# Wieambilla Estates Odour Investigation Results

July – December 2012

**Environmental Monitoring and Assessment Sciences, Science Delivery Division**
Department of Science, Information Technology, Innovation and the Arts

Queensland Government

Prepared by:
Environmental Monitoring and Assessment Sciences, Science Delivery Division

Department of Science, Information Technology, Innovation and the Arts

Published by the Queensland Government, January 2013


January 2013

# Summary

The Queensland Government commenced a community sampling program for volatile organic compounds (VOCs) in the Wieambilla Estate in response to community concerns about the impacts of air emissions from the local coal seam gas fields on the health and well-being of the surrounding community. The results of the community sampling program conducted between July – December 2012 indicate that a number of volatile organic compounds (VOCs) were detected in the ambient air, at levels generally well below relevant guidelines and criteria used to assess VOC concentrations.

# Table of contents

# Introduction

People living in the Wieambilla Estate have raised concerns about the impacts of air emissions from the local coal seam gas fields on the health and well-being of the surrounding community. These concerns have primarily focused on odours and the potential health implications from those odours. The Wieambilla Estate is located half-way between Chinchilla to the north and Tara to the south of the estate.

In response to residents' concerns raised about the health impact of odour emissions from the local coal seam gas fields on surrounding residential areas, the Department of Environment and Heritage Protection (DEHP) initiated a community sampling program for odours in July 2012. The Science Delivery Division of the Department of Science, Information Technology, Innovation and the Arts (DSITIA) was commissioned to assist in the study. This report details the results of this study.

# Monitoring study design

The DEHP and DSITIA air monitoring investigation at the Wieambilla Estate focused on acquiring data on the concentration of volatile organic compound species in the air when odour was present in the community.

A very helpful tool used by DSITIA to aid in odour complaint investigations is the summa canister (see Figure 1) which can be supplied to complainants to sample the air when odours are detected. A summa canister is an evacuated canister that is used to collect an instantaneous air sample. This method of obtaining an air sample is simple and can be used by any individual concerned about odours or emissions from a nearby source of air pollution. Participants receive written instructions on how to take a sample of air using the summa canister. It is at the discretion of the participant as to when a sample is taken.

**Figure 1**: Example of Summa Canister

Samples of air for VOC analysis were collected by residents during times when odour was detected at its worst. Residents were supplied with an evacuated summa canister. Air samples were collected by opening the canister valve, allowing the canister to come to atmospheric pressure and closing the valve (typically takes 30 to 60 seconds). The canister was then sent for laboratory analysis using gas chromatography and mass spectrometry (GC/MS) in accordance with USEPA Compendium Method TO-15 *Determination of Volatile Organic Compounds (VOCs) in air collected in specially-prepared canisters and analyzed by Gas Chromatography/Mass Spectrometry (GC/MS)*[1]. The analysis was carried out by the Queensland Government Forensic and Scientific Services Laboratory. The TO-15 analysis method can measure up to 102 VOC compounds.

Four Wieambilla Estate residents participated in the community sampling program using the summa canisters and collected six samples. Samples collected by these residents are identified as:

- [redacted]
- [redacted]
- [redacted]
- [redacted]

DEHP staff collected two samples associated with the coal seam gas fields. These samples are identified as:

- TO1743;
- Rhyme Pond.

A control sample was also collected by DEHP staff at the Barakula State Forest some 38 km north of Chinchilla.

VOC monitoring was also conducted using passive diffusion samplers to collect airborne VOCs on adsorbent material, followed by extraction of the adsorbed compounds and characterisation using capillary gas chromatography. The passive sampler worked by diffusion of gaseous VOC molecules through a permeable membrane and subsequent capture by Tenax TA adsorbing material positioned inside the permeable membrane. The passive samplers were deployed at four locations in the Wieambilla Estate and a control location in the town of Chinchilla for three weeks to maximise the detection of any VOCs present. Following collection, the passive samplers were sealed and sent for laboratory analysis. The average VOC concentration over the sampling period was calculated from the VOC mass collected, the sampling time and the rate of diffusion of the VOC species through the permeable membrane. Deployment and retrieval of the passive samplers was carried out by DEHP staff and the analysis was carried out by Gradko Environmental in the United Kingdom.

Four passive samplers were located in the Wieambilla Estate and are identified as:

- [redacted]
- [redacted]
- [redacted]
- [redacted]

A fifth passive sampler was located in the township of Chinchilla as a control.

# Results and Discussion

## Volatile Organic Compounds

Substances that are included in the VOC category include aliphatic hydrocarbons (such as hexane), aromatic hydrocarbons (such as benzene, toluene and the xylenes), and oxygenated compounds (such as acetone and similar ketones).

To assess the measured VOC concentrations, a number of sources of environmental and human health guidelines/criteria were considered to cover the full range of VOCs detected in the samples. These included the Queensland Environmental Protection (Air) Policy 2008 (EPP Air) air quality objectives, Ontario's Ambient Air Quality Criteria and the Texas Commission on Environmental Quality Effects Screening Levels (ESLs). For four of the compounds, Pentane, 3-Methylpentane, Methylcyclohexane and 3-Methylhexane there are no environmental and human health guidelines/criteria. For the first three compounds the United States National Institute for Occupational Safety and Health (NIOSH) Recommended Exposure Limits (RELs) are provided while Germany's occupational exposure limit is provided for 3-Methylhexane for assessment.

The number of compounds detected in the samples from the summa canister sampling ranged from 3 to 7. It should be noted that the results from the Summa canister are from a 1-minute sampling period and cannot be directly compared with guideline values that have longer averaging periods (10-minute, 1-hour, 24-hours or annual averages). Concentrations determined using short-term sampling techniques relates to times when air quality was considered by the community to be poor (odour present) and pollutant levels are expected to be at a maximum. This means that VOC concentrations in the short term samples are expected to be significantly higher than samples collected over a longer time frame, when air with little or no pollutants would also be sampled. For assessment purposes if the levels of individual VOCs measured in the Summa canister samples are less than the long term averages used to assess the exposure impacts as shown in the column 'Guideline/Criteria' in Table 1, then it can be assumed that the guideline/criteria would be met. However, if the levels of VOCs from the canister are higher than the longer term guideline/criteria it does not necessarily mean that the guideline/criteria was not met (ie. it cannot be demonstrated as meeting the guideline/criteria). It should be noted that none of the measured concentrations of VOCs in the summa canister samples collected over a 1-minute period were higher than the longer term guideline/criteria.

The number of compounds detected in the passive diffusion samples ranged from 4 to 18. The results of the passive diffusion sampling are shown in Table 2. The measurement of Phenylmaleic anhydride could possibly be derived from an ozone-adsorbing artefact of the Tenax TA adsorbing material used in the passive sampler to adsorb the VOCs[2]. Detection limits of <0.17ppb on the three week averaged results were achieved compared with the summa canister of 0.5 – 1.0 ppb on the 1-minute averaged results. This has resulted in more compounds being detected. If the levels of VOCs over the whole year were similar to the concentrations experienced over the three week sampling period then the relevant guidelines and criteria for annual average used to assess VOC concentrations in ambient air would not be exceeded.

.

**Table 1:** Results from summa canister sampling for chemical compounds with concentrations greater than the Limit of Reporting.

| Chemical Compound | TO-1743 (ppb) | [redacted] HPV 1 (ppb) | [redacted] HPV 1 (ppb) | [redacted] (ppb) | [redacted] (ppb) | [redacted] (ppb) | [redacted] (ppb) | Barakula State Forest (ppb) | Rhyme Pond (ppb) | Ambient Air Guideline/Criteria | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Averaging Period | ppb | µg/m$^3$ | Source | Effect |
| ***Sampling Date*** | ***3/07/12*** | ***4/07/12*** | ***4/07/12*** | ***11/09/12*** | ***1/11/12*** | ***25/11/12*** | ***1/12/12*** | ***4/12/12*** | ***6/12/12*** | | | | | |
| **Compounds detected** | 3 | 3 | 3 | 4 | 6 | 5 | 7 | 6 | 5 | | | | | |
| **Alkanes** | | | | | | | | | | | | | | |
| Hexane | **3** | **19.2** | **8.4** | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | 24 Hour | 2,027 | 7,500 | Ontario | Health |
| | | | | | | | | | | 1 Hour | 1,500 | 5,300 | Texas | Odour |
| | | | | | | | | | | Annual | 57 | 200 | Texas | Health |
| **Alkenes** | | | | | | | | | | | | | | |
| Propene | n/a | n/a | n/a | n/a | n/a | <0.5 | **7.7** | <0.5 | <0.5 | 24 Hour | 2,210 | 4,000 | Ontario | Health |
| **Haloalkanes/ alkenes** | | | | | | | | | | | | | | |
| Chloromethane | <1.0 | <1.0 | <1.0 | **0.7** | **0.7** | **0.6** | **0.6** | **0.6** | **0.7** | 24 Hour | 147 | 320 | Ontario | Health |
| | | | | | | | | | | 1 Hour | 1,030 | 500 | Texas | Health |
| | | | | | | | | | | Annual | 103 | 50 | Texas | Health |
| Dichlorodifluro-methane | <1.0 | <1.0 | <1.0 | **0.5** | **0.6** | <0.5 | <0.5 | <0.5 | **0.6** | 1 Hour | 10,000 | 50,000 | Texas | Health |
| | | | | | | | | | | Annual | 1,000 | 5,000 | Texas | Health |
| Methylene chloride | <1.0 | <1.0 | <1.0 | <0.5 | <0.5 | <0.5 | **5.2** | **0.7** | **0.7** | 24 Hour | 60 | 220 | Ontario | Health |
| | | | | | | | | | | Annual | 12 | 44 | Ontario | Health |
| | | | | | | | | | | 1 Hour | 1,100 | 3,600 | Texas | Health |
| | | | | | | | | | | Annual | 100 | 350 | Texas | Health |
| **Alcohols** | | | | | | | | | | | | | | |
| Ethanol | <1.0 | <1.0 | <1.0 | **0.8** | **1.5** | **1.6** | **5.5** | **1.5** | **1.2** | 1Hour | 10,096 | 19,000 | Ontario | Odour |
| | | | | | | | | | | 1 Hour | 10,000 | 18,800 | Texas | Health |
| | | | | | | | | | | Annual | 1,000 | 1,880 | Texas | Health |

| Chemical Compound | TO-1743 (ppb) | [redacted] HPV 1 (ppb) | [redacted] HPV 1 (ppb) | [redacted] (ppb) | [redacted] (ppb) | [redacted] (ppb) | [redacted] (ppb) | Barakula State Forest (ppb) | Rhyme Pond (ppb) | Ambient Air Guideline/Criteria | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Averaging Period | ppb | µg/m$^3$ | Source | Effect |
| ***Sampling Date*** | ***3/07/12*** | ***4/07/12*** | ***4/07/12*** | ***11/09/12*** | ***1/11/12*** | ***25/11/12*** | ***1/12/12*** | ***4/12/12*** | ***6/12/12*** | | | | | |
| **Carbonyls** | | | | | | | | | | | | | | |
| Acetone | <1.0 | <1.0 | <1.0 | **2.4** | **1.5** | **5.6** | **10** | **6.7** | **2.0** | 24 Hour | 5,007 | 11,880 | Ontario | Health |
| | | | | | | | | | | 1 Hour | 2,500 | 5,900 | Texas | Health |
| | | | | | | | | | | Annual | 250 | 590 | Texas | Health |
| Methyl ethyl ketone | **1.5** | **1.5** | **4.8** | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | 24 Hour | 400 | 1,000 | Ontario | Health |
| | | | | | | | | | | 1 Hour | 440 | 1,300 | Texas | Odour |
| | | | | | | | | | | Annual | 900 | 2,600 | Texas | Health |
| Acrolein | <1.0 | <1.0 | <1.0 | <0.5 | <0.5 | **0.5** | **0.6** | **0.5** | <0.5 | 1 Hour | 2.0 | 4.5 | Ontario | Health |
| | | | | | | | | | | 24 Hour | 0.17 | 0.4 | Ontario | Health |
| | | | | | | | | | | 1 Hour | 1.6 | 3.2 | Texas | Health |
| | | | | | | | | | | Annual | 0.066 | 0.14 | Texas | Health |
| Vinyl acetate | **4.4** | **3.9** | **4.6** | <0.5 | <0.5 | **1.0** | **0.6** | **0.7** | <0.5 | 1 Hour | 40 | 150 | Texas | Health |
| | | | | | | | | | | Annual | 4 | 15 | Texas | Health |
| **Aromatics** | | | | | | | | | | | | | | |
| Tolulene | <1.0 | <1.0 | <1.0 | <0.5 | **1.5** | <0.5 | <0.5 | <0.5 | <0.5 | 24 Hour | 1,000 | 4,112 | EPP Air | Health |
| | | | | | | | | | | Annual | 100 | 410 | EPP Air | Health |
| | | | | | | | | | | 30 Minute | 260 | 1,069 | EPP Air | Odour |
| | | | | | | | | | | 24 Hour | 504 | 2,000 | Ontario | Odour |
| | | | | | | | | | | 1 Hour | 170 | 640 | Texas | Odour |
| 1,2,4-Trimethylbenzene | <1.0 | <1.0 | <1.0 | <0.5 | **0.7** | <0.5 | <0.5 | <0.5 | <0.5 | 24 Hour | 43 | 220 | Ontario | Health |
| | | | | | | | | | | 1 Hour | 250 | 1,250 | Texas | Health |
| | | | | | | | | | | Annual | 25 | 125 | Texas | Health |

**Table 2:** Results from passive diffusion sampling for chemical compounds with concentrations greater than the Limit of Reporting.

| Chemical Compound | [redacted] (ppb) | [redacted] (ppb) | [redacted] (ppb) | [redacted] (ppb) | Chinchilla Control (ppb) | Ambient Air Guideline/Criteria | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Averaging Period | ppb | µg/m$^3$ | Source | Effect |
| ***Sampling Date*** | ***26/09/12 – 16/10/12*** | ***26/09/12 – 16/10/12*** | ***26/09/12 – 16/10/12*** | ***26/09/12 – 16/10/12*** | ***26/09/12 – 16/10/12*** | | | | | |
| **Compounds detected** | 5 | 4 | 5 | 18 | 5 | | | | | |
| **Alkanes** | | | | | | | | | | |
| Pentane | <0.17 | <0.17 | <0.09 | **0.3** | <0.17 | 8 Hour | 120,000 | 350,000 | NIOSH | REL |
| Hexane | <0.17 | <0.17 | <0.17 | **0.5** | <0.17 | 24 Hour | 2,027 | 7,500 | Ontario | Health |
| | | | | | | 1 Hour | 1,500 | 5,300 | Texas | Odour |
| | | | | | | Annual | 57 | 200 | Texas | Health |
| Heptane | <0.17 | <0.17 | <0.17 | **0.3** | <0.17 | 24 Hour | 2,552 | 11,000 | Ontario | Health |
| | | | | | | 1 Hour | 850 | 3,500 | Texas | Health |
| | | | | | | Annual | 85 | 350 | Texas | Health |
| Tetradecane | <0.17 | <0.17 | <0.17 | <0.17 | **0.2** | 1 Hour | 432 | 3,500 | Texas | Health |
| | | | | | | Annual | 43 | 350 | Texas | Health |
| Hexadecane | **0.2** | <0.17 | <0.17 | <0.17 | <0.17 | 1 Hour | 108 | 1,000 | Texas | Health |
| | | | | | | Annual | 11 | 100 | Texas | Health |
| Heptadecane | <0.17 | <0.17 | <0.17 | **0.4** | <0.17 | 1 Hour | 10 | 100 | Texas | Health |
| | | | | | | Annual | 1 | 10 | Texas | Health |
| Cyclohexane | <0.17 | **0.6** | <0.17 | <0.17 | <0.17 | 24 Hour | 1,685 | 6,100 | Ontario | Health |
| | | | | | | 1 Hour | 1,000 | 3,400 | Texas | Health |
| | | | | | | Annual | 100 | 340 | Texas | Health |
| 2-methylbutane (Isopentane) | <0.18 | <0.18 | <0.18 | **0.4** | <0.18 | 1 Hour | 1,300 | 3,800 | Texas | Odour |
| | | | | | | Annual | 2,400 | 7,200 | Texas | Health |

| Chemical Compound | [redacted] (ppb) | [redacted] (ppb) | [redacted] (ppb) | [redacted] (ppb) | Chinchilla Control (ppb) | Ambient Air Guideline/Criteria | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Averaging Period | ppb | µg/m$^3$ | Source | Effect |
| ***Sampling Date*** | ***26/09/12 – 16/10/12*** | ***26/09/12 – 16/10/12*** | ***26/09/12 – 16/10/12*** | ***26/09/12 – 16/10/12*** | ***26/09/12 – 16/10/12*** | | | | | |
| 3-Methylpentane | <0.17 | <0.17 | <0.17 | **0.3** | <0.17 | 8 Hour | 100,000 | 350,000 | NIOSH | REL |
| 3-Methylhexane | <0.17 | <0.17 | <0.17 | **0.3** | <0.17 | 8 Hour | 500,000 | 1,500,00 | Germany Occ. Health | OEL |
| 2,2,4,6,6-pentamethyl-heptane | **1.2** | <0.17 | <0.17 | **0.2** | <0.17 | 1 Hour | 503 | 3,500 | Texas | Health |
| | | | | | | Annual | 50 | 350 | Texas | Health |
| Methylcyclohexane | <0.17 | <0.17 | <0.17 | **0.2** | <0.17 | 8 Hour | 400,000 | 1,600,000 | NIOSH | REL |
| **Haloalkanes/alkenes** | | | | | | | | | | |
| Tetrachloroethylene | <0.17 | <0.17 | <0.17 | **0.4** | <0.17 | 24 Hour | 50 | 360 | Ontario | Health |
| | | | | | | 1 Hour | 300 | 2,000 | Texas | Health |
| | | | | | | Annual | 3.8 | 26 | Texas | Health |
| **Alcohols** | | | | | | | | | | |
| 2-ethyl-1-Hexanol | **0.2** | <0.17 | **0.3** | <0.17 | <0.17 | 1 Hour | 107 | 600 | Ontario | Odour |
| | | | | | | 1 Hour | 500 | 2,700 | Texas | Health |
| | | | | | | Annual | 50 | 270 | Texas | Health |
| **Carbonyls** | | | | | | | | | | |
| Ethyl Acetate | <0.18 | <0.18 | <0.18 | **0.2** | <0.18 | 1 Hour | 5,013 | 19,000 | Ontario | Odour |
| | | | | | | 1 Hour | 4,000 | 14,400 | Texas | Health |
| | | | | | | Annual | 400 | 1,440 | Texas | Health |
| **Aromatics** | | | | | | | | | | |
| Benzene | <0.17 | <0.17 | <0.17 | **0.6** | <0.17 | Annual | 3 | 10 | EPP Air | Health |
| | | | | | | 24 Hour | 0.69 | 2.3 | Ontario | Health |
| | | | | | | Annual | 0.13 | 0.45 | Ontario | Health |
| | | | | | | 1 Hour | 54 | 170 | Texas | Health |
| | | | | | | Annual | 1.4 | 4.5 | Texas | Health |

| Chemical Compound | [redacted] (ppb) | [redacted] (ppb) | [redacted] (ppb) | [redacted] (ppb) | Chinchilla Control (ppb) | Ambient Air Guideline/Criteria | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Averaging Period | ppb | µg/m$^3$ | Source | Effect |
| ***Sampling Date*** | ***26/09/12 – 16/10/12*** | ***26/09/12 – 16/10/12*** | ***26/09/12 – 16/10/12*** | ***26/09/12 – 16/10/12*** | ***26/09/12 – 16/10/12*** | | | | | |
| Toluene | <0.17 | **6.6** | <0.17 | **7.0** | **0.5** | 24 Hour | 1,000 | 4,112 | EPP Air | Health |
| | | | | | | Annual | 100 | 410 | EPP Air | Health |
| | | | | | | 30 Minute | 260 | 1,069 | EPP Air | Odour |
| | | | | | | 24 Hour | 504 | 2,000 | Ontario | Odour |
| | | | | | | 1 Hour | 170 | 640 | Texas | Odour |
| | | | | | | Annual | 330 | 1,200 | Texas | Health |
| Xylene | <0.17 | **1.8** | <0.17 | **1.3** | **0.8** | 24 Hour | 250 | 1,184 | EPP Air | Health |
| | | | | | | Annual | 200 | 950 | EPP Air | Health |
| | | | | | | 24 Hour | 160 | 730 | Ontario | Health |
| | | | | | | 10 Minute | 657 | 3,000 | Ontario | Odour |
| | | | | | | 1 Hour | 80 | 350 | Texas | Odour |
| | | | | | | Annual | 42 | 180 | Texas | Health |
| Ethylbenzene | <0.17 | **0.8** | <0.17 | **0.2** | **0.6** | 24 Hour | 231 | 1,000 | Ontario | Health |
| | | | | | | 10 Minute | 438 | 1,900 | Ontario | Odour |
| | | | | | | 1 Hour | 170 | 740 | Texas | Odour |
| | | | | | | Annual | 135 | 570 | Texas | Health |
| 1,2,4-Trimethylbenzene | <0.17 | <0.17 | <0.17 | **0.2** | <0.17 | 24 Hour | 43 | 220 | Ontario | Health |
| | | | | | | 1 Hour | 250 | 1,250 | Texas | Health |
| | | | | | | Annual | 25 | 125 | Texas | Health |
| Phenol | <0.17 | <0.17 | **0.12** | **0.3** | <0.17 | 24 Hour | 7.4 | 30 | Ontario | Health |
| | | | | | | 1 Hour | 40 | 150 | Texas | Odour |
| | | | | | | Annual | 5 | 19 | Texas | Health |

| Chemical Compound | [redacted] (ppb) | [redacted] (ppb) | [redacted] (ppb) | [redacted] (ppb) | Chinchilla Control (ppb) | Ambient Air Guideline/Criteria | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Averaging Period | ppb | µg/m$^3$ | Source | Effect |
| ***Sampling Date*** | ***26/09/12 – 16/10/12*** | ***26/09/12 – 16/10/12*** | ***26/09/12 – 16/10/12*** | ***26/09/12 – 16/10/12*** | ***26/09/12 – 16/10/12*** | | | | | |
| Benzothiazole | <0.18 | <0.18 | **0.12** | <0.18 | <0.18 | 24 Hour | 12 | 70 | Ontario | Health |
| | | | | | | 1 Hour | 9.1 | 50 | Texas | Health |
| | | | | | | Annual | 0.9 | 5 | Texas | Health |
| Naphthalene | **0.4** | <0.17 | <0.17 | <0.17 | <0.17 | 24 Hour | 4.3 | 22.5 | Ontario | Health |
| | | | | | | 10 Minute | 9.5 | 50 | Ontario | Odour |
| | | | | | | 1 Hour | 90 | 440 | Texas | Odour |
| | | | | | | Annual | 10 | 50 | Texas | Health |
| [1]Phenylmaleic anhydride | **0.6** | <0.17 | **0.4** | **0.5** | **0.4** | | | | | |
| **Terpenes** | | | | | | | | | | |
| Alpha-Pinene | <0.17 | <0.17 | **0.2** | <0.17 | <0.17 | 1 Hour | 10 | 60 | Texas | Odour |
| | | | | | | Annual | 63 | 350 | Texas | Health |

[1] Suspected ozone-adsorbing artefact of the Tenax TA adsorbing material used in the passive sampler to adsorb the VOCs.

# Conclusion

This investigation is based on limited air sampling conducted in the residential area in the Wieambilla Estate during July - December 2012. The results of the community sampling program indicate that a number of VOCs were detected in the ambient air, at levels generally well below relevant guidelines and criteria used to assess VOC concentrations in ambient air.

# References

[1]U.S. Environmental Protection Agency. (1999) Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. Second Edition. Compendium Method TO-15 Determination of Volatile Organic Compounds (VOCs) in air collected in specially-prepared canisters and analyzed by Gas Chromatography/Mass Spectrometry (GC/MS).

[2] Lee, J. H.; Batterman, S. A.; Jia, C.; Chernyak, S. Ozone Artefacts and Carbonyl Measurements Using Tenax GR, Tenax TA, Carbopack B and Carbopack X Adsorbents; *J Air and Waste Management Association 2006, 56, 1503-151.*

# Appendix

## Appendix 1: List of all VOCs monitored

In addition to the key pollutants measured, a range of additional pollutants were analysed for with the TO15 method. The full range of VOCs analysed for include:

| | | |
|---|---|---|
| **Propene** | Trichloroethylene | **2-Methylbutane** |
| **Dichlorodifluoromethane** | 1,4 Dioxane | 1-Pentene |
| **Chloromethane** | Methyl methacrylate | **Pentane** |
| Ethane, 1,2-dichloro-1,1,2,2-tetrafluoro- | **Heptane** | Isoprene |
| Ethene, chloro- | 1-Propene, 1,3-dichloro-, (Z)- | trans-2-Pentene |
| 1,3-Butadiene | 2-Hexanone | cis-2-Pentene |
| Methane, bromo- | 1-Propene, 1,3-dichloro-, (E)- | 2,2-Dimethylbutane |
| Ethyl Chloride | Ethane, 1,1,2-trichloro- | Cyclopentane |
| **Ethanol** | **Toluene** | 2,3-Dimethylbutane |
| **2-Propenal** | Methane, dibromochloro- | 2-Methylpentane |
| **Acetone** | Ethane, 1,2-dibromo- | **3-Methylpentane** |
| Trichloromonofluoromethane | **Tetrachloroethylene** | 1-Hexene |
| Isopropyl Alcohol | **m- & p-Xylene** | Methylcyclopentane |
| Ethene, 1,1-dichloro- | Styrene | 2,4-Dimethylpentane |
| **Methylene chloride** | Benzene, chloro- | 2-Methylhexane |
| Carbon disulfide | **Ethylbenzene** | 2,3-Dimethylpentane |
| Ethane, 1,1,2-trichloro-1,2,2-trifluoro- | Methane, tribromo | 3-Methylhexane |
| **Ethyl acetate** | Ethane, 1,1,2,2-tetrachloro- | 2,2,4-Trimethylpentane |
| Ethylene, 1,2-dichloro-, (E)- | **o-Xylene** | **Methylcyclohexane** |
| Ethane, 1,1-dichloro- | Toluene, 4-ethyl- | 2,3,4-Trimethylpentane |
| Methy tert-butyl ether | Benzene, 1,3,5-trimethyl- | 2-Methylheptane |
| **Vinyl acetate** | **Benzene, 1,2,4-trimethyl-** | 3-Methylheptane |
| 2-Butanone | Benzene, 1,3-dichloro- | Octane |
| Ethylene, 1,2-dichloro-, (Z)- | Benzene, 1,4-dichloro- | Nonane |
| **n-Hexane** | Benzene, 1,2-dichloro- | Cumene |
| Trichloromethane | Benzene, 1,2,4-trichloro- | Propylbenzene |
| Tetrahydrofuran | **Naphthalene** | 3-Ethyltoluene |
| Ethane, 1,2-dichloro | 1,3-Butadiene, 1,1,2,3,4,4-hexachloro- | 2-Ethyltoluene |
| Ethane 1,1,1-trichloro- | Propane | Decane |
| **Benzene** | Isobutane | 1,2,3-Trimethylbenzene |
| Carbon Tetrachloride | 1-Butene | 1,3-Diethylbenzene |

| | | |
|---|---|---|
| **Cyclohexane** | Butane | 1,4-Diethylbenzene |
| Propane, 1,2-dichloro- | trans-2-Butene | Undecane |
| Methane, bromodichloro- | Cis-2-Butene | Dodecane |
| **Methyl ethyl ketone** | | |

Compounds in bold type were present at concentrations greater than the minimum measurable concentration.