ACT Planning and Land Authority
16 February 2011

Molonglo Valley

Air Quality Assessment

Molonglo Valley

Air Quality Assessment

Prepared for

ACT Planning and Land Authority

Prepared by

AECOM Australia Pty Ltd
17 Warabrook Boulevard Warabrook NSW 2304,
T +61 2 4911 4900 F +61 2 4911 4999 www.aecom.com

16 February 2011

60156520

Quality Information

Document	Molonglo Valley
Ref	60156520 60156520 Molonglo AQIA\5. Delivery\5.2 Reports Final60156520_RPT_16Feb11.docx
Date	16 February 2011
Prepared by	Adam Plant Author Signature
Prepared by	Holly Marlin Author Signature
Reviewed by	David Rollings Technical Peer Reviewer Signature

Distribution

Copies	Recipient	Copies	Recipient
1	**April McCabe** **Senior Project Officer** **ACT Planning and Land Authority**	1	**AECOM File Copy**

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
Draft	20 Jan 2011	Draft submitted to client for review	Principal Engineer – David Rollings	
Revision 1	16 Feb 2011	Finalisation of report incorporating client comments	Technical Director/National Practice Leader – Graham Taylor	

Contents

List of Tables

Body Report

List of Figures

Body Report

List of Appendices

Executive Summary

The Molonglo Valley is a major area of future development for Canberra over the next 30 years. The proposed development of the area involves the creation of new residential suburbs and their associated community and commercial facilities, accommodating around 55,000 people when fully developed. The purpose of this Air Quality Assessment (AQA) was to assess the potential effects on air quality in the local area that might result from the development.

This AQA reviewed the climate and geographic setting of the development area and identified existing air quality issues in the ACT region that might affect the Molonglo Valley and potential changes to air quality that the development may cause. Additionally, mitigation measures were recommended to reduce any predicted adverse effects.

The development site is a valley with hilly to steep slopes. A drainage line running north-east through the site carries katabatic winds from other areas of Canberra through the valley. The valley is likely to experience significant temperature inversions during cold, clear nights and, as such, resultant pollution entrapment at ground level may potentially cause significant health impacts.

While air quality in the area is generally good, exceedences of particulate matter levels commonly occur, particularly in winter (wood heaters) and summer (bushfires). Furthermore, ozone levels occasionally exceed guideline levels. As existing levels of nitrogen dioxide and carbon monoxide are well below the guideline levels, increases in concentrations of these pollutants are not expected to negatively affect air quality to a large degree.

The primary risks to air quality from the development are considered to be particulate emissions from wood heaters and bushfires. Recommendations to mitigate these risks include considering the banning of wood heater use within the valley, as well as continuation of existing programs and actions to minimise wood heater use in the greater Canberra area, and implementation of bushfire management programs. The effects of odour from sewer vents should also be considered and mitigated where necessary.

The installation of an ambient monitoring station within the development area is recommended following construction. Such an action will enable pollutant concentrations in the area to be monitored, and will further increase the available knowledge of the Canberra airshed.

"This page has been left blank intentionally"

1.0 Introduction

The ACT Government has identified the Molonglo Valley as a major area of future development for Canberra over the next 30 years, supporting approximately 55,000 people when fully developed. The proposed development is to be staged over a number of years, resulting in the creation of new residential suburbs, and will include community and commercial facilities such as schools, shops, parks, green spaces and playgrounds in the East Molonglo area. The West Molonglo area is considered suitable for peri-urban land uses such as agriculture, educational establishments, animal care facilities and tourist facilities rather than residential purposes. Central Molonglo is not part of the Future Urban Area.

The ACT Government intends to implement best practice urban design, including the highest standards in energy efficiency, water conservation, solar access and ecological sustainability, to minimise the effects of the development on the natural environment. The first two suburbs of the development, Wright and Coombs, have both received accreditation as EnviroDevelopment projects by the Urban Development Institute of Australia in the categories of Energy, Waste, Community and Ecosystems, indicating that the development in these suburbs has incorporated sustainability features into their design and execution that are above and beyond normal practice.

The ACT Planning and Land Authority (ACTPLA) commissioned AECOM to assess the potential air quality impacts associated with the proposed development of the Molonglo Valley area. The key objectives of the Air Quality Assessment (AQA) were to:

- Understand the climate of the Molonglo development area;
- Identify the current air quality risks for the Molonglo Valley;
- Identify impacts that development within the Molonglo Valley may have on the local air quality; and
- Recommend potential mitigation measures.

1.1 Scope of Work

The scope of work for the AQA was as follows:

- Identification of the climate/geographic setting of the Molonglo Valley by reviewing available existing meteorological and topographical data representative of the study area;
- Identification of the current air quality issues for the Molonglo Valley by reviewing available existing air quality data representative of the study area;
- Identification of the effects that development within the Molonglo Valley may have on the air quality of the Valley; and
- Recommendation of potential mitigation measures for the construction and operational phases of the development.

"This page has been left blank intentionally"

2.0 Background

2.1 Project Background

In 2004, the ACT Government released The Canberra Plan (CMD, 2004) to guide Canberra's future growth and development. The Canberra Plan has three main components: The Canberra Spatial Plan, the Canberra Social Plan and the Canberra Economic White Paper. The aim of the strategic direction outlined in the Spatial Plan is to manage the change necessary to achieve sustainable urban growth that balances social, economic and environmental outcomes and fulfils the aspirations of the community.

The Molonglo and North Weston Structure Plan commenced under ACT Legislation in December 2008 (Variation to the Territory Plan No. 281 - Molonglo and North Weston). This plan enabled urban development in parts of the Molonglo Valley and North Weston through the introduction of urban zones and a structure plan for Molonglo and North Weston. It responds to the strategic direction provided by The Canberra Spatial Plan, which identified the Molonglo Valley as Canberra's next major urban area, and to issues raised during public consultation on the draft variation and the concurrent amendment to the National Capital Plan (No. 63) in 2007. The projected population for Molonglo at the time of commencement of Variation 281 was 55,000 people.

2.2 Location and Regional Context

The Molonglo Valley is a large valley covering an area of around 4,000 hectares between Belconnen and Weston Creek, approximately 7.5 km west of central Canberra as shown in **Figure 1**. The valley is surrounded by mountains (including Black Mountain, Dairy Farmers Hill, Mount Stromlo, Mount Painter and the Pinnacles) and undulating land. The Molonglo River runs from the south-east to the north-west through the valley, downstream of the Scrivener Dam and Lake Burley Griffin (Eco Logical, 2010).

The land has historically been used for rural purposes, and much of the area has been cleared. There are also some pine plantations in the area (Eco Logical, 2010).

The Molonglo Valley Stage 2 development area is located north of the suburbs of Coombs and Wright (Molonglo Stage 1) and south of the Molonglo River (downstream of Scrivener Dam). The site is bounded by the Molonglo River to the north and east, Uriarra Road and the Stromlo Forest Park to the south, and steep land not planned for urban development is located to the west. Coppins Crossing Road passes north-south through the Molonglo Stage 2 site.

2.3 Site Description

The site has been described in detail elsewhere [for example, ACTPLA (2007) and Eco Logical (2010)]. The key site features are summarised in the following sections.

2.3.1 Topography

The valley consists of undulating land interspersed with moderately steep slopes, the steepest of which are located in the river gorge downstream of Coppins Crossing. The western slopes of the valley tend to be steep, while the eastern slopes are both longer and more gentle. Low ridgelines form a series of gully lines along the sides of the valley. These gullies and the tributary creeks [including Yarralumla Creek (which drains the Woden Valley), Weston Creek (which drains the Weston Creek district), Holdens Creek, Coppins Creek, Deep Creek and Cliffs Creek] drain into the river.

Elevations within the proposed development area range up to 686 metres above sea level. The Valley is separated from central Canberra by a ridge running from the north to south.

2.3.2 Vegetation

As mentioned above, the site has been extensively cleared, largely as a consequence of bushfires in 2001 and 2003. Existing vegetation primarily consists of pasture land, with some pine plantations in the western and southern areas. Lowland woodlands and grasslands are also present. A protected reserve (Kama Nature Reserve) covering approximately 155 hectares is located to the west of the Eastern Molonglo development area. Woodland is found throughout the development areas; while the West Molonglo woodlands are found in three adjacent patches, the East Molonglo woodlands are fragmented (Eco Logical, 2010).

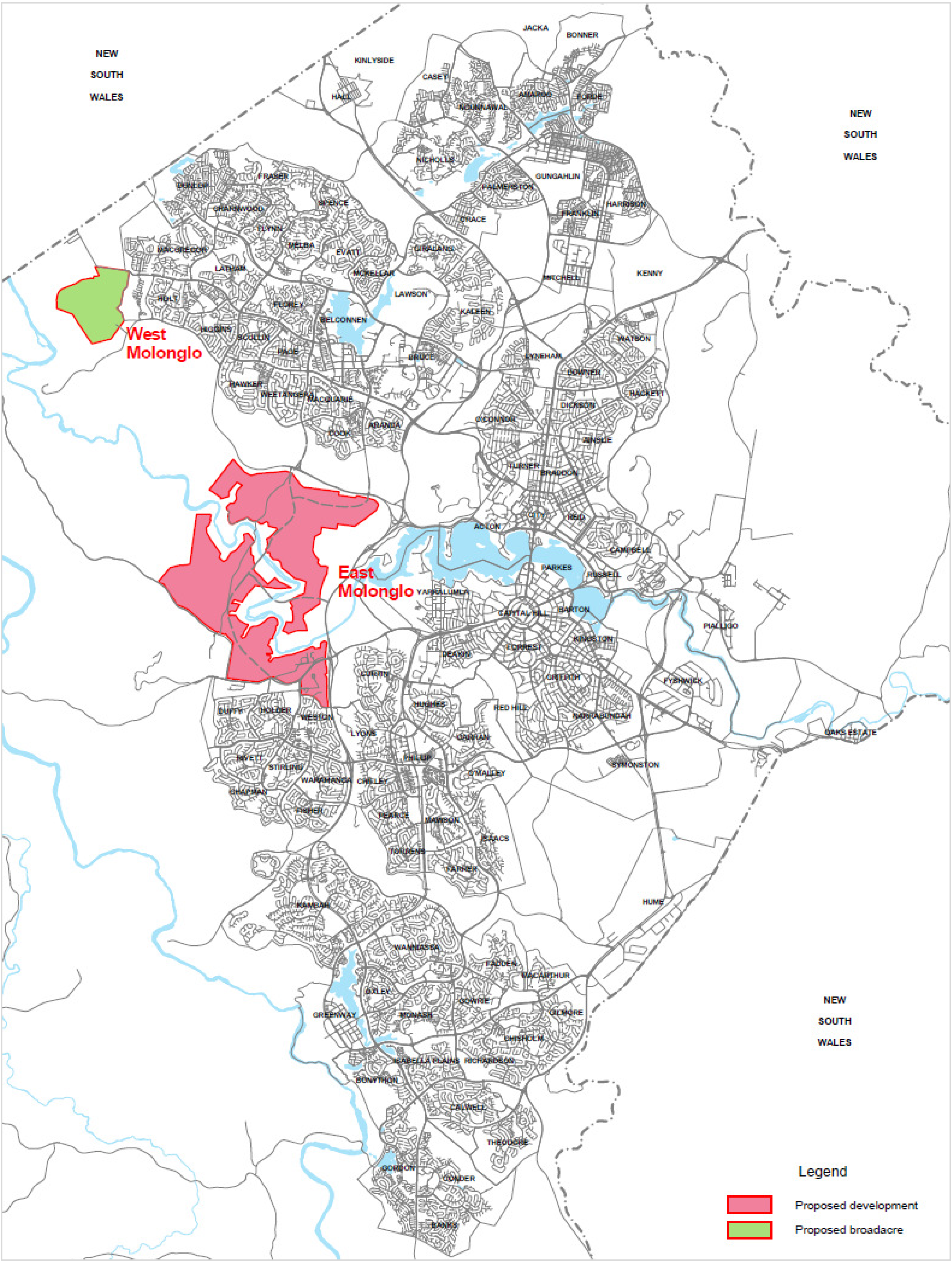


Figure 1: Location Plan

Source: ACTPLA

2.3.3 Bushfire Risk

Bushfires are a known hazard in the ACT due to the dry summers and flammable vegetation. Severe, damaging fires occur on a regular basis, generally every 6 – 27 years. The most serious fires occurred in 2003, and affected the Molonglo and Mount Stromlo areas.

The risk of bushfires occurring is most prominent when strong winds from central Australia are directed towards Canberra. The most dangerous wind direction for Canberra and its surrounding regions (north-west) is also the prevailing wind direction for the area (ACTPLA, 2007).

2.4 Project Staging

Land within the East Molonglo area will be released in a staged manner, an indicative outline of which is provided in **Table 1** and shown on **Figure 2**. The land in West Molonglo is set aside for peri-urban uses rather than residential uses: The timing of development in that area has yet to be determined.

Table 1: East Molonglo indicative Development Staging up to 2025

2009 - 2014	
Dwelling sites released	4,550
Other land uses	Local centre School site Community facilities Public open space
Infrastructure	Weston Creek Pond John Gorton Drive (to Holden's Creek) Trunk sewer Stormwater retention ponds Electricity zone substation
2015 - 2020	
Dwelling sites released	4,000 (estimated)
Other land uses	First blocks in major group centre Community facilities Public open space
Infrastructure	John Gorton Drive (to major group centre) Trunk sewers Stormwater retention ponds
2021 - 2025	
Dwelling sites released	4,000 (estimated)
Other land uses	Further development at major group centre Community facilities Public open space First releases in minor group centre
Infrastructure	John Gorton Drive (to William Hovell Drive) and bridge East-west arterial road and bridge Trunk sewers Stormwater retention ponds

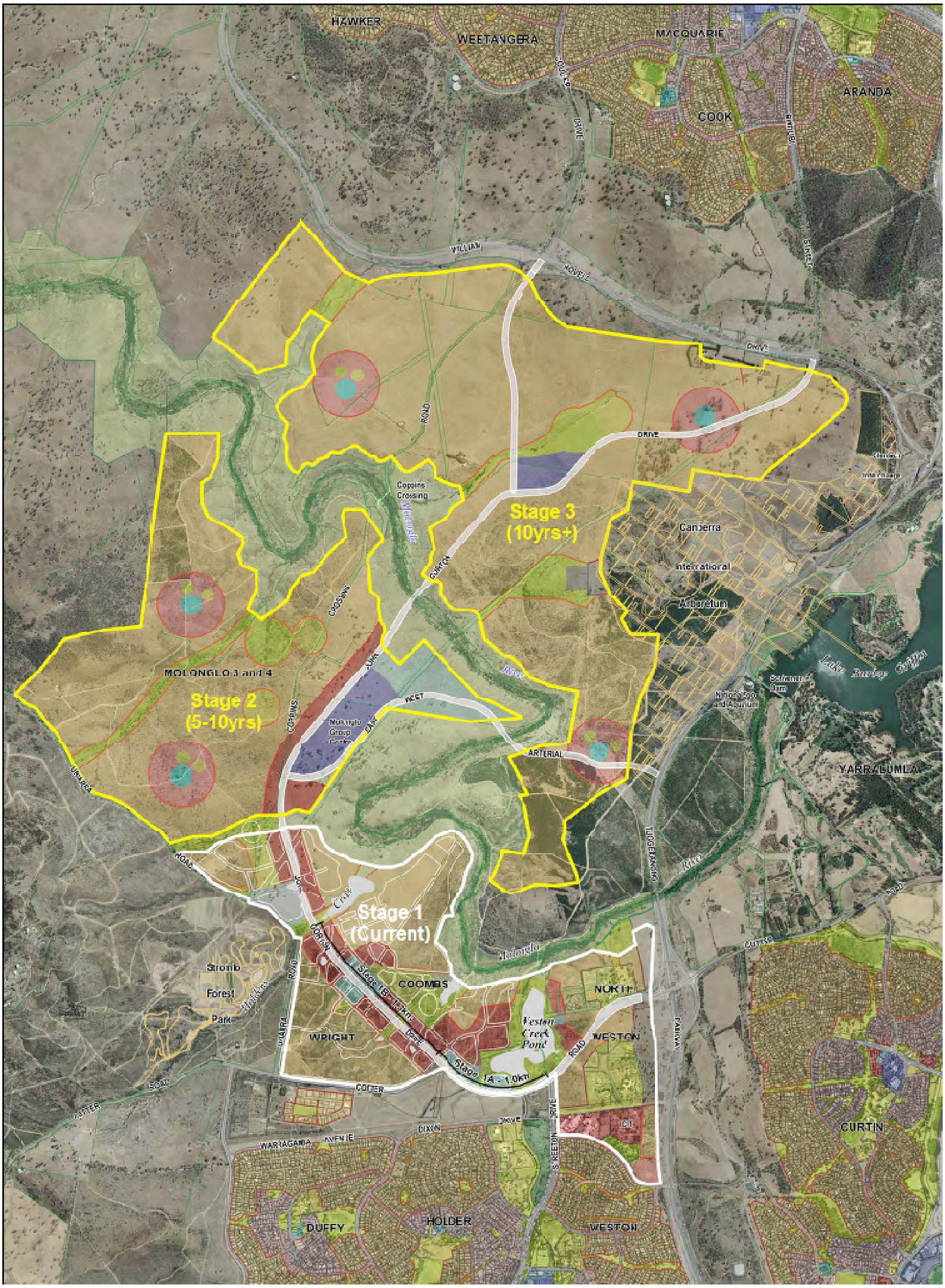


Figure 2: East Molonglo Staging Plan

Source: ACTPLA

3.0 Legislation

3.1 National Environment Protection Measures

National Environment Protection Measures (NEPMs) are broad framework-setting statutory instruments that outline agreed national objectives for protecting or managing particular aspects of the environment. Air quality in the ACT is governed by the National Environment Protection (Ambient Air Quality) Measure (the Air Quality NEPM) as amended (2003). This NEPM provides guidance relating to air in the external environment, which does not include air inside buildings or structures.

The Air Quality NEPM outlines monitoring, assessment and reporting procedures for the following criteria pollutants:

- Carbon monoxide;
- Nitrogen dioxide;
- Sulfur dioxide;
- Particles as PM_{10} (particles with diameters less than or equal to 10 µm);
- Particles as $PM_{2.5}$ (particles with diameters less than or equal to 2.5 µm);
- Photochemical oxidants (as ozone); and
- Lead.

The Air Quality NEPM standards apply to air quality experienced by the general population within a region, and not to air quality in areas within the region affected by localised air emissions, such as heavily trafficked streets. The goal of the Air Quality NEPM was to achieve the standards with the allowable exceedences, as assessed in accordance with the associated monitoring protocol, by 2008. The standards were set at a level intended to adequately protect human health and well-being. The ambient air quality standards defined in the Air NEPM are listed in **Table 2**.

Table 2: Air NEPM Air Quality Standards

Pollutant	Air NEPM Standards	Averaging Period
Carbon monoxide	9.0 ppm	8 hour*
Nitrogen dioxide	0.12 ppm 0.03 ppm	1 hour* Annual
Sulfur dioxide	0.20 ppm 0.08 ppm 0.02 ppm	1 hour* 24 hour* Annual
PM_{10}	50 µg/m^3	24 hour**
$PM_{2.5}$	25 µg /m^3 8 µg /m^3	24 hour (advisory only) Annual (advisory only)
Photochemical oxidants (as ozone)	0.10 ppm 0.08 ppm	1 hour* 4 hour*
Lead	0.50 µg /m^3	Annual

ppm: parts per million
µg / m^3: micrograms per cubic metre
* Not to be exceeded more than one day per year
** Not to be exceeded more than five days per year

In addition to the Air Quality NEPM, the National Environment Protection (Air Toxics) Measure (Air Toxics NEPM) provides a framework for monitoring, assessing and reporting on ambient levels of air toxics. The purpose of this NEPM is to collect information to facilitate the development of standards for ambient air toxics.

The Air Toxics NEPM includes monitoring investigation levels for use in assessing the significance of monitored levels of air toxics with respect to human health. The monitoring investigation levels are levels of air pollution below which lifetime exposure, or exposure for a given averaging time, does not constitute a significant health risk. If these limits are exceeded in the short term, it does not mean that adverse health effects automatically occur; rather some form of further investigation by the relevant jurisdiction of the cause of the exceedence is required. The relevant monitoring investigation levels defined in the Air Toxics NEPM are listed in **Table 3**.

Table 3: Air Toxics NEPM Air Quality Monitoring Investigation levels

Pollutant	Air Toxics NEPM Monitoring Investigation Level	Averaging Period
Benzene	0.003 ppm	Annual
Formaldehyde	0.04 ppm	24 hours
Benzo(a)pyrene as a marker for polycyclic aromatic hydrocarbons (PAHs)	0.3 ng/m^3	Annual
Toluene	1 ppm 0.1 ppm	24 hour Annual
Xylenes (as a total of ortho, meta and para isomers)	0.25 ppm 0.2 ppm	24 hour Annual
ppm: parts per million ng/m^3: nanograms per cubic metre		

3.2 Air Environment Protection Policy

The Air Environment Protection Policy 1999 (AEPP) was prepared by the Environment Management Authority to manage air emissions in the ACT such that the air quality standards in the Territory at least meet the NEPM standards. The AEPP provides guidance to assist people to meet their environmental obligations, but is not legally binding, and does not apply to motor vehicles operating on public streets, trains, or aircraft.

The major sources of air emissions in the ACT are transportation and fires from non-industrial activities. The AEPP recommends different strategies to control emissions for different types of activities, including:

- Restricting the purposes for which the activity may be undertaken;
- Requiring the activity to be undertaken in a particular way; and
- Requiring emissions from the activity to meet specified standards.

3.2.1 Transportation Activities

Emissions from motor vehicles are the major source of air pollution in the ACT. Urban planning, vehicle design and emission controls, and fuel composition are the primary means of mitigating the environmental impacts of their emissions.

Emissions from motor vehicles being driven on public streets are subject to the *Motor Traffic Act 1936* except when taking part in reliability trials or speed tests for which a permit under the Motor Traffic Act has been issued. Vehicles covered by the Motor Traffic Act are subject to random in-service testing. Where the Motor Traffic Act does not apply, emissions from the vehicle are subject to the Environment Protection Act. Under these circumstances, the vehicle must comply with the emission requirements of the Motor Traffic Act and the general environmental duty.

Part IV of Schedule 2 of the Act includes provisions that regulate the composition and sale of petrol.

3.2.2 Domestic, Social, Rural and Open Space Management Activities

The main air pollutants produced by these activities are smoke and fumes from fires, spray and fumes from the use of chemicals, and dust. Of these, fires are the main source of air emissions.

Outdoor fires are controlled both in the types of material that can be burned, when the fires may be lit, and in the allowable emissions, which are dependent on the purpose for which the fire was lit. Indoor fires are also restricted in the types of materials that can be burned and the way in which the fires are managed. Synthetic substances, painted or chemically treated woods, chemicals, unseasoned wood and wastes are not allowed to be burned, except in incinerators that hold an environmental authorisation to do so.

Under Regulation 14, a person must take "*such steps as are practicable and reasonable to prevent or minimise the environmental harm caused, or likely to be caused, by the emission of pollutants into the air from the fire*." These steps include managing the fire such that excessive smoke is not produced.

3.3 The Territory Plan

The Territory Plan guides the planning and development of the ACT. It is used to: manage development, particularly how land is used and what can be built; to assess development applications; and to guide the development of new estate areas (future urban land) and manage public land.

"This page has been left blank intentionally"

4.0 Climate

Climate refers to the average weather patterns experienced in a location over a long time period. Weather parameters commonly used to define climate include temperature, rainfall, wind speed and humidity.

The ACT State of the Environment Report (2007) summarised the local environment between 2003 and 2006. The weather was described as being warmer and drier than average, with 2006 being the warmest year on record and one of the driest years. Bushfires are a common occurrence in the region during the summer months, with significant bushfires occurring in January 2003, which affected 70 % of the ACT. Severe thunderstorms also occurred in 2003, and a severe hailstorm and flooding occurred in 2007.

The Bureau of Meteorology (BOM) reported that rainfall levels in Canberra in 2010 were higher than the historical average, and were more than double the level of rainfall recorded in 2009. Significant flooding occurred in December, 2010. The BOM also reported that 2010 was the 14th consecutive year where daily maximum temperatures were above historical averages, and the 12th consecutive year of minimum temperatures exceeding historical averages (BOM, 2011).

4.1 Climate Averages

The term climate refers to long-term average weather patterns that are experienced in an area. While substantial variation in weather conditions can occur between years, the climate of an area remains relatively stable, with changes occurring on a gradual basis.

The BOM records long-term meteorological data at a number of automatic weather stations across the country. The BOM station closest to the Molonglo Valley is located at the Canberra Airport (latitude 35.30°S, longitude 149.2°E, height 577 m), approximately 16 km east of the Molonglo Valley. This monitoring station is located on flat land between Canberra city and the Fairbairn Pine Plantation. The airport site is comparatively flatter than the Molonglo Valley, which, as described in **Section 2.3.1**, has undulating hills and valleys. As such, differences in wind patterns between the two sites would be expected. As hills and valleys create wind turbulence, drainage flows/katabatic winds not likely to be experienced on a flat plain, the wind conditions at Canberra Airport are not considered likely to represent conditions at the development site. Other climate parameters are, however, considered to be generally indicative of conditions at the site. Data recorded at Canberra Airport between 1939 and 2010 are summarised in **Table 4**. It should be noted that the recent weather conditions experienced in the area, such as the high rainfall levels of 2010, do not greatly affect the current climate averages (which are based on over 70 years of average weather data).

Table 4: BOM Climate Averages - Canberra Airport (1939 – 2010)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Average temperature (°C)													
Maximum	28	27	25	20	16	12	11	13	16	19	23	26	19.7
Minimum	13	13	11	6.7	3.2	1	-0.1	1	3.3	6.1	8.8	11	6.5
Rainfall													
Average rainfall (mm)	59	56	51	46	44	40	41	46	52	62	64	54	616.4
Decile 5 (median) rainfall (mm)	49	55	32	30	38	31	36	46	52	55	60	44	616.6
Mean number of days of rain ≥ 1 mm	5.6	5.1	4.8	4.8	5.1	5.7	5.8	7	7	7.8	7.5	5.9	72.1
Average 9 am conditions													
Temperature (°C)	19	18	16	12	8	5	3.9	5.9	9.6	13	16	18	12.1
Relative humidity (%)	63	68	71	75	82	85	85	78	71	65	63	60	72
Wind speed (km/h)	7.5	6.4	6.1	6.5	6.9	7.8	8.5	9.9	10	11	9.8	9.1	8.3

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Average 3 pm conditions													
Temperature (°C)	27	26	23	19	15	11	11	12	15	18	21	25	18.5
Relative humidity (%)	37	40	42	46	54	60	58	52	49	47	41	37	47
Wind speed (km/h)	17	15	15	14	14	15	17	20	21	21	20	19	17.3
red = highest value blue = lowest value													

The Tuggeranong BOM site was also examined for comparative reasons. The Tuggeranong station (latitude 35.42°S, longitude 149.09°E, height 587 m) is located in Monash, approximately 16 km south south-east of the Molonglo Valley. The Tuggeranong area is located in a pronounced basin with defined hills to the east and west closing to the south creating a 'v' shape. Data recorded in Monash are shown in **Table 5**.

Table 5: BOM Climate Averages - Tuggeranong (1996 – 2010)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Average Temperature (°C)													
Maximum	29.5	28.3	25.6	21.2	16.7	13	12	14	17.6	20.6	24.1	27	20.8
Minimum	14.2	14.3	11.2	6.7	2.7	1.2	-0.1	0.8	4	6.4	9.7	12	6.9
Rainfall													
Average rainfall (mm)	44.2	59.6	36.4	28.7	22.2	49	41	50	63.1	58	68.9	55	576
Decile 5 (median) rainfall (mm)	42.7	51.6	31.5	19.3	12.4	41	33	36	68.6	54.6	66.4	41	547
Mean number of days of rain ≥ 1 mm	4.7	5.3	3.7	3.5	3.5	6.1	5.5	5.5	6.7	6.6	7.7	5.5	64.3
Average 9 am conditions													
Temperature (°C)	19.6	18.6	15.7	13.1	8.3	5.9	4.8	6.9	10.9	13.9	15.8	18	12.6
Relative humidity (%)	61	68	70	69	78	83	82	73	65	60	62	59	69
Wind speed (km/h)	8.4	7.7	6.5	8	6.5	7.1	7.1	8.9	10.8	11.3	10.1	9.6	8.5
Average 3 pm conditions													
Temperature (°C)	27.8	26.6	24.3	20.1	15.6	12	11	13	16.2	19.2	22.5	26	19.5
Relative humidity (%)	34	39	38	42	50	57	56	50	46	41	39	34	44
Wind speed (km/h)	16.2	15.4	14.7	13.8	13.2	14	14	17	18.5	18.7	17.3	18	15.8
red = highest value blue = lowest value													

Climate data from these BOM stations are summarised in the following sections.

4.1.1 Temperature

The hottest temperatures occur between December and February, with peak average maximum concentrations occurring in January at both the Airport (28 °C) and Monash (30 °C) locations. Warm temperatures are also typical during November and March. Cool temperatures commonly occur from May to September, with the lowest average temperatures typically occurring in July (-0.1 °C at both locations).

4.1.2 Rainfall

The highest rainfall occurs in spring, with November the wettest month on average at both locations. Rainfall patterns between the two monitoring sites differed in terms of the driest months: At the Airport, the lowest rainfall occurs during winter (40 and 41 mm for June and July respectively), while the autumn is driest at Monash (29 and 22 mm in April and May respectively). Long-term data at both sites are similar for the average number of rain days per month, with the greatest rain frequency found in spring and the lowest rain frequency in autumn.

4.1.3 Relative Humidity

Relative humidity is a measure of how much moisture is in the air, and varies throughout the day. The highest relative humidities occur in winter while the lowest are in summer. Humidity levels at 9 am are higher than at 3 pm.

4.2 Microclimate

The term microclimate refers to a local atmospheric zone where the weather conditions differ from that of the surrounding area. The term is typically applied to a relatively small area, within a few metres of the Earth's surface.

Microclimates are affected by a number of factors including: latitude; soil type; the presence of (or proximity to) water bodies such as oceans, lakes and rivers; the slope or aspect of the area; vegetation coverage; and land use aspects, such as the presence of buildings and asphalt. Without detailed, site-specific data available, the microclimate of the Molonglo Valley development area is difficult to determine. As such, only general comments regarding the current microclimate and the potential changes resulting from the proposed development are discussed below.

4.2.1 Meteorology

As no meteorological monitoring is undertaken in the Molonglo Valley, actual meteorological conditions in the valley are not known. CSIRO has, however, developed a computer model (The Air Pollution model, or TAPM) that can be used to predict meteorological conditions in any area of Australia based on its extensive databases containing synoptic weather data, topography, and land use information (among other factors).

TAPM was run for the 2009 calendar year to estimate meteorological conditions at the site. The resultant data are summarised in **Appendix A**, and briefly described below.

4.2.1.1 Wind Conditions

The predominant winds in the area blow from the north-western quadrant, although there is substantial seasonal variation according to time of day. Light winds tend to blow from the southwest in the morning, while stronger winds blow from the northwest in the afternoon. Seasonal variation in wind direction is also apparent – while north-westerly winds are seen throughout the year, strong winds are also often seen from the east/southeast in summer and autumn and, occasionally, in spring. Winter winds, however, are almost exclusively from the southwest to northwest quadrant. These data support the assertion that the predominant winds in Canberra are north-westerly (**Section 2.3.3**).

The average wind speed for the area is 3.6 m/s. Approximately half the wind speeds are between 4 – 6 m/s, with the remainder all lower (it should be noted that TAPM does not predict calm conditions, i.e. wind speeds of less than 0.5 m/s when run in the configuration used for this assessment).

4.2.1.2 Stability Class

Stability class is a measure of the amount of turbulence in the air, which relates to how well pollutants in the airshed will disperse. The predominant stability classes in the Molonglo Valley were predicted to be the neutral and stable conditions (classes D – F). Stable conditions (classes E and F) are associated with strong temperature inversions and light winds (common at night). Neutral conditions (D) are associated with windy or cloudy conditions and the periods around sunset and sunrise when changes in surface temperatures are small, and are associated with coning plumes. Together, the data indicate a high likelihood for pollution released within the valley to become trapped within the valley with limited dispersion.

4.2.1.3 Mixing Height

Mixing height is the depth of the atmospheric surface layer beneath an elevated temperature inversion. The mixing height defines the height above the earth's surface where the mixing of air occurs. High mixing heights are associated with the greatest pollutant dispersion. Low mixing heights mean there is less air for pollutants to be dispersed within, leading to greater pollutant concentrations at ground level.

Diurnal variation is seen in mixing heights, with the maximum heights seen in the afternoon and minimum mixing heights occurring during the early morning. Average mixing heights in the Molonglo Valley are relatively low, with a maximum of around 1000 m and a minimum of around 250 m. Again, this is suggestive of higher pollutant concentrations at ground level if pollutants are present in the airshed.

4.2.2 Temperature Inversions

Under normal atmospheric conditions, air temperature decreases with increasing height. Under temperature inversions, this pattern is reversed such that the ground is rapidly cooled, making the air close to the ground cooler than the air above it. Cold air is denser than warm air, so the cold air tends to flow down hill (known as cold air drainage or katabatic winds), and pools in frost hollows (low topographic areas). Pollution within the cold air drainage flow can become trapped and accumulate below the inversion layer, resulting in high pollutant concentrations.

The topography of the development site is hilly to steep with about 90 % of the site with slopes greater than 5 % and around 40 % with slopes in excess of 10 %. The valley forms a drainage line running north-east through the centre of the site to the Molonglo River. The drainage line carries katabatic winds originating from the catchments of Central Canberra, Woden Valley and Weston Creek (ACTPLA, 2007). During the day, differential heating and atmospheric pressure of the slopes would be expected to draw wind away from valley bottom.

As temperature inversions commonly occur during winter, on still nights, air quality issues are exacerbated at these times, as these are the conditions during which domestic heating is likely to be employed. Particulates emitted from wood heaters are the main concern. As the meteorological conditions cannot be controlled, management of air quality associated with these conditions must be addressed through control of pollutant emissions.

4.2.3 Vegetation

Vegetation absorbs both light and heat. The proposed development site has been extensively cleared, with much of the area now consisting of grassland and remnant trees. The proposed development would involve further clearing to remove much of the current vegetation in many areas, and replacing it with buildings and asphalt roads, which radiate heat back into the air. As such, the temperature in the area is likely to increase as a result of the proposed development. Adverse temperature increases can potentially be mitigated through the extensive installation of solar collection devices, which would absorb sunlight and generate useful electricity.

4.2.4 Solar Access

The north-facing slopes within the area are exposed to more direct sunlight than the south-facing slopes and, as such, are warmer for longer. The degree to which this occurs depends on the exact orientation of the slopes.

4.3 Climate Change

The average global temperature has increased by 0.6° C over the past century. In Australia, an increase of around 0.7° C has been documented, and further increases of between 1 - 6 ° C are predicted to occur by 2070. Rainfall events are expected to decrease in frequency but become more intense, resulting in greater flooding (ACTPLA, 2007).

Climate change is likely to affect the ACT, including the Molonglo Valley, in a number of ways. Temperatures in the area are expected to increase over the coming decades, resulting in a greater number of hot days and fewer cold nights (ACT Government, 2007). This may result in additional energy requirements during the warmer months to power air conditioning, but may also result in lower demand for heating during winter. The higher temperatures may also result in decreased water availability due to increased evaporation, particularly as the total annual rainfall is not expected to dramatically change. Conversely, however, evaporation may decrease as a result of global dimming, which refers to a reduction of solar energy reaching the surface due to higher pollution levels in the atmosphere reflecting the energy back into space (ACTPLA, 2007).

A change in the distribution of rain events is, however, anticipated – summer and autumn are predicted to become wetter, while winter and spring are expected to become drier. More intense storm events are also expected to occur, and droughts are predicted to become both more severe and more frequent, particularly in winter and spring (ACT Government, 2007).

Average wind speeds are predicted to increase in summer months in the ACT (ACT Government, 2007). The risk of fires is also predicted to increase, with the number of days classified as having very high or extreme fire danger potentially increasing by 13 – 26 % (ACT Government, 2007).

"This page has been left blank intentionally"

5.0 Existing Air Quality

Air quality in the ACT is considered to be quite good, particularly in relation to other Australian capital cities, mainly because the area has no heavy industry. The primary sources of air pollution in the ACT are motor vehicles, wood smoke, and bushfires/dust storms. Other sources include landfills, agriculture, sewerage treatment plants and pipelines, and power stations (refer to **Appendix B**).

Temperature inversions during winter are associated with excessive particulate levels in some areas, particularly developed valley areas such as Tuggeranong. High particulate levels also occur in summer due to bushfires.

5.1 Air Quality Monitoring

ACT Health operates an ambient air quality network on behalf of the ACT Government, consisting of two monitoring stations. One station is located at Monash, approximately 200 m west of Cockcroft Avenue in the district sporting fields. The other station is located at Civic, near Allara Street, and is the closest station to Molonglo Valley as shown in **Figure 3**. It should be noted, however, that there is a substantial ridgeline between Molonglo Valley and both of the monitoring stations (**Section 2.3.1**). As such, the meteorology within the Molonglo Valley may be different to that recorded at those monitoring stations.

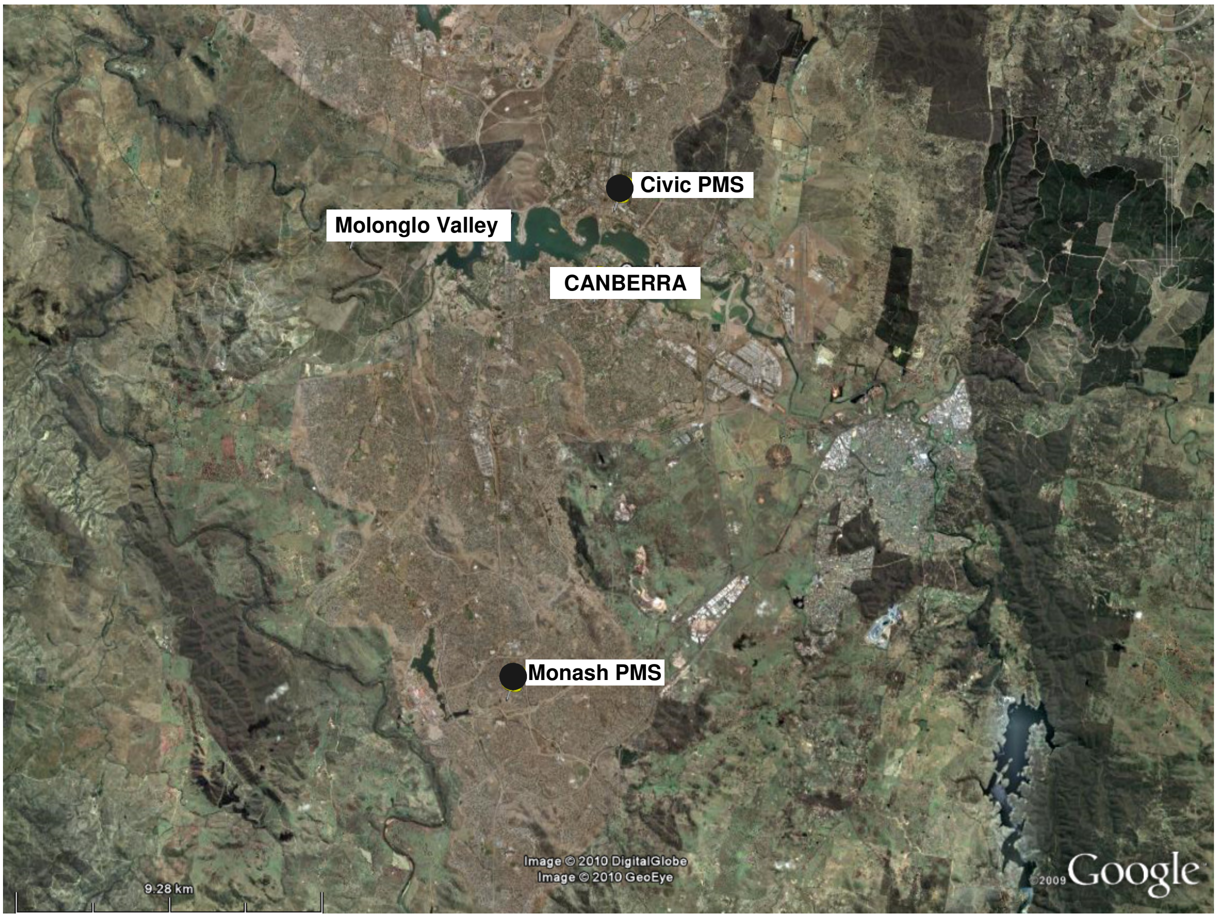


Figure 3: Performance Monitoring Station Locations

Continuous monitoring of carbon monoxide, nitrogen dioxide, and ozone is undertaken at both monitoring stations. Particulate matter (PM_{10} and $PM_{2.5}$) is only monitored at Monash. The stations ceased monitoring of lead in 2002, while sulphur dioxide has never been monitored due to the lack of heavy industry (EPA, 2010).

The Environment Protection Authority (EPA) recently published a report on air quality in the ACT (EPA, 2010). Overall air quality in the area is considered to be excellent, particularly in comparison to other capital cities, with all pollutant concentrations below NEPM standards. The only exception is elevated particulate concentrations, which are a recognised issue during with winter months, and are primarily caused by the use of domestic wood heaters. Motor vehicles are the primary source of air pollutants.

The following sections summarise the data presented in EPA (2010). It should be noted that while the existing data are generally indicative of pollutant levels in the proposed development area, the proposed development is located in an area that is quite different topographically to that of the existing monitoring stations, and that is currently undeveloped.

5.2 Carbon Monoxide

Carbon monoxide (CO) is a colourless, odourless gas produced by the incomplete combustion of fuels containing carbon (e.g. oil, gas, coal and wood). Carbon monoxide is absorbed through the lungs of humans, where it reacts to reduce the blood's oxygen-carrying capacity. In urban areas, motor vehicles account for up to 90 % of all CO emissions.

Historically, no exceedences of the 8-hour NEPM standard for carbon monoxide have occurred since 1999. Maximum concentrations at Monash have steadily declined since 2000, with the maximum concentration of 2.0 ppm representing less than half the maximum concentration of 5.8 ppm recorded in 2000 (the maximum concentrations recorded since 1999). A rapid decline in carbon monoxide concentrations is also apparent from the monitoring data from Civic. The highest 1-hour maximum concentration of 7.5 ppm occurred in 1999; in contrast, the maximum concentration in 2009 was 1.0 ppm, which represents a quarter of the highest recorded concentration.

On average, the maximum 8-hour carbon monoxide concentrations were typically higher at Monash than at Civic in 2009. The highest concentrations at Monash were recorded between May – September, while the highest concentrations at Civic were recorded in July and August. Levels of carbon monoxide during 2009 were typically less than 11 % of the NEPM standard, with the maximum concentration of 2.0 ppm representing 22 % of the 8 hour standard of 9.0 ppm.

Wood burning heating is considered to be the main source of carbon monoxide emissions (ACT Government, 2008), and explains the seasonal concentration pattern, with peak concentrations occurring in winter. Should wood burning heaters be permitted in the proposed development, carbon monoxide concentrations would be expected to increase. Carbon monoxide levels in Canberra are not currently a cause for concern, however, and the Canberra airshed has the capacity to accommodate a substantial increase in carbon monoxide levels without exceeding the NEPM standard.

5.3 Nitrogen Dioxide

Nitrogen dioxide (NO_2) is a brownish gas with a pungent odour. It exists in the atmosphere in equilibrium with nitric oxide. The mixture of these two gases is commonly referred to as nitrogen oxides (NO_x). Nitrogen oxides are a product of combustion processes. In urban areas, motor vehicles and industrial combustion processes are the major sources of ambient nitrogen oxides. Nitrogen dioxide can cause damage to the human respiratory tract, increasing a person's susceptibility to respiratory infections and asthma. Sensitive populations, such as the elderly, children, and people with existing health conditions are most susceptible to the adverse effects of nitrogen dioxide exposure. Nitrogen dioxide can also cause damage to plants, especially in the present of other pollutants such as ozone and sulphur dioxide. Nitrogen oxides are also primary ingredients in the reactions that lead to photochemical smog formation.

The data trend at both Monash and Civic between 1999 and 2009 indicates nitrogen dioxide levels have been essentially stable during the monitoring period, with maximum hourly concentrations varying between 0.039 – 0.103 ppm at Monash and 0.040 – 0.087 ppm at Civic. The NEPM standard is 0.12 ppm.

In 2009, recorded levels of nitrogen dioxide were well below the NEPM standards for hourly and annual concentrations. Maximum hourly concentrations were similar at both monitoring locations, and were typically below 0.03 ppm. The maximum recorded concentration of 0.043 ppm, recorded at Civic, represents 36 % of the hourly NEPM standard of 0.12 ppm. The highest annual average, occurring at Civic, was 26 % of the NEPM annual standard of 0.03 ppm. It should be noted that monitoring data between the end of February and the end of April were missing; however, based on historical trends and data from Monash, it is unlikely that exceedences occurred. While no strong trend was apparent, peak hourly nitrogen dioxide levels appear to be higher in the hotter months (November to February).

An increase in motor vehicles during the construction and operational phases of the development would contribute to increased levels of nitrogen dioxide or nitrogen oxides. The available air quality data, however, suggest that there is substantial room within the airshed to accommodate an increase in nitrogen dioxide concentrations.

5.4 Ozone

Photochemical oxidants (often referred to as photochemical smog) are a complex mixture of chemicals produced in the atmosphere by the action of sunlight. The principal component of photochemical oxidants is ozone. Ozone measurements are commonly used as a surrogate for photochemical oxidants. Ozone is a colourless, highly reactive gas with a distinctive sharp odour. At ground level, elevated concentrations of ozone can cause respiratory problems and cardiovascular disease in humans, and can affect the healthy normal population as well as sensitive sub-populations. It can worsen bronchitis, emphysema, and asthma. Ozone can also affect the growth of vegetation and damage materials and ecosystems.

At ground level, ozone is created by a chemical reaction between nitrogen oxides and volatile organic compounds (VOCs) in the presence of sunlight. As such, nitrogen oxides and volatile organic compounds are referred to as ozone precursors. Motor vehicle exhaust, industrial emissions, gasoline vapours, chemical solvents as well as natural sources (such as bushfires) emit ozone precursors. The highest concentrations of ozone normally occur on summer afternoons, downwind of major sources of ozone precursors. Elevated concentrations are most likely to occur on warm sunny days in areas where the surrounding topography prevents the precursors from dispersing.

Ozone levels have been relatively stable between 1999 and 2009 at Monash, with maximum 1-hour concentrations typically between 0.06 – 0.08 ppm. An exceedence occurred in 2003, where the maximum 1-hour concentration was recorded at 0.102 ppm, slightly exceeding the guideline value of 0.1 ppm. At Civic, exceedences occurred on 4 days during the past 11 years – three in 2006 (with a maximum concentration of 0.252 ppm, which is more than double the NEPM standard), and one in 2007 (0.112 ppm). Concentrations of ozone at Civic are generally higher than those recorded at Monash. The average maximum concentration at Civic between 1999 and 2009 was 0.09 ppm, which is close to the standard level, compared to 0.069 ppm at Monash.

The 4-hour concentrations show a similar pattern; the maximum average concentration at Civic of 0.071 ppm approached the NEPM standard of 0.080 ppm, and exceedences occurred on a single day for both 2006 and 2007. The maximum 4-hour ozone concentration at Civic occurred in 2007, with a recorded concentration of 0.145 ppm, which was nearly double the NEPM standard. When this outlier was removed, the average maximum concentration was very similar to that recorded at Monash (0.063 ppm vs. 0.062 ppm), both representing approximately 80 % of the NEPM standard. At Monash, an exceedence of the 4-hour standard occurred on a single day in the past 11 years (2003, with a recorded concentration of 0.082 ppm).

Recorded ozone levels were below the 1-hour and 4-hour standards throughout 2009. Concentrations at Monash were higher than those at Civic throughout the year. The highest 1-hour ozone concentration was 0.073 ppm, which represents 73 % of the NEPM standard. The highest 4-hour concentration was 0.068 ppm, or 85 % of the NEPM standard.

Ozone concentrations were elevated from August to April at both monitoring locations, with peak concentrations occurring in summer. An increase in motor vehicle use during the construction and operational phases of the development could increase the potential for ozone formation. Unlike carbon monoxide and nitrogen dioxide, there is less capacity in the Canberra airshed to accommodate increased ozone concentrations.

5.5 Particulate Matter (PM_{10} and $PM_{2.5}$)

Particulate matter is the term for solid or liquid particles found in the air. Some particles are large or dark enough to be seen as soot or smoke, but fine particulate matter is tiny and is generally not visible to the naked eye. Particulate matter is produced by the mechanical breakup of larger solid particles. The larger or coarse fraction can include dust from roads, agricultural processes, uncovered soil or mining operations, as well as non-combustible materials released when burning fossil fuels. Pollen grains, mould spores, and plant and insect parts can also contribute to the coarse fraction. Evaporation of sea spray can produce large particles near coasts. The smaller or fine particulates are largely formed by the oxidation of primary gases.

Particulate matter can be emitted from natural sources (bushfires, dust storms, pollens and sea spray) or as a result of human activities such as combustion activities (motor vehicle emissions, power generation and incineration), excavation works, bulk material handling, crushing operations, unpaved roads and, of particular importance to this project, wood heaters.

Airborne particles are commonly differentiated according to size based on their equivalent aerodynamic diameter. Particles with a diameter of less than or equal to 50 micrometres (µm) are collectively referred to as total suspended particulates (TSP). TSP primarily cause aesthetic impacts associated with coarse particles settling on surfaces, which also causes soiling and discolouration. These large particles, however, can cause some irritation of mucosal membranes and can increase health risks from ingestion if contaminated. Particles with diameters less than or equal to 10 µm (known as PM_{10} or fine particles) tend to remain suspended in the air for longer periods than larger particles, and can penetrate into human lungs. Epidemiological studies show a correlation between exposure to particles and adverse health effects. No safe threshold for particle exposure has been established.

Deposited dust refers to the larger fractions that fall from the air and deposit on exposed surfaces. While deposited dust generally has an aerodynamic diameter of greater than about 20 µm, there is no sharp size cut off between these particles and the smaller particles that remain suspended in the air for long periods. Larger dust particles are generally responsible for nuisance (amenity) effects, including vegetation damage and surface soiling. Depending on its physical or chemical characteristics, dust may also cause surface deterioration of materials due to its abrasive or corrosive properties. If the dust composition is dangerous, the dust is considered a hazardous air pollutant (and may contain toxic material).

Exceedences of the 24-hour PM_{10} standard commonly occur at both Monash and Civic. At Monash, exceedences were recorded in 10 of the 11 years of monitoring (56 exceedences in total). The highest historical concentrations occurred in 2003, which was the year Canberra experienced severe bush fires. The average peak concentration at this location is 116.5 µg/m^3, which is more than double the NEPM standard. The 95th percentile data, however, which demonstrate trends excluding extreme events, show a gradual decline between 1999 and 2008.

Fewer exceedences were recorded at Civic, occurring in 6 of the 10 years, but with a lower frequency (12 in total) and scale than those at Monash. The average peak concentration of 48.5 µg/m^3 represents 97 % of the NEPM standard. No clear trend in pollutant concentrations is evident from inspection of the data recorded between 1999 and 2008; while concentrations appeared to be decreasing between 1999 and 2003, they have generally increased since then.

$PM_{2.5}$ is only monitored at Monash. Exceedences of the 24 hour NEPM standard were recorded every year between 2004 and 2009, with 65 exceedences occurring over the six year period. The average maximum concentration of 38.95 µg/m^3 exceeds the NEPM standard of 25 µg/m^3.

Particulate matter was only monitored at Monash during 2009. Nine exceedances of the 24-hour PM_{10} standard were recorded at Monash in 2009, and data were not recorded between January and June, meaning that additional exceedences may have occurred. The peak maximum concentration of 210 µg/m^3 on 22 September 2009 was attributed to a severe dust storm that affected most of eastern Australia. While some exceedences occurred during the winter months, as would be expected as a result of wood heater emissions, one exceedence in November was associated with a concentration that was nearly double the NEPM standard of 50 µg/m^3, and was probably the result of a bushfire. Due to the lack of data availability, an assessment could not be made regarding the annual PM_{10} NEPM standard.

A substantial amount of $PM_{2.5}$ data were also missing due to instrument failure. Sufficient data were available to assess the annual $PM_{2.5}$ concentration, which was lower than the NEPM advisory standard (6.2 vs. 8 µg/m^3). Exceedences of the 24-hour NEPM standard occurred on two days, with concentrations approaching 35 µg/m^3.

Particulate matter is evidently an existing issue for the Canberra region, with concentrations in the southern areas appearing to be greater than those in the north. Exceedences occur during both the winter and summer seasons, likely to result from wood fire smoke and bushfires. Current sources of dust in the Molonglo Valley are primarily particulates from neighbouring areas and bushfires. Local particulate levels are likely to increase as a result of the development. Activities expected to generate dust include land-clearing activities, vehicle traffic (during both construction and settlement), and, if permitted, the use of wood-burning stoves during the winter months.

6.0 Pollutant Sources

Due to the lack of major industry in the region, motor vehicles are the primary sources of nitrogen oxides (92 %) and carbon monoxide (77 %) emissions in the ACT, with domestic wood heaters the main anthropogenic source of particulate matter. As such, ambient pollutant levels are likely to increase as a result of the proposed development, particularly due to increased vehicle traffic and other domestic sources. As existing levels of nitrogen dioxide and carbon monoxide are well below the NEPM standards, increases in levels of these pollutants are not expected to negatively affect air quality to a large degree.

Of particular concern, however, is the potential increase in particulate matter, which is already present in concentrations above national goals during summer and winter.

6.1 Motor Vehicle Emissions

Data from the National Pollutant Inventory (NPI) indicate that motor vehicles are the largest source of pollution in the ACT, accounting for approximately one quarter of all air emissions in the territory. Motor vehicles emit a range of pollutants including carbon monoxide, nitrogen oxides, particulates, sulphur, and hydrocarbons. The greater concentration of motor vehicles in the city centre compared to Monash is associated with the greater ozone concentrations found at the city monitoring station.

The pollution generated by motor vehicles results from both the amount of fuel burned; fuel type and composition; and the emission control standards of the engines.

6.2 Wood Smoke

Wood smoke pollution can harm the health of both the wood heater users and others in the community. Health effects depend on exposure levels and the age and health status of exposed people; people particularly susceptible to adverse effects include infants and very young children, the elderly, and people with existing cardiac, respiratory or vascular problems. Potential adverse health effects include asthma, chronic lung disease, heart problems and premature births and deaths, primarily as a result of the particulate matter. In addition to the particulates released, wood heaters can release excessive levels of carbon monoxide and polycyclic aromatic compounds, which can be carcinogenic.

Residential wood smoke is a common cause of air pollution problems in cooler areas, particularly those associated with residential developments in valley areas (Bridgman, 2009). Wood smoke is a recognised issue affecting air quality in the Canberra region during the winter months, with a layer of wood smoke over the city a common occurrence, particularly in the Tuggeranong Valley. Under temperature inversion conditions, the wood smoke hangs in the air close to ground level rather than dispersing, leading to elevated particulate concentrations that can result in adverse health effects.

The topography and meteorological conditions, particularly valley drainage flows, expected in the Molonglo Valley suggest that wood smoke could be a significant issue for the proposed development should wood heaters be installed. Furthermore, as the Molonglo Valley is known to receive drainage flows from other areas of Canberra, the use of wood heaters in other areas may also potentially contribute to elevated pollutant concentrations within the proposed development area under inversion conditions.

6.3 Odour

Odour is a sensory response to the inhalation of one or more chemicals in the air we breathe. A person’s perception of an odour can vary significantly depending on the sensitivity of the person, the acuteness of the person’s sense of smell and the connotations that the odour bestows on that person. Odour primarily affects a person’s quality of life and can have a large range of adverse effects including stress and other physical symptoms.

While odour is not monitored by state environmental agencies nor by industry, odorous emissions need to be taken into account in any air pollution assessment, as many air pollution complaints in residential (and sometimes industrial) areas often relate to odour. The main sources of offensive odour in the Molonglo Valley are the ten odour vents along the Molonglo Valley Interceptor Sewer (MVIS) (refer to **Figure 4**), which is one of the main lines carrying wastewater to the Lower Molonglo Water Quality Control Centre (the main treatment system for Canberra’s wastewater). While most of the vents are not currently of concern, the major vents located between

Cotter Road and the lower Molonglo River are known to produce offensive odours, and are likely to affect premises located in proximity to them under the current configuration. Additionally, Actew/AGL has an existing trade waste dump point just upstream of the major aqueduct on the Molonglo Valley Interceptor Sewer in the Molonglo Valley, which is also an existing source of odour. ACTPLA and ACTEW/ActewAGL propose to investigate these odours and their potential mitigation measures in 2011-12.

6.4 Greenhouse Gas Emissions

Increased population typically leads to increased greenhouse emissions through the increased use of fuel associated with transport and household appliances. Building design, siting and material use can significantly affect the greenhouse gas emissions associated with structures by affecting the amount of cooling and heating required to maintain comfortable temperatures within the buildings. Retention/replanting of vegetation in urban areas can help to offset the emissions associated with development.

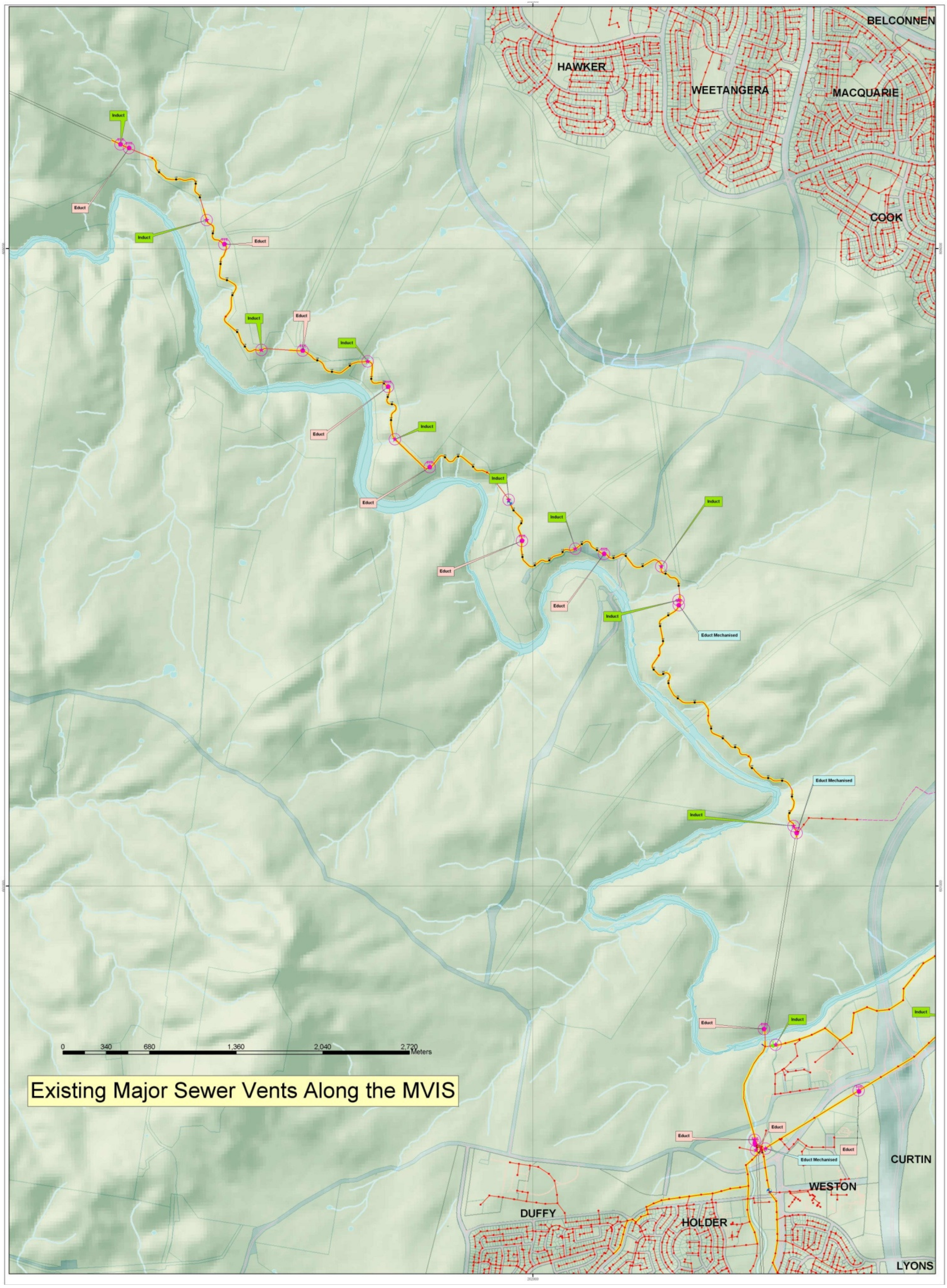


Figure 4: Sewer Vent Locations in the Molonglo Valley

7.0 Mitigation Measures

7.1 Motor Vehicles

Emissions from motor vehicles are affected by fuel use and content; engine efficiency and emission controls; transport mode; and trip distance.

The content of automotive fuels (petrol, diesel, biodiesel and auto gas) in Australia is governed by the Fuel Quality Standards Act 2000. Sulphur is the main pollutant of concern in fuel. The latest content reductions were made in 2009 and 2008, where the allowable sulphur contents were reduced to 10 ppm and 50 ppm in automotive diesel and petrol respectively. Reducing the sulphur content within fuel also reduces particulate emissions and enables treatment devices for exhaust gases to be installed.

Vehicle exhaust emissions of carbon monoxide, hydrocarbons and oxides of nitrogen are regulated by national legislation in the form of Australian Design Rules (ADRs), which have successively required more stringent emission controls for new vehicles. The latest ADR for light vehicles was introduced in 2010 (ADR 79/02; Euro 4), while the latest ADR for heavy vehicles is to be introduced in 2011 (ADR 80/03; Euro 5). The average age of private motor vehicles in the ACT is about 10 years, and most would have been built to comply with the 1986 legislation; much of it would now comply with the 1997 ADR and more recent ones (ACT Government, 2008).

The increased use of public transport is believed to greatly reduce overall transport emissions. The proposed development addresses this aspect by providing multi-modal transport options for residents, and encouraging the use of walking and bicycle use through the provision of walkways and bicycle paths that link the residential and community facilities. The proximity of the proposed development site to the main employment and entertainment centres of the ACT (particularly Civic, Woden, Belconnen and Weston Creek) means that the residents of the proposed development will have shorter trip distances than if the development was located elsewhere. Additionally, the proposed development includes a focus on public transport and fuel-free transport modes, by locating services and facilities within walking/cycling distance.

It should be noted, however, that recent evidence suggests that the differences between public transport and private vehicle emissions is not as large as commonly thought, and that improvements in the use of hybrid cars and uptake of new technologies will reduce the existing differences even further (Wendell Cox Consultancy, 2007). Furthermore, there is also evidence that greenhouse gas emissions are lower in areas where there are more cars when data are assessed according to consumption at the household level within a statistical area, which is quite contrary to popular belief that greater car numbers result in greater greenhouse gas emissions (Wendell Cox Consultancy, 2007). As such, it appears that the relationships between motor vehicle use and greenhouse gas emissions are more complex than originally thought. This should be taken into account with any assessment of greenhouse gas emissions.

7.2 Wood Smoke

The ACT Government has undertaken a number of actions to address the problem of wood smoke, including:

- Implementation of a Wood Heater Replacement Program in 2004 that offers financial incentives of up to $800 to encourage people to replace existing wood heaters with new natural gas heaters to improve air quality;
- Provision of education and assistance programs to help homeowners to use their wood heaters most efficiently;
- Running an annual campaign (Don't Burn Tonight) since 2001. This community education program involves alerts being broadcast by local media on cold still nights, when dispersion conditions are poor, that encourage residents to use alternative heating methods;
- Regulating the sale and supply of firewood in the ACT, which requires an environmental authorisation issued by the Environment Protection Authority, with conditions of authorisation including requiring only seasoned timber to be supplied to minimise smoke emissions; and
- Residents also have a responsibility to minimise air pollution in the ACT under the Environment Protection Act 1997, with penalties applicable for breaches.

In order to reduce potential wood smoke issues, restriction or banning of wood smoke heaters from being installed in the Molonglo Valley should be considered in conjunction with the existing actions being undertaken.

It is recommended that an ambient monitoring station be installed within the Molonglo Development following construction to track pollutant concentrations in the area, with a focus on particulate levels. The collected data will increase the available information on the ACT airshed in general, as well as identifying any issues specific to the Molonglo Valley that cannot be identified using the existing monitoring station data. The station should be sited in accordance with relevant Australian Standards (e.g. AS/NZS 3580.1.1:2007 and AS 2923 – 1987).

7.3 Odour

ACTPLA and ACTEW/ActewAGL propose to investigate the nature of sewer odours and their management options in 2011-12, subject to budget allocation. This report should be read in conjunction with the relevant reports resulting from those investigations. Management options include the implementation of buffer distances between the vents and residences, the installation and operation of odour scrubbers (such as exist near Weston Pond), and the relocation of vents with mechanical extraction.

7.4 Greenhouse Gas Emissions

In addition to the measures to be employed to reduce transport emissions, the plan for the Molonglo Valley development involves a number of energy efficiency initiatives (including appropriate siting and orientation of properties to maximise solar access; mandatory energy efficiency ratings; education and training for residents regarding appliance purchasing and sustainable living; and, potentially, use of renewable energy sources) that will reduce residential electricity consumption. As such, the potential increases in greenhouse gas emissions are reduced.

"This page has been left blank intentionally"

8.0 Conclusion

Existing air quality in the Molonglo Valley is considered to be quite good. The proposed development will affect air quality in the local area by introducing pollutant sources. The primary pollutant sources likely to affect air quality are wood heaters (if installed) and bushfires (including back-burning/hazard reduction activities).

Due to the topography of the development area, temperature inversions that occur on cold, clear nights are likely to trap any pollutants in the air at ground level. If substantial pollution is present, adverse health effects are likely to occur. In order to minimise these effects, the banning of wood heaters within the development area is recommended. Existing legislative measures are considered suitable for minimising the adverse effects of vehicle emissions in the area. Further investigation is required to address whether odours from the sewer vents are likely to result in adverse effects and, if so, appropriate mitigation measures should be taken to address those effects. As bushfires are a significant source of particulate emissions during summer months, appropriate measures should be taken to minimise bushfire risk around the development area, particularly as the incidence of bushfires is expected to increase over the coming years due to climate change.

"This page has been left blank intentionally"

9.0 References

ACT Government. (2008). ACT State of the Environment Report 2007/08. http://www.envcomm.act.gov.au/publications/soe/2007actreport; accessed 9 December, 2010.

ACT Government. (2007b). Weathering the Change. The ACT Climate change strategy 2007-2025. Australian Capital Territory, Canberra.

ACTPLA. (2007). Preliminary assessment of a draft variation to the Territory Plan (DV281) and major infrastructure associated withy urban development at Molonglo and North Weston. ACT Planning and Land Authority, Canberra.

Bridgman, H. (2009). Preliminary Assessment of Wintertime Air Quality in the Tuggeranong Valley, ACT. University of Newcastle.

BOM. (2011). Canberra in 2010: Fourth wettest year on record. http://www.bom.gov.au/climate/current/annual/act/summary.shtml; accessed 15 February, 2011.

Eco Logical. (2010). Draft Strategic Assessment Report of the Molonglo Valley Plan for the Protection of Matters of National Environmental Significance. Eco Logical Australia Pty Ltd.

EPA. (2010). ACT Air Quality Report 2009. Environment Protection Authority: ACT Government.

Wendell Cox Consultancy. (2007). Housing form in Australia and its impact on greenhouse gas emissions: An Analysis of Data from the Australian Conservation Foundation Conservation Atlas. Residential Development Property Council.

"This page has been left blank intentionally"

Appendix A

Meteorological Data Analyses

"This page has been left blank intentionally"

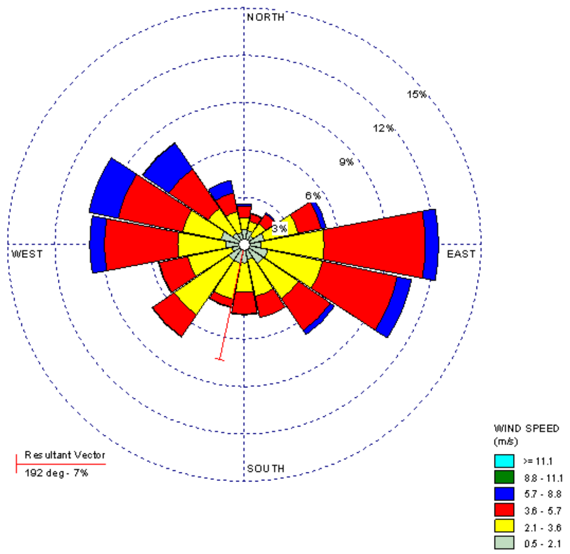
Meteorological data included in the air quality assessment were generated from The Air Pollution Model (TAPM) developed by CSIRO for the year 2009. Meteorological data from the BOM station at Canberra Airport (located approximately 16 km east of the Molonglo Valley) were input into the model to 'nudge' the predictions closer to actual observed data.

Wind Conditions

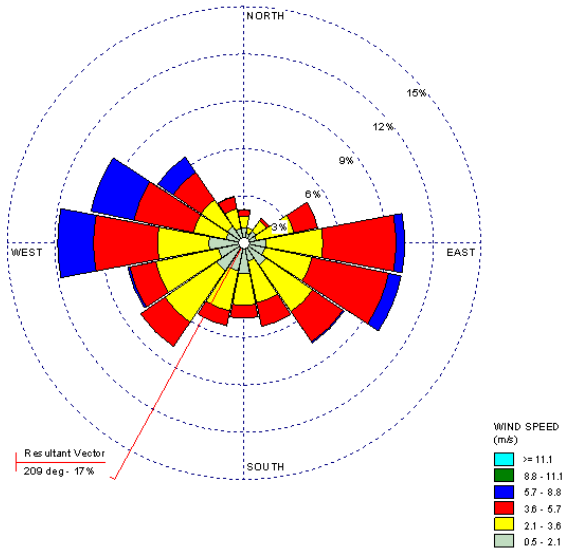
The wind roses show the frequency of occurrence of winds by direction and strength. Each wind rose arm represents a wind blowing from the direction it is projected i.e. arm pointing up represents northerly winds. The length of the bar represents the frequency of occurrence of winds from that direction, and wind speed categories are defined by different colours. The wind roses for each season, the 9 am and 3 pm data and the full year are provided below.

The winds for the Molonglo area are generally dominated by winds from the southwest in the morning and northwest in the afternoon. The afternoon shows a higher wind speed averaging 4.4 m/s compared to 3.1 m/s at 9 am.

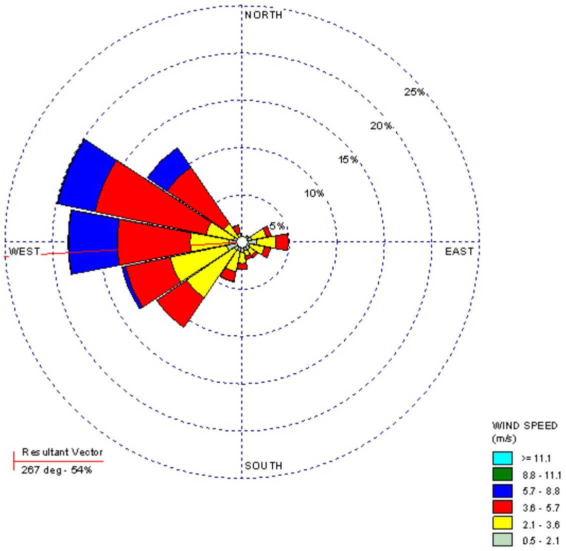
Seasonally, summer and autumn are dominated by winds from the west and east, with a resultant vector towards the south west. Winter and spring are dominated by winds from the west, with spring showing more variation in direction.



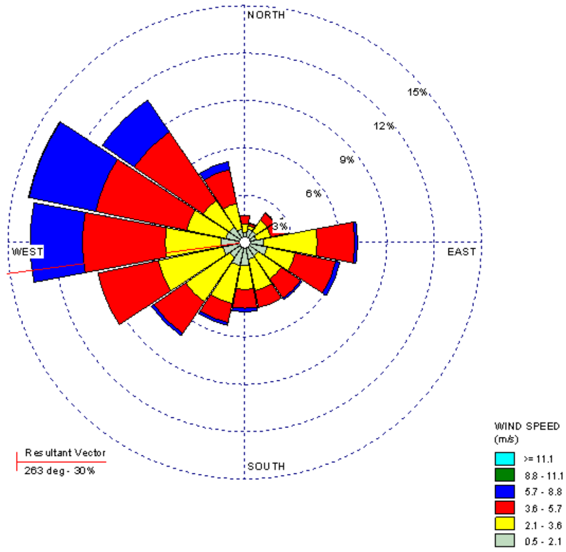
Summer 2009



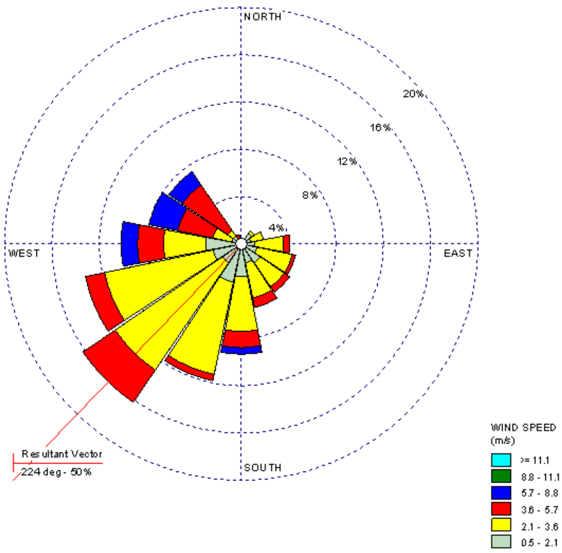
Autumn 2009



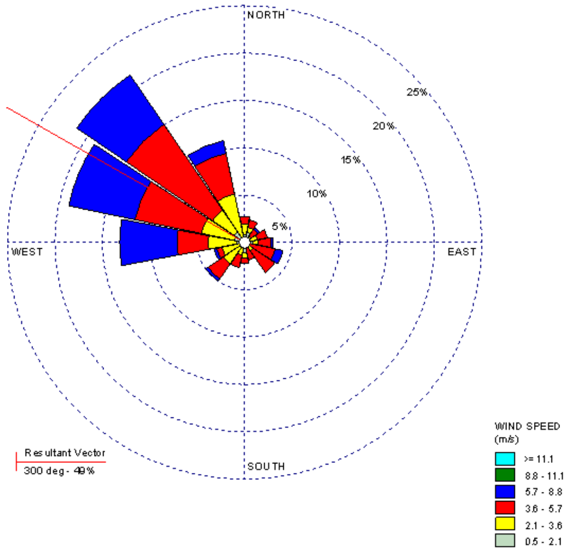
Winter 2009



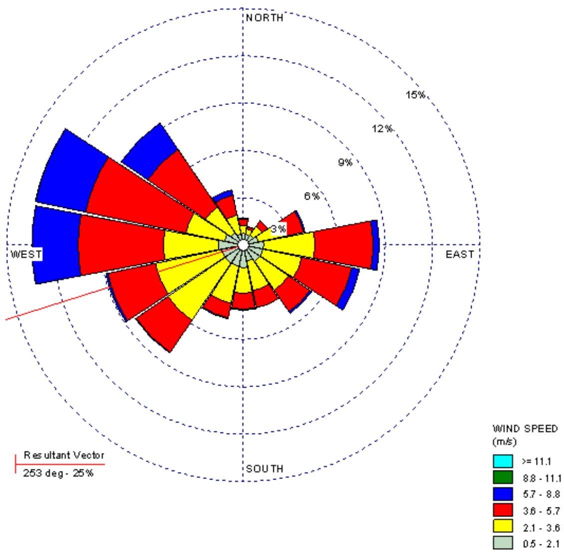
Spring 2009



9am 2009

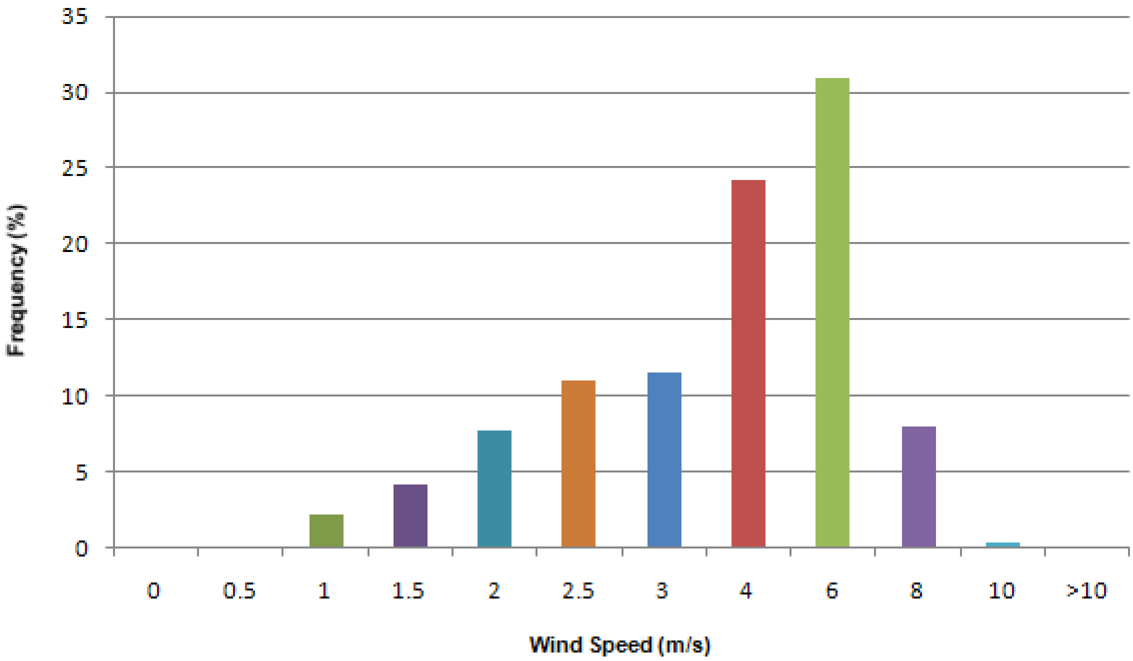


3pm 2009



Year 2009

The estimated mean wind speed for the year for the Molonglo area is 3.6 m/s. The frequency distribution of hourly averaged wind speed values from the Canberra data are shown below.



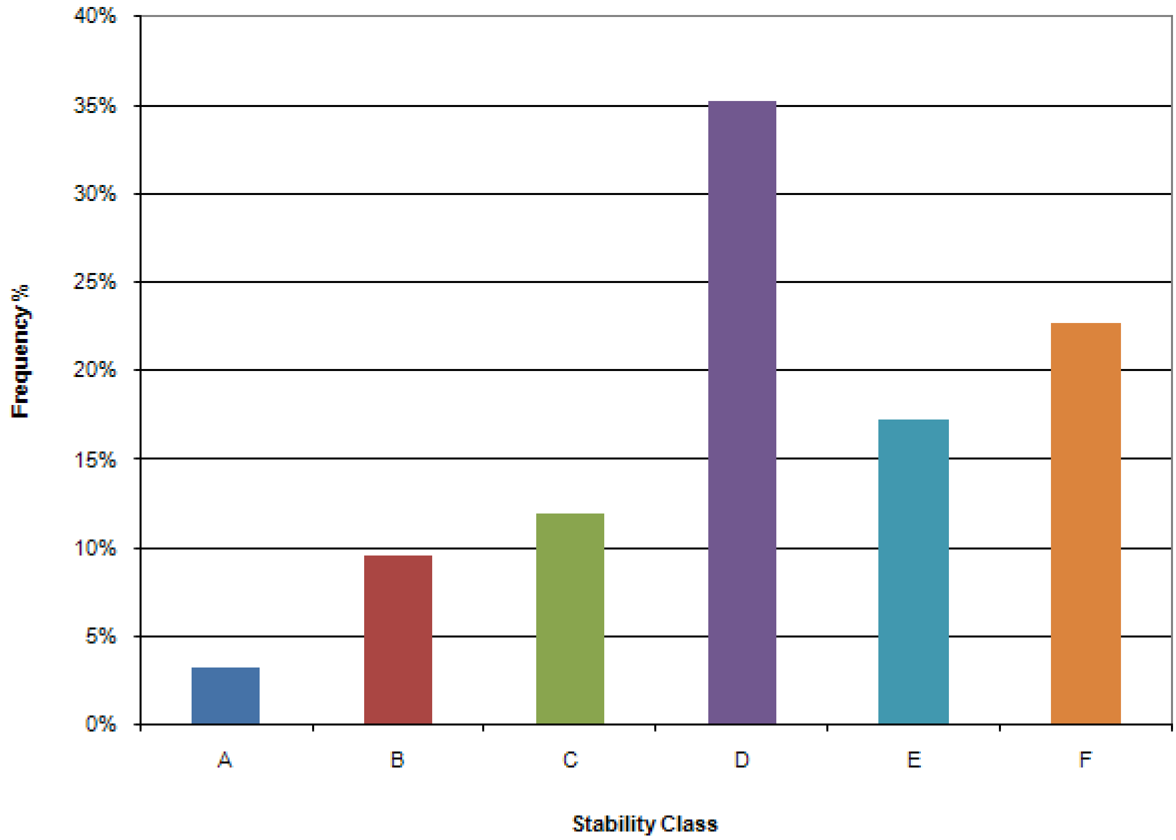
Frequency Distribution of Wind Speed

Stability Class

An important aspect of pollutant dispersion is the atmospheric turbulence level in the region of the pollution plume (near the ground in this case). Turbulence acts to increase the cross-sectional area of the plume due to random motions, thus diluting or diffusing a plume. Atmospheric stability categories are used in conjunction with other meteorological data to describe atmospheric conditions and thus dispersion.

The most well-known stability classification is the Pasquill-Gifford scheme, which denotes stability classes from A to F. Class A is described as highly unstable and occurs in association with strong surface heating and light winds, leading to intense convective turbulence and much enhanced plume dilution. At the other extreme, class F denotes very stable conditions associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in the early morning. Under these conditions, plumes can remain relatively undiluted for considerable distances downwind. Intermediate stability classes grade through moderately unstable (B), slightly unstable (C), neutral (D) to slightly stable (E). Whilst classes A and F are strongly associated with clear skies, class D is linked to windy and/or cloudy weather, and short periods around sunset and sunrise when surface heating or cooling is small.

As a general rule, unstable (or convective) conditions dominate during the daytime and stable flows are dominant at night. This diurnal pattern is most pronounced when there is relatively little cloud cover and light to moderate winds. The frequency distribution of estimated stability classes in the meteorological file is shown below. The data show a higher trend towards neutral and stable wind classes. The breakdown of classes was 13% for A and B (unstable), 47% for C and D (neutral) and 40% for E and F (stable) class, which is consistent with the pattern expected for an inland location in a valley setting.

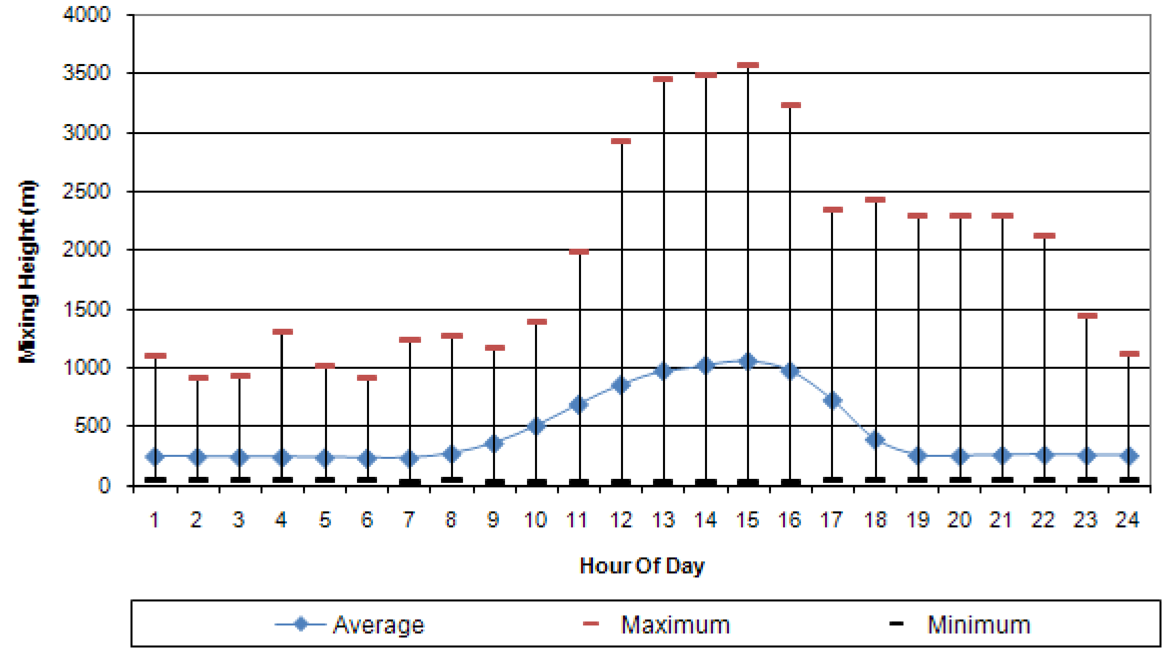


Frequency Distribution of Stability Class

Mixing Height

Mixing height is the depth of the atmospheric surface layer beneath an elevated temperature inversion. It is an important parameter within air pollution meteorology. Vertical diffusion or mixing of a plume is generally considered to be limited by the mixing height, as the air above this layer tends to be stable, with restricted vertical motions.

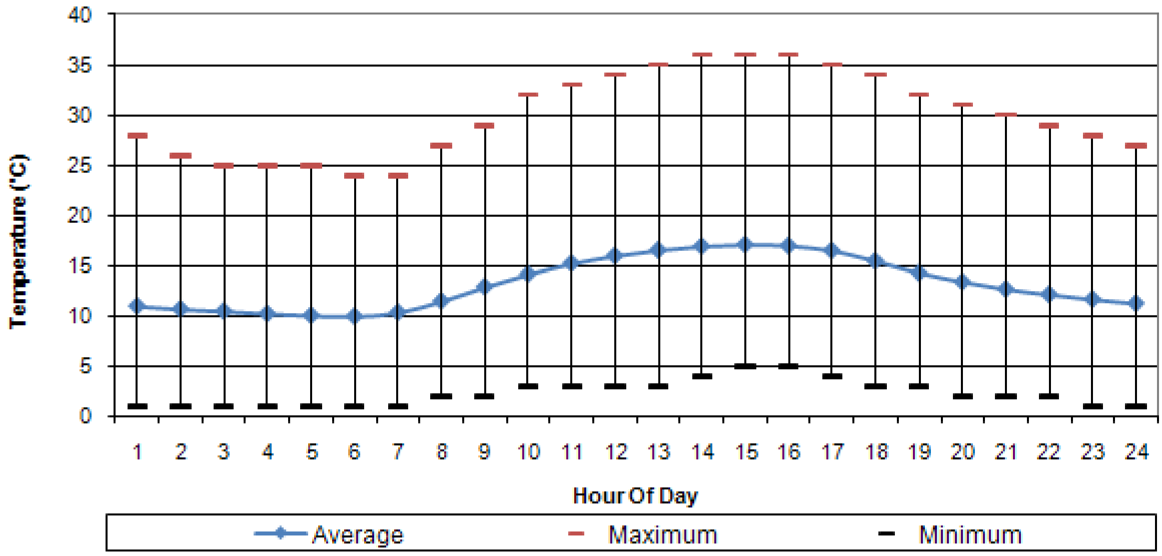
The diurnal variation of mixing height for the predicted data is summarised below. The average mixing heights are lower during the night and early morning hours (< 500 m), increasing after sunrise to a maximum of around 1000 m by mid-afternoon. This pattern of a diurnal cycle is consistent with expectations.



Hourly Mixing Height

Air Temperature

The following graph shows the predicted average hourly temperatures for 2009. The graph shows the expected diurnal variation in temperature, where the highest temperatures are found during the afternoon, and the lowest temperatures occur in the early morning.



"This page has been left blank intentionally"

Appendix B

NPI Data for Reporting Year 2008/2009

"This page has been left blank intentionally"

Pollutant Emissions for Each Facility Listed in the National Pollution Inventory for the Regional Area

Facility Name	Substance	Air (kg)
Australian Defence Force Academy [Campbell- ACT]	Carbon Monoxide	1482
	Sulfur Dioxide	28
	Total Volatile Organic Compounds	96
	Polycyclic Aromatic Hydrocarbons (B[A]Peq)	0.01
	Particulate Matter 2.5 Um	130
Australian National University [Acton- ACT]	Mercury & Compounds	0.02
	Carbon Monoxide	7942
	Lead & Compounds	0.04
	Cadmium & Compounds	0.09
	Arsenic & Compounds	0.02
Black Mountain [Acton- ACT]	Carbon Monoxide	2750
	Sulfur Dioxide	53
	Total Volatile Organic Compounds	180
	Polycyclic Aromatic Hydrocarbons (B[A]Peq)	0.02
	Particulate Matter 2.5 Um	242
Boral Asphalt -Mugga [Jerrabomberra- ACT]	Carbon Monoxide	5829
	Polycyclic Aromatic Hydrocarbons (B[A]Peq)	5
	Sulfur Dioxide	148
	Total Volatile Organic Compounds	1255
	Oxides Of Nitrogen	1068
Calvary Health Care Act Limited [Bruce- ACT]	Mercury & Compounds	0.004
	Carbon Monoxide	1159
	Lead & Compounds	0.01
	Cadmium & Compounds	0.02
	Arsenic & Compounds	0.003
Capital Linen Service [Canberra- ACT]	Mercury & Compounds	0.01
	Carbon Monoxide	2038
	Lead & Compounds	0.01
	Cadmium & Compounds	0.03
	Arsenic & Compounds	0.005
Coffman & Lawson Wine Co Pty Ltd [Lyneham- ACT]	Total Volatile Organic Compounds	430
	Ethanol	429
Fyshwick Depot [Fyshwick- ACT]	Total Volatile Organic Compounds	51974
	N-Hexane	891
	Benzene	167

Facility Name	Substance	Air (kg)
	Toluene (Methylbenzene)	498
	Ethylbenzene	22
	Total Volatile Organic Compounds	8050
	Benzene	19
	Toluene (Methylbenzene)	30
	Ethylbenzene	4
	Cyclohexane	14
Hmas Harman [Harman- ACT]	Total Volatile Organic Compounds	22
Lower Molonglo Water Quality Control [Holt- ACT]	Ammonia (Total)	2
	Mercury & Compounds	3
	Carbon Monoxide	57396
Mobil Depot Fyshwick [Fyshwick- ACT]	Benzene	17
	Total Volatile Organic Compounds	3343
	Toluene (Methylbenzene)	48
	Ethylbenzene	4
	Cyclohexane	7
Mugga Lane Lfg Power Station [Hume- ACT]	Mercury & Compounds	0.03
	Carbon Monoxide	46236
	Sulfur Dioxide	1568
	Total Volatile Organic Compounds	656
	Oxides Of Nitrogen	24659
Parliament House [Canberra Parliament House- ACT]	Mercury & Compounds	0.01
	Carbon Monoxide	1782
	Lead & Compounds	0.01
	Cadmium & Compounds	0.02
	Arsenic & Compounds	0.004
Queanbeyan [Queanbeyan-NSW]	Carbon Monoxide	12353
	Sulfur Dioxide	182
	Polycyclic Aromatic Hydrocarbons (B[A]Peq)	5
	Total Volatile Organic Compounds	909
	Zinc And Compounds	6
Queanbeyan Quarry [Queanbeyan-NSW]	Carbon Monoxide	18504
	Sulfur Dioxide	25
	Total Volatile Organic Compounds	4079
	Particulate Matter 2.5 Um	4410
	Polycyclic Aromatic Hydrocarbons (B[A]Peq)	1

Facility Name	Substance	Air (kg)
Royal Military College Duntroon [Duntroon-ACT]	Carbon Monoxide	957
	Sulfur Dioxide	18
	Total Volatile Organic Compounds	62
	Polycyclic Aromatic Hydrocarbons (B[A]Peq)	0.01
	Particulate Matter 2.5 Um	84
Russell Offices [Canberra- ACT]	Carbon Monoxide	1547
	Sulfur Dioxide	29
	Total Volatile Organic Compounds	101
	Polycyclic Aromatic Hydrocarbons (B[A]Peq)	0.01
	Particulate Matter 2.5 Um	136
The Canberra Hospital [Canberra- ACT]	Mercury & Compounds	0.01
	Carbon Monoxide	3286
	Lead & Compounds	0.02
	Cadmium & Compounds	0.04
	Arsenic & Compounds	0.01
Tip Top Canberra [Canberra- ACT]	Carbon Monoxide	219
	Total Volatile Organic Compounds	7590
	Sulfur Dioxide	15
	Polycyclic Aromatic Hydrocarbons (B[A]Peq)	0.01
	Ethanol	7530
University Of Canberra [Canberra University Lpo- ACT]	Mercury & Compounds	0.004
	Carbon Monoxide	328
	Lead & Compounds	0.01
	Cadmium & Compounds	0.02
	Arsenic & Compounds	0.00
West Belconnen Lfg Power Station [Belconnen- ACT]	Carbon Monoxide	8818
	Sulfur Dioxide	299
	Total Volatile Organic Compounds	125
	Oxides Of Nitrogen	4700
	Hydrochloric Acid	4

Pollutant Emissions for Each Substance and Source Type Listed in the National Pollution Inventory for the Regional Area

Substance	Source	Air (kg)
Ammonia (total)	Total	2
	Water Supply, Sewerage and Drainage Services [281]	2
Arsenic & compounds	Total	0.4
	Water Supply, Sewerage and Drainage Services [281]	0.4
	Tertiary Education [810]	0.02
	Hospitals [840]	0.01
	Other Personal Services [953]	0.005
	Central Government Administration [751]	0.004
Benzene	Total	203
	Mineral, Metal and Chemical Wholesaling [332]	203
Beryllium & compounds	Total	0.2
	Water Supply, Sewerage and Drainage Services [281]	0.2
	Tertiary Education [810]	0.0001
	Hospitals [840]	0.0001
	Other Personal Services [953]	0.00003
	Central Government Administration [751]	0.00003
Cadmium & compounds	Total	4
	Water Supply, Sewerage and Drainage Services [281]	3
	Tertiary Education [810]	0.1
	Hospitals [840]	0.1
	Other Personal Services [953]	0.03
	Central Government Administration [751]	0.02
Carbon monoxide	Total	172627
	Water Supply, Sewerage and Drainage Services [281]	57396
	Electricity Generation [261]	55054
	Construction Material Mining [091]	18504
	Petroleum and Coal Product Manufacturing [170]	12353
	Tertiary Education [810]	8270
Chromium (III) compounds	Total	6
	Petroleum and Coal Product Manufacturing [170]	6
	Water Supply, Sewerage and Drainage Services [281]	0.3
	Tertiary Education [810]	0.1
	Hospitals [840]	0.07
	Other Personal Services [953]	0.03

Substance	Source	Air (kg)
Cobalt & compounds	Total	0.02
	Tertiary Education [810]	0.01
	Hospitals [840]	0.004
	Other Personal Services [953]	0.002
	Central Government Administration [751]	0.002
Copper & compounds	Total	13
	Water Supply, Sewerage and Drainage Services [281]	13
	Tertiary Education [810]	0.1
	Hospitals [840]	0.04
	Other Personal Services [953]	0.02
	Central Government Administration [751]	0.02
Cumene (1-methylethylbenzene)	Total	14
	Mineral, Metal and Chemical Wholesaling [332]	14
Cyclohexane	Total	28
	Mineral, Metal and Chemical Wholesaling [332]	28
Ethanol	Total	7959
	Bakery Product Manufacturing [117]	7530
	Beverage Manufacturing [121]	429
Ethylbenzene	Total	30
	Mineral, Metal and Chemical Wholesaling [332]	30
Fluoride compounds	Total	17
	Petroleum and Coal Product Manufacturing [170]	15
	Electricity Generation [261]	2
n-Hexane	Total	997
	Mineral, Metal and Chemical Wholesaling [332]	997
Hydrochloric acid	Total	26
	Electricity Generation [261]	26
Hydrogen sulfide	Total	10
	Water Supply, Sewerage and Drainage Services [281]	10
Lead & compounds	Total	23
	Water Supply, Sewerage and Drainage Services [281]	23
	Tertiary Education [810]	0.05
	Hospitals [840]	0.03
	Other Personal Services [953]	0.01
	Central Government Administration [751]	0.01
Magnesium oxide fume	Total	37

Substance	Source	Air (kg)
	Water Supply, Sewerage and Drainage Services [281]	37
Manganese & compounds	Total	46
	Petroleum and Coal Product Manufacturing [170]	46
	Tertiary Education [810]	0.04
	Hospitals [840]	0.02
	Other Personal Services [953]	0.01
Mercury & compounds	Total	3
	Water Supply, Sewerage and Drainage Services [281]	3
	Electricity Generation [261]	0.03
	Tertiary Education [810]	0.02
	Hospitals [840]	0.01
	Other Personal Services [953]	0.01
Nickel & compounds	Total	1
	Water Supply, Sewerage and Drainage Services [281]	1
	Tertiary Education [810]	0.2
	Hospitals [840]	0.1
	Other Personal Services [953]	0.1
	Central Government Administration [751]	0.04
Oxides of Nitrogen	Total	153843
	Water Supply, Sewerage and Drainage Services [281]	61495
	Construction Material Mining [091]	38352
	Electricity Generation [261]	29359
	Tertiary Education [810]	8466
	Defence [760]	4731
Particulate Matter 10.0 um	Total	88587
	Construction Material Mining [091]	65801
	Water Supply, Sewerage and Drainage Services [281]	7584
	Petroleum and Coal Product Manufacturing [170]	7008
	Electricity Generation [261]	5652
	Tertiary Education [810]	700
Particulate Matter 2.5 um	Total	10221
	Construction Material Mining [091]	4410
	Water Supply, Sewerage and Drainage Services [281]	3027
	Tertiary Education [810]	700
	Petroleum and Coal Product Manufacturing [170]	698
	Hospitals [840]	391

Substance	Source	Air (kg)
Polychlorinated dioxins and furans (TEQ)	Total	0.000001
	Tertiary Education [810]	0.0000005
	Hospitals [840]	0.0000003
	Other Personal Services [953]	0.0000001
	Central Government Administration [751]	0.0000001
Polycyclic aromatic hydrocarbons (B[a]Peq)	Total	15
	Other Non-Metallic Mineral Mining and Quarrying [099]	5
	Petroleum and Coal Product Manufacturing [170]	5
	Water Supply, Sewerage and Drainage Services [281]	3
	Construction Material Mining [091]	1
	Tertiary Education [810]	0.1
Selenium & compounds	Total	0.2
	Hospitals [840]	0.1
	Other Personal Services [953]	0.05
	Central Government Administration [751]	0.04
	Tertiary Education [810]	0.03
Sulfur dioxide	Total	2677
	Electricity Generation [261]	1867
	Petroleum and Coal Product Manufacturing [170]	182
	Tertiary Education [810]	153
	Other Non-Metallic Mineral Mining and Quarrying [099]	148
	Hospitals [840]	85
Toluene (methylbenzene)	Total	576
	Mineral, Metal and Chemical Wholesaling [332]	576
Total Volatile Organic Compounds	Total	81571
	Mineral, Metal and Chemical Wholesaling [332]	63367
	Bakery Product Manufacturing [117]	7590
	Construction Material Mining [091]	4079
	Water Supply, Sewerage and Drainage Services [281]	1640
	Other Non-Metallic Mineral Mining and Quarrying [099]	1255
Xylenes (individual or mixed isomers)	Total	135
	Mineral, Metal and Chemical Wholesaling [332]	135
Zinc and compounds	Total	11
	Petroleum and Coal Product Manufacturing [170]	6

Substance	Source	Air (kg)
	Tertiary Education [810]	3
	Hospitals [840]	2
	Other Personal Services [953]	1

Worldwide Locations

Australia	+61-2-8484-8999
Azerbaijan	+994 12 4975881
Belgium	+32-3-540-95-86
Bolivia	+591-3-354-8564
Brazil	+55-21-3526-8160
China	+86-20-8130-3737
England	+44 1928-726006
France	+33(0)1 48 42 59 53
Germany	+49-631-341-13-62
Ireland	+353 1631 9356
Italy	+39-02-3180 77 1
Japan	+813-3541 5926
Malaysia	+603-7725-0380
Netherlands	+31 10 2120 744
Philippines	+632 910 6226
Scotland	+44 (0) 1224-624624
Singapore	+65 6295 5752
Thailand	+662 642 6161
Turkey	+90-312-428-3667
United States	+1 978-589-3200
Venezuela	+58-212-762-63 39

Australian Locations

Adelaide
Brisbane
Canberra
Darwin
Melbourne
Newcastle
Perth
Sydney
Singleton

www.aecom.com

About AECOM

AECOM is a leading provider of advanced environmental, planning, design, engineering, management and advisory services in the buildings, energy, environment, government, mining, power, transport and water markets.

From our offices across Australia and New Zealand, we leverage AECOM's global reach while providing a unique blend of local knowledge, innovation and technical excellence combined with a personal commitment to meeting our clients' specific needs.

Together, AECOM forms a strong global network of more than 43,000 professionals united by a common purpose to enhance and sustain the world's built, natural and social environments.

AECOM has over 740 offices across Africa, the Americas, Asia-Pacific, the Middle East, the United Kingdom & Europe.

For more information, please visit:
www.aecom.com

Australian Locations

Adelaide
Brisbane
Canberra
Darwin
Melbourne
Newcastle
Perth
Singleton
Sydney