLC) of pollutants emitted from the site and assesses the impact of these pollutants on the surrounding environment.

2.0 EXECUTIVE SUMMARY

2.1 Dispersion modelling was carried out using the United States Environmental Protection Agency approved AERMOD model. Modelling and a subsequent impact assessment was undertaken for a range of substances released to atmosphere from the site.

2.2 Assessment Summary

2.2.1 Ground level concentrations (GLCs) of toluene and ethylbenzene have been predicted to be below the Danish C-value (expressed as a 99^{th} %ile of hourly values) using both recently collected monitoring data (typical operation) and assuming emissions at the TA emission limit. Furthermore, GLCs of Total VOC (as C) at the TA Luft Class III emission limit are predicted not to exceed the TA Luft Immission limit for Class III Organics (expressed as a 98^{th} %ile).

2.2.2 Ground level concentrations of benzene have been predicted to exceed the Danish C-value using recently collected monitoring data. Typical operation exceeds the 99%ile immission limit by 100% while emissions at the TA Luft limit exceed the 99%ile immission limit for benzene by 65%.

2.2.3 Ground level concentrations of xylene from typical operation of the site and at the TA Luft limit are predicted to exceed the Danish C-values (expressed as a 99^{th} %ile) by a factor of 10 and 0.6, respectively.

2.2.4 Ground level concentrations of Total VOC (as C) from typical operation of the site are predicted to exceed the TA Luft Immission limit for Class III Organics (expressed as a 98^{th} %ile) by a factor of 10.

EDWARD PORTER	**FERGAL CALLAGHAN**
Senior Environmental Consultant	Environmental Manager

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3.0 INTRODUCTION

3.1 Process Details

Atlas Oil Ltd are a hazardous waste management and environmental services company, providing a range of services to industry and the public sector in Ireland. Atlas Oil collects all types of mineral oils, oily wastes, oily wastewaters, interceptor and tank-cleaning wastes from garages, industries and ships. After collection, the oily waste is segregated in receiving tanks. Once the waste is accepted, it is characterised by plant and laboratory personnel. Wastes that are not deemed treatable (such as PCB contaminated wastes) are returned to customers or arrangements made for proper treatment/disposal or recovery.

Once segregated and characterised, the wastes are pumped to the tank farm where like mixtures are accumulated to be treated similarly. The mixtures are heated to effect gravity separation of water. The oil is then pumped to process where Quality Control analysis determines the optimum processing conditions. Thereafter, the oil is pumped to the process room through a vibrating screen and filter and on to the centrifuge to remove sediments. A range of qualitative and quantitative tests are performed at varying stages of the whole cycle to help characterise the in-process mixtures and determine the most efficient processing conditions. If water content is beyond specification after processing then the oils may be dried by heating to atmosphere in jacketed vessels before blending. During the drying process, through stacks R24, R25 and R32, heating occurs leading to evaporation and potential VOC emissions to atmosphere. Blending is the last stage of the process where the product is finally manufactured according to strict specifications before shipment to the customer.

3.2 Modelling Approach

The United States Environmental Protection Agency (USEPA) approved AERMOD dispersion model has been used to predict the ground level concentrations (GLC) of compounds emitted from the principal emission sources on-site (R24, R25 & R32). To obtain all the meteorological information for use in the model, data collected from 1993-1997 from the Birr meteorological station has been incorporated into the modelling. Ground level concentrations have been predicted for every hour during the worst case year (1996). These are the most recent years for which such data is available without lengthy meteorological processing having to be carried out.

The modelling incorporated the following features:

- Receptors or locations spaced at 200m intervals on a 4km by 4km grid. GLC's were therefore predicted for distances up to 2km from the site. Boundary receptors were included, as where the closest residential receptors situated in Rowan Park and Oak Park.

- All on-site buildings and significant process structures were mapped into the computer to create a three dimensional visualisation of the site and its emission points. Buildings and process structures can influence the passage of airflow over the emission stacks and draw plumes down towards the ground (termed *building downwash*). The stacks themselves can influence airflow in the same way as buildings by causing low pressure regions behind them (termed *stack tip downwash*). Both building and stack tip downwash were incorporated into the modelling.

- Hourly-sequenced meteorological information. The most important parameters governing dispersion in the atmosphere are windspeed, wind-direction and the stability or turbulence of the atmosphere. These parameters along with the ambient temperature and inferred mixing heights for each hour during 1993-97 were included in the modelling.

- Source information. The source and emission data, including stack dimensions, gas volumes and emission temperatures have been incorporated into the model.

Emission concentrations of benzene, toluene, ethylbenzene, xylene and Total VOCs have been taken from monitoring data collected by NES during June/July 1999. During the monitoring survey, emissions were monitored from stacks R24, R25 and R32 which are used in the drying stage of the process. The measured concentrations have been reported in NES report reference 330964/AR01(1). During sampling, optimum thermal treatment of waste oil was not in operation in tanks R 24 and R 25 leading to very low mass flows in the stack. R 32, however, was fully operational. As a result, in all modelling scenarios, the velocity, concentration and mass flow rate measured in stack R32 has also been applied to stacks R24 and R25.

The following are the contents of each blowing tank at the time of sampling:

DATE	STACK	TANK CONTENTS
22/6/99	R 24	66,000 litres of ship oil at 3.5% water.
22/6/99	R 25	66,000 litres of garage oil at 1% water.
21/7/99	R 32	60,000 litres of ship oil at 21% water.

Ship oil is a combination of derv and /or gas oil and /or kerosene and heavy fuel oil. Garage oil is a combination of any type of lubricating oils.

Emission concentrations have also been predicted based on the TA Luft emission limits outlined in TA Luft "Technical Instructions on Air Quality Control (1986)". No IPC Licence limits have been determined nor any recommended emission levels given in the relevant BATNEEC Guidance Note. Therefore, no reference has been made to either of these typical sources of emission limits in the present study.

The topography of the surrounding land is relatively flat, and therefore, terrain elevations have not been included in the modelling. Background concentrations have not been considered in the report. The AERMOD model is described in further detail in ***Appendix 1***.

4.0 VOC MODELLING AND RESULTS

4.1 Sources of Volatile Organic Compounds (VOCs)

Emissions of volatile organic compounds used in the process are extracted to emission release points R24, R25 and R32 on-site before being released to atmosphere. The ground level concentrations of benzene, toluene, ethylbenzene, xylene and Total VOC emitted from the stacks have been predicted by dispersion modelling. The modelling has focused on identifying the ground level concentration of each of these compounds based on monitored data and at the TA Luft emission limit for each compound.

VOC emission rates under normal operation have been calculated from the monitoring survey carried out by NES in June/July 1999 (330964/AR01(0)). The monitoring data showed that emissions were within the limits outlined in TA Luft "Technical Instructions on Air Quality Control (1986)" with the exception of benzene emissions from R32 which exceeds the 5 mg/m^3 limit for a Class III carcinogens by 45%, xylene emissions from R32 which exceeds the 100 mg/m^3 limit for a Class II organics by 560% and Total VOC (as C) which exceeds the TA Luft Class III Emission Limit by a large margin.

4.2 Source Information

Source information including emission release heights, volume flows, locations and stack diameters has been taken from the NES report 330964/AR01(1) and from the Ordnance Survey map in which the site is situated. This information has also been summarised in ***Appendix II*** of this report.

4.3 Variation of Emissions with Time of Day

Atlas Oil's working day is from 7am-12 midnight five days per week (Monday-Friday) and from 7am-7pm Saturday. However, in the input to the model it was assumed that operations were 24 hours/day, seven days per week leading to worst-case conditions.

4.4 Comparison With Standards and Guidelines

No statutory air quality standards for benzene, toluene, ethylbenzene, xylene or Total VOC exist in Irish legislation. In the absence of statutory standards, it is common practice to reference other suitable authorities such as the World Health Organisation (WHO), the Danish EPA or derive an ambient air quality guideline from Occupational Exposure Limits (OEL).

The EU has recently published a proposed Council Directive relating to ground level concentrations of benzene in ambient air (COM(1998) 591 Final – 98/0333 (SYN)). The document proposes an annual benzene limit value, in ambient air, of 5 $\mu g/m^3$. Compounds have also been compared against the Danish C-values as outlined in the Danish EPA's "Industrial Air Pollution Control Guidelines (1992)". The C-values are based on 99%ile hourly ground level concentrations. The Danish EPA has set an air quality standard for benzene, toluene, ethylbenzene and xylene. The standards are shown in ***Table 4.4.1***, along with the other relevant standards for these compounds.

Compounds have been compared against the TA Luft Immission Standard for Class II compounds of 200$\mu g/m^3$ and for Class III compounds of 1000$\mu g/m^3$. This is based on the 'S' values used in the TA Luft stack height determination procedure. Class III includes the contribution from Class II & Class I compounds.

Substances	Time-weighted Average	Averaging Time	Statutory Body
Benzene	(a)	-	WHO[b]
Benzene	5 ppb	Running annual mean	UK NAQSO[c]
Benzene	5 $\mu g/m^3$	Annual average	EU[d]
Ethylbenzene	10.9 mg/m^3	1 hour	NAOSH[e]
Toluene	0.26 mg/m^3	1 week	WHO[b]
Xylene	10.9 mg/m^3	1 hour	NAOSH[e]
Total VOCs	240 ppb	3 hour	UK NAQSO[c]
Benzene	5 $\mu g/m^3$	1 hour	Danish EPA[f]
Ethylbenzene	500 $\mu g/m^3$	1 hour	Danish EPA[f]
Toluene	400 $\mu g/m^3$	1 hour	Danish EPA[f]
Xylene	100 $\mu g/m^3$	1 hour	Danish EPA[f]
Class III Carcinogens	10 $\mu g/m^3$	1 hour	TA Luft[g]
Class II Organics	200 $\mu g/m^3$	1 hour	TA Luft[g]
Class III Organics	1000 $\mu g/m^3$	1 hour	TA Luft[g]

(a) No safe level recommended owing to carcinogenicity.

(b) World Health Organisation Air Quality Guidelines For Europe 1996.

(c) UK National Air Quality Standards & Objectives.

(d) Proposed EU Council Directive COM(1998) 591 Final – 98/0333 (SYN).

(e) National Authority For Occupational Safety & Health / 40 = Environmental Assessment Level (EAL).

(f) Danish EPA, Industrial Air Pollution Control Guidelines, 1992. C-Values expressed as a 99%ile.

(g) TA Luft "Technical Instructions on Air Quality Control" (1996).

Table 4.4.1. Air Quality Guidelines.

4.5 TA LUFT CLASS III CARCINOGEN EMISSIONS AND RESULTS

Modelling of Benzene Emissions

Summary : VOC Modelling

- Ground level concentrations of benzene have been modelled using air dispersion modelling. Results have been compared against international air quality standards.
- Ground level concentrations of benzene have been predicted to exceed the Danish C-value using recently collected monitoring data. Typical operation exceeds the 99%ile immission limit by 100% while emissions at the TA Luft limit exceed the 99%ile immission limit for benzene by 65%.
- However, GLC of benzene have been predicted to be below both the TA Luft Immission limit for Class III Carcinogens (as a 98th%ile) and the EU ambient air quality standard as an annual average.

The measured concentrations of benzene determined by NES in June/July 1999 have been modelled to represent typical operation of the site. The source information for each modelled scenario has been summarised in ***Table 4.5.1***.

Model Scenario	Reason For Modelling	No of Stacks Emitting Benzene	Flow Rate	Emission Concentration	Benzene Emission Rate (g/hr)
1	Typical Operation	3	Measured	Measured Concentrations	78
2	Regulatory Limits	3	Measured	Class III Carcinogen - 5 mg/Nm^3	53
All Scenarios : Emission Temperature				Measured (87°C)	

Table 4.5.1 Summary Of Source Information (Benzene)

Modelling was carried out for the two scenarios described in ***Table 4.5.1***.

4.5.1 Result Findings

Table 4.5.2 details the predicted benzene GLC for the emission concentrations measured by NES and that predicted if all stacks emitted at the TA Luft emission limit of 5 mg/m^3.

Model Scenario	Reason For Modelling	No of Stacks Emitting Benzene	Flow Rate	Emission Concentration	98th %ile GLC (µg/m³)	99th %ile GLC (µg/m³)	Annual Average (µg/m³)
1	Typical Operation	3	Measured	Measured Concentrations	10.3	12.1	1.86
2	TA Luft Limit	3	Measured	Class III Carcinogen at 5 mg/Nm³	7.1	8.4	0.94
Relevant Standard					TA Luft: 10.0 µg/m³	C-value: 5.0 µg/ m³	Proposed EU: 5.0 µg/m³

All concentrations in µg/m³ unless stated otherwise

Table 4:5.2 Predicted Benzene Concentrations (µg/m³)

The 98th percentile of hourly benzene concentrations during typical operations and measured flow conditions is predicted to be 10.3 µg/m³. This concentration is similar to the TA Luft Immission S-value threshold for benzene of 10.0 µg/m³. The 98th percentile benzene concentration at the TA Luft emission limit from the plant and measured flow conditions is predicted to be 7.1 µg/m³. This concentration is below the TA Luft Immission S-value threshold for benzene of 10.0 µg/m³.

The 99th percentile of hourly benzene concentrations during typical operations and measured flow conditions is predicted to be 12.1 µg/m³. This concentration exceeds the Danish EPA's C-value threshold for benzene of 5.0 µg/m³ by 140%. The 99th percentile benzene concentration at the TA Luft emission limit from the plant and measured flow conditions is predicted to be 8.4 µg/m³. This concentration also exceeds the Danish EPA's C-value threshold for benzene of 5.0 µg/m³, this time by 65%.

The annual average benzene concentration during typical operation of the plant and measured flow conditions is predicted to be 1.9 µg/m³ while the annual average benzene concentration at the TA Luft emission limit is predicted to be 0.9 µg/m³. These concentrations are below the 5 µg/m³ proposed EU limit value for this compound. No exceedances of this threshold concentration are therefore predicted to occur under these conditions.

The nearest residential receptors to the Atlas Oil site are located at Rowan Park and Oak Park. The maximum one hour GLC at these receptors are outlined in

Table 4.5.3 and are compared with the Danish C-values which are, however, expressed as a 99th%ile. However, the data indicates that, under both conditions, exceedences of the Danish standard is likely.

Model Scenario	Reason For Modelling	No of Stacks Emitting Benzene	Emission Concentration	Maximum 1-Hour GLC (µg /m³) At Nearest Residential Receptor
1	Typical Operation	3	Measured Concentrations	12.1
2	TA Luft Limit	3	Class III Carcinogen at 5 mg/Nm³	8.4
Relevant Standard				C-value (as a 99th%ile): 5.0 µg/ m³

All concentrations in µg/m³ unless stated otherwise

Table 4:5.2 Maximum predicted Benzene Concentrations (µg/m³) At Nearest Residential Receptor.

NeS

4.5.2 Concentration Contours

The geographical variation in benzene ground level concentrations beyond the site boundary are illustrated as concentration contours in ***Figure 4:1*** to ***Figure 4:4***. The contents of each figure are described below:

Figure 4:1 Predicted Benzene 99th Percentile Concentration For Typical Operation

Figure 4:2 Predicted Benzene 99th Percentile Concentration At The Regulatory Limit

Figure 4:3 Predicted Benzene Annual Average Concentration For Typical Operation

Figure 4:4 Predicted Benzene Annual Average Concentration At The Regulatory Limit

The concentrations listed in ***Table 4.5.2*** are for the 99th %ile and annual average concentrations to be predicted at any location beyond the site boundary. All other locations are below these values. The concentration contours show where the maximum concentrations are predicted to occur and the reduction in concentration with distance away from the maxima.

The peak concentrations are observed either near the site boundary or slightly to the east or north east of the site. This is primarily due to the direction of the prevailing wind, influence of buildings on plume dispersion (building downwash) and the ambient release temperature of the emission.

Figure 4.1: Predicted Benzene 99th Percentile Concentration (microg/m3) For Typical Operation

Figure 4.2: Predicted Benzene 99th Percentile Concentration (microg/m3) At The TA Luft Limit

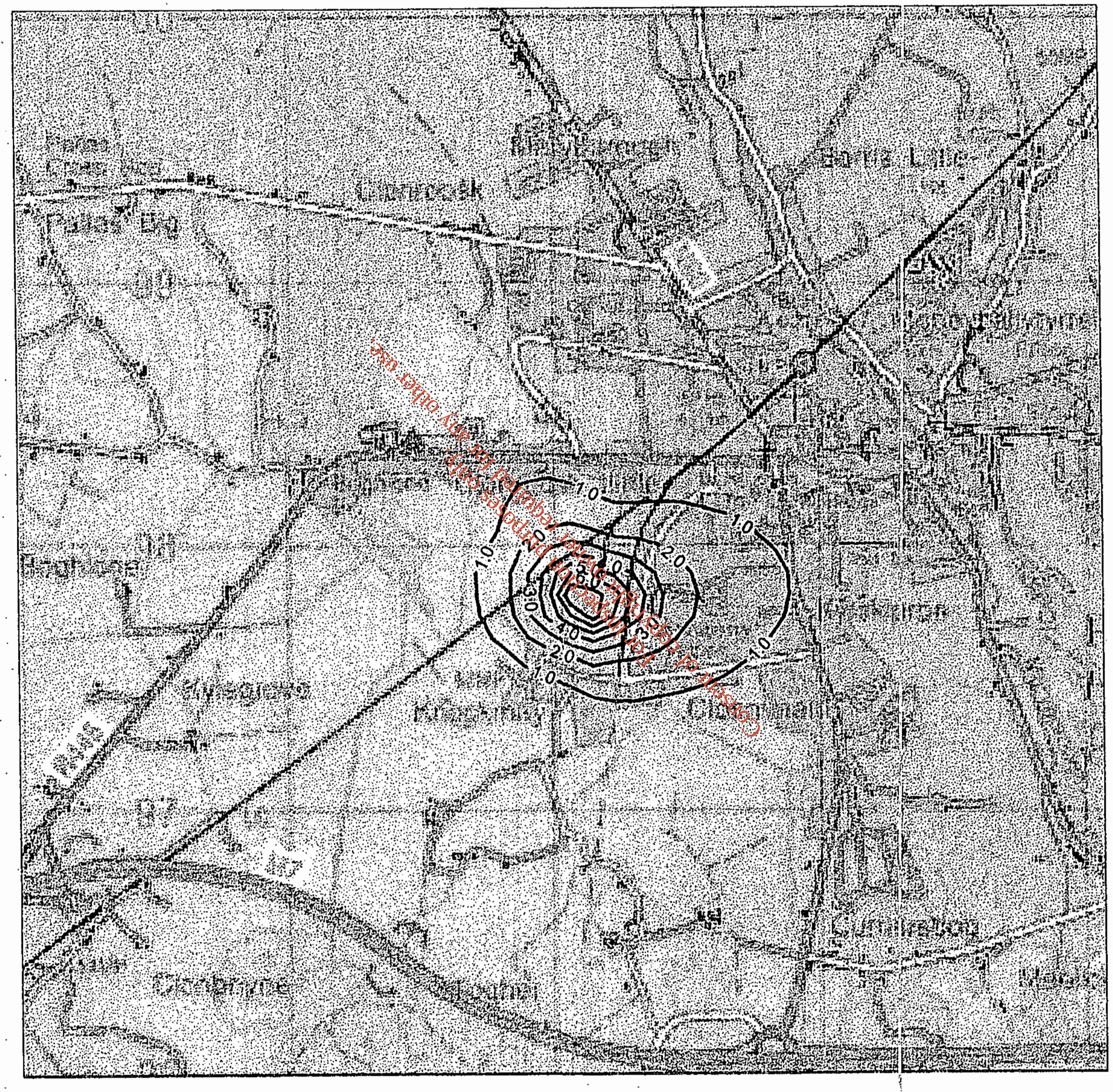


Figure 4.3: Predicted Benzene Annual Average Concentration (microg/m3) For Typical Operation

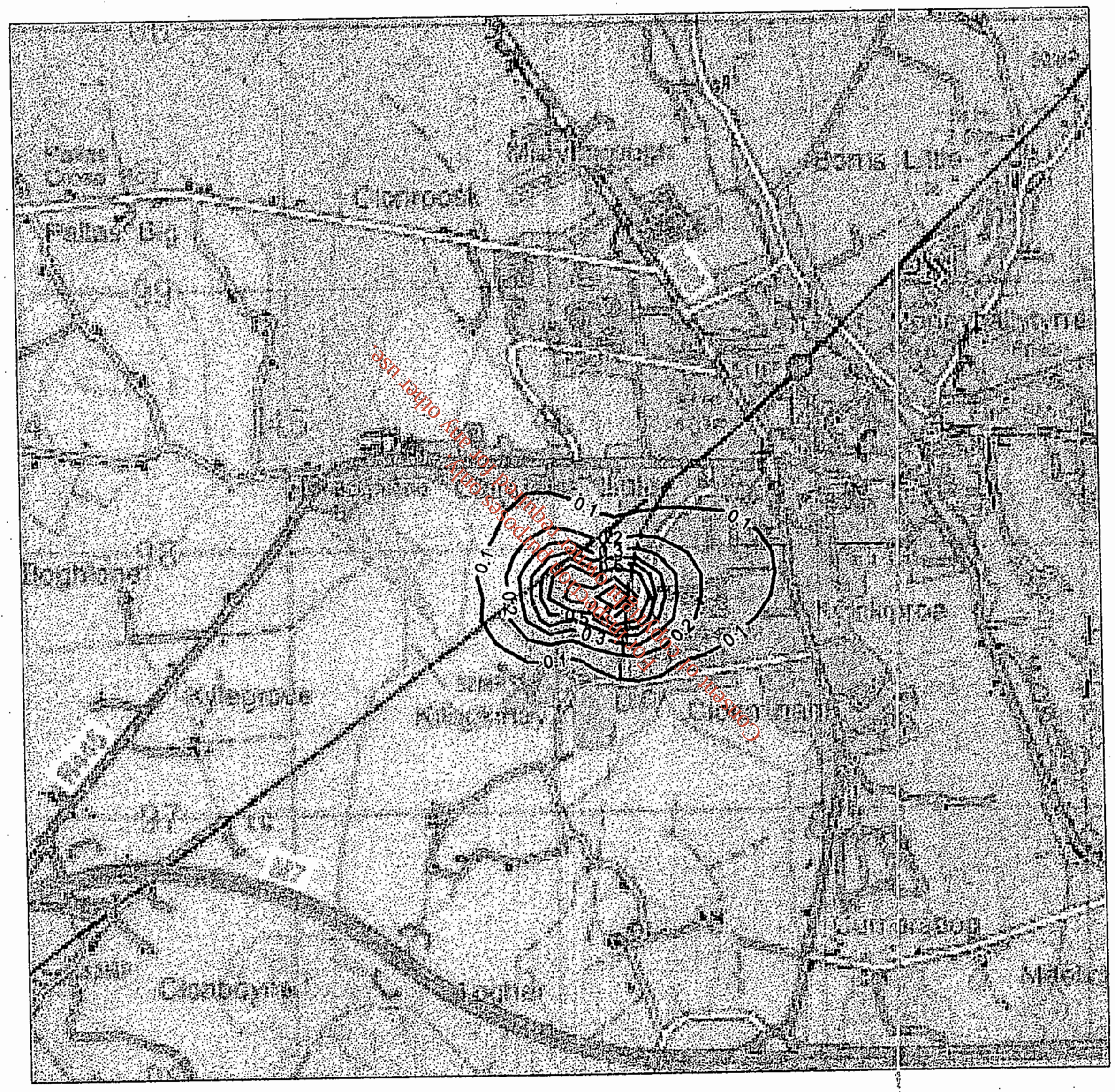
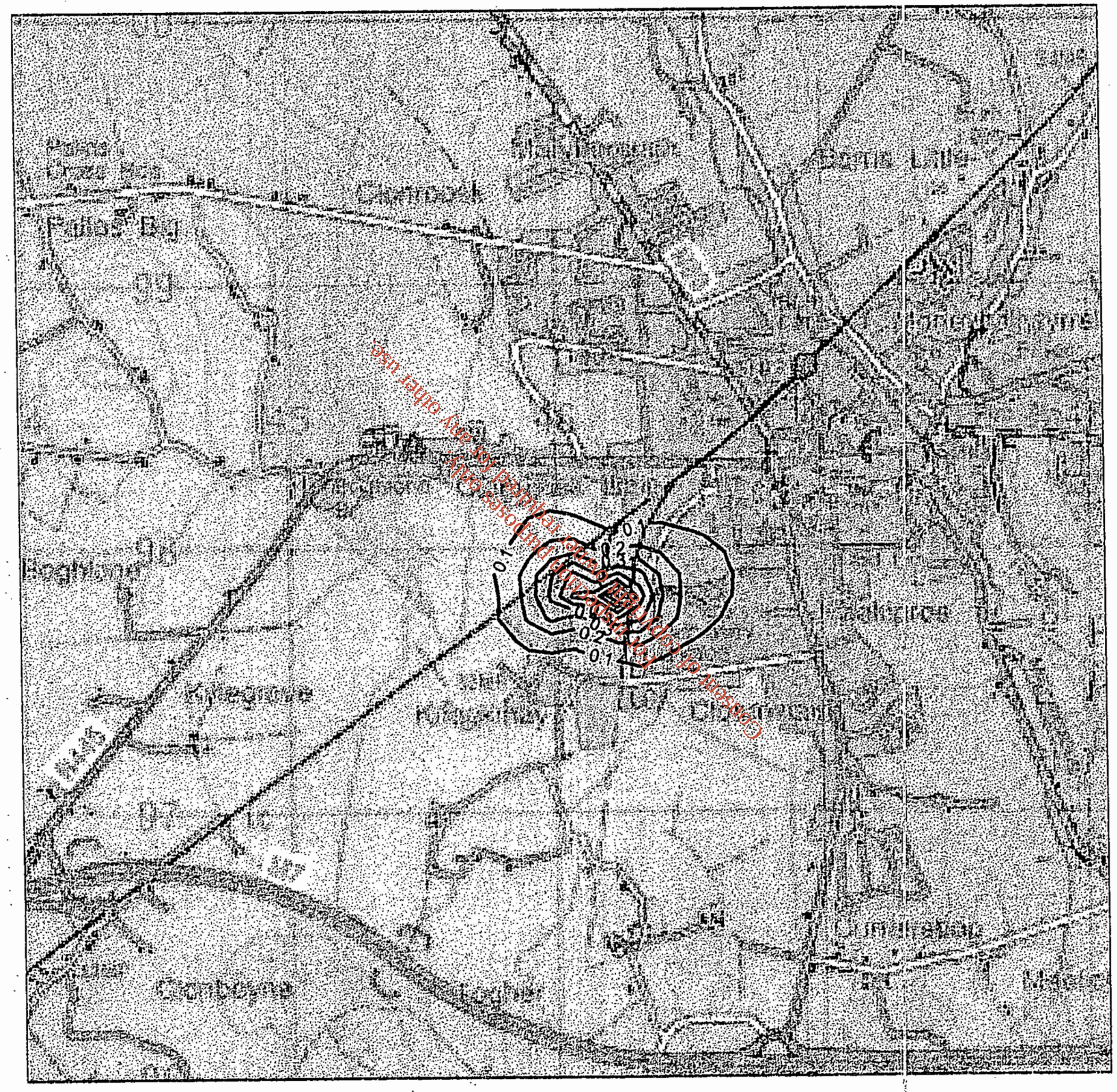


Figure 4.4: Predicted Benzene Annual Average Concentration (microg/m3) At The TA Luft Limit



4.5.3 Summary

4.5.3.1 Ground level concentrations of benzene have been modelled using dispersion modelling. Results have been compared against international air quality standards.

4.5.3.2 Ground level concentrations of benzene have been predicted to exceed the Danish C-value using recently collected monitoring data. Typical operation exceeds the 99%ile immission limit by 100% while emissions at the TA Luft limit exceed the 99%ile immission limit for benzene by 65%.

4.5.3.3 However, GLC of benzene have been predicted to be below both the TA Luft Immission limit for Class III Carcinogens (as a 98th%ile) and the EU ambient air quality standard as an annual average.

4.6 TA LUFT CLASS II ORGANIC EMISSIONS AND RESULTS

Modelling of Class II Organics Emissions

Summary : Class II Organics Modelling

- Ground level concentrations of organics have been modelled to assess their impact on ambient air quality. Results have been compared against the Danish C-values, TA Luft immission guidelines and appropriate guidelines for individual organic species.

- Emissions from the site have been modelled based on measured emissions and assuming that organic compounds are emitted at the TA Luft emission limits.

- Ground level concentrations of xylene from typical operation of the site and at the TA Luft limit are predicted to exceed the Danish C-values (expressed as a 99th %ile) by a factor of 10 and 0.6, respectively. GLC's of both toluene and ethylbenzene from typical operation of the site and at the TA luft limit are predicted not to exceed the Danish C-values (expressed as a 99th %ile).

- Ground level concentrations of Total VOC (as C) from typical operation of the site are predicted to exceed the TA Luft Immission limit for Class III Organics (expressed as a 98th %ile) by a factor of 10. GLC's of Total VOC (as C) at the TA Luft Class III emission limit are predicted not to exceed the TA Luft Immission limit for Class III Organics.

4.6.1 Sources of Class II Organics

In the absence of the IPC Licence, it is common practice to reference TA Luft emission limits for each release point. Using TA Luft guidelines, each stack must not release more than the organic concentrations described in ***Table 4.6.1.***

TA Luft Class	Emission Limit (mg/m^3 at ntp)
Classes I and II taken together	100$^{(1)}$
Classes III, II and I taken together	150$^{(2)}$

Note: ntp -Normal temperature and pressure, 273K 101.3kPa.
(1): At a mass flow of 2 kg/hr or more.
(2): At a mass flow of 3 kg/hr or more.

Table 4.6.1 TA Luft Organic Emission Limits

The compounds which have been identified in the emissions and the assigned TA Luft Class for that compound are summarised in ***Table 4.6.2.***

Organic Compound	TA Luft Class
Toluene	II
Ethylbenzene	II
Xylene	II
Total VOC	I, II & III

Table 4.6.2 Composition of Principal Organic Emissions

The source information for each scenario modelled has been summarised in ***Table 4.6.3.***

Model Scenario	Reason For Modelling	No of Stacks Emitting Organics	Flow Rate	Emission Concentration	Total Organic Emission Rate (g/sec as C)
1	Typical Operation	3	Measured	Measured Concentrations	75980
2	Regulatory Limits	3	Measured	Classes III at 150mg/Nm^3	1590
All Scenarios : Emission Temperature				Measured: 87°C	

Table 4.6.3 Summary Of Source Information

Compounds have been compared against the TA Luft Immission Standard for Class II compounds of 200µg/m^3 and for Class III compounds of 1000µg/m^3. This is based on the 'S' values used in the TA Luft stack height determination procedure. Class III includes the contribution from Class II & Class I compounds.

4.6.2 Modelling Results

Modelling was carried out for the two scenarios described in ***Table 4.6.3***. The predicted ground level concentrations (GLC) for total organic compounds and individual compounds have been predicted beyond the site boundary under both typical operation and at the TA Luft emission limit. The results have been presented as 98th percentile and 99th percentile concentrations of hourly values which are the concentrations that are not exceeded for 98 and 99 percent of the time respectively.

Under Typical Operation

Individual Organics

Table 4.6.4 details the 99%ile GLCs predicted under typical operation from emission levels measured by NES for each individual VOC. The results have been compared against the appropriate C-value as defined by the Danish EPA for the individual compound.

Compound	Danish C-value ($\mu g/m^3$)	Predicted 99th %ile GLC at typical emission ($\mu g/m^3$)	%age of Danish C-value
Toluene	400	210	53
Ethylbenzene	500	64	13
Xylene	100	1087	1087

Table 4.6.4 Modelling of Predicted 99%ile GLCs Under Typical Operation For Individual Compounds.

Table 4.6.4 illustrates that, with the exception of xylene, relatively low GLC's are predicted to occur during typical operation from the site.

Ground level concentrations of xylene from typical operation of the site are predicted to exceed the Danish C-values (expressed as a 99 percentile) by a factor of 10. GLC's of both toluene and ethylbenzene, from typical operation of the site, are predicted not to exceed the Danish C-values (expressed as a 99 percentile).

The ground level concentrations for toluene, ethylbenzene, and xylene, under typical operation, are illustrated as 99th percentile concentration contours in **Figures 4.5** to **Figure 4.7**.

Total VOCs

Table 4.6.5 details the 98th and 99th percentile concentrations predicted for measured emissions from the stacks. The table illustrates the predicted GLCs under typical operation of the site with the results compared against the TA Luft Class II Imission Standard (200.0 μg C/m³) and Class III Imission Standard (1000.0 μg C/m³), both measured as a 98th %ile of hourly values.

The results are presented as micrograms of carbon per cubic metre (μg C/m³).

Compound	98th percentile GLC (μg C/m³)	99th Percentile GLC (μg C/m³)	% of Class III S Value Ambient Concentration (98th percentile)
Total VOC (as C)	10035	11788	1000

Table 4.6.5 Predicted Maximum Organic Compound GLCs Under Typical Operation of the Site.

Table 4.6.5 illustrates that the TA Luft Imission Limits for Total VOC (as C), under typical operation, are predicted to be exceeded by a factor of 10 when compared to the Class III Organic limit (which also encompasses Class I and II).

The ground level concentrations for Total VOC (as C) under typical operation are illustrated as 98th percentile concentration contours in ***Figure 4.9***.

Operating at the Regulatory Limits

Individual Organics

Table 4.6.6 details the 99%ile GLCs predicted at the TA Luft emission limit assuming that each individual VOC, in turn, is solely emitting at the Class II limit ($100mg/Nm^3$). The results have been compared against the appropriate ground level concentration C-value as defined by the Danish EPA for the individual compound.

Compound	Danish C-value ($\mu g/m^3$)	Predicted GLC At typical emission concentrations ($\mu g/m^3$)	%age of Danish C-value
Toluene	400	165	40
Ethylbenzene	500	165	33
Xylene	100	165	165

Table 4.6.6 Modelling of Predicted 99th%ile GLCs At The Regulatory Limit For Individual Compounds.

Table 4.6.6 illustrates that ground level concentration of xylene is predicted to exceed the Danish C-value (expressed as a 99th%ile) of hourly values assuming the compound is emitting at the TA Luft Class II emission limit of $100mg/Nm^3$. GLC's of toluene and ethylbenzene at the TA Luft Class II emission limit are predicted not to exceed the Danish C-values (expressed as a 99th%ile).

The ground level concentrations for toulene at the regulatory limit are illustrated as 99th%ile concentration contours in ***Figures 4.8***. The same contour pattern may be applied to ethylbenzene and xylene, assuming that each compound is, in turn, emitting at the TA Luft Class II limit. This, however, is a worst case scenario as the emissions will be, most likely, composed of a mixture of compounds of Class II type.

Total Organics

The ambient GLCs of Total VOC (as C) has been modelled assuming each stack is emitting at the maximum concentration permitted for TA Luft Class III concentrations (150mg/Nm^3) (including Class I and Class II compounds).

TA Luft Class	98th percentile GLC (µg C/m^3)	99th Percentile GLC (µg C/m^3)	% of Class III S Value Ambient Concentration (98th percentile)
Class III (as C)	210	247	21

Table 4.6.7: Predicted 98th and 99th Percentile Total VOC (as C) GLCs With Each Stack Emitting at the TA Luft Class III Emission Limit.

Table 4.6.7 shows that when all stacks are emitting Class III compounds at the maximum emission limit, the ground level concentrations will be lower than the TA Luft Imission Limit value (as a 98th percentile) for Class III Organics (1000.0 µg C/m^3.

The ground level concentrations for Total Class III organics compounds, at the maximum emission limit, are illustrated as 98th percentile concentration contours in ***Figure 4.10***.

4.6.3 Concentration Contours

The geographical variation in organic ground level concentrations beyond the site boundary are illustrated as concentration contours in **Figures 4:5** to **Figure 4:10**. The contents of each figure are described below:

Figure 4.5 Predicted Toluene 99th Percentile Concentration For Typical Operation

Figure 4.6 Predicted Ethylbenzene 99th Percentile Concentration For Typical Operation

Figure 4.7 Predicted Xylene 99th Percentile Concentration For Typical Operation

Figure 4.8 Predicted Toulene 99th Percentile Concentration At The TA Luft Class II Limit

Figure 4.9 Predicted Total Class II 98th Percentile Concentration For Typical Operation

Figure 4.10 Predicted Total Class II 98th Percentile Concentration At The TA Luft Class III Limit

The maximum concentrations predicted are for the highest 99th %ile and 98th %ile concentrations to be predicted at any location beyond the site boundary. All other locations are below these values. The concentration contours show where the maximum concentrations are predicted to occur and the reduction in concentration with distance away from the maxima.

The peak concentrations are observed either near the site boundary or slightly to the north-east of the site. This is primarily due to the direction of the prevailing wind, influence of buildings on plume dispersion (building downwash) and the ambient release temperature of the emission.

The nearest residential receptors to the Atlas Oil site are located at Rowan Park and Oak Park. The maximum one hour GLCs for both Xylene and Total VOC (as C) at these receptors are outlined in ***Table 4.6.8*** and are compared with the Danish C-values for xylene and the TA Luft Immission limit value for Class III Organics which are expressed as a 99th%ile & 98th%ile, respectively. However, the data indicates that, for both compounds, exceedences are likely at the nearest residential receptors, under typical operating conditions.

Model Scenario	Reason For Modelling	No of Stacks	Emission Concentration	Maximum 1-Hour GLC of Xylene ($\mu g/m^3$) At Nearest Residential Receptor	Maximum 1-Hour GLC of Total VOC (as C) ($\mu g/m^3$) At Nearest Residential Receptor
1	Typical Operation	3	Measured Concentrations	989	10727
2	TA Luft Limit	3	Class II Organic at 100 mg/Nm^3	150	224
Relevant Standard				C-value (as a 99th%ile): 100.0 $\mu g/m^3$	TA Luft Class III: 1000.0 $\mu g/m^3$

Table 4:6.8 Maximum predicted Benzene Concentrations ($\mu g/m^3$) At Nearest Residential Receptor.

Figure 4.5: Predicted Toluene 99th Percentile Concentrations (microg/m3) For Typical Operation

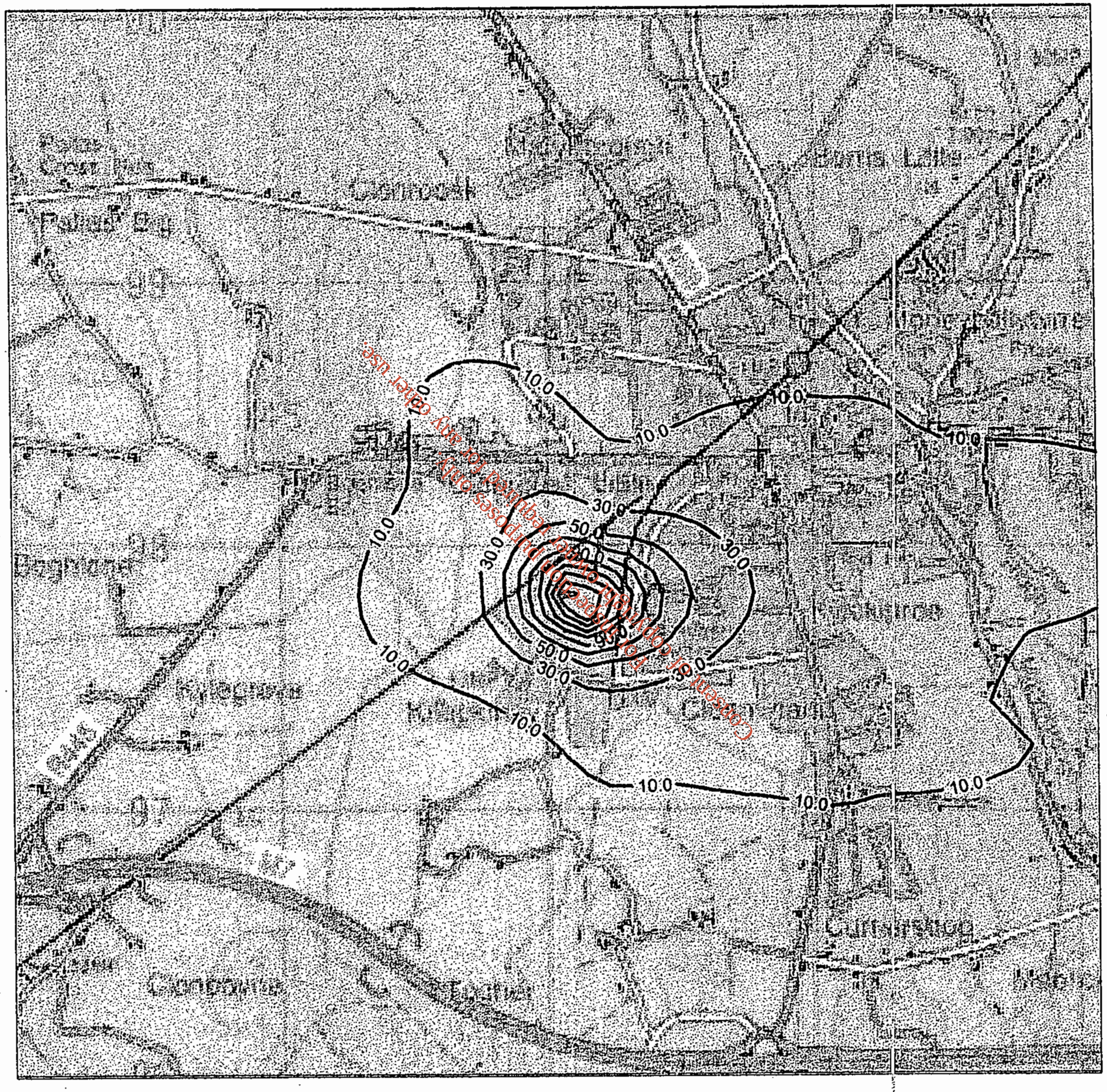


Figure 4.6: Predicted Ethylbenzene 99th Percentile Concentration (microg/m3) For Typical Operation

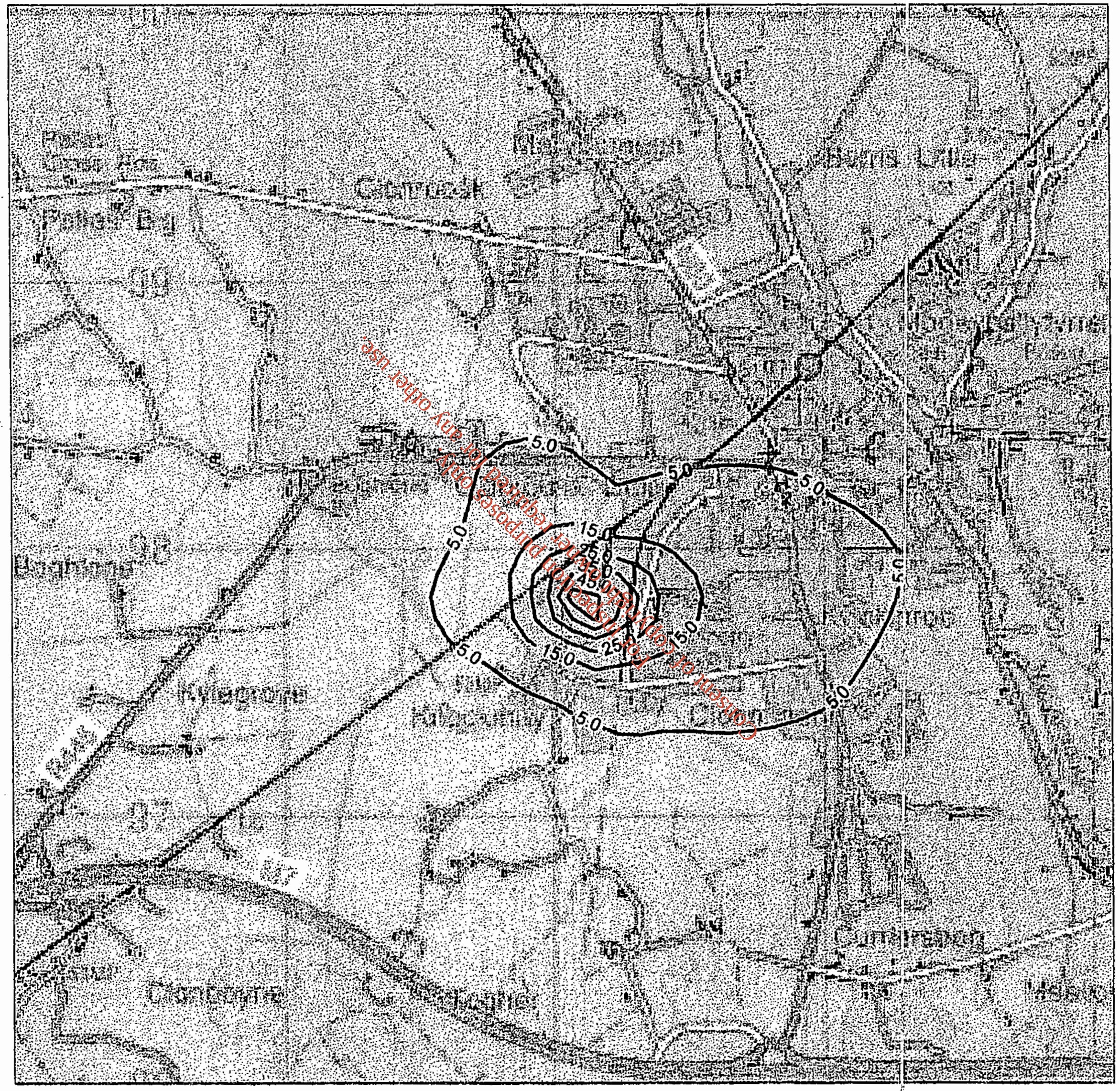


Figure 4.7: Predicted Xylene 99th Percentile Concentration (microg/m3) For Typical Operation

Figure 4.8: Predicted Toluene 99th Percentile Concentration (microg/m3) At The TA Luft Class II Limit

Figure 4.9: Predicted Total Class III 98th Percentile Concentration (microg/m3) For Typical Operation

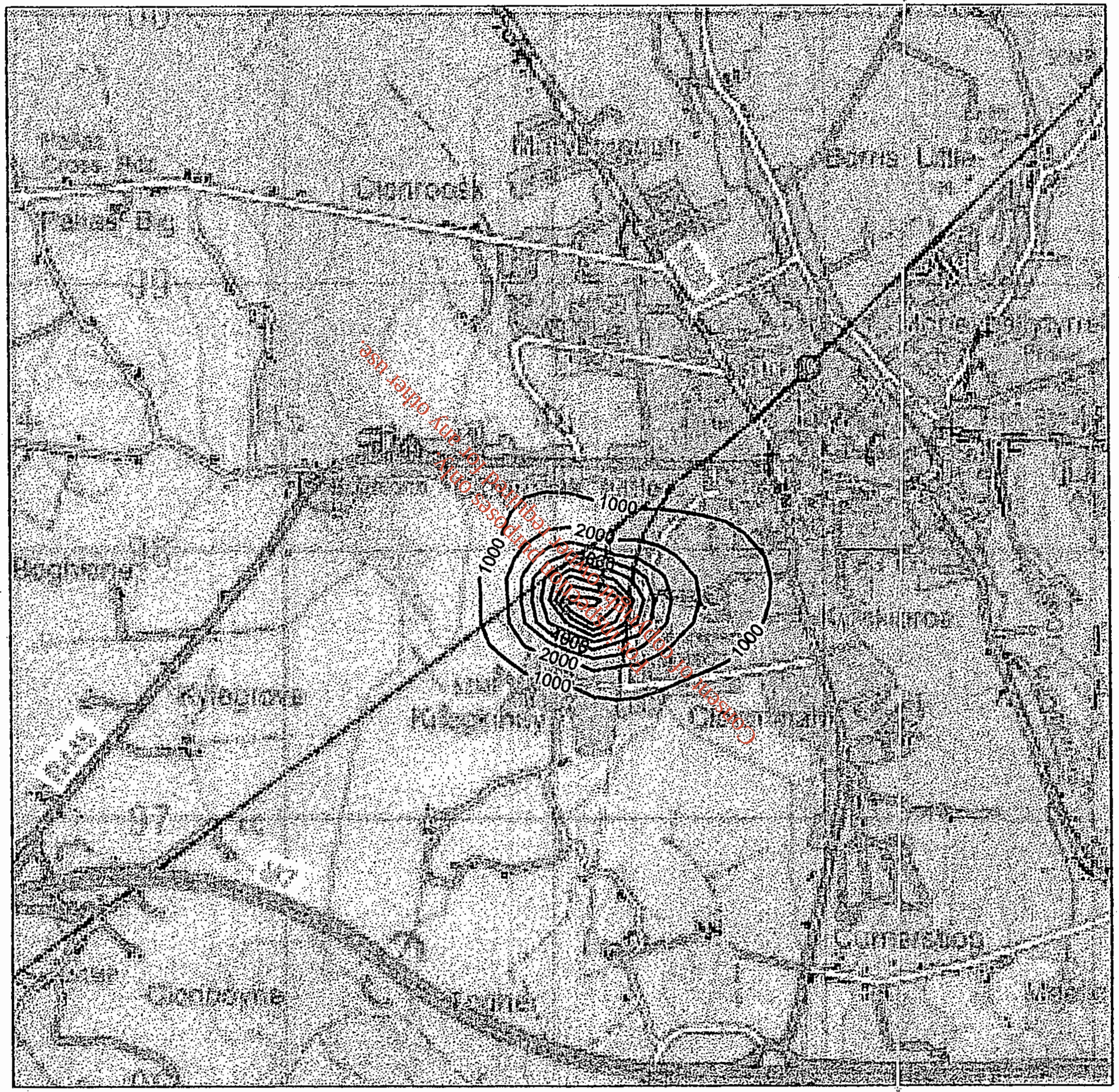


Figure 4.10: Predicted Total Class III 98th Percentile Concentration (microg/m3) At The TA Luft Class III Limit

4.6.5 Summary

4.6.5.1 Ground level concentrations of organics have been modelled to assess their impact on ambient air quality. Results have been compared against the Danish C-values, TA Luft immission guidelines and appropriate guidelines for individual organic species.

4.6.5.2 Emissions from the site have been modelled based on measured emissions and assuming that organic compounds are emitted at the TA Luft emission limits.

4.6.5.3 Ground level concentrations of xylene from typical operation of the site and at the TA Luft limit are predicted to exceed the Danish C-values (expressed as a 99^{th} %ile) by a factor of 10 and 0.6, respectively. GLC's of both toluene and ethylbenzene from typical operation of the site and at the TA luft limit are predicted not to exceed the Danish C-values (expressed as a 99^{th} %ile).

4.6.5.4 Ground level concentrations of Total VOC (as C) from typical operation of the site are predicted to exceed the TA Luft Immission limit for Class III Organics (expressed as a 98^{th} %ile) by a factor of 10. GLC's of Total VOC (as C) at the TA Luft Class III emission limit are predicted not to exceed the TA Luft Immission limit for Class III Organics

5.0 OVERALL SUMMARY OF EMISSIONS FROM ATLAS OIL LTD

5.1 Assessment Summary

5.1.1 Ground level concentrations (GLCs) of toluene and ethylbenzene have been predicted to be below the Danish C-value (expressed as a 99th %ile of hourly values) using both recently collected monitoring data and assuming emissions at the TA emission limit Furthermore, GLCs of Total VOC (as C) at the TA Luft Class III emission limit are predicted not to exceed the TA Luft Immission limit for Class III Organics (expressed as a 98th %ile).

5.1.2 Ground level concentrations of benzene have been predicted to exceed the Danish C-value using recently collected monitoring data. Typical operation exceeds the 99%ile immission limit by 100% while emissions at the TA Luft limit exceed the 99%ile immission limit for benzene by 65%.

5.1.3 Ground level concentrations of xylene from typical operation of the site and at the TA Luft limit are predicted to exceed the Danish C-values (expressed as a 99th %ile) by a factor of 10 and 0.8, respectively.

5.1.4 Ground level concentrations of Total VOC (as C) from typical operation of the site are predicted to exceed the TA Luft Immission limit for Class III Organics (expressed as a 98th %ile) by a factor of 10.

APPENDIX I

DESCRIPTION OF THE AERMOD MODEL

Emissions from Atlas Oils Ltd. factory have been modelled using the AERMOD dispersion model which has been developed, in part, by the U.S. Environmental Protection Agency (USEPA). The model is a steady-state Gaussian model used to assess pollutant concentrations associated with industrial sources. The model is an enhancement on the Industrial Source Complex-Short Term 3 (ISCST3) model which has been widely used for emissions from industrial sources.

AERMOD is a multi source model which can take into account the following:

- Source location
- Pollutant mass emission rates
- Emission heights, velocity and release temperatures
- Source, terrain and receptor elevations
- Building and on-site structure dimensions
- Variable emissions with hour of day, month and season
- Gravitational settling
- Pollutant decay and washout or deposition
- Generic or hourly sequenced meteorological data

The model builds up a 3 dimensional visualisation of the site and surrounding area to assess the impact of these factors on plume dispersion. Like many other models available, the AERMOD model predicts pollutant dispersion in two stages: plume rise and subsequent Guassian dispersion.

Plume Rise and Behaviour

The core of the plume rise equations use algorithms developed by Briggs (1969, 1971 and 1975). The height of the final plume rise is dependant on the prevailing windspeed, atmospheric stability and momentum and buoyancy associated with the plume. The plume is also influenced by stack tip and building downwash, the equations of which used in this study have been calculated by Briggs (1974) and Schulman Scrire (1980) and subsequently refined by the USEPA. Downwash is a function of the structure dimensions, windspeed, wind-direction and emission height.

The plume is assumed to rise initially due to momentum and buoyancy and gradually rise to its maximum height above ground level once the heat and subsequent buoyancy of the plume has equilibriated with the surrounding air. AERMOD has made substantial improvements in the area of plume growth rates. ISCST3 approximates turbulence using six Pasquill-Gifford-Turner Stability Classes and bases the resulting dispersion curves upon surface release experiments. This treatment, however, cannot explicitly account for turbulence in the formulation. AERMOD is based on the more realistic modern planetary boundary layer (PBL) theory which allows turbulence to vary with height. This use of turbulence-based plume growth with height leads to a substantial advancement over the ISCST3 treatment.

Guassian Dispersion

When the height of the plume has stabilised, the dispersion of pollutants is then based on Guassian dispersion horizontally and vertically from the plume centreline. A number of dispersion coefficients are available to the model. In this study rural dispersion coefficents as opposed to equations used in densely populated areas have been used.

Improvements over the ISCST3 model include the treatment of the vertical distribution of concentration within the plume. ISCST3 assumes a Gaussian distribution in both the horizontal and vertical direction under all weather conditions. AERMOD, however, treats the vertical distribution as non-Gaussian under convective (unstable) conditions while maintaining a Gaussian distribution in both the horizontal and vertical direction during stable conditions. This treatment reflects the fact that the plume is skewed upwards under convective conditions due to the greater intensity of turbulence above the plume than below. The result is a more accurate portrayal of actual conditions using the AERMOD model.

Improvements have also been made in relation to mixing height. The treatment of mixing height by ISCST3 is based on a single morning upper air sounding each day. AERMOD, however, calculates mixing height on an hourly basis based on the morning upper air sounding and the surface energy balance, accounting for the solar radiation, cloud cover, reflectivity of the ground and the latent heat due to evaporation from the ground cover. This more advanced formulation provides a more realistic sequence of the diurnal mixing height changes.

Model Outputs

AERMOD can calculate hourly, 2hr, 3hr, 4hr, 6hr, 8hr, 12hr, 24hr, monthly and period average ground level concentrations for selected meteorological periods. The concentrations can be presented in both tabular and graphical form (with a suitable support package). In conjunction with the PERCENTILE programme, percentiles for each averaging period can be calculated at each location investigated.

AERMOD has been extensively validated in field studies covering a range of both terrain options and averaging times. For all averaging times, in general, and in most terrain options, AERMOD's model performance was better than that of ISCST3. As a result of the advancements in the formulation and rigorous validation, a joint USEPA-AMS (American Meteorological Society) committee has recently recommended that AERMOD may be used as a replacement for ISCST3 for regulatory modelling applications.

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APPENDIX II

SOURCE DATA

Stack Reference	Stack Height (m)	Stack Location	Exit Diameter (m)	Cross-Sectional Area (m^2)	Temperature (°C)	Max Volume Flow (Nm^3/hr)	Exit Velocity (m/sec actual)	Concentration (mg/Nm^3)	Mass Emission (g/hr)
R24	10	Tank Farm	0.6	0.283	88	10600	13.8	7.3	78
R25	10	Tank Farm	0.6	0.283	88	10600	13.8	7.3	78
R32	10	Tank Farm	0.6	0.283	88	10600	13.8	7.3	78

Table A2.1: ***Source Emission Data For Emissions of Benzene***

Monitored Data Carried Out By NES, June-July 1999.

Stack Reference	Stack Height (m)	Stack Location	Exit Diameter (m)	Cross-Sectional Area (m^2)	Temperature (°C)	Max Volume Flow (Nm^3/hr)	Exit Velocity (m/sec actual)	Concentration (mg/Nm^3)	Mass Emission (g/hr)
R24	10	Tank Farm	0.6	0.283	88	10600	13.8	128	1350
R25	10	Tank Farm	0.6	0.283	88	10600	13.8	128	1350
R32	10	Tank Farm	0.6	0.283	88	10600	13.8	128	1350

Table A2.2: ***Source Emission Data For Emissions of Toluene***

Monitored Data Carried Out By NES, June-July 1999.

Stack Reference	Stack Height (m)	Stack Location	Exit Diameter (m)	Cross-Sectional Area (m^2)	Temperature (°C)	Max Volume Flow (Nm^3/hr)	Exit Velocity (m/sec actual)	Concentration (mg/Nm^3)	Mass Emission (g/hr)
R24	10	Tank Farm	0.6	0.283	88	10600	13.8	7170	75900
R25	10	Tank Farm	0.6	0.283	88	10600	13.8	7170	75900
R32	10	Tank Farm	0.6	0.283	88	10600	13.8	7170	75900

Table A2.5: ***Source Emission Data For Emissions of Total VOC***

Monitored Data Carried Out By NES, June-July 1999.

Stack Reference	Stack Height (m)	Stack Location	Exit Diameter (m)	Cross-Sectional Area (m^2)	Temperature (°C)	Max Volume Flow (Nm^3/hr)	Exit Velocity (m/sec actual)	Concentration (mg/Nm^3)	Mass Emission (g/hr)
R24	10	Tank Farm	0.6	0.283	88	10600	13.8	38.5	410
R25	10	Tank Farm	0.6	0.283	88	10600	13.8	38.5	410
R32	10	Tank Farm	0.6	0.283	88	10600	13.8	38.5	410

Table A2.3: Source Emission Data For Emissions of Ethylbenzene

Monitored Data Carried Out By NES, June-July 1999.

Stack Reference	Stack Height (m)	Stack Location	Exit Diameter (m)	Cross-Sectional Area (m^2)	Temperature (°C)	Max Volume Flow (Nm^3/hr)	Exit Velocity (m/sec actual)	Concentration (mg/Nm^3)	Mass Emission (g/hr)
R24	10	Tank Farm	0.6	0.283	88	10600	13.8	664	7000
R25	10	Tank Farm	0.6	0.283	88	10600	13.8	664	7000
R32	10	Tank Farm	0.6	0.283	88	10600	13.8	664	7000

Table A2.4: Source Emission Data For Emissions of Xylene

Monitored Data Carried Out By NES, June-July 1999.