Statement of opinion and supporting reasons of

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Environment, Resources & Development Court
No 308 of 2013

In the matter of an Appeal between:

PAREPG	Appellant
and	
PAE & OTR 97 Pty Ltd	Respondents

12 May 2014

1.0 Qualifications, accreditations and experience

I hold the following formal qualifications:
Bachelor of Applied Science (Queensland Institute of Technology)
Masters of Science (University of Queensland)
Doctor of Philosophy (Pharmacology, University of Melbourne)

I have the following experience:
I am a research scientist of 25 years standing in pharmacology and toxicology. My research includes work on venoms, defense peptides and the toxicity of herbal medicines. Of relevance to this submission is my work with my collaborators and students on the environmental toxin acrolein and the waterway pollutant saxitoxin and related chemicals.

I also have 10 years of experience teaching and coordinating the course “Drugs Chemicals and the Environment” which deals with environmental toxicology.

I am currently the chair of the Toxicology Special Interest Group of the Australasian Society of Experimental Pharmacology and Toxicology, the peak pharmacology/toxicology body in Australia. I am also on the Nominating Committee of the International Union of Toxicologists.

I have organized symposia on the toxicology of herbal medicines and am organizing a symposium on regulatory toxicology for the upcoming ASCEPT national meeting in 2014.

In my capacity of chair of the Toxicology Special Interest Group I have made a submission to the Therapeutic Goods Administration of the toxicity of DMAA. I have made other submissions to the TGA as well but these are not directly related to toxicology.

I have also been part of the community consultation group tasked with providing feedback to the EPA’s air quality plan for the LeFevre peninsula.

I have appeared as an expert witness:
I have consulted on toxicology matters for two law firms, neither case came to trial.

2.0 Introduction

2.1 The site

This matter concerns a proposal to establish an integrated use shop and service station with ancillary vehicle/dog wash bays at Peterhead. The site is in close proximity to residential areas to the south and north-west. Industrial land is to the north and east of the site.

Relevant to this proposal is that this area already has poor air quality, and a 1999 survey showed that in Port Adelaide males had higher rates of asthma, bronchitis or emphysema than the national rates. Children aged 5-14 also had significantly higher asthma rates (Pillotto et al., 1999).

Other sources of hydrocarbon vapor that will impact fuel emission from the proposed station:

The site is adjacent to a major road way so fugitive fuel emissions from traffic will contribute to the background hydrocarbon levels.

There is a fuel farm whose boundary is within 400 metres of the proposed site and a bitumen plant whose boundary is within 300 metres. These are potential sources of hydrocarbons which can provide an elevated background of hydrocarbon emissions.

2.2 The proposal

The development includes:

- 18 petrol bowsers
- fuel tanks fitted with a Stage 1 Vapour Recovery System
- shop, restaurant and dine in facility for 36 people
- drive through service from the 'Oporto' fast food chain
- car wash facility and dog wash facilities (7am -10pm Sunday to Thursday and 7am to midnight on Fridays and Saturdays)
- fuel delivery occurring between 7am and 10pm
- rubbish collection occuring between 7am and 7pm except on Sundays and public holidays when the start time is 9am
- entry and exit from Hargrave St and Victoria Rd
- 23 parking spaces

Vapor emission from the fuel station
Fuel emissions from the site will come from multiple sources. Emissions from bowsers during refueling, emissions when tankers are emptied, fugitive emissions from vehicle movements to and from site 24x7 and fugitive emissions from vehicles idling at the drive through food service.

3.0 The Development Plan imperatives

The development will be associated with intensive fuel emissions, in an area which already has poor air quality and high petrochemical emissions.

The Development Plan recognises the existing hazard impact of industry, including air pollution and seeks to minimise further harm to amenity and public health, suggesting an intent to 'not make a bad situation worse.' By adding to the air pollution load (specifically fuel emissions) this development will potentially extend the period when hazard impact remains beyond levels compatible with residential development.

Residential Policy Area 65

OBJECTIVES

1 The continuation of existing residential uses but no new residential development until the potential hazard impact from nearby industry is reduced to a level compatible with residential development.

DESIRED CHARACTER

This policy area is located in close proximity to significant industrial activities. The impacts of these industrial activities will constrain development opportunities in the area. Existing dwellings at the end of their economic life cycle will be replaced but there will be no additional dwellings built until the hazard risk associated with nearby industry has been reduced to acceptable levels.

Interface between Land Uses

OBJECTIVES

1. **Development located and designed to prevent adverse impact and conflict between land uses**
2. **Protect community health and amenity and support the operation of all desired land uses**

PRINCIPLES OF DEVELOPMENT CONTROL

1 Development should not detrimentally affect the amenity of the locality or cause unreasonable interference through any of the following:

(a) the emission of effluent, odour, smoke, fumes, dust or other airborne pollutants

2 Development should be sited and designed to minimise negative impact on existing and potential future land uses considered appropriate in the locality.

4.0 Approach

Emissions from petrol stations are recognized to contain compounds harmful to health. Recent peer reviewed papers measuring these compounds include Morales Terrés et al., (2010), Correa et al., (2012) and Kheirbek et al., (2012). For example vapor emitted from petrol stations include significant quantities of benzene (Morales Terrés et al., 2010, Correa et al., 2012 and Kheirbek et al., 2012) a known health risk and carcinogen, (US EPA, 2007). The health risk from benzene is recognized by the South Australian EPA in setting exposure limits for benzene (SA EPA, 2006).

The area where the fuel station is proposed to be sited already has poor air quality, and a 1999 survey showed that in Port Adelaide males had higher rates of asthma, bronchitis or emphysema than the national rates. Children aged 5-14 also had significantly higher asthma rates (Pillotto et al., 1999).

Health impacts of petrol stations.

Exposure to emissions from petrol stations is associated with health risks (Duarte-Davidson et al., 2001, reviewed in Brender et al., 2011). For example, proximity to petrol stations has been shown to be associated with increased risks of childhood leukemia, independent of other risk factors (Steffan et al., 2004, Brosselin et al., 2009, Weng et al., 2009, reviewed in Brender et al., 2011)

Likely exposure of residents to fuel vapors

No data has been offered on the potential vapor concentrations from the site. However, we can gain insight into likely residential exposures from international studies.

A study of one Spanish station with 4 bowsers is Morales Terrés el al., (2010, p 2761 Fig 5). This showed that the radius of significant levels of hydrocarbons of concern was of the order of approximately 75m from the station. For example the levels of benzene at 75 meters were 4 $\mu g/m^3$, which is 25% of the EPA yearly exposure limit of 16 $\mu g/m^3$.

The proposed petrol station is larger in scale (18 Bowsers vs 4 bowsers) but is similar in construction to the Spanish station (the proposed station uses phase 1 vapor collection systems as did the station the Morales Terrés study), and the

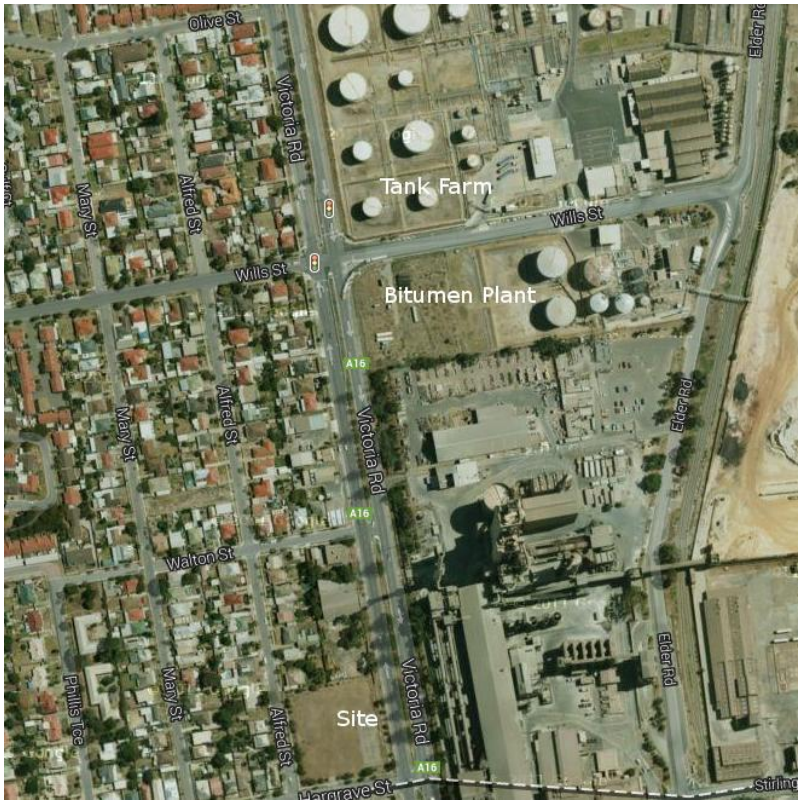
climate is similar. A 75m contour from the proposed station boundary is shown in the figure above, which covers a substantial number of residences. Given the larger scale of the proposed development, it would be likely that the concentrations of vapor in the vicinity of the station would be larger.

It must be emphasized the air temperature and wind will alter these contours. Warmer conditions increase the amount of vapor release from the stations (Morales Terrés et al., 2010) During summer with north-easterly winds the likelihood of much higher vapor levels being present in the residential zone is increased (Karakitsios et al., 2007, Correa et al., 2012, Kountouriotis et al., 2014). These are overseas studies; however an Environment Australia report (2003) suggests summer vapor exposure in Adelaide will be higher than in winter.

Other factors to be considered were that in the Morales Terrés (2010) outdoor vapor levels only were measured. Benzene concentrations are typically higher indoors than in outdoor settings (de Bruin et al., 2008) and it is likely that benzene can also accumulate indoors in the adjacent dwellings next to fuel stations (Brender et al., 2011). This will make residential exposure higher than estimated from outdoor measurements alone. Again, while these are overseas studies, one Australian study also suggests exposure will be higher indoors (Environment Australia, 2003)

Another issue is that as well as high temperatures increasing vapor levels, they are also likely to increase the adverse health impacts of these vapors (Hansen 2010). With summer temperatures potentially exceeding 30 degrees for significant portions of the summer, the health impact of the fuel vapors is likely to be greater than the EPA regulatory levels would suggest.

Interaction with other fuel vapor sources



Importantly, the proposed petrol station is not the only source of hydrocarbon vapors in the close vicinity of the residential areas. There is a fuel farm and a bitumen storage facility (both with boundaries within 400 meters of the proposed petrol station), and further fuel storage facilities to the north of these establishments as well as existing petrol stations.

In 2006 the South Australian EPA performed a 12 month monitoring survey of the Birkenhead area (Powell 2006). The survey monitored benzene

and toluene and found peak values consistent with emissions from the Birkenhead fuel depots.

Worst case and annual average concentrations are shown in the table below and are compared to the guidelines provided in the EPA report (Powell 2006). In both cases emissions measured are approximately 50 % of the guidelines supplied by the EPA. The monitoring site was over a kilometer away from the fuel depots to the south. Based on the fuel station emission data and modelling of emissions (Karakitsios et al., 2007, Morales Terrés et al., 2010, Correa 2012, Kountouriotis et al., 2014) we can reasonably conclude that close to the tank facilities the EPA guidelines may well have been approached or even exceeded in 2006.

Compound	**Worst Case measured 30 minute average µg/m3**	**Annual Average µg/m^3**	**Maximum Guidelines µg/m^3**	**% of maximum guidelines**
Benzene	53.4	7.8	16 (Annual average)	49%
Toluene	559.4	15.3	1000 (30 min Average)	56%

Benzene Pollution Roses presented in Powell (2006), indicate that raised benzene levels are likely to occur in the direction where residential housing is located (see Appendix).

Modifications to some of the fuel facility tanks to reduce emissions have occurred since this survey and lower emissions compared to 2006 would be expected. Despite these modifications a higher background level of emissions will be present in the residential areas close to the proposed site as a result of these fuel storage and bitumen facilities. Any emissions from the petrol station will be additive to those from the fuel depots and bitumen works, impacting hazard levels and amenity.

It is of relevance that the study of Weng et al., (2009) found that the risk of childhood leukemia increased with the density of petrol stations. The researchers found an Odds Ratio of 1.95 with a median density of 0.585 petrol stations per km^2, (this means that the likelihood of leukemia nearly doubled compared to areas with a median density of 0.065 petrol stations per km^2).

While a lower traffic density, low benzene levels in modern fuels (maximum 1% as of January 2006) and more modern vapor collection systems will likely see reduced emissions in an Australian context, with a fuel farm and bitumen storage facility all within a 500 meter radius of the proposed site this raises substantial concerns for the health impacts on the residents living within 1km^2 of the proposed fuel station.

Summary

The area where the proposed petrol station is to be sited already has poor air quality and higher levels of chronic disease (Pilotto etal., 1999). This proposed development is in close proximity to a major road, a fuel farm and a bitumen plant and their emissions will be combined with those of the proposed fuel station.

Without substantial monitoring data, and modeling of emissions during summer and winter under the prevailing wind conditions the possibility of significant impacts on the health of residents in close proximity to the proposed petrol station cannot be dismissed.

The Development Plan recognises the existence of hazards in the area and the need to minimize these for the residential areas and to contribute further fuel emissions runs counter to the planning imperative of "Not making a bad situation worse".

6.0 References

Brender JD, Maantay JA, Chakraborty J. Residential proximity to environmental hazards and adverse health outcomes. *Am J Public Health*. 2011 Dec;101 Suppl1:S37-52. doi: 10.2105/AJPH.2011.300183.

Brosselin P, Rudant J, Orsi L, Leverger G, Baruchel A, Bertrand Y, Nelken B, Robert A, Michel G, Margueritte G, Perel Y, Mechinaud F, Bordigoni P, Hémon D, Clavel J. Acute childhood leukaemia and residence next to petrol stations and automotive repair garages: the ESCALE study (SFCE). Occup Environ Med. 2009 Sep;66(9):598-606.

Bruinen de Bruin Y, Koistinen K, Kephalopoulos S, Geiss O, Tirendi S, Kotzias D. Characterisation of urban inhalation exposures to benzene, formaldehyde andacetaldehyde in the European Union: comparison of measured and modelled exposure data. *Environ Sci Pollut Res Int*. 2008 Jul;15(5):417-30.

Corea SM, Arbilla G, Marques M, Oliveria K. The impact of BTEX emissions from gas stations into the atmosphere. *Atmospheric Pollution Research* 3 (2012) 163-169. <Online http://www.atmospolres.com/articles/Volume3/issue2/APR-12-016.pdf >

Duarte-Davidson R, Courage C, Rushton L, Levy L. Benzene in the environment: an assessment of the potential risks to the health of the population. *Occup Environ Med*. 2001 Jan;58(1):2-13.

Environment Australia. Technical Report No. 6: BTEX Personal Exposure Monitoring in Four Australian Cities 2003
http://www.environment.gov.au/system/files/resources/dc6c0439-ac47-4c53-981a-876fa8d8e6d4/files/report6.pdf

Morales Terrés IM, Miñarro MD, Ferradas EG, Caracena AB, RicoJB , *Assessing the impact of petrol stations on their immediate surroundings ,* Journalof Environmental Management 91 (2010) 2754-2762
< Online: http://www.butarque.es/IMG/pdf/EstudioMurcia.pdf>

Hansen AL, Risk Assessment for environmental health in Adelaide. (2010). PhD thesis, University of Adelaide.

Karakitsios SP, Delisa VK, Kassomenos PA, Pilidisa GA, Contribution to ambient benzene concentrations in the vicinity of petrol stations: Estimation of the associated health risk. *Atmospheric Environment* 41 (2007) 1889–1902

Kheirbek I, Johnson S, Ross Z ,Pezeshki G, Ito K, Eisl H, Matte1 T. Spatial variability in levels of benzene, formaldehyde, and total benzene, toluene, ethylbenzene and xylenes in New York City: a land-use regression study. Environ Health. 2012; 11: 51. Published online Jul 31, 2012. doi: 10.1186/1476-069X-11-51

Kountouriotis A, Aleiferis PG, Charalambides AG. Numerical investigation of VOC levels in the area of petrol stations. Sci Total Environ. 2014 Feb 1;470-471:1205-24.

Powell C, Air Quality Monitoring Hot Spot Report No 6 - Jenkins Street, Birkenhead; *Environmental Protection Authority*. October 2006. <Online http://www.epa.sa.gov.au/pdfs/birkenhead.pdf >

Pilotto LS, Smith BJ, Nitschke M, Ruffin RE, Mitchell R. Industry, air quality, cigarette smoke and rates of respiratory illness in Port Adelaide. *Aust N Z J Public Health*. 1999 Dec;23(6):657-60. PubMed PMID: 10641362.

Steffen C, Auclerc M F, Auvrignon A, Baruchel A, Kebaili K, Lambilliotte K, Leverger G,D Sommelet, E Vilmer, D He Ì□mon, J Clavel, *Occup Environ Med* (2004) 61:778.

US EPA. Toxicological Profile for Benzene. August 2007 <Online www.atsdr.cdc.gov/toxprofiles/tp.asp?id=40&tid=14>.

SA EPA. EPA Guidelines: Air quality impact assessment, January 2006 http://www.epa.sa.gov.au/xstd_files/Air/Guideline/guide_airquality.pdf

Weng HH, Tsai SS, Chiu HF, Wu TN, Yang CY. Childhood leukemia and traffic air pollution in Taiwan: petrol station density as an indicator. J Toxicol Environ Health A. 2009;72(2):83-7.

Appendix: Benzene Level Roses from Powell C, Air Quality Monitoring Hot Spot Report No 6 - Jenkins Street, Birkenhead; *Environmental Protection Authority*. October 2006

Benzene (C_6H_6)

Health effects

Benzene is a recognised human carcinogen. Studies of industrial workers exposed to a high level of benzene have demonstrated a greater risk of leukaemia, which increased in relation to their working lifetime exposure. As benzene is a carcinogen, no safe level can be specified for an ambient air concentration of benzene and, as yet, there is no ambient standard for benzene in Australia. The Expert Panel on Air Quality Standards (EPAQS-UK) has recommended an air quality standard of 0.005 ppm (16 $\mu g/m^3$) as an annual average [2].

Sources

Benzene is a volatile organic compound. In Adelaide, the main source is the combustion and distribution of petrol, of which benzene is a minor constituent. Benzene is also formed during the combustion of aromatics in petrol. Motor vehicles contribute up to 70% of benzene emissions. Smoke from domestic wood fires and emissions from lawn mowers and some industries are also significant contributors.

Monitoring results

One-hour averages for benzene (Figure 4) were within the range 0.0 to 53.4 $\mu g/m^3$. The average for the entire sampling period for was 7.8 $\mu g/m^3$. The UK air quality guideline (Department of the Environment, Transport and the Regions 1994) for benzene is 16 $\mu g/m^3$ (measured as an annual average). The annual average for 2004 was 7.8 $\mu g/m^3$, which does not exceed the UK air quality guideline.

Ambient concentrations of benzene are expected to fall by 2005 after the introduction of the national fuel quality standard. [1,3].

The three highest levels of benzene occurred on the same dates as some of the highest toluene measurements (25/2/2004, 23/3/2004 and 25/3/2004). Benzene pollution roses for these dates are shown in Appendix A (A-17 to A-19). The similarities of the high events suggest that the source is the same.

Ten-minute averaged values of benzene reached 149.6 $\mu g/m^3$ and showed high short-term events. It was also noted that all ten minute averaged benzene data greater than 40 $\mu g/m^3$ (15 events) occurred between midnight and 8:00 am.

The high level occurrences of benzene (25/2/05, 23/3/05 and 25/3/05) appear to come from the industrial sector. Other sources of benzene expected to affect the monitoring site included vehicle traffic along Semaphore Road and Victoria Drive.

Table 3: Dates of high benzene levels and the direction from which they were detected

Date	Benzene (µg/m^3) 1-hour averages	Comments from pollution roses 10-minute averages
25/2/04 0400 & 0500	27.5	Values greater than 20 µg/m^3 from north to east-north-east
	36.3	
23/3/04 0700 & 0800	53.4	Values greater than 20 µg/m^3 predominantly from north-west to north-north-east
	49.5	
25/3/04	51.9	Values greater than 20 µg/m^3 predominantly from north to north-north-east

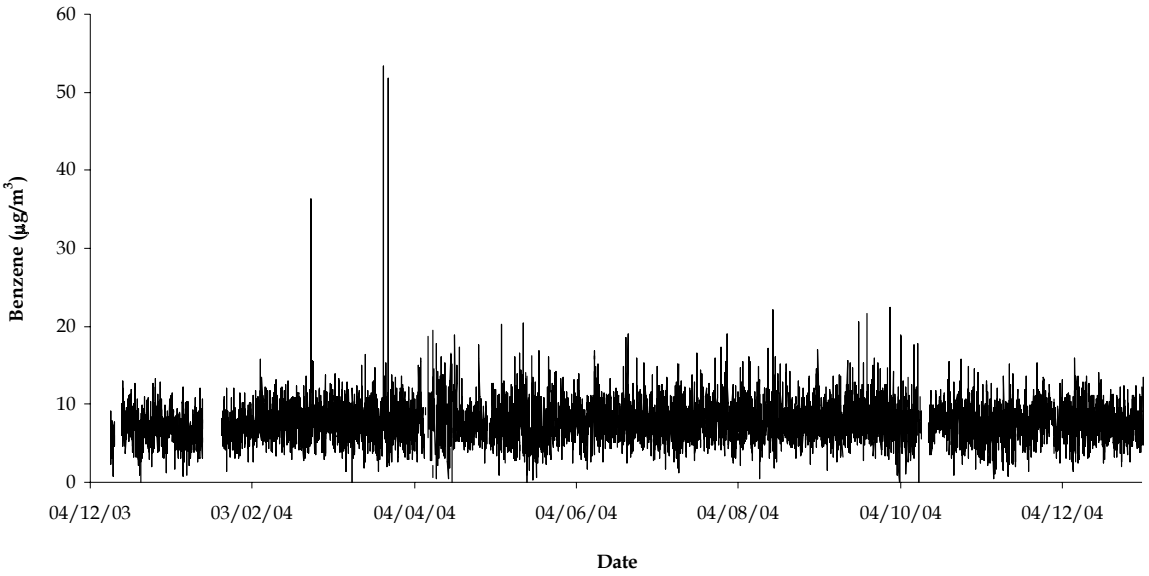


Figure 4: Benzene one-hour averages measured at Birkenhead (11 December 2003 to 3 January 2005)

Benzene pollution roses

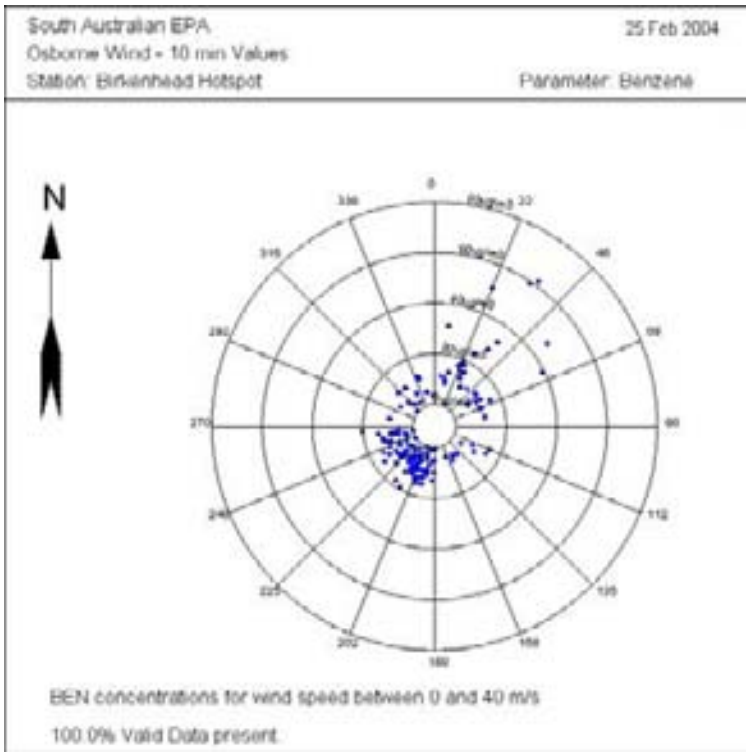


Figure A-17: Benzene pollution rose—25/2/04

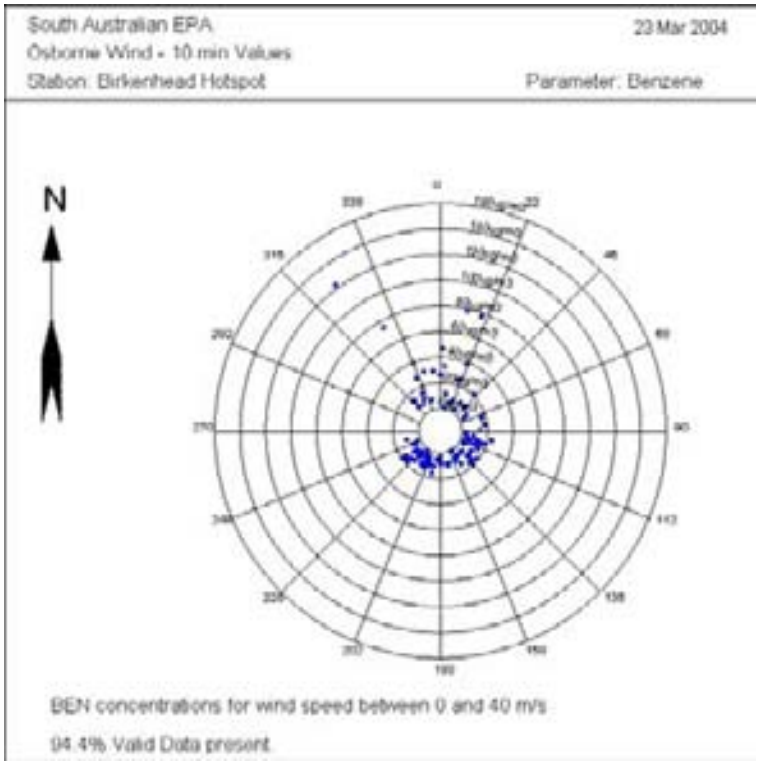


Figure A-18: Benzene pollution rose—23/3/04

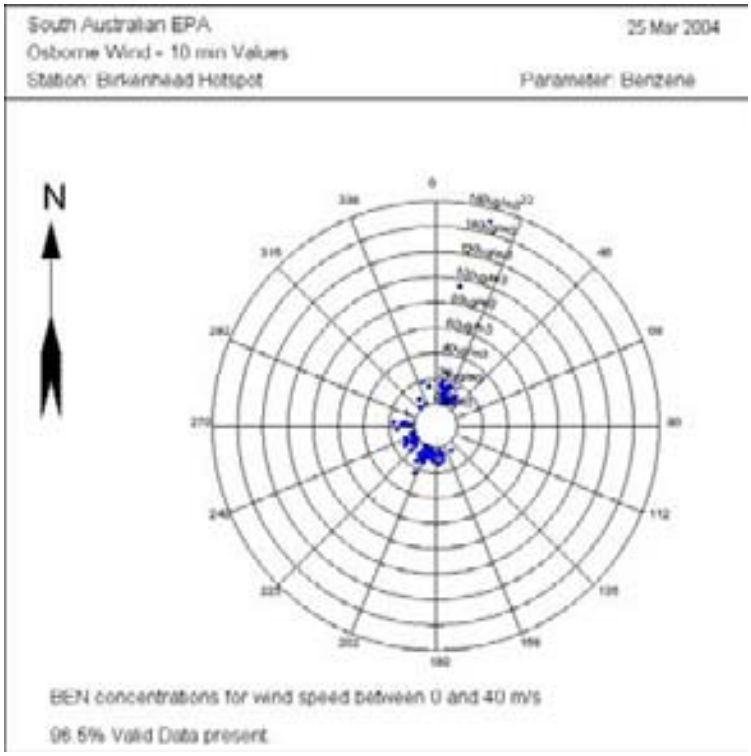


Figure A-19: Benzene pollution rose—25/3/04