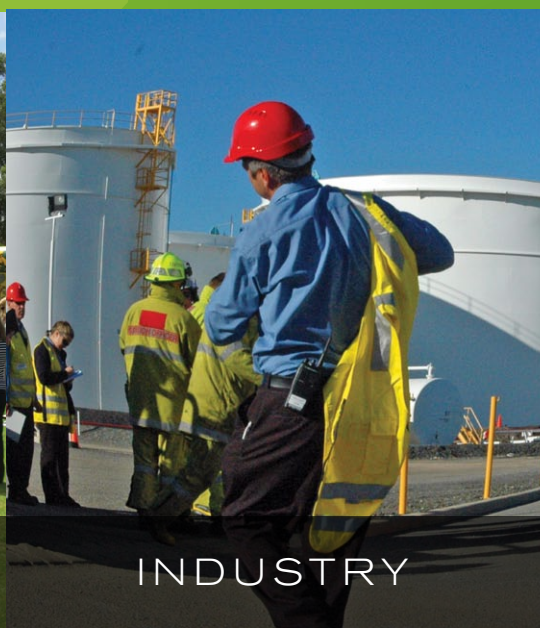
KWINANA
INDUSTRIES COUNCIL

AIR QUALITY MANAGEMENT IN KWINANA

FACT SHEET ON

# Toxic **Organic** Compounds





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## What are Toxic Organic Compounds and how are they produced?

Toxic Organic Compounds refers to the class of compounds whose molecular structure typically contains a carbon to hydrogen bond, and that is capable of causing injury or damage to a living organism. A wide variety of substances are considered as toxic, but it is the level of exposure that determines if any harm is caused.

The National Environmental Protection Measure (NEPM) for Air Toxics includes five compounds, all of which are Toxic Organic Compounds:

- Benzene
- Formaldehyde
- Toluene
- Xylenes
- Benzo(a)pyrene (BaP)

In the Kwinana Industrial Area (KIA), located south of Perth, Western Australia, Toxic Organic Compounds are produced by Kwinana Industry as an unintended by-product of manufacturing processes, typically as a result of incomplete combustion of fossil fuels, or volatilisation of organic products. Table 1 presents information on the relative contribution of Toxic Organic Compound emissions in Kwinana according to industry sector.

Petroleum refining was the largest contributor to the emissions of compounds included in the Air Toxics NEPM in 2008/09, making up over half of the total emissions of benzene (91%), formaldehyde (61%), toluene (66%) and xylenes (57%) from Kwinana industry. Alumina production and petroleum refining were the largest contributors to PAH emissions in 2008/09, together making up the vast majority (85%) of the total emissions of PAHs from Kwinana industry.

*[1] Benzo(a)pyrene is a marker for Polycyclic Aromatic Hydrocarbons (PAHs)*

***Table 1: Summary of Toxic Organic Compound Emissions from Kwinana Industry for 2008/09***

| Industry Sector | Benzene | | Formaldehyde | | Toluene | | Xylenes | | PAHs | |
|---|---|---|---|---|---|---|---|---|---|---|
| Emissions (per annum) Relative Contribution (%) | tpa | % | tpa | % | tpa | % | tpa | % | tpa | % |
| Alumina Production | | | 15.0 | 38.8% | | | | | 99 | 44% |
| Basic Inorganic Chemical Manufacturing | 0.2 | 6.9% | | | 0.9 | 5.7% | 0.5 | 3.0% | 0.3 | 0.1% |
| Cement and Lime Manufacturing | | | | | | | | | 3.2 | 1.5% |
| Fertiliser Manufacturing | | | | | | | | | 0.8 | 0.4% |
| Fossil Fuel Electricity Generation | | | | | | | | 0.1% | 19 | 8.6% |
| Natural Rubber Product Manufacturing | | | | | | | 5.8 | 39% | | |
| Other Basic Non-Ferrous Metal Manufacturing | | | | | 0.1 | 0.5% | | | 0.6 | 0.3% |
| Pesticide Manufacturing | | | | | 4.2 | 26% | | | | |
| Petroleum Refining | 3.3 | 91% | 23.6 | 61% | 10.7 | 66% | 8.5 | 57% | 92 | 41% |
| Other | 0.1 | 1.7% | 0.03 | 0.1% | 0.4 | 2.2% | 0.1 | 0.7% | 7.8 | 3.5% |

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## How much is emitted by Kwinana Industry?

According to National Pollutant Inventory (NPI) data for the 2008/09 reporting period, the total quantity of emissions of benzene, formaldehyde, toluene and xylene emitted to air by Kwinana Industry (i.e. all NPI reporting facilities located in the Cockburn, Kwinana and Rockingham local government areas) was equal to 3.6 tpa of benzene, 38.7 tpa of formaldehyde, 16.2 tpa of toluene, and 14.9 tpa of xylenes.

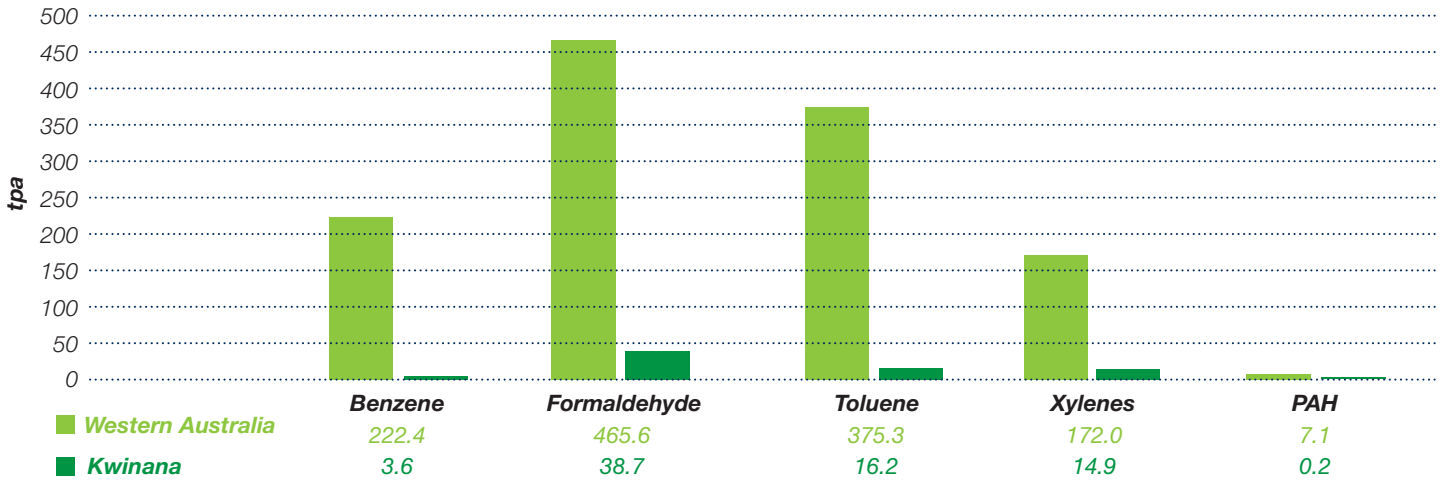
To put these quantities of emissions into context, according to NPI data for the same reporting period the total quantity emitted to air by Western Australian industry (i.e. all NPI reporting facilities located in Western Australia) was equal to 222.4 tpa of benzene, 465.6 tpa of formaldehyde, 375.3 tpa of toluene, and 172 tpa of xylenes (Figure 1). The total quantity of emissions of PAHs to air by Kwinana Industry was equal to 0.2 tpa, compared to 7.1 tpa from Western Australian industry over the same reporting period.

Therefore, Kwinana Industry contributed between 2% (benzene) and 9% (xylenes) to the state's total industrial emissions of the compounds included in the Air Toxics NEPM during 2008/09.

NPI data for the 2008/09 reporting period has also been analysed to compare the quantity of emissions released into the Perth Airshed by Kwinana Industry to large domestic sources, including motor vehicles and domestic solid fuel burning (e.g. wood heaters) (Figure 2). The analysis shows that more emissions of benzene, formaldehyde, toluene, xylenes and PAHs are released into the Perth Airshed from motor vehicles, and from domestic solid fuel burning, than from Kwinana Industry. Notwithstanding, Kwinana industries take measures to manage emissions of Toxic Organic Compounds.

*Emissions information for Kwinana industry has been obtained from Australia's National Pollutant Inventory (NPI) database for the 2008/09 reporting period. NPI data for 2009/10 will not be publicly available until 2011. The NPI contains emissions information on 93 substances deemed important due to their possible effect on human health and the environment. Facility operators determine their emissions each year, and government agencies periodically estimate diffuse emissions such as from motor vehicles and households. The NPI reports PAH emissions as benzo(a)pyrene equivalents. NPI data are freely accessible via the website www.npi.gov.au.*

***Figure 1: Annual Quantity of Toxic Organic Compound Emissions Generated by Industry in 2008/09***



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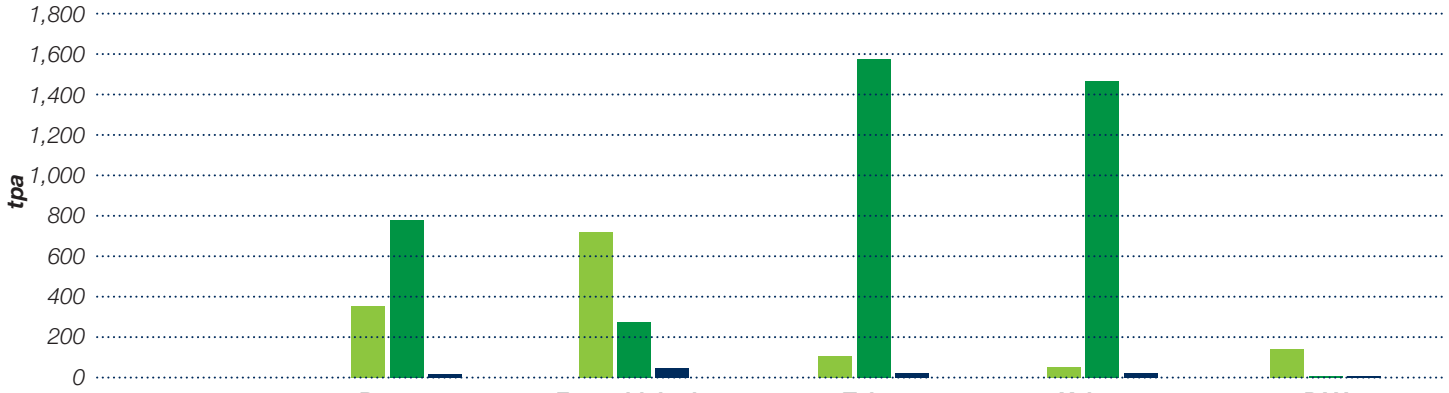
## How are emissions managed?

The quantity of Toxic Organic Compounds produced from industrial combustion processes depends on the fuel type used and the combustion conditions, whilst the quantity of Toxic Organic Compounds produced from volatilisation of organic products depends on the properties of the product(s) being handled. In order to minimise Toxic Organic Compounds emissions, Kwinana industry:

- manages choice of fuel;
- ensures optimum combustion conditions within their manufacturing processes;
- prevents the volatilisation of organic products through engineering design measures; and uses pollution control equipment.

***Figure 2: Annual Quantity of Toxic Organic Compounds Released into the Perth Airshed by Kwinana Industry Compared to Large Domestic Sources in 2008/09***




| | Benzene | Formaldehyde | Toluene | Xylenes | PAH |
|---|---|---|---|---|---|
| Domestic Solid Fuel Burning | 354 | 722 | 111 | 52 | 132 |
| Motor Vehicles | 789 | 277 | 1,585 | 1,474 | 0.3 |
| Kwinana Industries | 3.6 | 39 | 16 | 15 | 0.2 |

**Case Study in emission reductions: Alcoa Kwinana Alumina Refinery**

VOCs are emitted from Alcoa's Kwinana Alumina Refinery as a result of:

- the breakdown of naturally occurring organic material contained in the bauxite ore;
- additives to the refining process; and
- by-products of fuel combustion processes.

During alumina refining these organics are degraded and produce a range of substances, some of which are emitted to atmosphere. These VOC emissions are the cause of the characteristic odour associated with alumina refineries.

In order to manage emissions of VOC from the Kwinana Alumina Refinery, some of the measures that have been undertaken by Alcoa include:

- an extensive VOC monitoring program to understand the sources and composition of emissions;
- installation of a Regenerative Thermal Oxidiser (RTO) to reduce VOC emissions (greater than 99% removal efficiency) from the Liquor Burner stack;
- development of a biological Oxalate Removal Treatment process that uses naturally occurring soil micro-organisms to completely degrade oxalate waste to carbonate (a usable by-product) and water. This avoids the need for thermal destruction of oxalate waste that would involve greater air emissions, and avoids the need to have oxalate disposal ponds within Alcoa's Residue Storage Areas (RSAs); and
- investigations into the potential to treat and reduce VOC emissions from the Digestion Area of the refinery.

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## How are emissions managed?

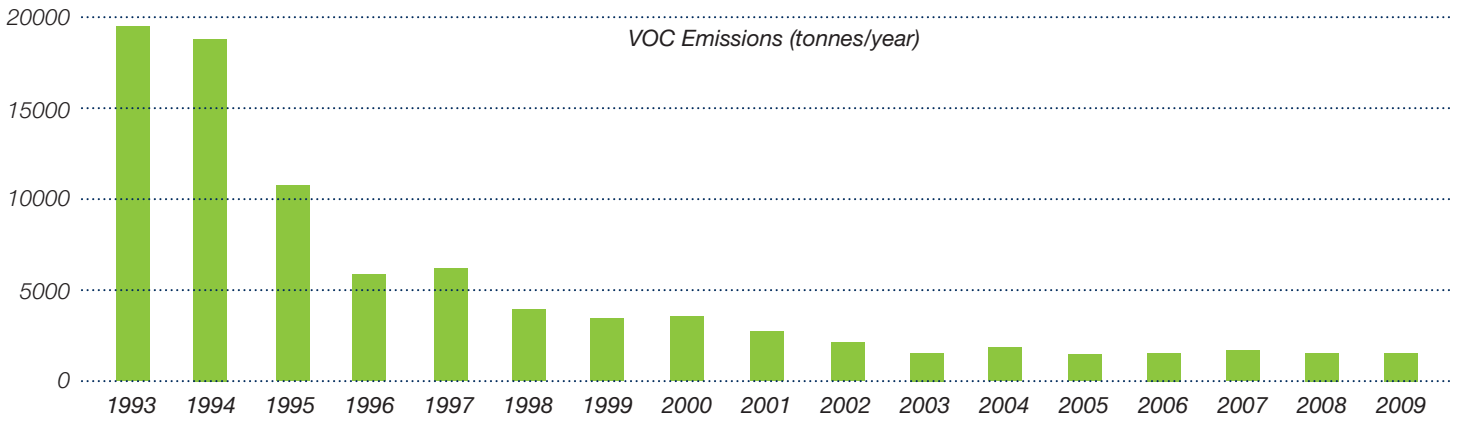
Natural gas is a 'clean burning' fuel that contains very low levels of non-combustible impurities, hence the emissions of Toxic Organic Compounds associated with the combustion of natural gas are minimal. Following the supply of natural gas to Kwinana in 1984, air quality in the Kwinana area improved significantly as industries switched to using natural gas rather than alternative fuels such as heavy fuel oil.

**Case Study in emission reductions: BP Refinery Kwinana**
BP Refinery (Kwinana) has reduced VOC emissions by approximately 85% since introducing a VOC Reduction Program in 1995. Changes to the refining process and infrastructure included:

- Upgrading crude and product storage tanks by installing secondary seals and replacing still wells with a low emission design;
- Tracking process fugitives with a leak detection and repair program, that tests nearly 52,000 potential leak points (flanges, valves etc) and repairs any leaks found;
- And changes to the refining process such as decommissioning the Minalk unit, changing to closed loop sample points and redirecting off-spec material to the Residue Cracking Unit instead of the Crude unit.

Additionally, BP has begun producing products that burn cleaner in cars, therefore lowering emissions outside the refinery.

***Figure 3: Emissions of Volatile Organic Compounds from BP Refinery (Kwinana).***
*VOC Emissions by BP Refinery Kwinana*



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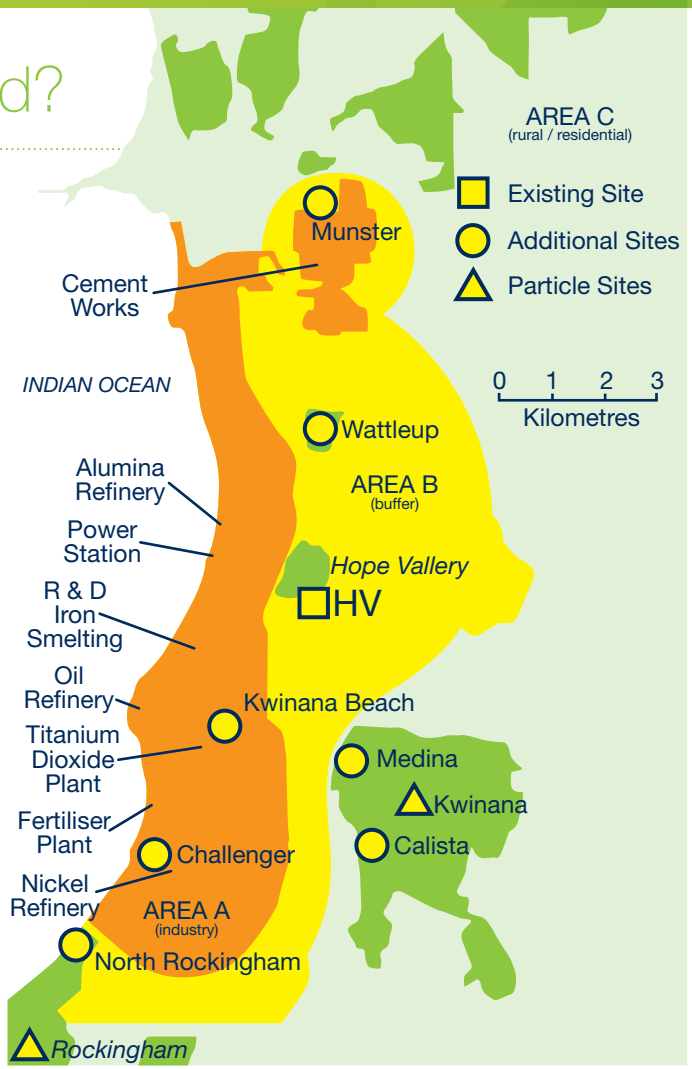
## What monitoring is conducted?

Ambient air quality monitoring for Toxic Organic Compounds in Western Australia is conducted on a campaign basis by the Department of Environment and Conservation (DEC). The key ambient air quality monitoring projects involving Toxic Organic Compound monitoring in Kwinana are summarised in Table 2.

***Table 2: Summary of Key Ambient Air Quality Monitoring Projects Involving Toxic Organic Compound Monitoring in Kwinana***

| Volatile Organic Compounds Monitoring in Perth Baseline Air Toxics Project | |
|---|---|
| Monitoring Period | 1997 - 1998 |
| Compounds Monitored | VOCs[2] |
| Monitoring Locations | Hope Valley |
| **Background Air Quality (Air Toxics) Study** | |
| Monitoring Period | 2005 - 2006 |
| Compounds Monitored | VOCs, carbonyls[3], PAHs |
| Monitoring Locations | 8 locations in the Kwinana area |
| **Small to Medium Enterprise Air Emissions Monitoring Project** | |
| Monitoring Period | 2005 - 2007 |
| Compounds Monitored | VOCs |
| Monitoring Locations | Wattleup |




The Background Air Quality (Air Toxics) Study involved the most extensive monitoring of Toxic Organic Compounds in the Kwinana area. Monitoring was conducted at eight locations in the Kwinana Area (as shown on the map), as well as two other locations in the Perth metropolitan area (Perth CBD and Duncraig), and a number of other regional centres throughout the state.

Table 3 presents a summary of levels of Toxic Organic Compounds measured in the ambient air in Kwinana compared to national air quality guidelines, as specified in the NEPM for Air Toxics. From the data presented in Figure 4 it can be seen that the ambient concentrations measured in the Kwinana area comfortably comply with the guidelines specified in the NEPM for Air Toxics.

***Table 3: Summary Results of Toxic Organic Compound Monitoring in Kwinana [4]***

| Compound | Units | 24-hour Average Concentration | | Average Concentration Over Entire Sampling | | |
|---|---|---|---|---|---|---|
| | | Highest - Hope Valley | Air Toxics NEPM Guideline | Highest - Kwinana Area | Location | Air Toxics NEPM Guideline |
| Benzene | µg/m³ | 1.4 | - | 0.72 | Kwinana Beach | 10.4 |
| Formaldehyde | µg/m³ | 4.2 | 53 | 1.34 | Hope Valley [5] | - |
| Toluene | µg/m³ | 2.5 | 4,110 | 3.2 | Kwinana Beach | 411 |
| Xylenes | µg/m³ | 5.2 | 1,190 | 2.8 | Kwinana Beach | 952 |
| Benzo(a)pyrene | µg/m³ | 0.2 | - | 0.05 | Hope Valley [1] | 0.3 |

*[2] Volatile Organic Compounds (VOCs) (e.g. benzene, toluene and xylenes)*
*[3] Carbonyls (e.g. formaldehyde)*
*[4] Data supplied by the Department of Environment and Conservation (DEC).*
*[5] Hope Valley was the only location in Kwinana which included monitoring of formaldehyde and benzo(a)pyrene.*

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## What monitoring is conducted?

***Figure 4: Average and Maximum Concentrations Measured***
*Background Air Quality (Air Toxics) Study*

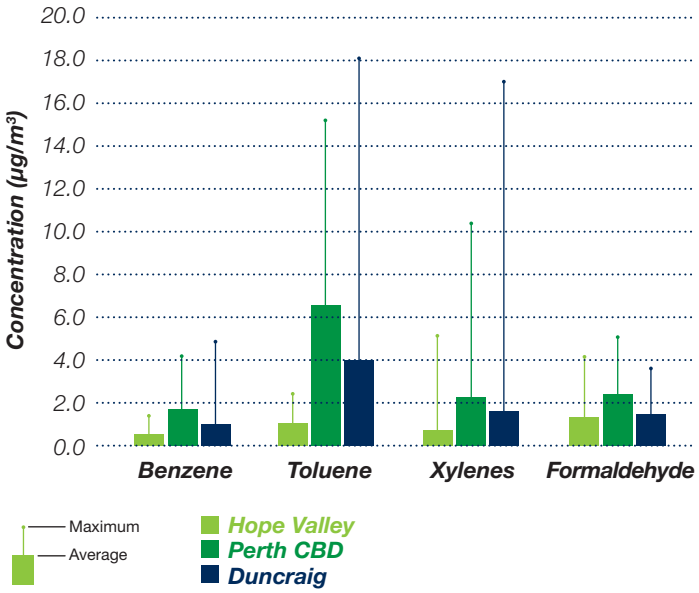


***Figure 5: Average and Maximum Concentrations Measured***
*Background Air Quality (Air Toxics) Study*

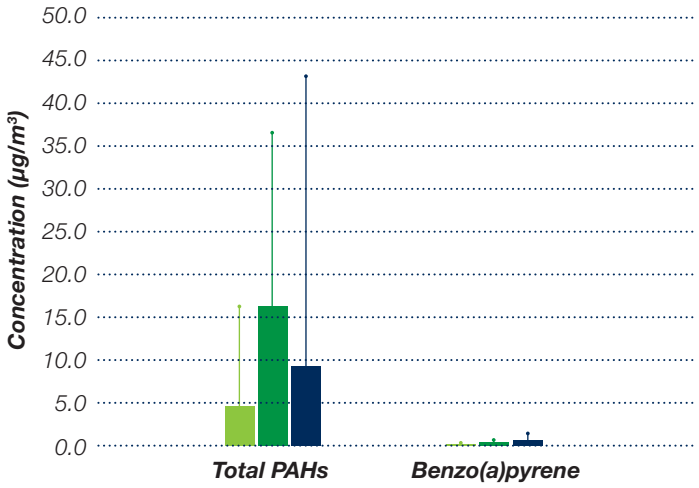


Figure 4 presents the maximum 24 hour and average concentrations of benzene, toluene, xylenes and formaldehyde measured at the Hope Valley, Perth CBD and Duncraig monitoring sites, and Figure 5 presents the same concentration statistics measured for total PAHs and benzo(a)pyrene.

The monitoring results show that the concentrations of benzene, toluene, xylenes and formaldehyde measured at Hope Valley were lower than measured in the Perth CBD and in Duncraig. Similarly, the concentrations of total PAHs and benzo(a)pyrene measured at Hope Valley were also lower compared to the other Perth metropolitan monitoring sites.

Further information on the DEC's ambient air quality monitoring projects, including the Background Air Quality (Air Toxics) Study, is available on the DEC's website www.dec.gov.au.

# More Information

Fact Sheets in the “Air Quality Management in Kwinana” series include:

- Sulphur Dioxide;
- Nitrogen Dioxide;
- Particulate Matter (including $PM_{10}$ and $PM_{2.5}$);
- Toxic Organic Compounds; and
- Heavy Metals.

Fact Sheets and the associated presentations are available on the KIC website www.kic.org.au

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