National Pollutant Inventory

NPi

AIR EMISSIONS STUDY
1998-1999

Summary Report
Adelaide and Regional Airsheds

EPA South Australia

AIR

Government of South Australia

South Australian National Pollutant Inventory

SUMMARY REPORT

ADELAIDE AND REGIONAL AIRSHEDS

AIR EMISSIONS STUDY 1998–99

Prepared by Dr Jolanta Ciuk

**Environment Protection Authority
South Australia**

South Australian NPI Summary Report
Adelaide and regional airsheds air emissions study 1998–99

This document is a summary of the NPI aggregated air emissions estimated in the South Australian airsheds for 1998–99. Aggregate and industry reported emissions data are accurate at the time of printing.

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Abbreviations

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
AGA	Australian Natural Gas Association
AIP	Australian Institute of Petroleum
ALPGA	Australian Liquid Petroleum Gas Association
APMF	Australian Paint Manufacturing Federation
BTEX	benzene-toluene-ethylbenzene-xylene
CO	carbon monoxide
EET	emission estimation technique
GIS	geographical information systems
km	kilometres
L	litres
LPG	liquefied petroleum gas
MOU	memorandum of understanding
NEPM	National Environment Protection Measure
NO_x	oxides of nitrogen
NPI	National Pollutant Inventory
PM10	particulate matter less than 10 μm
SA EPA	South Australian Environment Protection Authority*
SO_2	sulfur dioxide
VKT	vehicle kilometres travelled
VOC	volatile organic compounds

* Known as 'Environment Protection Agency' prior to July 2002

Executive summary

Introduction

This report provides an overview of the inventory work carried out within South Australia as part of the National Pollutant Inventory (NPI). Detailed methodologies describing the various estimation techniques can be found in the referenced aggregated emissions estimation technique (EET) manuals for each source studied, available at www.npi.ea.gov.au.

NPI emissions were investigated in 17 airsheds, representing a large cross-section of the State's population and commercial/industrial activities. These airsheds—one metropolitan and 16 regional—were divided into grid squares measuring either 1 x 1 km or 5 x 5 km in area.

Aggregated emission sources studied in each airshed represent a range of domestic, commercial and transportation related activities. Eighteen aggregate sources were estimated for the emissions of 90 substances in Table 2 of the National Environment Protection Measure (NEPM) for the NPI. However, emissions were only calculated for those substances for which emission factors were known. Substances with no data are either not related to the source or no emission factors were available.

Data in this report is available on the Internet NPI database and can be viewed at www.npi.ea.gov.au.

Background

The NPI is a national database containing pollutant inventories of annual emission loads to air, land and water. NPI data is collated by individual States and consists of aggregate and industry emission estimates in kilograms emitted annually. The purpose of the NPI is to:

- provide the community, industry and governments with consistent and reliable information about pollutant emissions in Australia
- become an integral part of policy and program formulation for government and assist in environmental planning and management
- promote cleaner, more efficient manufacturing processes and energy resource savings programs for industry, government and the community.

As part of the NPI program, the South Australian Environment Protection Agency (SA EPA) was committed to supplying the national NPI database with estimations of aggregated emissions to air from the Adelaide and 16 regional airsheds for the 1998-99 year. This requirement is stipulated in Schedule C of the NPI Memorandum of Understanding (MOU). The MOU provides the basis for implementation of the NEPM.

Under the NPI MOU, states and territories were not required to report emissions from aggregated sources for which there were no relevant aggregated EET manuals. Emissions represented in this report were all estimated using the available manuals developed by Environment Australia.

Airsheds

The 17 South Australian airsheds examined in this report comprise six major airsheds divided into grid squares 1 x 1 km or 5 x 5 km, and 11 minor airsheds with 1 x 1 km grid squares, each located within the boundaries of a major airshed. Airsheds cover the major populated, commercial and industrial areas of the State in the Adelaide metropolitan area, the Barossa Valley, Port Lincoln, the Riverland, the South East and upper regions of the Spencer Gulf.

Air emission sources

The sources of air pollutants studied in each of the airsheds include a range of domestic, commercial and mobile activities listed below. Each source was estimated in-house according to EET methodologies. Motor vehicle emissions in the Adelaide and regional airsheds were also calculated in accordance with the methodology of the NPI Aggregated Motor Vehicles EET, while strongly relying on emission factors, vehicle fleet profiles and other activity parameters determined by McLennan Magasanik Associates.

Aggregate air emission sources

Aeroplanes	Paved roads
Architectural surface coatings	Print shops/graphic arts
Cutback bitumen	Railways
Domestic/commercial solvents/aerosols	Recreational boating
Domestic gas fuel	Service stations
Dry cleaning	Shipping and commercial boating
Lawn mowing (domestic)	Solid fuel burning (domestic)
Motor vehicles	Sub-threshold fuel combustion
Motor vehicle refinishing	Sub-threshold solvents

For comparative purposes, emission sources have been grouped into the five source types:

Mobile – motor vehicles: includes emissions from all passenger vehicles, four-wheel drives, light vehicles, rigid trucks, articulated trucks, buses, motor cycles and other vehicles.

Mobile – other: includes aircraft, railways and watercraft operating within the airshed. Watercraft include the emission sources of ships, commercial boats and recreational boats.

Area based: includes emissions from a range of domestic and commercial activities as well as activities associated with roads such as cutback bitumen and paved roads.

Sub-threshold facilities: includes emissions from fuel combustion and solvent use by industrial facilities below the reporting threshold.

NPI reporting facilities: includes self-reported emissions from a range of industries operating above the NPI thresholds. This data is valid for the 1999–2000 reporting year and is used in place of the 1998–99 preliminary data.

Results

In the Adelaide airshed, aggregate emissions from area-based sources and the single source type, motor vehicles, indicate these sources are major contributors to the emissions of the pollutants carbon monoxide, lead, oxides of nitrogen and particulate matter. Emissions of sulfur dioxide were predominantly from industry-reported emissions (53%), followed by motor vehicle emissions (30%). Total volatile organic compounds (VOC) were dominated by motor vehicle emissions (45%), followed by the area-based sources, largely domestic solid fuel burning (15%) and domestic and commercial solvents and aerosols (13%). Paved road emissions resulting from vehicle use on sealed roads were identified as a major source of resuspended particulate matter less than 10 μm as well as other metallic compounds. The full list of substances estimated and the percentage of emissions attributed to each source type is shown in Table E1.

Regional airshed emissions of NPI substances were predominantly from aggregate sources, although industry emissions were found to be significant in two of the airsheds studied, Barossa and Spencer Gulf. Area-based emissions, representing 11 separate sources, were the largest contributors of NPI substances, ranging from 58% to 79% of total emission in the airshed. These sources were consequently the major contributor of NPI emissions in each of the regional airsheds relative to other sources estimated. However, between 40% and 50% of the substances emitted by motor vehicles were identified as the largest contributors of NPI substances in each airshed. Area-based sources and motor vehicles collectively contributed more than 60% of the total NPI emission estimates in these regional airsheds.

Regional emissions of the major pollutants carbon monoxide, oxides of nitrogen, particulate matter less than 10 µm, sulfur dioxide and VOC were dominated by industry sources in the Barossa and Spencer Gulf airsheds, and motor vehicle or area-based sources in the remaining airsheds. A summary of substances emitted from contributing sources, in the regional airsheds combined, is listed in Table E2; a more detailed list of sources and their percentage contribution to the total emissions of each NPI substance is given by airshed in Table E3 to Table E8.

Emissions from natural sources such as wildfires or biogenics have not been included in these calculations, although these may be significant contributors in the regional airsheds. The Perth study, where natural sources accounted for only a small fraction of the total emissions in the metropolitan area, indicates that large contributions should not be expected from natural sources in the Adelaide airshed.

Paved roads included in the general source type 'area-based' were highlighted as a significant source of particulate matter less than 10 µm. However, these emissions are not newly generated but a result of the resuspension of loose matter from the road surface, introduced onto the roads from a variety of activities such as dust fall, litter, erosion from adjacent areas or spillage. Industry-reported emissions were the largest source of newly generated particulate matter less than 10 µm. In regional airsheds, emissions from domestic solid fuel burning were also identified as a major source generating particulate matter less than 10 µm.

Emissions determined on a per capita basis for the Adelaide, Port Lincoln, Riverland and South East airsheds were of similar magnitude. However, per capita emissions of selected substances in the Barossa and Spencer Gulf airsheds were exceedingly high due to the dominance of industry sources. Similarities between the Adelaide and all regional airsheds was most evident for the following substances: VOC, benzene-toluene-ethylbenzene-xylene (BTEX) and all combined metallic compounds, which were mostly related to area-based sources or motor vehicles. The emission estimates of carbon monoxide, oxides of nitrogen, sulfur dioxide and particulate matter less than 10 µm were greatly influenced by industry sources within some airsheds. In the absence of industry dominance, there was a close agreement in the per capita emission estimates between regional airsheds and the Adelaide airshed, suggesting the possibility of transposing data to other regions of the State on a population basis. However, inventory estimates must be validated against monitoring data to confirm these findings.

Key conclusions and recommendations

The 1998–99 NPI inventory confirms the significant contribution made by motor vehicles to the total emissions of the major air quality pollutants carbon monoxide, oxides of nitrogen, total VOC, and particulate matter less than 10 µm through resuspension from paved roads. Independent comparisons of NPI substances carbon monoxide, oxides of nitrogen and VOC by Professor Neville Clark (Flinders Consulting Pty Ltd) indicate a very close agreement with direct measurements from aircraft as well as other inventories[3]. These independent data assessments increase confidence in the NPI estimates.

Industry emissions from facilities reporting in the 1999–2000 reporting year, the second year of the NPI reporting program, indicate significant contributions to the total emission load in the regional airsheds of Barossa and Spencer Gulf. These included emissions of carbon monoxide, oxides of nitrogen, total VOC, particulate matter less than 10 µm and sulfur dioxide.

Emissions of VOC are largely contributed by domestic area-based sources such as solvent and aerosol use and solid fuel burning. These sources contributed approximately half of the total VOC emission load in the airsheds studied, with the remaining portion being greatly influenced by motor vehicle emissions.

The dominant source of BTEX substances identified under the Air Toxics Program was the combustion of petroleum products in motor vehicles. Some area-based sources, in particular lawn mowing and solid fuel burning, also contribute.

Comparisons between the Adelaide and regional airsheds indicate a close agreement in the magnitude of emissions on a per capita basis, in the absence of industry dominance. This is not surprising based on the methodologies applied in these estimates, which strongly rely on the apportioning of State data to airsheds according to population in the absence of locally available data. However, every effort was made to use locally derived data. Where industry emissions occur these strongly influence the airshed's total emission load. This is particularly noticeable in the Barossa and Spencer Gulf airsheds.

In view of these estimates and applied methodologies, there are several recommendations that should be addressed to improve the accuracy of this inventory in the future.

- The inventory should be repeated within a short period of the Australian Bureau of Statistics Census collection year. This will provide a more accurate representation of emissions based on the latest demographic information.
- Domestic activity data associated with the solid fuel burning particularly should be improved in the regional airsheds such as the South East. In the current inventory, regional responses to the domestic survey were limited to certain areas and therefore did not provide the desirable cross-sectional representation. This may be improved with better promotion of the South Australian Environment Protection Authority (SA EPA) inventory program through its community education programs such as Air Watch.
- Recreational and commercial boating activity data should be improved within airsheds where this source is known to contribute significantly to the total emission load such as the Spencer Gulf, Port Lincoln and Riverland airsheds. The current accuracy of the estimates is considered to be less than 20%[4], since activity within regional airsheds was based on a combination of responses from the domestic survey and boat registration data. The many assumptions made for the estimation may have grossly over- or under- estimated the true contributions.
- The source 'bushfires and prescribed burning' should be included in future inventory estimates. Currently there is limited information available on the practice of prescribed burning within South Australia, and a more thorough accounting of prescribed burning practices would enable these emissions to be accurately represented. This can be achieved by collecting more detailed information on the proposed burn-off activity as a condition of permit issue. Information should include the proposed burn location, area to be burnt, burn material such as crop type, quantity to be burnt, and the time and length of burn.
- Motor vehicles were consistently the largest source of emissions in each airshed. Future changes in fuel and vehicle age will have significant impacts on the choice of emission factors. Efforts need to be directed to determining accurate emission factors and vehicle fleet compositions. In addition, residential roads were determined based on population-based emission factors rather than on actual vehicle kilometres travelled (VKT) data. Further work needs to be directed towards determining VKT data from traffic counts on residential roads.

- The inventory values need to be validated with monitoring data to determine spatial and temporal distributions. This can be achieved with techniques such as pollutant modelling, and by independent assessments. The independent assessment by Professor Neville Clark for a limited number of substances indicated strong agreement between these estimates and alternative inventory techniques for the Adelaide airshed[3]. However, it remains difficult to predict if these agreements will apply to some of the regional airsheds or to other substances.
- Industry reported emissions for the 1999–2000 year, under the NPI requirement, include 218 reporters state-wide from a range of industry sectors. Facilities not required to report have been included in the sub-threshold estimates. However, the accuracy of data provided by industries needs further investigation and assessment to validate contributions and thus help to identify long-term trends within industry sectors.

Table E1 ***Emissions from sources (%) within the Adelaide airshed*** *(in descending order of total emissions)*

NPI substances	Motor vehicles	Other mobile	Area based	Sub-threshold facilities	1999–2000 NPI reporting facilities	Total emissions
	(%)	(%)	(%)	(%)	(%)	kg/yr†
Carbon monoxide	85	<1	12	1	2	170,000,000
Total volatile organic compounds	44	<1	48	<1	7	40,000,000
Oxides of nitrogen	60	4	2	9	26	30,000,000
Particulate matter < 10 µm	5	2	65	2	26	11,000,000
Sulfur dioxide	20	9	2	6	63	3,200,000
Toluene (methylbenzene)	59	<1	29	<1	12	2,900,000
Xylenes (individual or mixed isomers)	63	<1	16	<1	21	2,400,000
Formaldehyde (methyl aldehyde)	47	1	51	<1	<1	990,000
n-Hexane	31	<1	53	5	11	990,000
Benzene	74	<1	23	<1	3	930,000
Acetaldehyde	23	<1	77			590,000
Acetone	21	<1	75		3	540,000
Cyclohexane	5		93	<1	2	520,000
Methanol			100		<1	420,000
Ammonia (total)	95				5	270,000
Ethylbenzene	88	<1	10	<1	2	270,000
Polycyclic aromatic hydrocarbons	11	<1	14	<1	75	250,000
1,3-Butadiene (vinyl ethylene)	81	1	18		<1	160,000
Trichloroethylene			<1	74	26	140,000
Tetrachloroethylene			100		<1	130,000
Methyl ethyl ketone			32		68	110,000
Lead & compounds	54	1	44	<1	<1	65,000
Ethylene glycol (1,2-ethanediol)			100			59,000
Dichloromethane			100		<1	46,000
Styrene (ethenylbenzene)	77	<1	21		1	45,000
Fluoride compounds			1	<1	99	44,000
2-Ethoxyethanol acetate			78		22	38,000
Zinc and compounds		<1	97	3	<1	30,000
Ethanol			55		45	25,000
Manganese & compounds		<1	100	<1	<1	23,000
Methyl isobutyl ketone			100		<1	19,000
Carbon disulfide			<1		100	13,000
Ethylene oxide			100			7,100

† Emissions to 2 significant figures

Table E1 (cont) Emissions from sources (%) within the Adelaide airshed (in descending order of total emissions)

NPI substances	Motor vehicles	Other mobile	Area based	Sub-threshold facilities	1999-2000 NPI reporting facilities	Total emissions
	(%)	(%)	(%)	(%)	(%)	kg/yr†
Ethyl acetate			100			6,600
Cumene (1-methylethylbenzene)			83		17	5,900
Copper & compounds		<1	99	<1	<1	4,800
Cobalt & compounds		<1	100	<1	<1	3,400
Nickel & compounds		7	74	3	16	2,800
Hydrogen sulfide	100					1,600
Arsenic & compounds		64	32	<1	3	1,400
Cadmium & compounds		12	80	4	5	720
Chromium (III) compounds		93	4	4		670
Mercury & compounds		<1	96	1	2	490
Chloroform (trichloromethane)			100			470
Chromium (VI) compounds		62	28	2	7	430
Antimony & compounds		<1	93	<1	6	420
Sulfuric acid					100	420
1,2-Dichloroethane			<1		99	350
Hydrochloric acid			<1	42	57	300
Phenol		71	<1		29	180
Selenium & compounds		2	92	1	5	73
Biphenyl (1,1′-biphenyl)			100			10
Cyanide (inorganic) compounds			100			9.5
Nickel carbonyl					100	4.8
Beryllium & compounds		54	37	9	<1	3.3
1,2-Dibromoethane					100	3.2
Nickel subsulfide					100	0.60
Di-(2-Ethylhexyl) phthalate (DEHP)			100			0.28
Acrylic acid			100			0.0019

† Emissions to 2 significant figures

Table E2 **Emissions from sources (%) within the regional airsheds combined** *(in descending order of total emissions)*

NPI substances	Motor vehicles	Other mobile	Area based	Sub-threshold facilities	1999-2000 NPI reporting facilities	Total emissions
	(%)	(%)	(%)	(%)	(%)	kg/yr†
Carbon monoxide	12	1	8	1	78	130,000,000
Sulfur dioxide	<1	<1	<1	<1	99	61,000,000
Oxides of nitrogen	11	3	<1	7	79	26,000,000
Particulate matter < 10 µm	<1	<1	24	2	72	7,800,000
Total volatile organic compounds	28	5	65	1	1	7,500,000
Toluene (methylbenzene)	47	10	42	<1	1	440,000
Formaldehyde (methyl aldehyde)	19	5	75	<1		300,000
Xylenes (individual or mixed isomers)	62	4	32	<1	<1	290,000
Acetaldehyde	8	4	89		<1	230,000
Benzene	36	6	46	<1	13	230,000
Acetone	9	<1	91			180,000
Methanol			34		66	180,000
n-Hexane	25	2	50	22	<1	150,000
Cyclohexane	4	<1	94	2	<1	72,000
Fluoride compounds			<1	<1	100	59,000
Ethylbenzene	70	7	23	<1	<1	40,000
Lead & compounds	11	<1	14	<1	74	38,000
Polycyclic aromatic hydrocarbons	10	3	73	<1	15	34,000
Ammonia (total)	100					30,000
1,3-Butadiene (vinyl ethylene)	52	13	35		<1	30,000
Trichloroethylene			<1	100		11,000
Tetrachloroethylene			100			9,700
Methyl ethyl ketone			100			8,500
Ethylene glycol (1,2-ethanediol)			100			8,400
Styrene (ethenylbenzene)	52	5	43			8,000
Dichloromethane			100			6,400
Zinc and compounds		<1	91	9		6,100
Manganese & compounds		<1	100	<1		4,400
2-Ethoxyethanol acetate			100			4,100
Methyl isobutyl ketone			100			2,700
Arsenic & compounds		5	5	<1	90	1,900
Ethanol			100			1,900
Cumene (1-methylethylbenzene)			98		2	1,100

† Emissions to 2 significant figures

Table E2 (cont) Emissions from sources (%) within the regional airsheds combined (in descending order of total emissions)

NPI substances	Motor vehicles	Other mobile	Area based	Sub-threshold facilities	1999-2000 NPI reporting facilities	Total emissions
	(%)	(%)	(%)	(%)	(%)	kg/yr†
Ethylene oxide			100			1,000
Copper & compounds			100			920
Ethyl acetate		<1	97	2	1	930
Cobalt & compounds		<1	93	<1	6	710
Nickel & compounds		31	62	6	<1	620
Chromium (VI) compounds		73	2	2	23	380
Cadmium & compounds		4	44	8	44	240
Hydrogen sulfide	100					180
Mercury & compounds		<1	76	4	20	120
Chromium (III) compounds		69	10	18	3	96
Antimony & compounds		3	97	<1		79
Chloroform (trichloromethane)			100			66
Phenol		100	<1			26
Selenium & compounds		9	88	2		18
Hydrochloric acid			2	98		4.8
Nickel subsulfide					100	4.2
Nickel carbonyl			100			3.2
Biphenyl (1,1′-biphenyl)					100	3.9
Beryllium & compounds		91	2	7		3.0
1,2-Dibromoethane					100	0.5
Cyanide (inorganic) compounds			100			0.39
1,2-Dichloroethane			100			0.31
Carbon disulfide			100			0.021
Di-(2-Ethylhexyl) phthalate (DEHP)			100			0.012
Polychlorinated dioxins and furans					100	0.0018
Acrylic acid			100			0.00026

† Emissions to 2 significant figures

Table E3 ***Percentage contribution by source to the total emission of NPI substances in the Adelaide airshed***

ADELAIDE AIRSHED	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)	
		OTHER MOBILE																					
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL: OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL: SUB-THRESHOLD	Reporting Facilities 1999-2000	**Total (kg/yr)** (2 sig. fig.)
Acetaldehyde	22.6	0.4	0.1	0.2	0.1	0.9											76.5	76.5					590,000
Acetone	21.4	0.2				0.2	13.5						1.0				60.9	75.4				3.0	540,000
Acrylic acid									100.0									100.0					0.0019
Ammonia (total)	94.8																					5.2	270,000
Antimony & compounds			0.4		0.2	0.6								90.4			2.2	92.5	0.5		0.5	6.4	420
Arsenic & compounds		64.0	<0.1		0.1	64.1					<0.1			31.8			0.5	32.3	0.4		0.4	3.2	1,400
Benzene	73.8	0.1	<0.1	0.2	<0.1	0.5	0.2		<0.1		<0.1	10.8				2.9	9.2	23.0	<0.1		<0.1	2.7	930,000
Beryllium & compounds					54.0	54.0					0.6						36.0	36.6	9.5		9.5	<0.1	3.3
Biphenyl (1,1′-biphenyl)								100.0										100.0					10
1,3-Butadiene (vinyl ethylene)	81.1	0.6	0.2	0.3	0.2	1.4						8.1					9.4	17.5				<0.1	160,000
Cadmium & compounds		11.7	0.1		<0.1	11.9					0.5			78.3			0.8	79.5	4.1		4.1	4.5	720
Carbon disulfide																	<0.1	<0.1				100.0	13,000
Carbon monoxide	84.6	0.5	<0.1	0.1	<0.1	0.7					<0.1	3.2					8.7	12.0	1.2		1.2	1.5	170,000,000
Chloroform (trichloromethane)									100.0									100.0					470
Chromium (III) compounds		92.6	<0.1	<0.1	<0.1	92.7					0.7	3.0						3.6	3.6		3.6		670
Chromium (VI) compounds		62.4	<0.1	<0.1	<0.1	62.4					0.4	1.9					25.6	28.0	2.5		2.5	7.1	430
Cobalt & compounds			<0.1	<0.1	<0.1	<0.1					0.2	0.8		98.8			<0.1	99.8	0.1		0.1	<0.1	3,400
Copper & compounds			<0.1	<0.1	<0.1	<0.1					<0.1	0.6		98.5				99.2	0.5		0.5	0.3	4,800
Cumene (1-methylethylbenzene)								40.5								42.2		82.7				17.3	5,900
Cyanide (inorganic) compounds																	100.0	100.0					9.5
Cyclohexane	4.8						91.5	<0.1			<0.1	0.6	0.2			0.3		92.6	0.4		0.4	2.1	520,000
1,2-Dibromoethane																						100.0	3.2
1,2-Dichloroethane									0.6									0.6				99.4	350
Dichloromethane							62.4		37.3								<0.1	99.8				0.2	46,000
Ethanol							55.4											55.4				44.6	25,000
2-Ethoxyethanol acetate							77.9											77.9				22.1	38,000
Ethyl acetate													100.0					100.0					6,600
Ethylbenzene	87.7	<0.1	<0.1	0.2	<0.1	0.2		<0.1	0.4			8.9	0.3			0.6	<0.1	10.3	<0.1		<0.1	1.8	270,000
Ethylene glycol (1,2-ethanediol)							27.4		72.6									100.0					59,000
Ethylene oxide									100.0									100.0					7,100

Table E3 (cont) Percentage contribution by source to the total emission of NPI substances in the Adelaide airshed

ADELAIDE AIRSHED	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)	
		OTHER MOBILE																					
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL: OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL: SUB-THRESHOLD	Reporting Facilities 1999-2000	Total (kg/yr) (2 sig. fig.)
Di-(2-Ethylhexyl) phthalate (DEHP)																	100.0	100.0					0.28
Fluoride compounds									<0.1								1.3	1.3	<0.1		<0.1	98.7	44,000
Formaldehyde (methyl aldehyde)	46.9	0.8	0.2	0.2	0.2	1.4			<0.1		<0.1	1.8					49.5	51.4	0.2		0.2	0.1	1,000,000
n-Hexane	31.0		<0.1	<0.1	<0.1	0.1	47.6	<0.1	4.1		0.6	0.5				0.4	<0.1	53.2	4.7		4.7	11.0	990,000
Hydrochloric acid									0.3									0.3	42.4		42.4	57.3	300
Hydrogen sulfide	100.0																						1,600
Lead & compounds	54.2	1.4	<0.1	<0.1	<0.1	1.4					<0.1	0.5		43.0		<0.1	<0.1	43.6	<0.1		<0.1	0.7	65,000
Manganese & compounds			<0.1	<0.1	<0.1	<0.1					<0.1	0.1		99.6			0.2	99.9	<0.1		<0.1	<0.1	23,000
Mercury & compounds			<0.1		<0.1	<0.1					0.2			95.8			0.1	96.0	1.4		1.4	2.5	490
Methanol							21.1		78.9									100.0				<0.1	420,000
Methyl ethyl ketone									22.5				4.2				4.9	31.6				68.4	110,000
Methyl isobutyl ketone							72.4		19.0				8.5					99.9				<0.1	19,000
Nickel & compounds		3.0	<0.1	<0.1	3.9	6.9					0.3	1.0		72.5			<0.1	73.9	3.2		3.2	16.0	2,800
Nickel carbonyl																						100.0	4.8
Nickel subsulfide																						100.0	0.60
Oxides of nitrogen	60.0	0.7	1.8	<0.1	1.0	3.5					1.0	<0.1					0.6	1.7	8.8		8.8	26.0	30,000,000
Particulate matter < 10 µm	5.1	1.5	0.1	<0.1	0.2	1.8					0.2	0.4		50.7			13.6	64.9	1.8		1.8	26.3	11,000,000
Phenol		71.2				71.2											<0.1	<0.1				28.8	180
Polycyclic aromatic hydrocarbons	10.8	0.2	<0.1	<0.1	<0.1	0.3		<0.1			<0.1	2.2					11.8	14.0	<0.1		<0.1	74.8	250,000
Selenium & compounds			<0.1		1.5	1.6					2.5			80.4			8.9	91.8	1.2		1.2	5.5	73
Styrene (ethenylbenzene)	77.4	0.5		0.1	<0.1	0.6		<0.1				4.2				<0.1	16.3	20.6				1.3	45,000
Sulfur dioxide	19.7	1.3	0.7	<0.1	6.7	8.8					<0.1	0.1					1.8	2.0	6.0		6.0	63.5	3,200,000
Sulfuric acid																						100.0	420
Tetrachloroethylene									10.2	89.8							<0.1	100.0				<0.1	130,000
Toluene (methylbenzene)	59.3	<0.1	<0.1	0.2	<0.1	0.3	4.1	<0.1	6.9	<0.1	<0.1	6.2	7.9			0.8	2.7	28.6	<0.1		<0.1	11.8	2,900,000
Total volatile organic compounds	44.0	0.1	<0.1	0.1	<0.1	0.4	7.1	0.1	13.5	0.4	<0.1	4.8	1.5		1.1	4.0	15.2	47.9	0.4	0.3	0.6	7.1	40,000,000
Trichloroethylene									0.2									0.2		73.9	73.9	25.9	140,000
Xylenes (individual or mixed isomers)	62.6	<0.1	<0.1	<0.1	<0.1	0.2	2.4	<0.1	4.0	0.4		5.4	1.9			0.4	1.7	16.1	<0.1		<0.1	21.1	2,400,000
Zinc and compounds			<0.1	<0.1	<0.1	<0.1					0.3	<0.1		93.6			2.6	96.5	2.5		2.5	0.9	30,000

Table E4 ***Percentage contribution by source to the total emission of NPI substances in the Barossa airshed***

BAROSSA AIRSHED	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)	
		OTHER MOBILE																					
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL: OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL: SUB-THRESHOLD	Reporting Facilities 1999-2000	Total (kg/yr) (2 sig. fig.)
Acetaldehyde	12.4	-	0.2	-	-	0.2											86.7	86.7				0.7	23,000
Acetone	13.5	-		-	-		5.6						0.4				80.5	86.5					19,000
Acrylic acid		-		-	-				100.0									100.0					0.000027
Ammonia (total)	100.0	-		-	-																		5,200
Antimony & compounds		-	0.7	-	-	0.7								96.7			2.6	99.3	<0.1		<0.1		19
Arsenic & compounds		-	<0.1	-	-						<0.1			87.2			1.4	88.6	2.0		2.0	9.4	25
Benzene	60.0	-	0.1	-	-	0.1	<0.1		<0.1		<0.1	11.1				1.7	26.9	39.7	<0.1		<0.1		23,300
Beryllium & compounds		-		-	-						<0.1						14.2	14.2	85.8		85.8		0.035
Biphenyl (1,1′-biphenyl)		-		-	-			100.0										100.0					0.43
1,3-Butadiene (vinyl ethylene)	74.6	-	0.7	-	-	0.7						9.3					15.4	24.7					3,500
Cadmium & compounds		-	0.2	-	-	0.2					<0.1			89.8			0.8	90.5	9.3		9.3		30
Carbon disulfide		-		-	-												100.0	100.0					0.0020
Carbon monoxide	68.7	-	0.1	-	-	0.1					<0.1	3.9					20.2	24.1	4.9		4.9	2.1	4,100,000
Chloroform (trichloromethane)		-		-	-				100.0									100.0					6.7
Chromium (III) compounds		-	0.2	-	-	0.2					8.4	15.6						24.0	75.8		75.8		3.1
Chromium (VI) compounds		-	<0.1	-	-						0.6	1.1					2.5	4.2	5.8		5.8	90.0	18
Cobalt & compounds		-	<0.1	-	-						0.8	0.4		98.6			<0.1	99.8	0.1		0.1		170
Copper & compounds		-	<0.1	-	-						<0.1	0.3		98.7				99.0	0.9		0.9		230
Cumene (1-methylethylbenzene)		-		-	-			74.5								25.5		100.0					140
Cyanide (inorganic) compounds		-		-	-												100.0	100.0					0.039
Cyclohexane	6.6	-		-	-		89.0	<0.1			<0.1	1.0	0.2			0.3		90.5	2.9		2.9		7,600
1,2-Dichloroethane		-		-	-				100.0									100.0					0.032
Dichloromethane		-		-	-		62.1		37.9								<0.1	100.0					660
Ethanol		-		-	-		100.0											100.0					190
2-Ethoxyethanol acetate		-		-	-		100.0											100.0					430
Ethyl acetate		-		-	-								100.0					100.0					94
Ethylbenzene	88.0	-	<0.1	-	-			0.1	0.3			11.0	0.2			0.4	<0.1	12.0	<0.1		<0.1		5,400
Ethylene glycol (1,2-ethanediol)		-		-	-		27.2		72.8									100.0					850

Table E4 (cont) *Percentage contribution by source to the total emission of NPI substances in the Barossa airshed*

BAROSSA AIRSHED	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)	
		OTHER MOBILE																					
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL: OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL: SUB-THRESHOLD	Reporting Facilities 1999-2000	**Total (kg/yr)** (2 sig. fig.)
Ethylene oxide		-		-	-				100.0									100.0					100
Di-(2-Ethylhexyl) phthalate (DEHP)		-		-	-												100.0	100.0					0.0011
Fluoride compounds		-		-	-				<0.1								0.3	0.3	<0.1		<0.1	99.7	790
Formaldehyde (methyl aldehyde)	30.0	-	0.4	-	-	0.4			<0.1		<0.1	1.4					67.5	68.9	0.6		0.6		32,000
n-Hexane	34.1	-	0.1	-	-	0.1	36.9	<0.1	3.1		<0.1	0.9				0.3	<0.1	41.2	24.5		24.5		18,000
Hydrochloric acid		-		-	-				2.1									2.1	97.9		97.9		0.56
Hydrogen sulfide	100.0	-		-	-																		32
Lead & compounds	34.1	-	<0.1	-	-						<0.1	0.5		64.0		<0.1	<0.1	64.4	<0.1		<0.1	1.3	2,100
Manganese & compounds		-	<0.1	-	-						<0.1	<0.1		99.7			0.1	99.9	<0.1		<0.1		1,100
Mercury & compounds		-	<0.1	-	-						<0.1			73.9			<0.1	73.9	2.1		2.1	23.9	31
Methanol		-		-	-		20.9		79.1									100.0					6,100
Methyl ethyl ketone		-		-	-				40.3				7.6				52.1	100.0					840
Methyl isobutyl ketone		-		-	-		72.4		19.0				8.6					100.0					270
Nickel & compounds		-	<0.1	-	-						0.3	0.6		93.7			<0.1	94.7	5.2		5.2		100
Nickel carbonyl		-		-	-																	100.0	1.9
Oxides of nitrogen	23.0	-	2.1	-	-	2.1					0.1	<0.1					0.6	0.7	13.5		13.5	60.7	1,900,000
Particulate matter < 10 µm	0.7	-	<0.1	-	-						<0.1	<0.1		17.4			5.2	22.6	1.2		1.2	75.3	1,600,000
Phenol		-		-	-												100.0	100.0					0.00025
Polycyclic aromatic hydrocarbons	19.1	-	0.4	-	-	0.4		0.3			<0.1	4.8					75.2	80.3	<0.1		<0.1	0.1	2,900
Selenium & compounds		-	0.1	-	-	0.1					10.7			84.5			3.0	98.1	1.8		1.8		3.4
Styrene (ethenylbenzene)	69.5	-		-	-			<0.1				4.4				<0.1	26.0	30.5					1,000
Sulfur dioxide	51.1	-	6.5	-	-	6.5					<0.1	0.5					7.7	8.2	3.8		3.8	30.4	26,000
Tetrachloroethylene		-		-	-				21.3	78.7							<0.1	100.0					890
Toluene (methylbenzene)	68.1	-	<0.1	-	-		3.2	<0.1	5.6		<0.1	8.2	6.3			0.7	7.9	31.9	<0.1		<0.1		52,000
Total volatile organic compounds	40.9	-	0.2	-	-	0.2	4.6	0.3	8.9	<0.1	<0.1	5.3	1.0		4.1	2.7	30.1	57.0	1.6	0.2	1.8	<0.1	860,000
Trichloroethylene		-		-	-				0.2									0.2		99.8	99.8		1,400
Xylenes (individual or mixed isomers)	79.4	-	<0.1	-	-		2.2	<0.1	3.6			8.2	1.6			0.3	4.6	20.5	<0.1		<0.1		39,000
Zinc and compounds		-	<0.1	-	-						<0.1	<0.1		92.2			2.7	94.9	5.0		5.0		1,400

Table E5 ***Percentage contribution by source to the total emission of NPI substances in the Port Lincoln airshed***

PORT LINCOLN AIRSHED	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)	
		OTHER MOBILE																					
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL: OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL: SUB-THRESHOLD	Reporting Facilities 1999-2000	Total (kg/yr) (2 sig. fig.)
Acetaldehyde	6.2	0.8	<0.1	0.5	0.5	1.9											91.9	91.9					18,000
Acetone	6.6	0.5				0.5	5.7						0.4				86.6	92.8					15,000
Acrylic acid									100.0									100.0					0.000022
Ammonia (total)	100.0																						2,100
Antimony & compounds			0.3		1.9	2.2								93.1			4.6	97.7	0.1		0.1		9.6
Arsenic & compounds		67.2	<0.1		1.4	68.6								30.5			0.9	31.4	<0.1				34
Benzene	34.6	0.4	<0.1	1.1	0.5	2.0	0.1		<0.1		<0.1	25.1				1.9	32.3	59.5	<0.1			3.8	16,700
Beryllium & compounds					99.0	99.0											1.0	1.0	<0.1				0.41
Biphenyl (1,1′-biphenyl)								100.0										100.0					0.21
1,3-Butadiene (vinyl ethylene)	48.2	2.6	0.3	2.0	2.2	7.1						23.4					21.2	44.6				0.1	2,300
Cadmium & compounds		14.2	<0.1		0.8	15.0								83.6			1.3	84.9	<0.1				16
Carbon disulfide																	100.0	100.0					0.0018
Carbon monoxide	54.1	2.6	<0.1	0.8	0.4	3.8					<0.1	9.1					33.0	42.1	<0.1				2,200,000
Chloroform (trichloromethane)									100.0									100.0					5.5
Chromium (III) compounds		93.4	<0.1	<0.1	0.7	94.1					1.3	4.7						5.9	<0.1				17
Chromium (VI) compounds		98.8	<0.1	<0.1	<0.1	98.8					0.1	0.5					0.6	1.2	<0.1				71
Cobalt & compounds			<0.1	<0.1	0.4	0.4					1.3	1.3		96.8			<0.1	99.5	<0.1				82
Copper & compounds			<0.1	<0.1	0.5	0.5					<0.1	1.0		98.5				99.5	<0.1				110
Cumene (1-methylethylbenzene)								54.5								32.2		86.7				13.3	90
Cyanide (inorganic) compounds																	100.0	100.0					0.034
Cyclohexane	3.5				<0.1		93.5	<0.1			<0.1	2.2	0.2			0.4		96.2	<0.1			0.2	6,000
1,2-Dibromoethane																						100.0	0.30
1,2-Dichloroethane									100.0									100.0					0.026
Dichloromethane							63.0		37.0								<0.1	100.0					540
Ethanol							100.0											100.0					170
2-Ethoxyethanol acetate							100.0											100.0					350
Ethyl acetate													100.0					100.0					78
Ethylbenzene	64.6	0.2	<0.1	1.2	0.2	1.6		0.1	0.4			31.9	0.3			0.6	<0.1	33.4	<0.1			0.5	3,100
Ethylene glycol (1,2-ethanediol)							27.8		72.2									100.0					710
Ethylene oxide									100.0									100.0					84

Table E5 (cont) *Percentage contribution by source to the total emission of NPI substances in the Port Lincoln airshed*

PORT LINCOLN AIRSHED	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)	
		OTHER MOBILE																					
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL: OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL: SUB-THRESHOLD	Reporting Facilities 1999-2000	Total (kg/yr) (2 sig. fig.)
Di-(2-Ethylhexyl) phthalate (DEHP)																	100.0	100.0					0.0010
Fluoride compounds									3.7								93.1	96.8	3.2		3.2		2.1
Formaldehyde (methyl aldehyde)	16.0	2.1	0.1	0.6	1.2	4.0			<0.1		<0.1	2.8					77.1	79.9	<0.1				25,000
n-Hexane	27.6		<0.1	0.4	0.9	1.4	59.8	<0.1	5.1		<0.1	1.7				0.6	<0.1	67.1	<0.1			3.8	9,400
Hydrochloric acid									1.5									1.5	98.5		98.5		0.66
Hydrogen sulfide	100.0																						13
Lead & compounds	30.2	2.4	<0.1	0.1	<0.1	2.5					<0.1	1.2		65.9		<0.1	0.1	67.2	<0.1				990
Manganese & compounds			<0.1	<0.1	<0.1						<0.1	0.2		99.6			0.2	100.0	<0.1				550
Mercury & compounds			<0.1		0.1	0.1								99.8			<0.1	99.8	<0.1				11
Methanol							21.2		78.8									100.0					5,000
Methyl ethyl ketone									39.3				7.4				53.3	100.0					710
Methyl isobutyl ketone							73.0		18.6				8.4					100.0					230
Nickel & compounds		2.9	<0.1	<0.1	33.1	36.1					0.4	1.5		61.7			<0.1	63.6	0.2		0.2		75
Oxides of nitrogen	67.9	0.6	3.5	<0.1	21.4	25.4					0.8	0.2					3.8	4.8	1.8		1.8		250,000
Particulate matter < 10 µm	2.1	1.9	<0.1	<0.1	2.6	4.5					<0.1	0.9		59.9			32.4	93.2	<0.1				220,000
Phenol		100.0				100.0											<0.1						7.9
Polycyclic aromatic hydrocarbons	9.5	1.5	0.1	0.4	<0.1	2.0		0.2				9.2					79.1	88.5	<0.1				2,400
Selenium & compounds			<0.1		12.3	12.3					15.7			67.4			4.5	87.6	<0.1				2
Styrene (ethenylbenzene)	47.7	2.1		0.8	<0.1	2.9		<0.1				12.1				<0.1	37.2	49.3					620
Sulfur dioxide	11.2	0.2	0.8	<0.1	81.7	82.7					<0.1	0.3					3.9	4.2	1.9		1.9		47,000
Tetrachloroethylene									18.6	81.4							<0.1	100.0					860
Toluene (methylbenzene)	43.8	<0.1	<0.1	1.8	0.3	2.1	4.2	<0.1	7.2		<0.1	21.2	8.4			0.9	10.5	52.3	<0.1			1.8	33,000
Total volatile organic compounds	23.6	0.5	<0.1	0.8	0.5	1.8	5.3	0.2	10.4	0.1	<0.1	12.1	1.2		0.3	3.1	37.3	69.9	<0.1	0.2	0.2	4.4	620,000
Trichloroethylene									0.2									0.2		99.8	99.8		1,300
Xylenes (individual or mixed isomers)	56.9	<0.1	<0.1	0.8	0.2	1.0	3.2	<0.1	4.9			23.2	2.4			0.4	7.1	41.2	<0.1			0.7	22,000
Zinc and compounds			<0.1	<0.1	0.1	0.1					<0.1	0.2		94.6			5.0	99.8	<0.1				680

Table E6 ***Percentage contribution by source to the total emission of NPI substances in the Riverland airshed***

RIVERLAND AIRSHED	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)	
		OTHER MOBILE																					
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL: OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL: SUB-THRESHOLD	Reporting Facilities 1999-2000	**Total (kg/yr)** (2 sig. fig.)
Acetaldehyde	8.0	-	<0.1	6.6	3.0	9.6											82.3	82.3					44,000
Acetone	10.0	-					5.8						0.5				83.7	90.0					31,000
Acrylic acid		-							100.0									100.0					0.000047
Ammonia (total)	100.0	-																					6,000
Antimony & compounds		-	0.1			0.1								92.2			7.6	99.8	<0.1		<0.1		12
Arsenic & compounds		-	<0.1			<0.1					<0.1			95.3			4.4	99.7	0.3		0.3		14
Benzene	39.8	-	<0.1	13.4	6.1	19.6	<0.1		<0.1		<0.1	11.2				1.7	26.9	39.9	<0.1		<0.1	0.7	41,000
Beryllium & compounds		-									<0.1						77.3	77.3	22.7		22.7		0.011
Biphenyl (1,1′-biphenyl)		-						100.0										100.0					0.64
1,3-Butadiene (vinyl ethylene)	46.6	-	<0.1	20.4	9.3	29.7						8.8					14.9	23.7				<0.1	6600
Cadmium & compounds		-	<0.1			<0.1					<0.1			96.1			2.4	98.5	1.4		1.4		17
Carbon disulfide		-															100.0	100.0					0.0036
Carbon monoxide	55.8	-	<0.1	8.4	3.7	12.1					<0.1	5.0					26.7	31.7	0.3		0.3	<0.1	5,600,000
Chloroform (trichloromethane)		-							100.0									100.0					12
Chromium (III) compounds		-	<0.1	5.4	2.2	7.7					28.4	51.8						80.2	12.1		12.1		1.6
Chromium (VI) compounds		-	<0.1	2.2	0.9	3.1					11.3	20.9					47.1	79.2	5.1		5.1	12.5	1.7
Cobalt & compounds		-	<0.1	0.1	<0.1	0.2					2.3	1.2		96.2			0.1	99.8	<0.1		<0.1		100
Copper & compounds		-	<0.1	<0.1	<0.1	0.1					<0.1	0.9		98.8				99.7	0.1		0.1		140
Cumene (1-methylethylbenzene)		-						70.4								28.6		99.0				1.0	220
Cyanide (inorganic) compounds		-															100.0	100.0					0.070
Cyclohexane	4.6	-					93.4	<0.1			<0.1	1.1	0.2			0.3		95.1	0.2		0.2	0.2	13,000
1,2-Dibromoethane		-																				100.0	0.10
1,2-Dichloroethane		-							100.0									100.0					0.055
Dichloromethane		-					62.6		37.4								<0.1	100.0					1,200
Ethanol		-					100.0											100.0					350
2-Ethoxyethanol acetate		-					100.0											100.0					750
Ethyl acetate		-											100.0					100.0					160
Ethylbenzene	66.6	-	<0.1	13.2	5.7	18.9		0.2	0.3			13.2	0.3			0.5	<0.1	14.4	<0.1		<0.1	0.1	8,400

Table E6 (cont)   Percentage contribution by source to the total emission of NPI substances in the Riverland airshed

RIVERLAND AIRSHED	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)	
		OTHER MOBILE																					
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL: OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL: SUB-THRESHOLD	Reporting Facilities 1999-2000	Total (kg/yr) (2 sig. fig.)
Ethylene glycol (1,2-ethanediol)		-					27.2		72.8									100.0					1,500
Ethylene oxide		-							100.0									100.0					180
Di-(2-Ethylhexyl) phthalate (DEHP)		-															100.0	100.0					0.0020
Fluoride compounds		-							3.8								94.7	98.5	1.5		1.5		4.4
Formaldehyde (methyl aldehyde)	20.6	-	<0.1	7.6	3.5	11.1			<0.1		<0.1	1.4					66.8	68.3	<0.1		<0.1		57,000
n-Hexane	31.7	-	<0.1	5.2	2.4	7.6	51.5	<0.1	4.4		<0.1	1.3				0.5	<0.1	57.7	1.7		1.7	1.4	23,000
Hydrochloric acid		-							3.3									3.3	96.7		96.7		0.64
Hydrogen sulfide	100.0	-																					37
Lead & compounds	48.9	-	<0.1	2.9	<0.1	2.9					<0.1	1.0		47.0		<0.1	0.2	48.2	<0.1		<0.1		1,700
Manganese & compounds		-	<0.1	<0.1	<0.1	<0.1					<0.1	0.2		99.4			0.4	100.0	<0.1		<0.1		690
Mercury & compounds		-	<0.1			<0.1					<0.1			99.5			<0.1	99.6	0.4		0.4		14
Methanol		-					20.9		79.1									100.0					11,000
Methyl ethyl ketone		-							40.3				7.4				52.3	100.0					1,500
Methyl isobutyl ketone		-					72.5		18.9				8.6					100.0					480
Nickel & compounds		-	<0.1	0.2	<0.1	0.3					1.0	2.0		95.5			0.2	98.7	1.0		1.0		61
Oxides of nitrogen	90.3	-	0.9	0.5	<0.1	1.4					0.6	0.2					3.0	3.8	3.9		3.9	0.5	640,000
Particulate matter < 10 µm	4.7	-	<0.1	<0.1	<0.1	0.1					<0.1	0.6		50.9			43.1	94.6	0.5		0.5	<0.1	320,000
Phenol		-															100.0	100.0					0.00045
Polycyclic aromatic hydrocarbons	12.2	-	<0.1	5.7	2.5	8.3		0.2			<0.1	4.6					74.7	79.6	<0.1		<0.1	<0.1	5,200
Selenium & compounds		-	<0.1			<0.1					25.0			67.3			7.4	99.7	0.2		0.2		2.6
Styrene (ethenylbenzene)	51.5	-		8.9	3.9	12.8		<0.1				5.2				<0.1	30.4	35.7					1,600
Sulfur dioxide	38.8	-	0.5	1.5	0.4	2.4					<0.1	0.5					7.9	8.4	1.9		1.9	48.4	45,000
Tetrachloroethylene		-							10.8	89.2							<0.1	100.0					3,100
Toluene (methylbenzene)	42.9	-	<0.1	17.8	8.2	26.0	3.1	<0.1	5.3		<0.1	8.1	6.2			0.6	7.5	30.8	<0.1		<0.1	0.3	96,000
Total volatile organic compounds	27.8	-	<0.1	9.6	4.2	13.8	4.8	0.3	8.9	0.2	<0.1	5.6	1.0		1.1	2.8	32.1	56.7	<0.1	0.1	0.2	1.5	1,500,000
Trichloroethylene		-							0.3									0.3		99.7	99.7		2,100
Xylenes (individual or mixed isomers)	62.1	-	<0.1	9.0	4.2	13.2	2.6	0.1	4.2			9.7	1.9			0.4	5.7	24.6	<0.1		<0.1	0.1	58,000
Zinc and compounds		-	<0.1	<0.1	<0.1	<0.1					<0.1	0.1		91.3			7.8	99.3	0.7		0.7		880

Table E7 ***Percentage contribution by source to the total emission of NPI substances in the South East airshed***

SOUTH EAST AIRSHED	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)	
		OTHER MOBILE																					
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL: OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL: SUB-THRESHOLD	Reporting Facilities 1999-2000	**Total (kg/yr)** (2 sig. fig.)
Acetaldehyde	11.4	<0.1		0.6	<0.1	0.6											87.9	87.9					60,000
Acetone	12.8	<0.1					5.5						0.4				81.2	87.1					48,000
Acrylic acid									100.0									100.0					0.000068
Ammonia (total)	100.0																						12,000
Antimony & compounds					<0.1									94.1			5.8	99.9	<0.1				22
Arsenic & compounds		25.1			<0.1	25.1					<0.1			26.9			1.0	27.8	3.2		3.2	43.9	93
Benzene	55.6	<0.1		1.2	0.1	1.3	0.1		<0.1		<0.1	12.1				1.8	28.5	42.5	<0.1			0.5	56,000
Beryllium & compounds					2.3	2.3					0.2						6.7	6.9	90.8		90.8		0.19
Biphenyl (1,1′-biphenyl)								100.0										100.0					1.2
1,3-Butadiene (vinyl ethylene)	69.6	0.3		1.9	0.2	2.4						10.2					17.8	28.0					8,400
Cadmium & compounds		4.1			<0.1	4.1					0.1			58.4			1.1	59.6	30.8		30.8	5.5	54
Carbon disulfide																	100.0	100.0					0.0054
Carbon monoxide	48.5	0.5		0.5	<0.1	0.9					<0.1	3.3					17.5	20.8	9.6		9.6	20.0	13,000,000
Chloroform (trichloromethane)									100.0									100.0					17
Chromium (III) compounds		46.2		<0.1	<0.1	46.2					2.1	3.4						5.5	39.5		39.5	8.8	35
Chromium (VI) compounds		82.0		<0.1	<0.1	82.0					0.4	0.6					1.4	2.4	7.1		7.1	8.5	86
Cobalt & compounds				<0.1	<0.1						1.7	0.9		95.7			0.1	98.4	0.6		0.6	1.0	200
Copper & compounds				<0.1	<0.1						<0.1	0.6		91.5				92.1	4.4		4.4	3.4	290
Cumene (1-methylethylbenzene)								76.1								23.5		99.7				0.3	380
Cyanide (inorganic) compounds																	100.0	100.0					0.10
Cyclohexane	5.7						85.9	<0.1			<0.1	1.1	0.2			0.3		87.5	6.7		6.7	0.1	20,000
1,2-Dichloroethane									100.0									100.0					0.080
Dichloromethane							61.3		38.6								<0.1	100.0					1,600
Ethanol							100.0											100.0					500
2-Ethoxyethanol acetate							100.0											100.0					1,100
Ethyl acetate													100.0					100.0					240
Ethylbenzene	84.9	<0.1		1.0	0.1	1.1		0.2	0.3			12.8	0.3			0.5	<0.1	13.9	<0.1			0.1	13,000
Ethylene glycol (1,2-ethanediol)							26.9		73.1									100.0					2,200

Table E7 (cont) Percentage contribution by source to the total emission of NPI substances in the South East airshed

SOUTH AIRSHED	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)	
		OTHER MOBILE																					
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL: OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL: SUB-THRESHOLD	Reporting Facilities 1999-2000	Total (kg/yr) (2 sig. fig.)
Ethylene oxide									100.0									100.0					260
Di-(2-Ethylhexyl) phthalate (DEHP)																	100.0	100.0					0.0030
Fluoride compounds									0.3								6.8	7.0	0.2		0.2	92.8	92
Formaldehyde (methyl aldehyde)	27.4	0.2		0.6	<0.1	0.8			<0.1		<0.1	1.4					68.8	70.2	1.4		1.4		83,000
n-Hexane	23.0			0.2	<0.1	0.2	27.9	<0.1	2.5		0.2	0.7				0.3	<0.1	31.5	44.7		44.7	0.5	60,000
Hydrochloric acid									2.2									2.2	97.8		97.8		1.4
Hydrogen sulfide	100.0																						70
Lead & compounds	49.0	0.7		0.1	<0.1	0.9					<0.1	0.8		47.7		<0.1	0.1	48.6	0.2		0.2	1.3	3,200
Manganese & compounds				<0.1	<0.1						<0.1	0.1		99.1			0.3	99.6	0.4		0.4		1,300
Mercury & compounds					<0.1						<0.1			85.5			<0.1	85.5	12.5		12.5	1.9	31
Methanol							2.4		9.1									11.5				88.5	130,000
Methyl ethyl ketone									39.0				7.2				53.8	100.0					2,200
Methyl isobutyl ketone							72.5		18.8				8.7					100.0					690
Nickel & compounds		1.5		<0.1	<0.1	1.5					0.7	1.2		73.8			0.1	75.8	21.3		21.3	1.3	150
Nickel carbonyl																						100.0	2.0
Nickel subsulfide																						100.0	4.2
Oxides of nitrogen	33.5	<0.1		<0.1	<0.1						0.4	<0.1					1.0	1.4	51.8		51.8	13.2	2,900,000
Particulate matter < 10 µm	2.5	0.4		<0.1	<0.1	0.4					<0.1	0.3		27.9			18.8	46.9	10.0		10.0	40.1	1,100,000
Phenol		100.0				100.0											<0.1						2.9
Polychlorinated dioxins and furans																						100.0	0.0018
Polycyclic aromatic hydrocarbons	12.3	0.1		0.4	<0.1	0.5		0.2			<0.1	3.6					58.4	62.2	0.1		0.1	24.8	10,000
Selenium & compounds					<0.1						19.7			67.3			5.6	92.6	7.4		7.4		4.8
Styrene (ethenylbenzene)	64.8	0.2		0.7	<0.1	0.9		<0.1				4.9				<0.1	29.3	34.2					2400
Sulfur dioxide	12.3	<0.1		<0.1	<0.1						<0.1	0.1					2.1	2.2	1.3		1.3	84.1	260,000
Tetrachloroethylene									25.9	74.1							<0.1	100.0					1,900
Toluene (methylbenzene)	63.2	<0.1		1.6	0.2	1.8	3.5	<0.1	6.0		<0.1	8.9	6.9			0.7	8.9	34.7	<0.1			0.2	120,000
Total volatile organic compounds	36.5	<0.1		0.8	<0.1	0.8	4.8	0.3	9.3	<0.1	<0.1	5.6	1.0		0.9	2.8	32.2	56.9	3.8	0.1	4.0	1.6	2,100,000
Trichloroethylene									0.3									0.3		99.7	99.7		2,800
Xylenes (individual or mixed isomers)	75.9	<0.1		0.7	<0.1	0.7	2.4	0.1	3.9			9.3	1.8			0.4	5.4	23.3	<0.1			0.1	90,000
Zinc and compounds				<0.1	<0.1						0.1	<0.1		74.0			4.9	78.9	21.0		21.0		2,100

Table E8 ***Percentage contribution by source to the total emission of NPI substances in the Spencer Gulf airshed***

SPENCER GULF AIRSHED	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)	
		OTHER MOBILE																					
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL: OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL: SUB-THRESHOLD	Reporting Facilities 1999-2000	Total (kg/yr) (2 sig. fig.)
Acetaldehyde	4.1	0.3	0.4	1.0	2.1	3.8											92.1	92.1					86,000
Acetone	4.7	0.2				0.2	6.0						0.4				88.6	95.0					65,000
Acrylic acid									100.0									100.0					0.000099
Ammonia (total)	100.0																						6,000
Antimony & compounds			5.0		7.0	12.0								75.1			12.7	87.8	0.1		0.1		16
Arsenic & compounds		2.7	<0.1		0.2	2.9					<0.1			0.8			<0.1	0.8	<0.1			96.2	1,700
Benzene	16.6	0.1	0.2	1.8	3.2	5.3	<0.1		<0.1		<0.1	20.1				1.5	26.5	48.1	<0.1			29.9	90,000
Beryllium & compounds					99.0	99.0					<0.1						0.8	0.8	0.2		0.2		2.3
Biphenyl (1,1′-biphenyl)								100.0										100.0					0.68
1,3-Butadiene (vinyl ethylene)	32.4	1.2	1.8	4.6	9.5	17.2						26.3					24.1	50.4				0.0	9,000
Cadmium & compounds		3.4	0.3		0.6	4.3					<0.1			13.5			0.7	14.2	0.3		0.3	81.2	130
Carbon disulfide																	100.0	100.0					0.0080
Carbon monoxide	2.7	0.1	<0.1	0.1	0.3	0.5					<0.1	0.8					3.1	3.9	<0.1			92.8	110,000,000
Chloroform (trichloromethane)									100.0									100.0					25
Chromium (III) compounds		84.4	<0.1	<0.1	2.1	86.5					2.8	9.7						12.5	0.9		0.9		38
Chromium (VI) compounds		67.1	<0.1	<0.1	0.1	67.2					0.2	0.7					0.8	1.7	<0.1			31.0	210
Cobalt & compounds			<0.1	<0.1	1.3	1.3					3.2	3.3		66.2			0.2	72.9	<0.1			25.7	160
Copper & compounds			0.1	<0.1	1.6	1.7					0.1	3.4		94.6				98.1	0.2		0.2		150
Cumene (1-methylethylbenzene)								54.7								44.2		98.9				1.1	290
Cyanide (inorganic) compounds																	100.0	100.0					0.15
Cyclohexane	2.1				<0.1		94.9	<0.1			<0.1	2.2	0.2			0.3		97.6	0.1		0.1	0.1	26,000
1,2-Dibromoethane																						100.0	0.10
1,2-Dichloroethane									100.0									100.0					0.12
Dichloromethane							62.2		37.8								<0.1	100.0					2,400
Ethanol							100.0											100.0					720
2-Ethoxyethanol acetate							100.0											100.0					1,500
Ethyl acetate													100.0					100.0					350
Ethylbenzene	49.4	<0.1	<0.1	3.1	5.0	8.1		0.1	0.5			40.5	0.4			0.8	<0.1	42.3	<0.1			0.1	11,000

Table E8 (cont) Percentage contribution by source to the total emission of NPI substances in the Spencer Gulf airshed

SPENCER GULF AIRSHED	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)	
		OTHER MOBILE																					
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL: OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL: SUB-THRESHOLD	Reporting Facilities 1999-2000	**Total (kg/yr)** (2 sig. fig.)
Ethylene glycol (1,2-ethanediol)							27.2		72.8									100.0					3,200
Ethylene oxide									100.0									100.0					380
Di-(2-Ethylhexyl) phthalate (DEHP)																	100.0	100.0					0.0045
Fluoride compounds									<0.1								<0.1		<0.1			100.0	58,000
Formaldehyde (methyl aldehyde)	10.8	0.9	0.9	1.3	3.2	6.2			<0.1		<0.1	3.0					79.9	82.9	<0.1				106,000
n-Hexane	18.7		0.4	1.0	2.2	3.6	66.8	<0.1	5.9		0.3	1.9				0.6	<0.1	75.4	1.8		1.8	0.6	37,000
Hydrochloric acid									2.8									2.8	97.2		97.2		1.6
Hydrogen sulfide	100.0																						40
Lead & compounds	2.7	0.2	<0.1	<0.1	<0.1	0.2					<0.1	0.2		2.9		<0.1	<0.1	3.1	<0.1			94.0	30,000
Manganese & compounds			<0.1	<0.1	<0.1						<0.1	0.7		98.4			0.8	99.9	<0.1				730
Mercury & compounds			0.5		0.3	0.8					<0.1			49.1			<0.1	49.1	0.3		0.3	49.7	30
Methanol							20.7		79.3									100.0					23,000
Methyl ethyl ketone									40.1				7.4				52.5	100.0					3,200
Methyl isobutyl ketone							72.2		19.1				8.7					100.0					1,000
Nickel & compounds		1.9	<0.1	<0.1	68.2	70.1					0.7	2.2		26.4			0.1	29.4	0.5		0.5		230
Oxides of nitrogen	3.1	<0.1	1.2	<0.1	1.6	2.8					<0.1	<0.1					0.2	0.2	0.2		0.2	93.6	20,000,000
Particulate matter < 10 µm	0.3	0.2	0.1	<0.1	0.8	1.1					<0.1	0.2		3.8			7.0	11.0	<0.1			87.5	4,600,000
Phenol		100.0				100.0											<0.1						15
Polycyclic aromatic hydrocarbons	4.6	0.5	0.6	0.7	1.1	2.9		<0.1			<0.1	7.6					65.6	73.2	<0.1			19.2	13,000
Selenium & compounds			0.5		27.5	28.0					28.0			35.8			8.1	71.8	0.2		0.2		5.1
Styrene (ethenylbenzene)	32.9	1.0		1.8	2.9	5.8		<0.1				14.4				0.1	46.7	61.3					2,400
Sulfur dioxide	<0.1	<0.1	<0.1	<0.1	0.4	0.4					<0.1	<0.1					<0.1		<0.1			99.5	61,000,000
Tetrachloroethylene									24.4	75.6							<0.1	100.0					2,900
Toluene (methylbenzene)	28.7	<0.1	0.1	3.9	6.4	10.4	4.5	<0.1	8.0		<0.1	23.3	8.7			0.9	11.6	57.0	<0.1			3.9	140,000
Total volatile organic compounds	15.9	0.3	0.4	1.7	3.3	5.7	6.0	0.2	11.4	<0.1	<0.1	13.8	1.3		0.6	3.5	40.7	77.5	<0.1	0.1	0.1	0.6	2,500,000
Trichloroethylene									0.4									0.4		99.6	99.6		3,200
Xylenes (individual or mixed isomers)	41.7	<0.1	<0.1	2.0	3.3	5.3	3.8	<0.1	6.2			27.8	2.9			0.6	8.7	50.0	<0.1			2.9	80,000
Zinc and compounds			0.2	<0.1	0.4	0.6					0.3	0.5		82.9			14.6	98.4	1.0		1.0		1,000

Section 1: Introduction

This report provides an overview of the aggregated air emissions estimated within the Adelaide and regional South Australian airsheds. Emissions from each source are listed in Table 2 of the National Pollutant Inventory (NPI)—National Environment Protection Measure (NEPM). Table 2 NPI substances include 90 substances that are common products of combustion, metals, and volatile organic compounds (VOC). Aggregate air emission sources include facilities that are not required to report, as well as anthropogenic sources such as domestic and commercial activities. These aggregate sources together contribute a significant proportion of the total pollution products emitted to the environment.

The 18 sources for which aggregate emissions have been investigated within the Adelaide and regional airsheds have been grouped into three sections as presented in Table 1.

Table 1 Classification of emission sources

Mobile sources	Aeroplanes Motor vehicles (including cars, trucks, buses and motorcycles) Railways Recreational boating Shipping and commercial boating
Area based sources	Architectural surface coatings Domestic commercial solvents Cutback bitumen Domestic gas fuel Dry cleaning Lawn mowing Motor vehicle refinishing Paved roads Printing and graphic arts Service stations Solid fuel burning
Sub-reporting threshold facilities	Fuel combustion Industrial solvent use

The South Australian Environment Protection Agency (SA EPA) was contracted to estimate emissions from these aggregate sources within the Adelaide airshed and five regional airsheds. The airsheds selected together represent over 79% and 85% of the South Australian population and industry respectively. They therefore capture most emissions and sources that have the potential to impact on both health and the environment.

1.1 Study areas — airsheds

The NPI airshed study presented in this report includes regions of metropolitan Adelaide together with the five major regional areas shown in Figure 1.

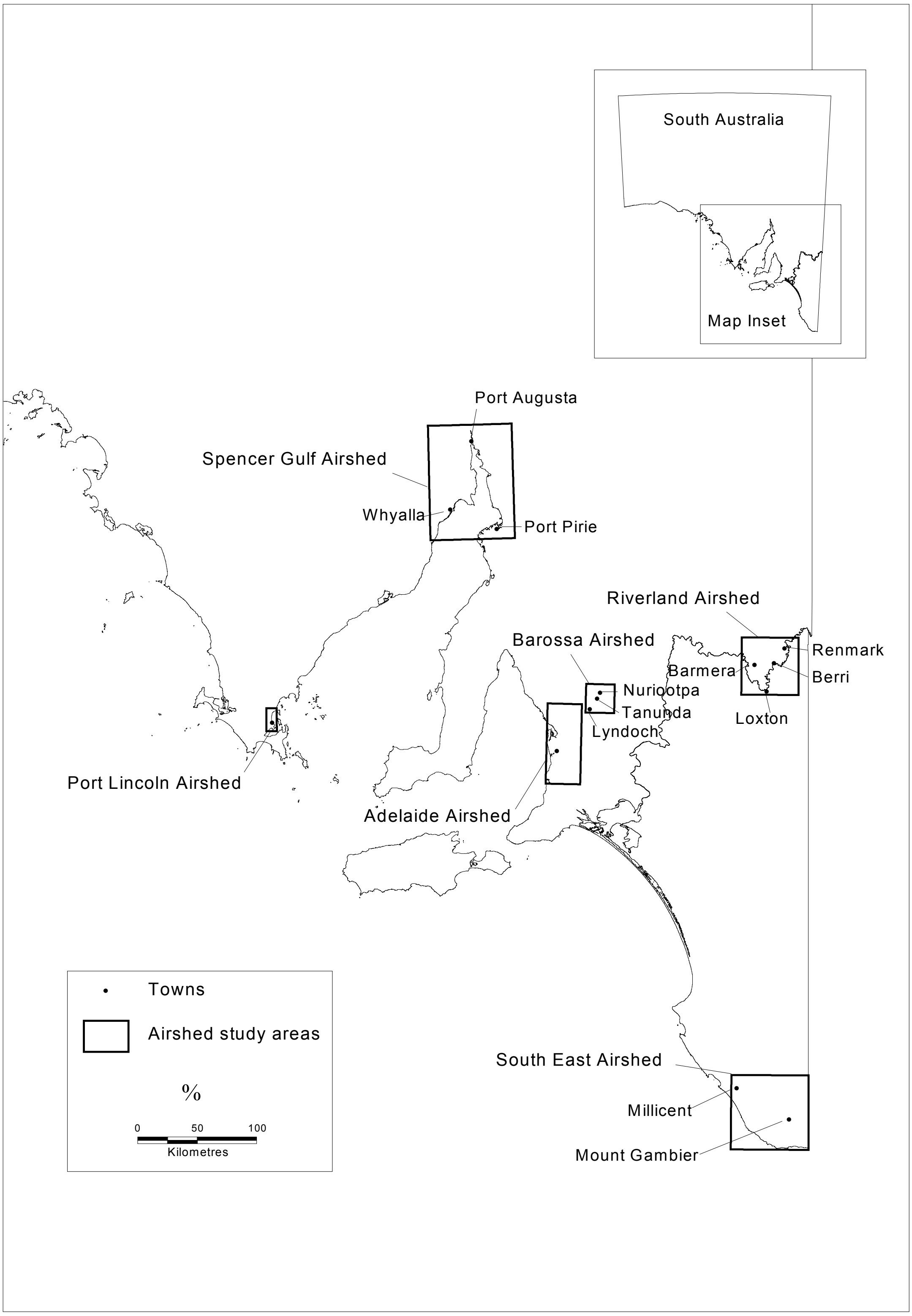


Figure 1 South Australian airsheds map

The five major regional airsheds—Barossa, Port Lincoln, Riverland, South East and the Spencer Gulf—represent the State's diverse land use and industrial activities. With the exception of Port Lincoln, each major regional airshed was sectioned into 5-km square grids to represent each area's varying population density as well as large areas of agricultural and natural vegetation. The Port Lincoln airshed was sectioned into 1-km square grids to represent the town's population and industrial activities.

Within four of the major regional airsheds, smaller airsheds were constructed to better represent the town's populations and industrial activities. These minor regional airsheds were proportioned into grids measuring 1 km square. A total of 11 minor regional airsheds were studied within the major regional airsheds of Barossa, Riverland, South East and Spencer Gulf.

In summary, airsheds presented in this report have been grouped for presentation purposes into six major airsheds and 11 minor airsheds. The minor regional airsheds are contained within an area defined by the major airshed as shown in Table 2.

Table 2 South Australian airshed populations and housing data

Major airshed	Minor airshed	Population	Households
Adelaide		1,041,882	436,214
Barossa		14,893	6,132
	Lyndoch	1,393	4,627
	Nuriootpa	11,080	578
Port Lincoln		12,333	5,338
Riverland		26,147	10,876
	Barmera	2,002	978
	Berri	4,299	1,888
	Loxton	4,407	1,846
	Renmark	6,465	2,713
South East		37,988	16,113
	Millicent	4,639	2,024
	Mount Gambier	23,656	9,792
Spencer Gulf		55,098	24,037
	Port Augusta	13,909	5,911
	Port Pirie	14,556	6,299
	Whyalla	23,313	9,980

1.1.1 Adelaide airshed

The Adelaide airshed, shown in Figure 2, consists of an area measuring 70 km north–south and 30 km east–west. The airshed represents a population of 1,041,882 people and over 76% of the State's industrial and commercial facilities. The airshed was disaggregated into 1 km square grids for greater spatial resolution of NPI emissions.

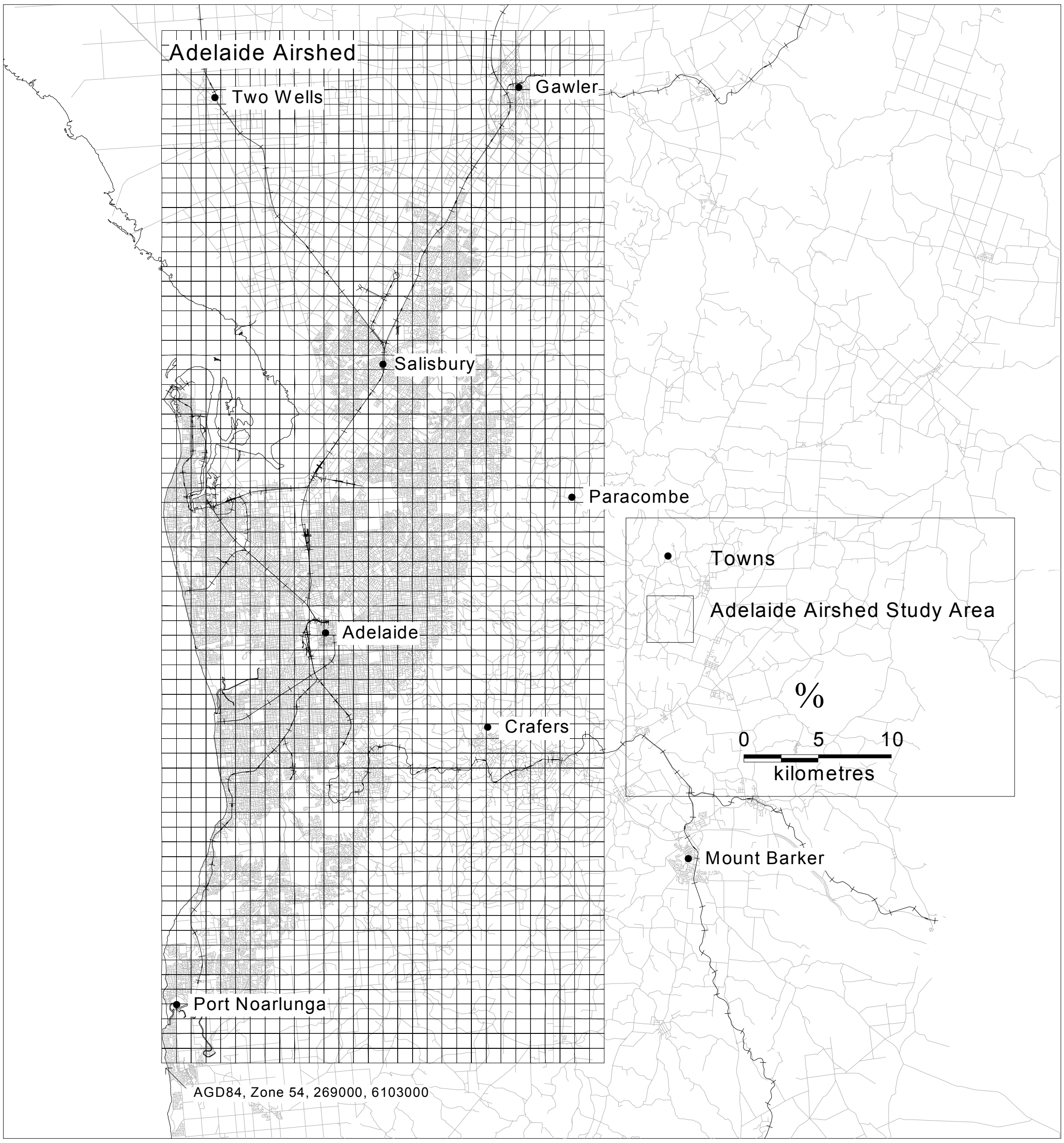


Figure 2 Adelaide airshed map

1.1.2 Barossa airshed

The Barossa airshed is a region of viticulture and tourism with a population of 14,893 people, according to 1996 census data. The airshed, shown in Figure 3, consists of an area that measures 25 km north–south and 25 km east–west, spatially disaggregated into 5 km square grid cells. The major townships of Angaston, Lyndoch, Nuriootpa and Tanunda represent 84% of the airshed's population. Two minor airsheds, Lyndoch and Nuriootpa, were therefore constructed to provide greater resolution of area-based emissions.

The Lyndoch airshed consists of an area 5 km north–south and 5 km east–west. The Nuriootpa airshed, the commercial centre for the Barossa Valley, includes Angaston and Tanunda, and represents an area 10 km north–south and 15 km east–west. Both minor airsheds are spatially disaggregated into 1 km square grid cells.

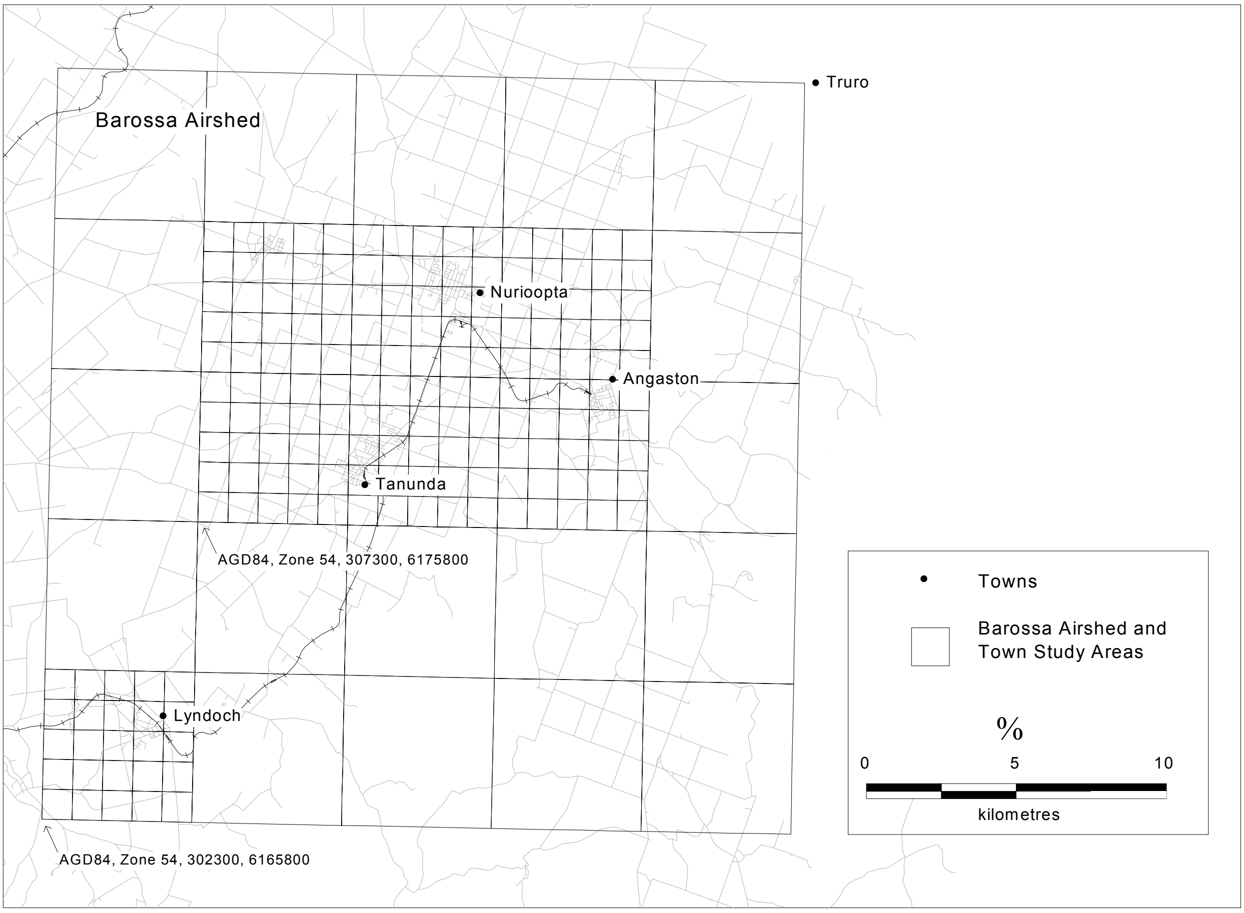


Figure 3 Barossa airshed map

1.1.3 Port Lincoln airshed

Port Lincoln is a coastal town renowned as Australia's largest commercial tuna fishing region. The airshed, shown in Figure 4, represents an area that is 20 km north–south and 9 km east–west with a population of 12,333 people, according to 1996 Census data. The airshed was spatially disaggregated into 1 km square grids for the allocation of NPI aggregated emissions.

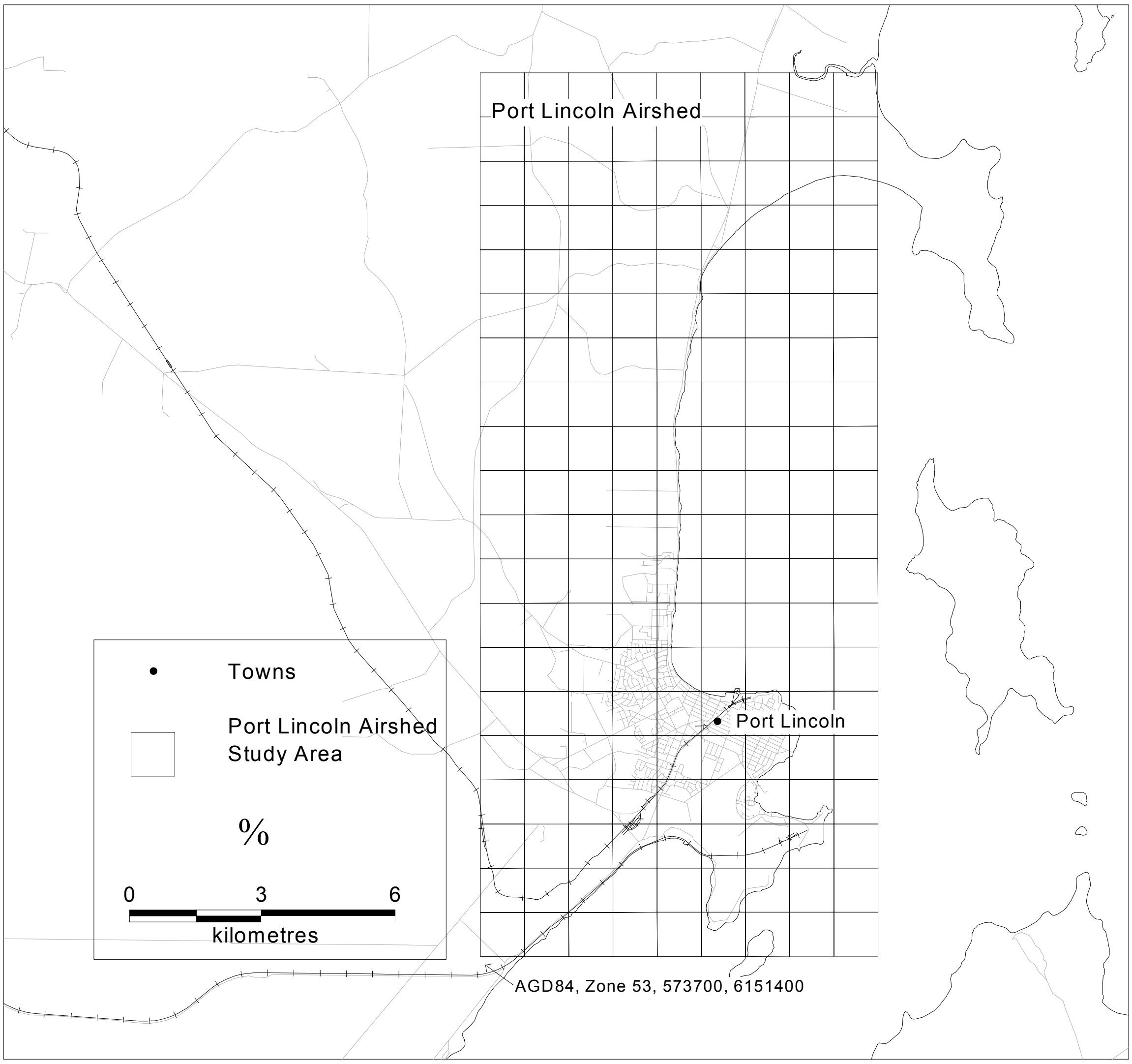


Figure 4 Port Lincoln airshed map

1.1.4 Riverland airshed

The Riverland airshed is an area scattered with small towns along the River Murray. Major agricultural activities in the region include viticulture and fruit growing. Water sports are common activities for locals and associated with seasonal tourism. The region has a population of 26,147 people according to 1996 census data. The Riverland airshed, shown in Figure 5, is defined as an area 50 km north–south and 50 km east–west, spatially disaggregated into 5 km square grid cells. The regions with highest population density relate to the various towns in this airshed. Smaller airsheds were therefore constructed around the various townships to provide greater resolution of population related emissions.

The minor airsheds of the Riverland—Barmera, Berri, Loxton and Renmark—are shown in Figure 5. Both Loxton and Renmark, the largest of the minor airsheds, cover an area 10 km north–south and 10 km east–west, spatially disaggregated into 1 km square grids. Berri is the next largest airshed with an area measuring 5 km north–south and 10 km east–west. Barmera airshed, which is not located on the River Murray but on the banks of Lake Bonney and fed by the River Murray through Chambers Creek, is the smallest airshed at 5 km north–south and 5 km east–west.

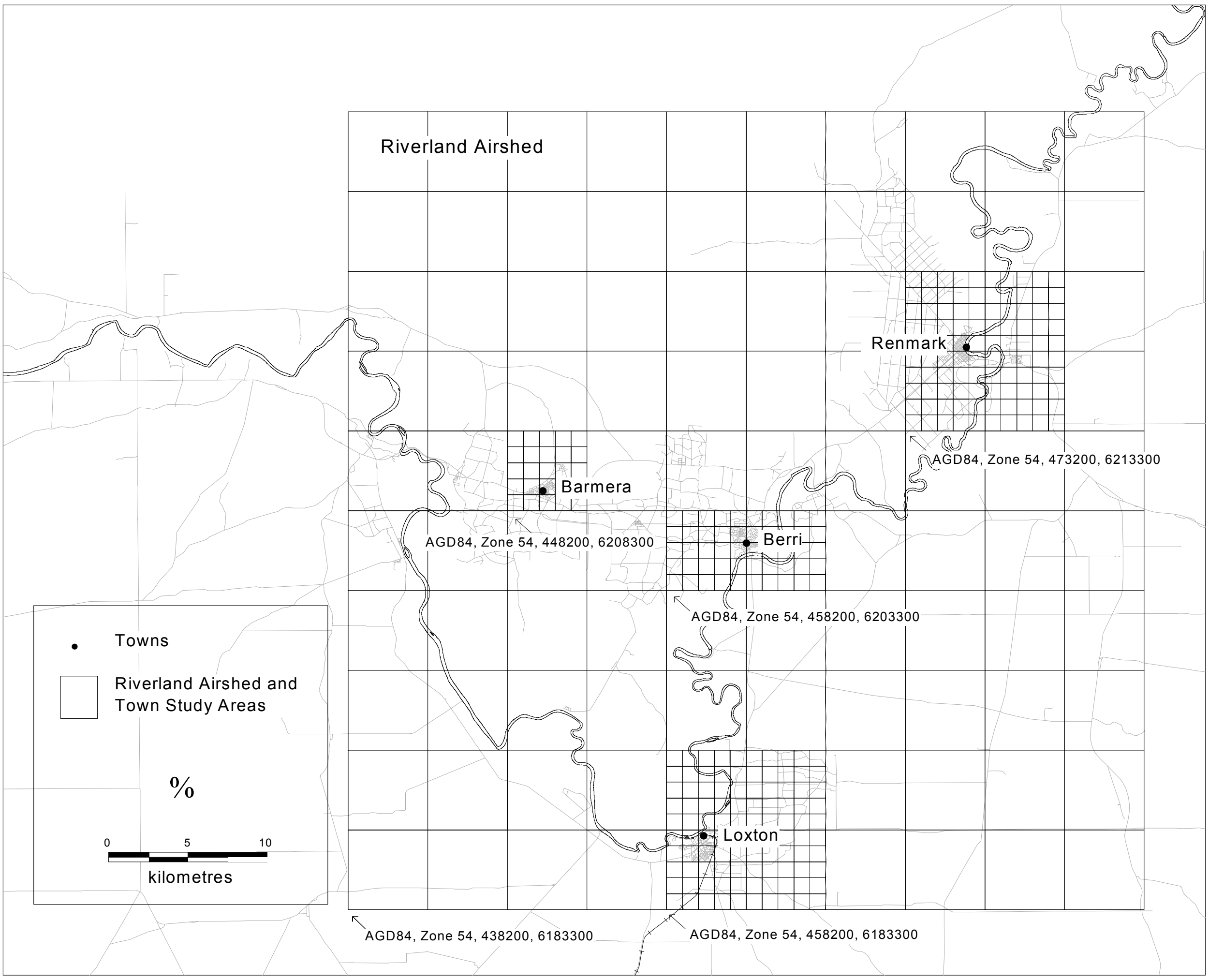


Figure 5 Riverland airshed map

1.1.5 South East airshed

The South East region of South Australia is considered climatically different to the rest of the State since it lies within a reliable rainfall zone. The South East airshed, shown in Figure 6, consists of an area 65 km north–south and 65 km east–west and includes two towns—Millicent and Mount Gambier—with a population of 37,988 people. The South East airshed was disaggregated into grids 5 km square in area.

The minor airsheds include Millicent, which lies inland and is an important commercial centre for the forestry industry, taking advantage of the favourable climate and rainfall of the district, and Mount Gambier, the commercial centre of the South East. Major industries in the Mount Gambier airshed include timber, dairy products—especially cheese—vegetables and wool. The Millicent airshed represents an area 5 km north–south and 10 km east–west, while Mount Gambier airshed covers an area 15 km north–south and 15 km east–west. Both minor airsheds were disaggregated into 1 km square grid cells.

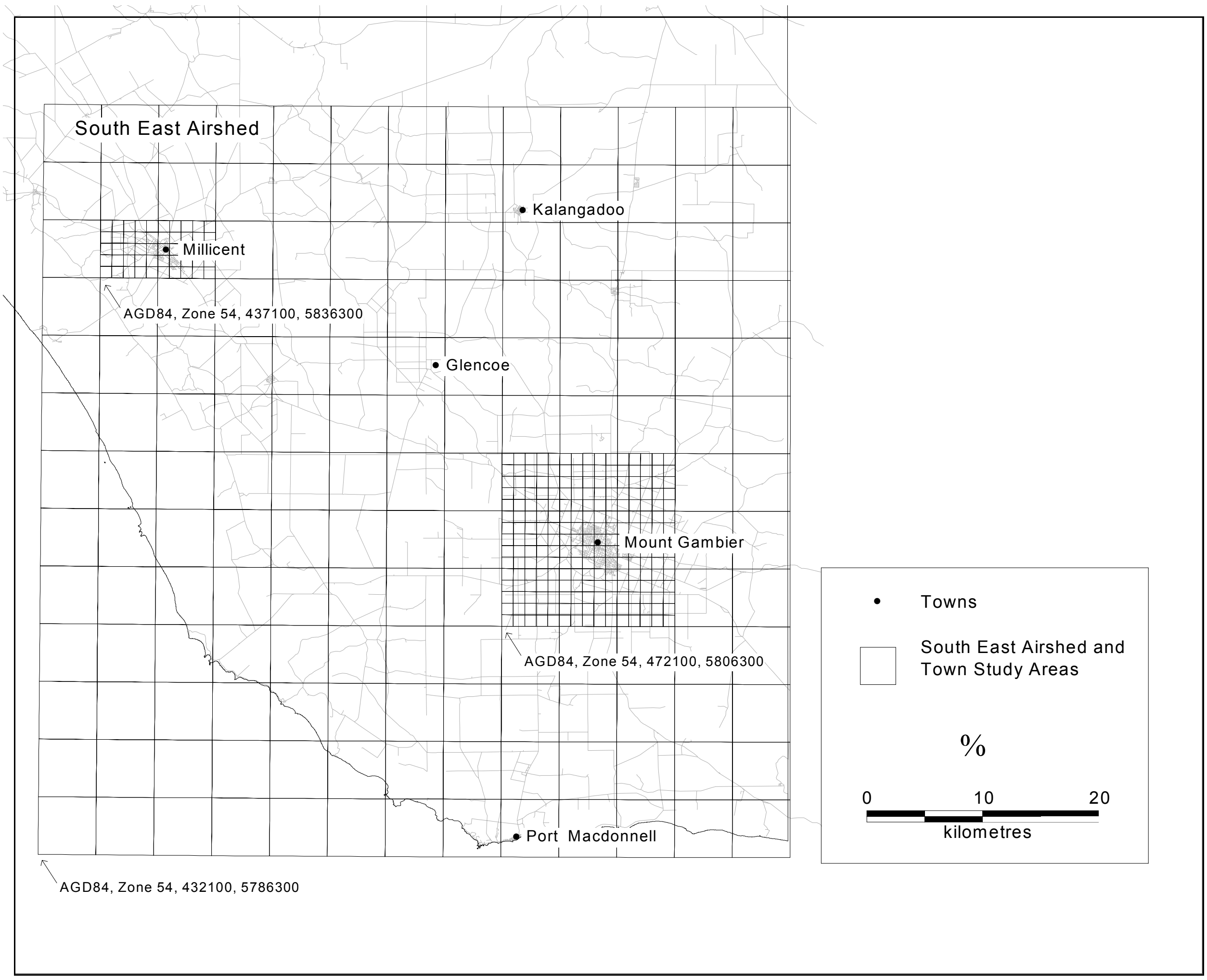


Figure 6 South East airshed map

1.1.6 Spencer Gulf airshed

The semi-arid Upper Spencer Gulf region depends largely on industrial activities ranging from electricity generation to steel works, but also includes some agricultural activities such as grazing and grain farming. The Spencer Gulf airshed, shown in Figure 7, represents the largest geographical region in this study, an area covering 105 km north–south and 75 km east–west. This airshed contains the highest population density after Adelaide with a total of 55,098 people. Three major towns—Port Augusta, Port Pirie and Whyalla—are within this airshed, which is spatially disaggregated into 5 km square grids.

The minor airsheds in the region include Port Augusta airshed, Port Pirie airshed and Whyalla airshed. Port Augusta is a thriving industrial city at the head of the Spencer Gulf. It covers an area 15 km north–south and 15 km east–west.

Port Pirie airshed on the east coast of Spencer Gulf is important for its port and metal smelting activities producing lead, zinc, copper, silver, gold and other metals. The Port Pirie airshed covers an area 15 km north–south and 15 km east–west.

Whyalla, on the western shores of the Spencer Gulf, is South Australia's second largest city and is important for its production of steel. An area 15 km north–south and 15 km east–west represents the Whyalla airshed, with a population of 23,313 people.

All minor airsheds in this region were disaggregated into 1 km square grids.

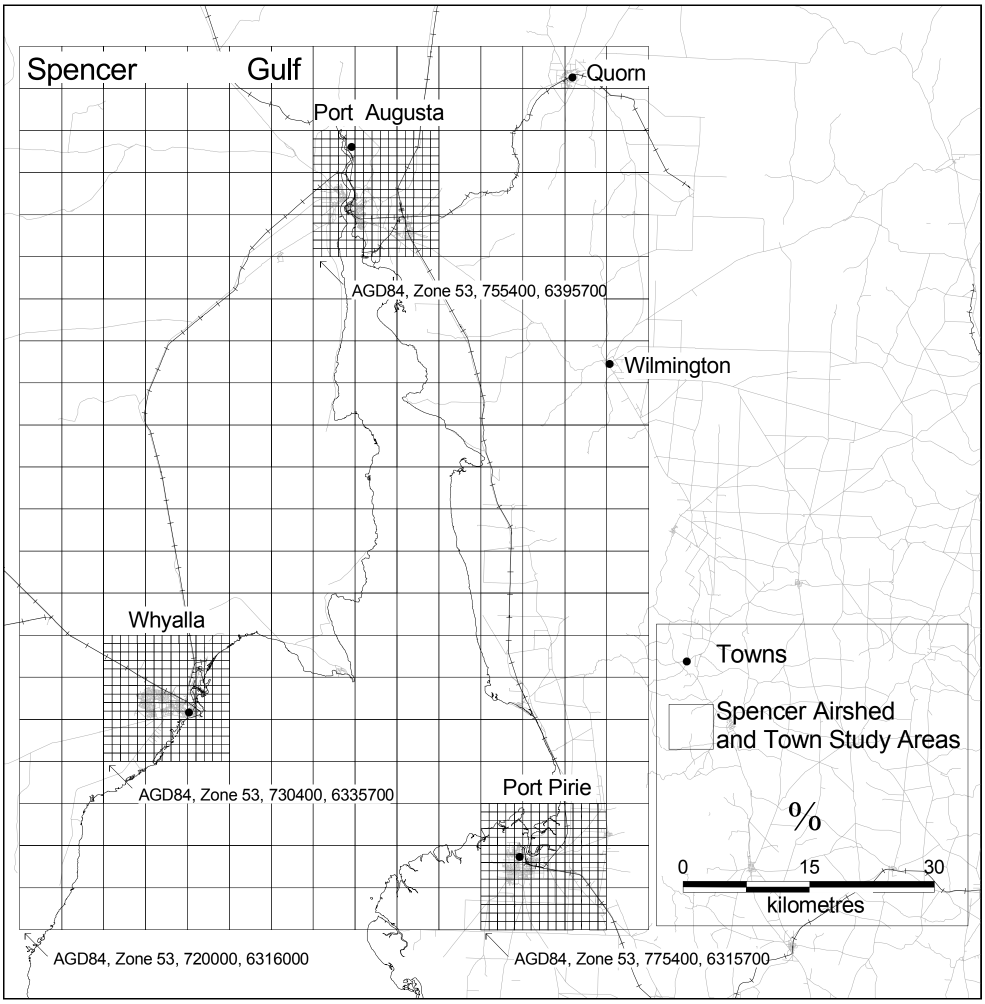


Figure 7 Spencer Gulf airshed map

1.2 Air emission sources

A range of domestic, industrial, commercial and recreational sources emitting pollutants to air was estimated in each of the airsheds. The complete list of aggregated sources studied per airshed is presented in Table 3. Some sources were not applicable to all airsheds and were therefore excluded from those airshed calculations.

The selection of aggregate sources to be estimated in the South Australian airsheds was based on the availability of emission estimation technique (EET) manuals. These aggregated EET manuals were developed by Environment Australia in consultation with a range of experts to provide standardised methodologies for generating the NPI Database.

Aggregated source emissions presented in this report have been grouped into three sections:

- *Mobile sources*: aeroplanes, motor vehicles (including cars, trucks, buses and motorcycles), railways, recreational boating and shipping and commercial boating
- *Area-based sources*: architectural surface coatings, cutback bitumen, domestic and commercial solvents, domestic gas fuel, dry cleaning, lawn mowing, motor vehicle refinishing, paved roads, printing and graphic arts, service stations and solid fuel burning
- *Sub-threshold sources*: sub-threshold fuel combustion and sub-threshold industrial solvents.

A detailed description of the sources and substances estimated are presented in the following sections. Estimations were made for the 90 substances listed in Table 2 of the NPI NEPM. However, estimates for substances in each source category could only be made where an emission factor was available. Therefore, between 56 and 59 substances out of the total list of 90 substances were estimated for the South Australian metropolitan and regional airsheds.

Table 3 Aggregated sources estimated within the Adelaide and regional airsheds

Source	Adelaide airshed	Barossa airshed	Port Lincoln airshed	Riverland airshed	Spencer Gulf airshed	South East airshed
Aeroplanes	✓		✓		✓	✓
Architectural surface coatings	✓	✓	✓	✓	✓	✓
Cutback bitumen	✓	✓	✓	✓	✓	✓
Domestic/commercial solvents/aerosols	✓	✓	✓	✓	✓	✓
Domestic gas fuel	✓	✓	✓	✓	✓	✓
Dry cleaning	✓	✓	✓	✓	✓	✓
Lawn mowing (domestic)	✓	✓	✓	✓	✓	✓
Motor vehicles	✓	✓	✓	✓	✓	✓
Motor vehicle refinishing	✓	✓	✓	✓	✓	✓
Paved roads	✓	✓	✓	✓	✓	✓
Print shops / graphic arts	✓	✓	✓	✓	✓	✓
Railways	✓	✓	✓	✓	✓	
Recreational boating	✓		✓	✓	✓	✓
Service stations	✓	✓	✓	✓	✓	✓
Shipping and commercial boating	✓		✓	✓	✓	✓
Solid fuel burning (domestic)	✓	✓	✓	✓	✓	✓
Sub-threshold fuel combustion	✓	✓	✓	✓	✓	✓
Sub-threshold solvents	✓	✓	✓	✓	✓	✓

(Shaded) Not applicable to airshed

1.3 Domestic survey

Household information relating to a range of activities was collected using a domestic survey. These activities included information on the use of solid fuel combustion heaters, lawn mowing practices and recreational boating activities.

The survey was distributed during 1999 to high school students in the Adelaide and regional areas of the State. Students were asked to take the questionnaires home and complete them with the assistance of a parent or guardian. An incentive was offered to the school with the highest number of returned survey forms, although some schools still chose not to participate.

The total responses to the survey from 1632 households comprised 1387 returned survey forms from the Adelaide metropolitan area, and only 211 forms returned from regional areas; 38 forms could not be included because they had invalid postcodes.

A large proportion of the regional responses came from the Port Lincoln area (48%); other responses ranged randomly from the upper Spencer Gulf to the Riverland areas. No responses were provided by schools within the South East area. All survey responses, both regional and metropolitan, were used to estimate domestic activity within the regional airsheds. Only metropolitan responses were used to estimate domestic activity estimates in the Adelaide airshed.

Section 2: Mobile sources

2.1 Aeroplanes

Emissions from aircraft operating within each of the airsheds result from the various modes of enging operation between ground level and 1000 metres above ground level, including approach, landing, taxiing, idling, take-off and climb-out. Evaporative emissions from aircraft were not included in these estimations since no emission factors for this process were available. Ground and maintenance operations at each airport were not included as these emissions are considered point sources to be included in industry estimates provided by the airport operators as described in the *Airports Industry Handbook*[5].

The emission estimates included in this report were calculated according to the *NPI Emission Estimation Technique Manual for Aggregated Emissions from Aircraft*[6]. The best practice technique was applied to all airports using detailed information provided by airport operators as to the number of aircraft operating, modes of operation per aircraft type, use of auxiliary power units and time spent in each operating mode.

2.1.1 Adelaide airshed—aeroplane emissions

Aeroplane emissions within the Adelaide airshed include aircraft activity at three airports, Adelaide, Parafield and Edinburgh, as shown in Figure 8. Adelaide is the airshed's main commuter airport, with domestic and international flights. Parafield is a busy light-aircraft aerodrome, with major activities including general aviation training. Activity data for Adelaide and Parafield airports was provided by Adelaide Airport Limited, which engaged the consultant Airport Technical Services to compile the activity information. Aircraft activity information was provided for the 1998–99 financial year in the form of reports and geographic information systems (GIS) data for flight arrivals and departures by aircraft type and flight track. This information was derived from local information as well as information collected by Air Services Australia for the Environment Branch Noise and Flight Path Systems 1998–99 quarterly reports.

Edinburgh airport is a military facility, which operates within a military airspace performing routine training flights. The airport generally operates three types of aircraft—PC3 Orion, PC9 and FA-18—and two types of helicopters, Black Hawk and Iroquois, used by the Air Force and Navy for training and transits.

General helicopter activities within the Adelaide airshed mainly include the search-and-rescue and media aircraft. These aircraft commonly operate at heights below 1000 metres and therefore within the area of interest.

The calculated emissions from all commercial and general aviation aircraft operating within the airspace of the Adelaide airshed were attributed to the grid squares that best represented annual flight patterns. Each flight route was estimated separately for different aircraft types in the categories: jet, turbo prop, piston and general aviation. These aircraft types have different climb rates for take-off, climb-out and approach. Flight paths were also found to vary depending on the aircraft type. The time and subsequent distance travelled in reaching heights of 200 metres and 1000 metres, the heights for take-off and climb-out respectively, by each aircraft type were calculated based on the climb rates provided by Airport Technical Services. Accordingly for each mode of operation, aircraft type and reported annual flight paths, the length of the flight path corresponding to a particular mode of operation was calculated for each grid square within the airshed. Emissions were then calculated by multiplying the total emissions for each mode of operation by the portion of the total length corresponding to that mode's flight path in each grid. Emissions from aircraft taxiing and idling were assigned to the grids corresponding to the airport's runway and tarmac. Total aeroplane emissions were calculated by summing individual emissions for each mode of operation in each grid square.

General helicopter flights do not have specific flight routes to follow, so total estimated emissions were attributed to all grids within the airshed. Military and general training aircraft emissions were assigned to grids representing the areas of the source emissions. These were allocated to grid squares representing areas of military airspace and training zones respectively.

The total emissions of each NPI substance from aircraft operating within the Adelaide airshed are presented in Table 4. These total emissions represent the total Adelaide airshed aircraft activity within the airspace up to 1000 metres above ground level.

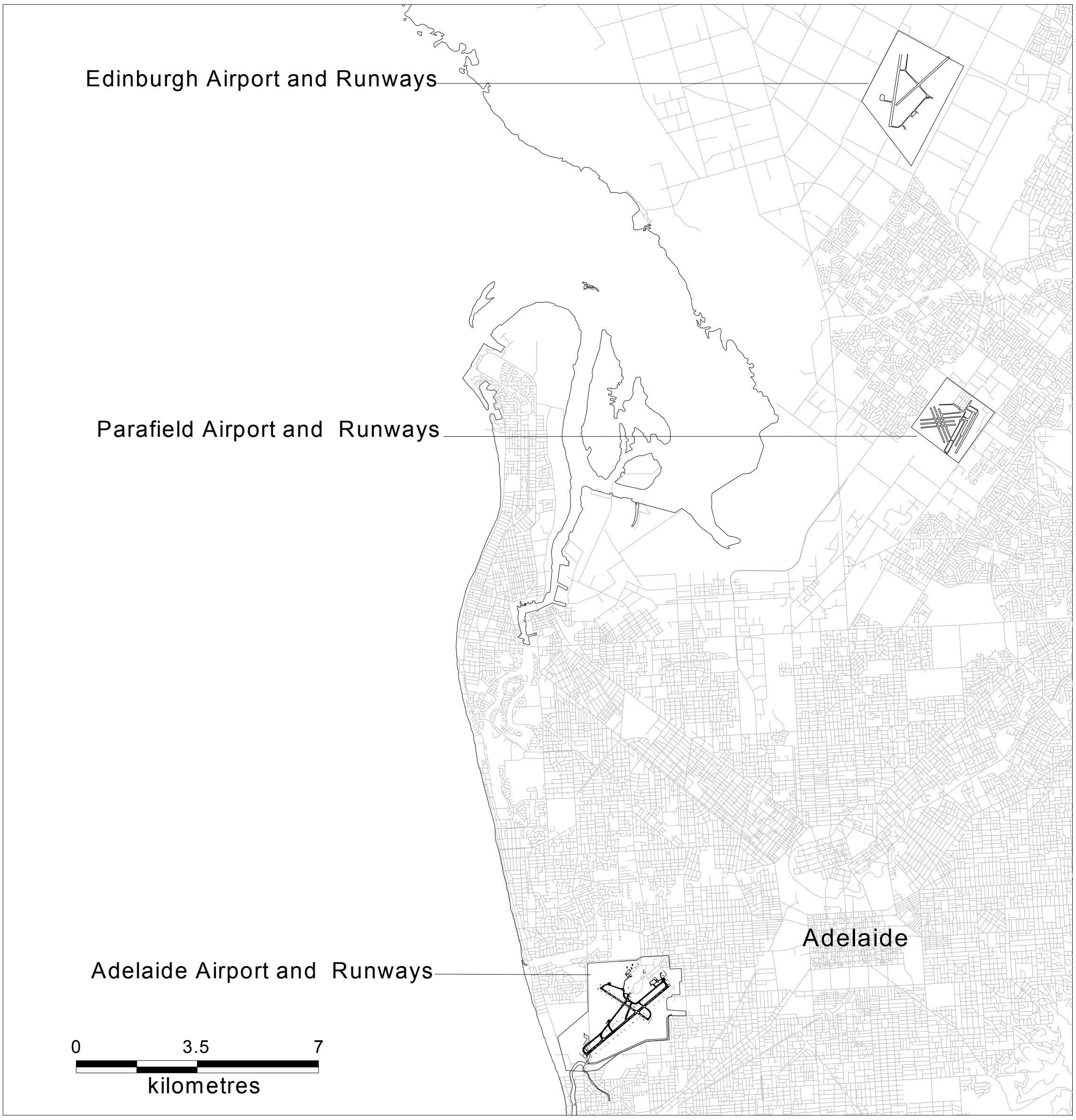


Figure 8 Airport locations within the Adelaide airshed

2.1.2 Port Lincoln airshed—aeroplane emissions

Aircraft emissions at Port Lincoln Airport were calculated using activity data provided by the airport operators for the 1999 calendar year. Data included monthly records of the number of different aircraft landings and take-offs; a total of 6069 aircraft were estimated to operate from the airport during an annual period. The location of the airport in the airshed, as shown in Figure 9, puts some arrival and departure flight paths outside of the airshed boundary. Aircraft calculated emissions represent activity relating to each mode of operation and portion of the flight path within the airshed. Total aircraft emissions for the Port Lincoln airshed are presented in Table 4. The portions of flights and flight routes within the grids of the airshed were used as spatial surrogates for the allocation of aircraft emissions to the airshed.

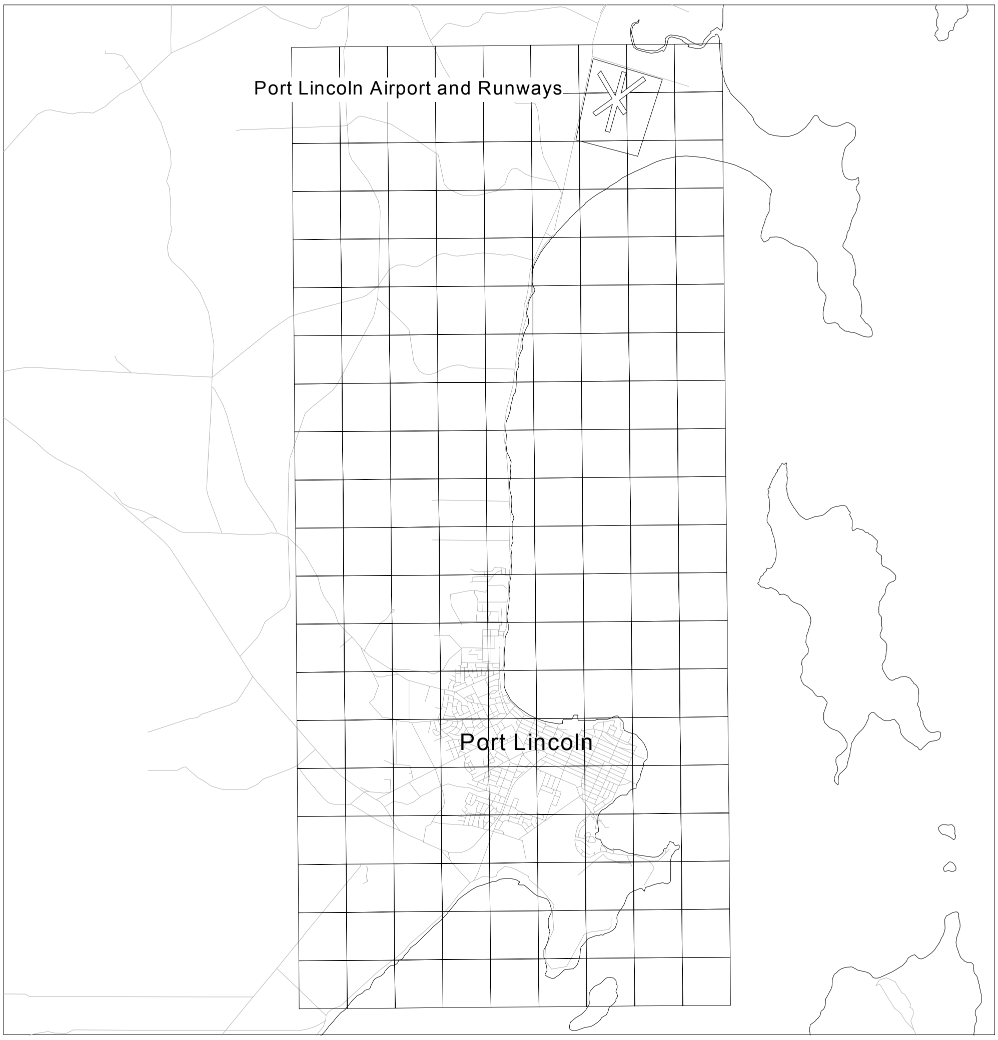


Figure 9 Airport location within the Port Lincoln airshed

2.1.3 South East airshed—aeroplane emissions

The South East airshed contains a regional commuter airport just north of Mount Gambier, as shown in Figure 10, which operates regular flights to Adelaide and Melbourne. Aircraft activity data provided by the operator for the month of July 2000 was taken as representative of the average monthly activity at the airport. According to the provided data, annual aircraft activity of 4786 movements was estimated within 1000 metres above the airshed for the 1998–99 calendar year. Due to the location of the airport and corresponding flight paths, aircraft emissions calculated in the Mount Gambier airshed (Table 6) represent only a small portion (17%) of the total South East airshed.

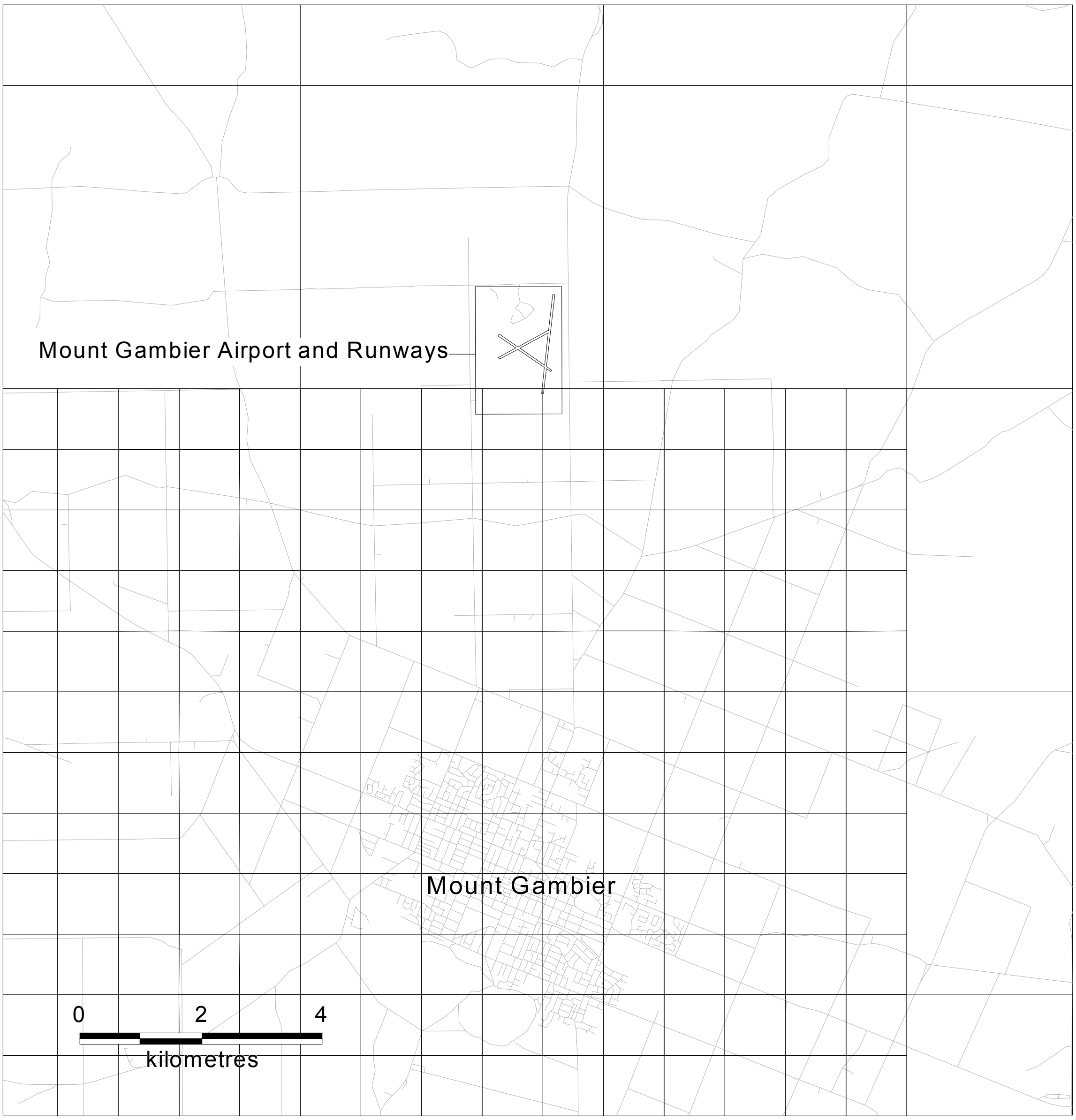


Figure 10 Airport location within the South East airshed

2.1.4 Spencer Gulf airshed—aeroplane emissions

Aeroplane emissions in the Spencer Gulf airshed are based on the aircraft activity at two domestic regional airports—Port Pirie and Whyalla—and one minor aerodrome specifically used by the Royal Flying Doctor Service in Port Augusta (Figure 11). Each airport operator provided aircraft descriptions and activity information. A total of 9248 movements, by varying aircraft, were used to estimate aeroplane emissions within these airsheds. Total aeroplane emissions for the major Spencer Gulf airshed are presented in Table 4, while emissions for each of the minor airsheds are presented in Table 5.

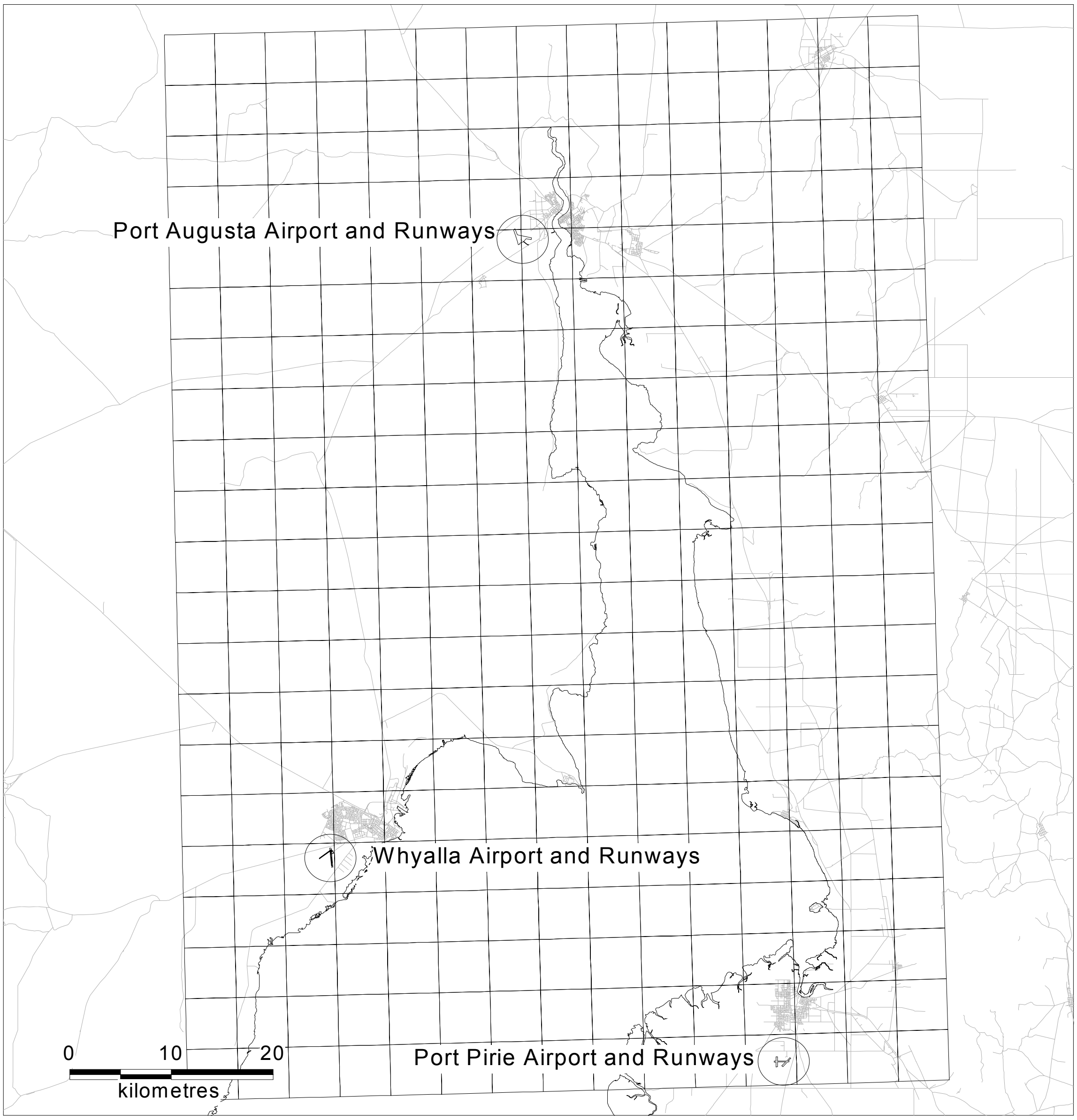


Figure 11 Airport locations within the Spencer Gulf airshed

Table 4 Aeroplane emissions in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†			
Substance	**Adelaide**	**Port Lincoln**	**South East**	**Spencer Gulf**
1,3-Butadiene (vinyl ethylene)	980	60	22	110
Acetaldehyde	2,500	160	57	290
Acetone	1,300	82	30	150
Arsenic & compounds	890	23	23	46
Benzene	1,100	65	24	120
Cadmium & compounds	84	2.2	2.2	4.4
Carbon monoxide	910,000	57,000	57,000	110,000
Chromium (III) compounds	620	16	16	32
Chromium (VI) compounds	270	70	70	140
Ethylbenzene	93	5.7	2.1	11
Formaldehyde (methyl aldehyde)	8,200	510	180	940
Lead & compounds	920	24	24	48
Nickel & compounds	84	2.2	2.2	4.4
Oxides of nitrogen	220,000	1,400	1,100	1,100
Particulate matter < 10 µm	160,000	4,200	4,300	8,500
Phenol	130	7.9	2.9	15
Polycyclic aromatic hydrocarbons	580	35	13	66
Styrene (ethenylbenzene)	210	13	4.8	24
Sulfur dioxide	42,000	97	82	130
Toluene (methylbenzene)	280	17	6.4	33
Total volatile organic compounds	53,000	3,300	1,200	6,300
Xylenes (individual or mixed isomers)	2,100	16	5.9	30

† Emissions to 2 significant figures

Table 5 Aeroplane emissions in the minor regional airsheds

	Emissions per airshed (kg/yr)†			
	SOUTH EAST	SPENCER GULF		
Substance	**Mount Gambier**	**Port Augusta**	**Port Pirie**	**Whyalla**
1,3-Butadiene (vinyl ethylene)	3.7	3.9	50	27
Acetaldehyde	9.6	10	130	69
Acetone	5.1	5.3	69	36
Arsenic & compounds	4.1	0.46	22	15
Benzene	4.0	4.2	54	29
Cadmium & compounds	0.39	0.043	2.1	1.4
Carbon monoxide	18,000	820	9,800	52,000
Chromium (III) compounds	2.9	0.32	15	10
Chromium (VI) compounds	12	1.4	66	44
Ethylbenzene	0.35	0.37	4.8	2.5
Formaldehyde (methyl aldehyde)	31	32	420	220
Lead & compounds	4.3	0.48	23	15
Nickel & compounds	0.39	0.043	2.1	1.4
Oxides of nitrogen	470	29	320	280
Particulate matter < 10 µm	760	84	4,000	2,700
Phenol	0.50	0.52	6.7	3.6
Polycyclic aromatic hydrocarbons	2.2	2.3	30	16
Styrene (ethenylbenzene)	0.81	0.84	11	5.8
Sulfur dioxide	15	2.5	30	62
Toluene (methylbenzene)	1.1	1.1	15	7.7
Total volatile organic compounds	210	220	2,800	1,500
Xylenes (individual or mixed isomers)	0.99	1.0	13	7.1

† Emissions to 2 significant figures

2.2 Motor vehicles

Aggregate emissions from motor vehicle use were estimated for all on-road vehicles. This category includes three age categories of passenger vehicles, four-wheel drives, light vehicles, rigid trucks, articulated trucks, buses, motor cycles and other vehicles.

Emissions from motor vehicles arise from two sources—the combustion products from the engine and the evaporation of fuel from tank and fuel lines. Emissions can vary depending on the fuel used, fuel delivery equipment, engine configuration, vehicle age, maintenance regime, engine size, engine load, emission control technology, driver behaviour, speed of acceleration and road grade. Many of these factors are difficult to quantify and correlate with emission factors. Therefore, vehicle emission rates are generally determined over a standardised drive cycle that attempts to represent typical driving conditions[7]. The emissions calculated in this study were based on local activity data and vehicle kilometres travelled (VKT), together with a range of corresponding emission factors. Emission factors represent the quantity of pollutant being released into the air per kilometre travelled. These factors have been derived from local and overseas engine testing facilities for each vehicle category.

2.2.1 Adelaide airshed—motor vehicle emissions

Total Adelaide airshed emissions (Table 6) were calculated using emission factors, vehicle fleet mix and speed correction data provided by McLennan Magasanik Associates consultants[7], together with local activity data according to the methodology outlined in the *NPI Emission Estimation Technique Manual for Aggregated Emissions from Motor Vehicles*[8] (Motor vehicles EET manual).

Activity data

Traffic count data, spatially distributed as VKT, was obtained from South Australia's road transport authority, Transport SA. Relative VKT by vehicle type, vehicle numbers and fuel consumption for vehicle–fuel type combinations were obtained from the consultant's report[7].

Road types

Road types were derived from the South Australian road network 'StreetWorks' provided by ERSIS Australia. A total of eight road types in this database were either ignored (e.g. pathways, lanes, malls and unsealed roads) or aggregated to approximate the three road types in each regional airshed.

The three road types considered in the estimation were:

- freeways (made up of only 'freeways'): major roads with average high speeds and low congestion
- arterial (made up of 'highways' and 'main roads'): major roads with moderate congestion
- residential (made up of 'sealed roads'): secondary roads with moderate average speeds.

Vehicle and fuel types

The vehicle and fuel types considered in the estimations were:

- passenger vehicles (pre-1976, 1976-1985, post 1985) — unleaded, leaded
- four-wheel drives — diesel, unleaded, leaded
- light commercial vehicles — unleaded, leaded
- rigid trucks — diesel
- articulated trucks — diesel
- buses — diesel
- motorcycles
- other trucks — diesel.

Derivation of gridded VKT data

VKT data for different road types (freeway, arterial and residential roads) was provided in a GIS format and was derived from traffic count data. Traffic counts did not cover every part of the road network. Estimates of traffic numbers were made in those parts of the network where data was not available by the following methods:

- Gridded VKT data for residential roads was derived using population data. In those cells where residential roads existed, the population of that cell was multiplied by the average daily VKT per capita (km/day), method based on EPAV 1996 and NPI aggregated emissions from Motor Vehicles, August 2000[8].
- For other road types, the grids of each airshed were overlaid by the road network and the length of road segment for each road type calculated. For roads with traffic count data, the VKTs were summed to give the known total VKT for each road type in each cell. A VKT for remaining roads without traffic count data was derived by multiplying their total length (km) by the average known VKT/km for each cell.

Emission factors

Emission factors for each substance from each vehicle and fuel type were derived from locally conducted vehicle testing data in the first instance, although this data was mostly available for passenger vehicles only. It was necessary in the absence of locally available emission testing data to consult other sources such as the United States Environment Protection Agency's mobile source emission model, Mobile 5A. These emission factors have been previously incorporated in other NPI trials conducted within Australia[9].

2.2.2 Regional airshed—motor vehicle emissions

Motor vehicle emissions within each of the regional airsheds (Table 6 and Table 7) were calculated according to the methodology presented in the motor vehicles EET manual[8]. Emission factors, vehicle fleet mix and speed correction data provided by the consultant[7] for the Adelaide airshed were applied to all regional airsheds. VKT data for the regional airsheds consisted of actual traffic count data where possible; however, an average was used for roads with no available data.

Table 6 Motor vehicle emissions in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†					
Substance	**Adelaide**	**Barossa**	**Port Lincoln**	**Riverland**	**South East**	**Spencer Gulf**
1,3-Butadiene (vinyl ethylene)	130,000	2,700	1,100	3,100	5,900	3,000
Acetaldehyde	130,000	2,900	1,100	3,500	6,900	3,500
Acetone	120,000	2,500	1,000	3,100	6,100	3,100
Ammonia (total)	260,000	5,200	2,100	6,000	12,000	5,800
Benzene	690,000	14,000	5,800	16,000	31,000	16,000
Carbon monoxide	150,000,000	2,900,000	1,200,000	3,100,000	6,100,000	2,900,000
Cyclohexane	25,000	510	210	580	1,100	560
Ethylbenzene	240,000	4,800	2,000	5,600	11,000	5,400
Formaldehyde (methyl aldehyde)	460,000	9,800	4,000	12,000	23,000	11,000
Hydrogen sulfide	1,600	32	13	37	70	35
Lead & compounds	35,000	720	300	830	1,600	800
n-Hexane	310,000	6,300	2,600	7,300	14,000	7,000
Oxides of nitrogen	18,000,000	430,000	170,000	590,000	980,000	640,000
Particulate matter < 10 µm	570,000	12,000	4,800	15,000	29,000	15,000
Polycyclic aromatic hydrocarbons	27,000	560	230	650	1,200	620
Styrene (ethenylbenzene)	35,000	720	300	830	1,600	800
Sulfur dioxide	640,000	14,000	5,400	17,000	33,000	17,000
Toluene (methylbenzene)	1,700,000	36,000	15,000	41,000	78,000	39,000
Total volatile organic compounds	17,000,000	360,000	150,000	410,000	790,000	400,000
Xylenes (individual or mixed isomers)	1,500,000	31,000	13,000	36,000	68,000	34,000

† Emissions to 2 significant figures

Table 7 Motor vehicle emissions in the minor regional airsheds

	Emissions per airshed (kg/yr)†										
	BAROSSA		RIVERLAND				SOUTH EAST		SPENCER GULF		
Substance	Lyndoch	Nuriootpa	Barmera	Berri	Loxton	Renmark	Millicent	Mount Gambier	Port Augusta	Port Pirie	Whyalla
1,3-Butadiene (vinyl ethylene)	220	1,100	140	300	390	420	300	1,600	550	480	530
Acetaldehyde	230	1,200	190	370	400	530	340	1,900	750	610	640
Acetone	200	1,000	170	340	350	480	300	1,700	680	550	570
Ammonia (total)	430	2,200	280	600	760	840	580	3,100	1,100	950	1,000
Benzene	1,100	5,900	760	1,600	2,000	2,300	1,600	8,400	2,900	2,600	2,800
Carbon monoxide	230,000	1,200,000	140,000	300,000	410,000	420,000	300,000	1,600,000	530,000	480,000	530,000
Cyclohexane	41	210	27	57	74	80	60	300	100	92	100
Ethylbenzene	390	2,000	260	550	700	770	540	2,900	1,000	880	960
Formaldehyde (methyl aldehyde)	790	4,100	590	1,200	1,400	1,700	1,100	6,200	2,300	2,000	2,100
Hydrogen sulfide	2.6	13	1.7	3.6	4.6	5.1	3.5	19	6.6	5.8	6.3
Lead & compounds	59	310	38	82	100	110	80	430	150	130	140
n-Hexane	510	2,700	340	710	910	1,000	700	3,800	1,300	1,100	1,300
Oxides of nitrogen	31,000	180,000	33,000	62,000	56,000	92,000	54,000	290,000	130,000	110,000	100,000
Particulate matter < 10 µm	960	5000	800	1,600	1,700	2,300	1,500	8,000	3,300	2,700	2,700
Polycyclic aromatic hydrocarbons	46	240	30	64	82	89	62	330	120	100	110
Styrene (ethenylbenzene)	59	300	38	81	100	110	80	430	150	130	140
Sulfur dioxide	1,100	5,700	950	1,900	1,900	2,700	1,700	9,300	3,900	3,100	3,200
Toluene (methylbenzene)	2,900	15,000	1,900	4,000	5,200	5,700	3,900	21,000	7,300	6,500	7,100
Total volatile organic compounds	29,000	150,000	19,000	41,000	52,000	57,000	40,000	210,000	75,000	66,000	72,000
Xylenes (individual or mixed isomers)	2,500	13,000	1,700	3,500	4,500	4,900	3,400	19,000	6,400	5,600	6,200

† Emissions to 2 significant figures

2.3 Railways

Emissions from railways depend on the types of operations performed by locomotives in the area of interest. Typically the two different types of operations are line haul and yard haul. Line haul locomotives operate generally by travelling between distant locations, such as from one city or town to another. Yard haul locomotives perform yard operations, moving railcars within a particular railway yard. Throughout South Australia[10], line haul locomotives were reported to perform most of line and yard shunt duties. Diesel–electric engines power these locomotives and the emissions arise as a result of the generation of electricity to power the traction motors, thus the term diesel–electric. Steam locomotives are seldom used and none were located within the airsheds studied, so steam locomotives were excluded from these emission estimates.

Railway information, such as locomotive types, total diesel consumption and rail track locations, was obtained from local and national operators. Rail track lengths per grid were determined by overlaying GIS airshed grid data with track length data for each airshed. Emissions from the operation of railways within each airshed were apportioned to gridded track data. The South East airshed does not have regular passenger or freight services and therefore was not included in this section of the report. Railway activity within the Riverland airshed is limited to within the Loxton airshed only, mainly as a regional freight service. The methodology for calculating and apportioning emissions was calculated according to the *NPI Emissions Estimation Technique Manual for Aggregated Emissions from Railways*[11] (Railways EET manual).

Railway emissions were calculated based on the volume of diesel fuel used during the 1998–99 year within the two main services, Adelaide metropolitan transport service and the National Rail service. The total volume of diesel used by the metropolitan transport service was used to calculate total emissions within the Adelaide airshed. However, diesel fuel reported for the national service was provided as a national figure only. This diesel fuel quantity required further apportioning according to the length of railway tracks to determine diesel consumption per airshed.

2.3.1 Adelaide airshed—railway emissions

Adelaide airshed railway activity consists of two railway systems: the metro passenger service and a national passenger and freight service (Figure 2). The metro service operates entirely within the Adelaide airshed, so all emissions were allocated to grid squares relating to the location of rail tracks within the airshed. The national train service, however, operates a only small fraction of the entire service within the Adelaide airshed., so emissions calculated for the national train service were apportioned according to the length of the national track within the Adelaide airshed.

The only types of locomotives used within the metro and national services are diesel–electric, so emissions were calculated from the portion of diesel fuel used within the airshed during the study period. The volume of diesel fuel used during 1998–99 was multiplied by the corresponding emission factor for diesel line haul locomotives in the EET manual[11] to calculate total emissions of individual NPI substances. These emission factors represent the mass of substance emitted per litre of fuel used. Total emissions from railways within the Adelaide airshed are listed in Table 8.

2.3.2 Regional airshed—railway emissions

Barossa airshed

The Barossa airshed has a regular passenger service operating three times a week between Adelaide and the towns of Tanunda and Angaston. Additionally, there is freight activity between the Barossa airshed and the Adelaide metropolitan area. The map of the Barossa airshed (Figure 3) indicates the location of the rail network within this airshed. Total railway emissions were calculated by multiplying the volume of diesel fuel consumed within the airshed by the emission factors presented in the Railways EET manual[11]. The volume of diesel fuel consumed was calculated by apportioning the national diesel fuel consumption figure according to the length of rail tracks within the airshed.

Total emissions from railways within this airshed are presented in two tables: total emissions calculated for the major Barossa airshed in Table 8 and emissions calculated for the minor Barossa airsheds of Lyndoch and Nuriootpa in Table 9.

Port Lincoln airshed

An independent rail service within the Port Lincoln airshed provides mainly freight facilities between various towns on the Eyre Peninsula and the sea port of Port Lincoln (Figure 4). However, only a small portion of the entire rail length is represented within this airshed. Consumption of diesel fuel for this service was estimated by apportioning the national fuel consumption figure according to the length of rail tracks within the airshed. The volume of diesel consumed by this service was multiplied by the diesel line haul locomotive emission factors to calculate total railway emissions in this airshed. The resultant railway emissions in the Port Lincoln airshed are presented in Table 8.

Riverland airshed

The rail network within the Riverland airshed is contained entirely within the minor Loxton airshed. This section of the rail network, shown in Figure 5, is a small branch of the major Adelaide–Melbourne track providing mainly freight services to the area. Total railway emissions within these airsheds are presented in Table 8 and Table 9, for the Riverland and Loxton airsheds respectively.

Spencer Gulf airshed

Railway activity within the Spencer Gulf airsheds (Figure 7) consists of interstate freight and passenger services, which transect each of the towns Port Pirie, Port Augusta and Whyalla. Additionally, Port Augusta and Whyalla are termination points for industry freight services of Flinders Power and BHP respectively. Total railway emissions for the Spencer Gulf airshed are presented in Table 8, and Table 9 presents emissions calculated for the minor airsheds of Port Augusta, Port Pirie and Whyalla.

Table 8 Railway emissions in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†				
Substance	**Adelaide**	**Barossa**	**Port Lincoln**	**Riverland**	**Spencer Gulf**
Acetaldehyde	690	49	11	7.0	310
Antimony & compounds	1.8	0.13	0.028	0.018	0.79
Arsenic & compounds	0.038	0.0027	0.00061	0.00039	0.017
Benzene	400	29	6.4	4.1	180
1,3-Butadiene (vinyl ethylene)	370	26	5.8	3.7	170
Cadmium & compounds	0.85	0.061	0.014	0.0086	0.38
Carbon monoxide	68,000	4,900	1,100	690	31,000
Chromium (III) compounds	0.081	0.0058	0.0013	0.00082	0.037
Chromium (VI) compounds	0.033	0.0024	0.00053	0.00034	0.015
Cobalt & compounds	0.076	0.0054	0.0012	0.00077	0.034
Copper & compounds	0.38	0.027	0.0061	0.0039	0.17
Ethylbenzene	14	0.99	0.22	0.14	6.3
Formaldehyde (methyl aldehyde)	2,000	150	32	21	920
Lead & compounds	0.38	0.027	0.0061	0.0039	0.17
Manganese & compounds	0.29	0.021	0.0046	0.003	0.13
Mercury & compounds	0.32	0.023	0.005	0.0032	0.14
n-Hexane	330	23	5.2	3.3	150
Nickel & compounds	0.19	0.014	0.003	0.0019	0.086
Oxides of nitrogen	540,000	39,000	8,600	5,500	240,000
Particulate matter < 10 μm	13,000	910	200	130	5,700
Polycyclic aromatic hydrocarbons	170	12	2.7	1.7	78
Selenium & compounds	0.051	0.0036	0.00081	0.00051	0.023
Sulfur dioxide	24,000	1,700	380	240	11,000
Toluene (methylbenzene)	410	29	6.5	4.1	180
Total volatile organic compounds	23,000	1,700	370	230	10,000
Xylenes (individual or mixed isomers)	65	4.6	1.0	0.70	29
Zinc and compounds	5.1	0.36	0.081	0.051	2.3

† Emissions to 2 significant figures

Table 9 Railway emissions in the minor regional airsheds

	Emissions per airshed (kg/yr)†					
	BAROSSA		RIVERLAND	SPENCER GULF		
Substance	**Lyndoch**	**Nuriootpa**	**Loxton**	**Port Augusta**	**Port Pirie**	**Whyalla**
Acetaldehyde	6.7	24	7.0	54	22	25
Antimony & compounds	0.017	0.061	0.018	0.14	0.056	0.064
Arsenic & compounds	0.00037	0.0013	0.00039	0.0030	0.0012	0.0014
Benzene	3.9	14	4.1	31	13	15
1,3-Butadiene (vinyl ethylene)	3.6	13	3.7	29	12	13
Cadmium & compounds	0.0083	0.030	0.0086	0.067	0.027	0.031
Carbon monoxide	670	2,400	690	5,400	2,200	2,500
Chromium (III) compounds	0.00079	0.0028	0.00082	0.0063	0.0026	0.0030
Chromium (VI) compounds	0.00033	0.0012	0.00034	0.0027	0.0011	0.0012
Cobalt & compounds	0.00074	0.0027	0.00077	0.006	0.0025	0.0028
Copper & compounds	0.0037	0.013	0.0039	0.030	0.012	0.014
Ethylbenzene	0.14	0.48	0.14	1.1	0.45	0.51
Formaldehyde (methyl aldehyde)	20	71	21	160	66	75
Lead & compounds	0.0037	0.013	0.0039	0.03	0.012	0.014
Manganese & compounds	0.0028	0.010	0.0030	0.023	0.0094	0.011
Mercury & compounds	0.0031	0.011	0.0032	0.025	0.010	0.012
n-Hexane	3.2	11	3.3	26	11	12
Nickel & compounds	0.0019	0.0066	0.0019	0.015	0.0061	0.0070
Oxides of nitrogen	5,300	19,000	5,500	42,000	17,000	20,000
Particulate matter < 10 µm	120	440	130	990	410	470
Polycyclic aromatic hydrocarbons	1.7	6.0	1.7	13	5.5	6.3
Selenium & compounds	0.00049	0.0018	0.00051	0.0040	0.0016	0.0019
Sulfur dioxide	230	830	240	1,900	760	870
Toluene (methylbenzene)	4.0	14	4.1	32	13	15
Total volatile organic compounds	230	810	230	1,800	750	850
Xylenes (individual or mixed isomers)	0.63	2.3	0.70	5.1	2.1	2.4
Zinc and compounds	0.049	0.18	0.051	0.40	0.16	0.19

† Emissions to 2 significant figures

2.4 Recreational boating

Recreational boating includes all powered vessels operating on coastal and river waters, including those used for cruising, water skiing, sport fishing and other recreational activities. Emissions arise from the burning of fuel in inboard or outboard motors.

Emissions generated by recreational boats vary with a range of factors such as climate, type of activity (fishing or sporting), location and duration of activity. Boats registered at one location may not be used for several months or may be used several kilometres away. Each of these factors can significantly alter the estimated emissions within a particular airshed. To minimise these impacts, information regarding activity patterns, volume and type of fuels used as well as engine details is required.

General boating information was determined from the responses to the domestic survey, which provided an annual indication of fuels used, preferred locations for use (sea, coast or river) and prevalence of boat engine types (inboard or outboard). The survey results, together with boat registration data and coastline lengths, provided for the estimation of annual emissions within each of the airsheds according to the methodology described in the *NPI Emissions Estimation Technique Manual for Aggregated Emissions from Commercial Ships/Boats and Recreational Boats*[4] (Boating EET manual). The section of coastline within each airshed compared to the State total (3700 km) was used to apportion boat numbers in the regional airsheds only. For the Adelaide airshed, the metropolitan survey percentage response indicating the preferred location of boating activity was used to apportion the use of boats to the coastal waters. The Barossa airshed with no recreational water activities was excluded from these emission estimates.

Some of the NPI substances listed in Table 10 and Table 11 indicate zero emission. These substance emissions relate to the use of diesel fuel or fuel oil, which were considered not to be used in recreational boats within the study airsheds. Recreational boating emissions reflect the use of leaded and unleaded fuels only.

Recreational boating emissions calculated in each of the airsheds studied are considered of low reliability. This is a consequence of the limited activity data particularly in determining accurate airshed boat numbers and fuel consumption statistics. It is therefore suggested that caution be used when interpreting these results.

2.4.1 Adelaide airshed—recreational boating emissions

The Adelaide airshed contains recreational boating activities along 84 km of the coastline, 2.3% of the State's coastline. The household survey identified prevalence of use according to the three categories: at-sea, coast or river. At-sea activity refers to boating activities more than 5 km off shore, while boating activities within 5 km of the shoreline were considered as coastal. Since the survey estimate of boats per household overestimated the total number of boats registered within the State, a range of assumptions was applied in determining the number of boats operating in each airshed.

Boats were assumed to operate in either freshwater or seawater based on a 30/70 split for powered boats, 70/30 split for ski boats and jet skis. All houseboats were assumed to operate in fresh water only. Boats assumed to operate in seawater include 80% of coastal boating and 20% at-sea. This apportioning provided a breakdown of boat numbers to the categories sea, coast and river. Further apportioning to the Adelaide airshed was based on survey reported prevalence of use. Responses from the metropolitan area only indicated a prevalence of boat use of 14% and 53% at-sea and coast respectively. It was estimated that 11,600 powered vessels and 666 speedboats and jet skis operated annually within the airshed.

Powered vessels were separated into two engine types—inboard and outboard—and leaded or unleaded fuel, based on reported prevalence of boat and fuel type data. Jet skis and speedboats were assumed as outboard powered, using unleaded fuel only. Final boat numbers were multiplied by the annual consumption of 362 L and 380 L per boat of leaded and unleaded fuel respectively. However, the airshed contains only a portion of the coast and coastal waters. To determine the area of coastal activities within the airshed, a 5 km wide buffer was created following the shoreline. The area of the buffer within the grid squares of the Adelaide airshed was used to apportion the total volume of fuel estimated per boat type. Approximately 20% of the coast (as determined by the area of the buffer contained within the airshed's grids) lies within the airshed. The airshed does not extend sufficiently out to sea (more than 5 km off shore); however, less than 5% of at-sea activity could account for boats transecting the coast.

Based on the above assumption of survey results and boat registration data it was estimated that inboard powered boats used 48,400 L and 67,400 L annually of leaded and unleaded fuel respectively. Boats powered by outboard motors used 19,200 L and 410,000 L annually of leaded and unleaded fuel respectively. These estimated fuel consumption figures were multiplied by the respective emission factor in the Boating EET manual to calculate emissions of each NPI substance. Total emissions from recreational boating activities within the Adelaide airshed (the sum of coastal and at-sea emissions) are presented in Table 10.

These estimates are based entirely on the assumptions that boats are used at one place only, that 90% of registered boats are used somewhere within the State, and that domestic survey reported data is an accurate account of boating activity within the airsheds studied. The reliability of these NPI emission estimates is therefore considered low, and the use of this data and consequent emissions of each NPI substance should be considered with caution until more detailed boating activity data becomes available.

2.4.2 Regional airsheds—recreational boating emissions

Port Lincoln airshed

The Port Lincoln airshed contains only a small portion of the State's coastline, in fact less than 1% (33 km). Therefore emissions from recreational boating activities were apportioned in relation to the length of coastline and area of coast within the airshed by applying a 5 km buffer, as described in Section 2.4.1. Boats operating within this airshed were determined from the State boat registration data provided by Transport SA.

The use of boat registration data, coastal area buffer, portion of coastline and the domestic survey results of fuel consumption provided an estimate of the total volume of leaded and unleaded fuel use within the airshed. Fuel consumption was determined according to the boat engine classifications of inboard or outboard. Inboard powered boats were estimated to use approximately 3920 L and 5450 L annually of leaded and unleaded fuel respectively. Outboard powered boats within the Port Lincoln airshed used 5480 L and 33,100 L of leaded and unleaded fuel respectively.

Emissions were calculated by multiplying each fuel figure by the corresponding emission factor listed in the Boating EET manual for each NPI substance. The resulting emissions are presented in Table 10 for recreational boating activities within the Port Lincoln airshed.

Riverland airshed

The River Murray is a popular destination for a range of water activities by residents as well as the many tourists visiting the area. Three of the towns, Berri, Loxton and Renmark, are located on the River Murray. Barmera is located on the edge of Lake Bonney, which is fed by the River Murray.

Domestic survey responses indicated that 25% of respondents owning a boat preferred to use the river as the main location for boating activities. Responses from the Adelaide metropolitan area indicated that as many as 33% of boat owners preferred the river for their boating activities. These responses were reflected in calculating emissions from powered boats, jet skis and houseboats.

Houseboats included in this category exclude those registered for commercial purposes, which are included in the Shipping/Commercial Boating section of this report.

The number of boats registered within South Australia was apportioned according to the river activity prevalence reported in the domestic survey and the length of the river within the Riverland airshed. It was estimated that 458 powered inboard boats, 2460 powered outboard boats, 776 jet skis/speedboats and 58 houseboats operate within the Riverland airshed on an annual basis.

The emissions were estimated for the number of outboard and inboard powered boats and the average annual volume of fuel per boat, as reported in the domestic survey. Powered boats were reported to operate on either leaded or unleaded fuel. Jet skis, speedboats and houseboats were assumed to have outboard powered motors, operating unleaded fuel only. Inboard powered boats were estimated to use approximately 64,400 L and 89,500 L annually of leaded and unleaded fuel respectively. Outboard powered boats used 346,000 L and 783,000 L annually of leaded and unleaded fuel respectively. The total annual emissions of each NPI substance were determined by multiplying the annual consumption of fuel by boat type by the available inboard, leaded/unleaded fuel and outboard, leaded/unleaded fuel emission factors in the Boating EET manual[4].

The resultant total emissions from recreational boating during the 1998–99 year within the Riverland airshed are presented in Table 10. Table 11 presents emissions calculated for the minor Riverland airsheds of Barmera, Berri, Loxton and Renmark.

South East airshed

The South East airshed contains less than 3% (90.4 km) of the total South Australian coastline. Coastal and at-sea activities for this airshed were proportioned according to the length of the coast as well as the area of the coastal buffer. Emissions were calculated as outlined in previous sections. In brief, the State number of registered boats was apportioned to the airshed according to the length of coastline. Further apportioning of emissions, to less than or greater than 5 km representing coastal or at-sea activities, was made by assuming 80% of boats operate within the coast and 20% at-sea. Approximately 29,300 L and 131,000 L of leaded and unleaded fuel respectively were estimated as used within the South East airshed during the 1998–99 year.

The total emissions from coastal, at-sea and lake boating activities are presented in Table 10 for the South East airshed. Boating activities on the lake in Mount Gambier are considered minimal due to the restricted access and size of the lake, although the lake is seasonally popular for water skiing. Therefore emissions presented for the Mount Gambier airshed (Table 11) represent ski boat and jet ski activity only.

Spencer Gulf airshed

The Spencer Gulf airshed contains approximately 7% (240 km) of coastline, the largest portion of coastline relative to the other airsheds. Recreational boating activities were calculated based on survey responses as determined in the other airsheds and include activities along the coastline and at-sea. Emissions for this region were only calculated for the major airshed of Spencer Gulf as presented in Table 10. These emissions reflect the total annual use of 107,000 L and 324,000 L of leaded and unleaded fuels respectively.

Table 10 Recreational boating emissions in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†				
Substance	**Adelaide**	**Port Lincoln**	**Riverland**	**South East**	**Spencer Gulf**
1,3-Butadiene (vinyl ethylene)	520	46	1,300	160	420
Acetaldehyde	1,100	99	2,900	340	900
Antimony & compounds	0	0	0	0	0
Arsenic & compounds	0	0	0	0	0
Benzene	2100	190	5,500	660	1,700
Beryllium & compounds	0	0	0	0	0
Cadmium & compounds	0	0	0	0	0
Carbon monoxide	190,000	17,000	470,000	57,000	150,000
Chromium (III) compounds	0.038	0.0033	0.088	0.011	0.030
Chromium (VI) compounds	0.016	0.0014	0.037	0.0046	0.012
Cobalt & compounds	0.053	0.0047	0.13	0.016	0.042
Copper & compounds	0.053	0.0047	0.13	0.016	0.042
Cyclohexane	0	0	0	0	0
Ethylbenzene	410	37	1,100	130	330
Formaldehyde (methyl aldehyde)	1,700	150	4,300	510	1,300
Lead & compounds	8.6	1.2	49	3.6	13
Manganese & compounds	0.053	0.0047	0.13	0.016	0.042
Mercury & compounds	0	0	0	0	0
n-Hexane	460	41	1,200	140	370
Nickel & compounds	0.053	0.0047	0.13	0.016	0.042
Oxides of nitrogen	2,000	180	3,300	520	1,500
Particulate matter < 10 µm	110	6.9	190	23	62
Polycyclic aromatic hydrocarbons	79	10	300	35	93
Selenium & compounds	0	0	0	0	0
Styrene (ethenylbenzene)	53	4.7	140	16	43
Sulfur Dioxide	220	21	690	70	210
Toluene (methylbenzene)	6,600	590	17,000	2,000	5,400
Total volatile organic compounds	53,000	4,700	140,000	16,000	43,000
Xylenes (individual or mixed isomers)	2,000	180	5,200	620	1,600
Zinc and compounds	0.053	0.0047	0.13	0.016	0.042

† Emissions to 2 significant figures

Table 11 Recreational boating emissions in the minor regional airsheds

	Emissions per airshed (kg/yr)†				
	SOUTH EAST	RIVERLAND			
Substance	Mount Gambier	Barmera	Berri	Loxton	Renmark
1,3-Butadiene (vinyl ethylene)	27	120	520	610	860
Acetaldehyde	57	260	1,100	1,300	1,800
Antimony & compounds	0	0	0	0	0
Arsenic & compounds	0	0	0	0	0
Benzene	110	500	2,100	2,500	3,500
Beryllium & compounds	0	0	0	0	0
Cadmium & compounds	0	0	0	0	0
Carbon monoxide	9,100	42,000	180,000	220,000	300,000
Chromium (III) compounds	0.0016	0.0079	0.034	0.040	0.056
Chromium (VI) compounds	0.00065	0.0033	0.014	0.017	0.024
Cobalt & compounds	0.0022	0.011	0.048	0.057	0.080
Copper & compounds	0.0022	0.011	0.048	0.057	0.080
Cyclohexane	0	0	0	0	0
Ethylbenzene	21	95	410	490	680
Formaldehyde (methyl aldehyde)	86	390	1,700	2,000	2,800
Lead & compounds	0.037	4.4	19	22	31
Manganese & compounds	0.0022	0.011	0.048	0.057	0.080
Mercury & compounds	0	0	0	0	0
n-Hexane	24	110	460	550	760
Nickel & compounds	0.0022	0.011	0.048	0.057	0.08
Oxides of nitrogen	18	300	1,300	1,500	2,100
Particulate matter < 10 µm	3.3	17	71	85	120
Polycyclic aromatic hydrocarbons	5.9	27	110	140	190
Selenium & compounds	0	0	0	0	0
Styrene (ethenylbenzene)	2.7	12	53	63	87
Sulfur Dioxide	6.9	62	270	320	440
Toluene (methylbenzene)	340	1,500	6,600	7,800	11,000
Total volatile organic compounds	2,700	12,000	53,000	63,000	87,000
Xylenes (individual or mixed isomers)	100	500	2,000	2,400	3,400
Zinc and compounds	0.0022	0.011	0.048	0.057	0.080

† Emissions to 2 significant figures

2.5 Shipping and commercial boating

Commercial shipping and boating emissions were calculated for each airshed with an active port. Shipping and commercial boating includes cargo ships, passenger ships, chemical tankers, colliers, naval ships, fishing boats, tug boats, work boats, passenger and cargo boats, and other small commercial utility craft. The emissions in this section were calculated according to the methodology specified by the Boating EET manual[4]. The emissions from shipping within each airshed were calculated separately from commercial boating, although total emissions represent the sum of both activities.

Emissions from shipping include exhaust emissions for the vessel while under way and at berth. Excluded from the total estimates were emissions associated with the loading and unloading of petroleum liquids, as these were considered the responsibility of the maritime operator to report[12].

Commercial boating emissions were calculated for all boats registered as 'commercial' with Transport SA, and separated into less than or greater than 7 metres. This reference size separates boats into inboard or outboard powered. Boats of less than 7 metres were considered to have outboard motors, while boats longer than 7 metres were categorised as inboard[13]. The emissions from commercial boats reflect the volume of fuel consumed within an airshed.

2.5.1 Adelaide airshed—shipping and commercial boating emissions

The Adelaide airshed includes two ports: an inner harbour located within the Port River and an outer harbour located on the tip of the Lefevre Peninsula. The inner harbour caters for roll-on roll-off and bulk cargoes. The outer harbour is equipped with specialist berths including a motor vehicle terminal for roll-on roll-off and general cargo as well as passenger transport.

Adelaide airshed shipping emissions were calculated from shipping activity data provided by Ports Corp, South Australia for both harbours[14]. The emissions include engine exhausts from ships 'under way' and at 'berth'. The unloading of petroleum fuels was not included in these estimates neither were emissions from the refuelling of tankers. Shipping activity at the Port Stanvac refinery was also not included as part of aggregated emissions since these emissions calculations were considered the responsibility of the Mobil refinery and therefore should be estimated by the operators.

Commercial boating emissions were estimated from the number of boats registered within the Adelaide airshed. These boats were classified as either under 7 metres or over 7 metres by the data provided by Transport SA[15]. Since commercial boating emissions arise from the fuel and boat engine type, boats above 7 metres were categorised as having inboard engines using diesel fuel and boats under 7 metres were considered as having an outboard engine using unleaded petrol fuel. The volume of automotive diesel fuel used in recreational transport was reported as part of the Australian Bureau of Agricultural and Resource Economics (ABARE) research report[16]. This national diesel fuel figure was apportioned according to the number of commercial boats registered in the Adelaide airshed compared to the State. Unleaded fuel use was not reported by ABARE for this industry sector, so the volume was estimated by assuming that diesel consumption by diesel powered boats was similar to that used by unleaded boats.

Fuel emission factors were used to determine total emissions of NPI substances; however, it was necessary to apportion these emissions according to the time spent within the airshed. In the Adelaide airshed, the distance of the coastal waters varies from 0 km to 2.5 km off shore. This is only a small fraction of the total distance in which these boats would generally operate. Therefore the average time boats would spend operating within the airshed was estimated at approximately 10%, which was assumed to reflect the function of leaving and returning to port.

The combined emissions from shipping and commercial boating activities within the Adelaide airshed are presented in Table 12.

2.5.2 Regional airshed—shipping and commercial boating emissions

Port Lincoln airshed

Ports Corp[14] and Transport SA[15] provided all of the regional airshed shipping and commercial boating data. Port Lincoln shipping emissions include emissions from engine exhaust while the boat travels along the shipping route and while at berth. Port Lincoln is also regarded as a major commercial fishing port, so all boats registered within the area were considered to operate from ports within the airshed.

Total emissions presented in Table 12 comprise those from combined shipping and commercial boating activities within the airshed. Since shipping emissions are calculated according to the length of the shipping route or channel, there was no need to further apportion the total emissions estimated. However, emissions from commercial boats do not relate to any specific route and it was therefore necessary to determine the portion of time spent within the airshed and consequently apportion the emissions respectively. Based on the location of the coastal waters in relation to the airshed boundary, it was estimated that only 10% of the total commercial boating emissions should be allocated to the airshed.

Riverland airshed

Commercial boating is the only activity estimated in this airshed, which mostly consists of houseboats. Data provided by Transport SA[15] showed that all boats registered within the airshed area were less than 7 metres in length. Thus emissions calculated for this airshed exclude those relating to inboard, diesel powered boats. A number of operators within the airshed disclosed their fuel use and from this the average volume of fuel used by individual houseboats was assessed.

Emissions were calculated according to the methodology described in the Boating EET manual[4] for the total number of commercial boats registered in the area. These estimates do not account for the unknown number of boats that may be registered in other areas but operate within the airshed. Without accurate activity data, it is difficult to accurately determine the number of boats operating within the area. Therefore emissions were calculated with the assumption that only registered boats operate entirely within the airshed, without apportioning the data by the actual time spent in the airshed. It is possible that this assumption may overestimate emissions by including boats that may not have operated in the airshed during the inventory period, although this may be compensated by the unknown number of boats that did operate in the area during the inventory period but were registered elsewhere.

Table 12 and Table 13 present total emissions calculated within the Riverland airshed and the minor Riverland airsheds of Berri, Loxton and Renmark. Barmera airshed was considered to have no commercial boating activity and therefore excluded from this section of the report.

South East airshed

The South East airshed does not have an operating shipping port. Total emissions shown in Table 12 relate only to the use of commercial boats registered within the South East airshed area. Again, commercial boats were grouped into the two categories of less than and greater than 7 metres in length, which can be related to the type of fuel used for propulsion. Emissions were calculated according to the methodology described in the Boating EET manual[4].

The emissions presented in Table 12 have been apportioned to represent those related to the area of coast within the airshed. Approximately 10% of the total emissions from commercial boats was allocated to the airshed, which represents the transit of boats to and from port.

Spencer Gulf airshed

The Spencer Gulf airshed has three active shipping ports located at Port Bonython, Port Pirie and Whyalla. Port Bonython provides shipping of liquid hydrocarbons recovered from the Cooper and Eromanga basins. Port Pirie is an active port that ships large quantities of lead, zinc and other ores as well as agricultural produce such as grain. The Whyalla port exports locally produced ore and steel from the main steelworks industry, BHP.

Shipping data was provided by Ports Corp[14] and used to determine engine exhaust emissions for vessels 'under way' along the shipping routes within the airshed and while berthed at dock. Information relating to the unloading of petrol fuels only was provided for the ports at Whyalla and Port Bonython. However, emissions from the unloading of leaded fuel, diesel and liquefied petroleum gas (LPG) were not included in these estimates.

Commercial boating emissions were calculated assuming all boats registered within the Spencer Gulf airshed operate within the airshed waters. Registered boats were categorised according to length into two groups: greater than 7 metres (operating inboard, diesel engines) and less than 7 metres (operating outboard, unleaded fuel engines). The volume of diesel fuel was apportioned from ABARE data[16]. This information was used to extrapolate the volume of petrol fuel used by outboard powered boats.

The combined emissions from shipping and commercial boating for the 1998–99 year are presented for the major Spencer Gulf airshed in Table 12. Due to the minimal spatial representation of water within the minor airsheds of Port Augusta, Port Pirie and Whyalla, shipping and commercial boating emissions were not resolved in these airsheds.

Table 12 Shipping and commercial boating emissions in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†				
Substance	**Adelaide**	**Port Lincoln**	**Riverland**	**South East**	**Spencer Gulf**
1,3-Butadiene (vinyl ethylene)	420	49	610	18	870
Acetaldehyde	870	100	1,300	38	1,800
Antimony & compounds	1.2	0.18	0	0.0012	1.1
Arsenic & compounds	3.1	0.48	0	0.0012	3.0
Benzene	930	85	2,500	72	3,000
Beryllium & compounds	2.6	0.41	0	0.0045	2.3
Cadmium & compounds	0.78	0.12	0	0.00013	0.75
Carbon monoxide	100,000	8,800	21,0000	5,900	270,000
Chromium (III) compounds	0.81	0.12	0.036	0.0013	0.79
Chromium (VI) compounds	0.34	0.050	0.015	0.00055	0.31
Cobalt & compounds	2.1	0.31	0.050	0.0023	2.0
Copper & compounds	3.2	0.51	0.05	0.014	2.4
Cyclohexane	0.072	1.5	0	0	0.61
Ethylbenzene	130	5.0	480	14	540
Formaldehyde (methyl aldehyde)	2,100	290	2,000	58	3,400
Lead & compounds	0.98	0.27	0.84	0.025	1.7
Manganese & compounds	0.012	0.00013	0.050	0.0014	0.057
Mercury & compounds	0.10	0.016	0	0.0003	0.081
n-Hexane	400	87	540	16	810
Nickel & compounds	170	25	0.05	0.10	160
Oxides of nitrogen	420,000	53,000	410	180	320,000
Particulate matter < 10 µm	37,000	5,600	75	21	35,000
Polycyclic aromatic hydrocarbons	32	0.43	130	3.8	150
Selenium & compounds	1.6	0.25	0	0.0027	1.4
Styrene (ethenylbenzene)	15	0.46	62	1.8	69
Sulfur Dioxide	320,000	38,000	160	16	250,000
Toluene (methylbenzene)	2,200	100	7,800	220	8,800
Total volatile organic compounds	32,000	3,100	62,000	1,800	81,000
Xylenes (individual or mixed isomers)	730	46	2,400	67	2,700
Zinc and compounds	4.7	0.75	0.050	0.013	3.9

† Emissions to 2 significant figures

Table 13 Shipping and commercial boating emissions in the minor regional airsheds

	Emissions per airshed (kg/yr)†		
	RIVERLAND		
Substance	**Berri**	**Loxton**	**Renmark**
1,3-Butadiene (vinyl ethylene)	31	36	51
Acetaldehyde	65	77	110
Antimony & compounds	0	0	0
Arsenic & compounds	0	0	0
Benzene	130	150	210
Beryllium & compounds	0	0	0
Cadmium & compounds	0	0	0
Carbon monoxide	10,000	12,000	17,000
Chromium (III) compounds	0.0018	0.0021	0.0030
Chromium (VI) compounds	0.00074	0.00088	0.0012
Cobalt & compounds	0.0025	0.0030	0.0042
Copper & compounds	0.0025	0.0030	0.0042
Cyclohexane	0	0	0
Ethylbenzene	24	29	40
Formaldehyde (methyl aldehyde)	98	120	160
Lead & compounds	0.042	0.050	0.070
Manganese & compounds	0.0025	0.0030	0.0042
Mercury & compounds	0	0	0
n-Hexane	27	32	45
Nickel & compounds	0.0025	0.0030	0.0042
Oxides of nitrogen	21	24	34
Particulate matter < 10 µm	3.7	4.4	6.2
Polycyclic aromatic hydrocarbons	6.8	8.0	11
Selenium & compounds	0	0	0
Styrene (ethenylbenzene)	3.1	3.7	5.2
Sulfur Dioxide	7.9	9.3	13
Toluene (methylbenzene)	390	460	640
Total volatile organic compounds	3,100	3,700	5,200
Xylenes (individual or mixed isomers)	120	140	200
Zinc and compounds	0.0025	0.0030	0.0042

† Emissions to 2 significant figures

Section 3: Area-based sources

3.1 Architectural surface coatings

Architectural surface coatings protect the substrates to which they are applied from corrosion, abrasion, decay, ultra-violet light and water damage. The predominant emissions from architectural surface coatings are volatile organic compounds (VOCs), contained both in the coatings themselves (i.e. paint, paint primer, varnish or lacquer) and in the solvents used as thinners and for cleaning up. Emission of particulate matter was not considered in these estimates since most applications assumed the use of brushes and rollers.

The estimation of architectural surface coating emissions was calculated from the reported sale of paints for domestic and industrial purposes during the 1998–99 financial year and apportioned using population and industry densities respectively. The methodology for calculating these emissions is outlined in the *NPI Emissions Estimation Technique Manual for Aggregated Emissions from Architectural Surface Coatings* [17](Surface coating EET manual).

3.1.1 Adelaide airshed—architectural surface coating emissions

Emissions from architectural surface coating activities within the Adelaide airshed were estimated from national paint consumption data apportioned according to population using the total production and net import/export volumes data provided by the Australian Paint Manufacturing Federation[18] (APMF). Various paint types were grouped into the two categories, domestic and industrial. Domestic paints were further split into solvent and water based; industrial paints are only solvent based.

The uses of domestic and industrial paints throughout the airshed were considered relative to housing and industry demands. Therefore emissions from both these paint types were considered separately to account for the varying distribution throughout the airshed. Emission factors listed in the surface coating EET manual[17] were multiplied by the volume of each paint type used within the airshed. For spatial distribution of total emissions, emissions were apportioned to grid squares to reflect the corresponding housing or industry density. Total emissions from architectural surface coatings (Table 14) include the emissions from domestic and industrial, solvent and water based paints.

3.1.2 Regional airsheds—architectural surface coating emissions

Emissions from architectural surface coatings in each of the regional airsheds were estimated according to the methodology described in the surface coating EET manual[17] and applied in calculating architectural surface coating emissions in the Adelaide airshed.

In brief, architectural surface coating emissions were calculated by apportioning national paint consumption data to each of the regional airsheds according to the population of each airshed. These apportioned paint consumption figures were then multiplied by the respective emission factors listed in the EET manual[17]. Emissions from domestic and industrial paints were calculated separately due to the variation in geographical distribution. However, once values were apportioned to respective grid squares according to either housing or industry density data for domestic and industrial paints respectively, total emission estimates were calculated by summing all grid squares together.

Table 14 and Table 15 present total emissions from architectural surface coatings estimated for each of the major and minor regional airsheds respectively. The data represents total emissions of all domestic and industrial paint used during 1998–99.

Table 14 Architectural surface coating emissions in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†					
Substance	**Adelaide**	**Barossa**	**Port Lincoln**	**Riverland**	**South East**	**Spencer Gulf**
Acetone	73,000	1,000	860	1,800	2,600	3,900
Benzene	1,600	22	19	39	57	83
Cyclohexane	470,000	6,800	5,600	12,000	17,000	25,000
Dichloromethane	29,000	410	340	720	1,000	1,500
Ethanol	14,000	190	170	350	500	720
2-Ethoxyethanol acetate	30,000	430	350	750	1,100	1,500
Ethylene glycol (1,2-ethanediol)	16,000	230	200	410	590	860
n-Hexane	470,000	6,800	5,600	12,000	17,000	25,000
Methanol	89,000	1,300	1,100	2,200	3,200	4,700
Methyl ethyl ketone	130,000	1,800	1,500	3,200	4700	6,800
Methyl isobutyl ketone	14,000	190	170	350	500	720
Toluene (methylbenzene)	120,000	1,700	1,400	2,900	4,300	6,200
Total volatile organic compounds	2,800,000	40,000	33,000	70,000	100,000	150,000
Xylenes (individual or mixed isomers)	59,000	850	710	1,500	2,200	3,200

† Emissions to 2 significant figures

Table 15 Architectural surface coating emissions in the minor regional airsheds

	Emissions per airshed (kg/yr)†										
	BAROSSA		RIVERLAND				SOUTH EAST		SPENCER GULF		
Substance	Lyndoch	Nuriootpa	Barmera	Berri	Loxton	Renmark	Millicent	Mount Gambier	Port Augusta	Port Pirie	Whyalla
Acetone	97	780	140	300	310	460	320	1,700	970	1,000	1,700
Benzene	2.1	17	3.0	6.5	6.6	9.7	7.0	36	21	22	35
Cyclohexane	630	5,000	900	1,900	2,000	2,900	2,100	11,000	6,300	6,600	10,000
Dichloromethane	38	310	55	120	120	180	130	650	380	400	640
Ethanol	18	140	26	57	58	85	61	310	180	190	300
2-Ethoxyethanol acetate	40	320	57	120	130	180	130	670	400	420	660
Ethylene glycol (1,2-ethanediol)	22	170	31	68	69	100	73	370	220	230	360
n-Hexane	630	5,000	900	1,900	2,000	2,900	2,100	11,000	6,300	6,600	10,000
Methanol	120	940	170	360	370	550	400	2,100	1,200	1,200	2,000
Methyl ethyl ketone	170	1,400	250	530	540	790	570	2,900	1,700	1,800	2,900
Methyl isobutyl ketone	18	140	26	57	58	85	61	310	180	190	300
Toluene (methylbenzene)	150	1,300	220	490	500	740	530	2,600	1,500	1,700	2,600
Total volatile organic compounds	3,700	29,000	5,400	12,000	12,000	17,000	12,000	63,000	37,000	39,000	63,000
Xylenes (individual or mixed isomers)	79	630	110	250	250	370	260	1,300	790	830	1,300

† Emissions to 2 significant figures

3.2 Cutback bitumen

Cutback bitumen refers to the process of sealing or resurfacing roads. Primers or primer binder materials, which are generally solvents such as kerosene or aviation turbine fuels, reduce the viscosity of the bitumen. These products can be applied either as surface treatments or to prime the surface before other surfacing work, or may be blended with bitumen in spray sealing operations.

The emissions from cutback bitumen result from the use of primers and primer binders. These products give off emissions of volatile organic compounds during the application and drying stages. The solvent kerosene was considered the only type of primer used in each of the airsheds. Additionally, the quantity of solvent kerosene used generally falls into four categories—very light prime, medium prime, heavy prime and cutback bitumen. These categories vary by the percentage of solvent kerosene used, from 55% in very light prime to 5% in cutback bitumen.

The calculation of emission estimates in each airshed was in accordance with the methodology described in the *NPI Emissions Estimation Technique Manual for Aggregated Emissions from Cutback Bitumen*[19] (Cutback bitumen EET manual). This methodology assumes the mass balance approach where the annual emissions are equal to the annual consumption of product per airshed.

3.2.1 Adelaide airshed—cutback bitumen emissions

Cutback bitumen emissions within the Adelaide airshed were based on data provided by the major suppliers of primer products—Boral Asphalt, CSR Emoleum and Pioneer Road Services[20-22]. Approximately 400,000 L of solvent kerosene was applied to road surfaces during the 1998–99 year, of which approximately 29% was used throughout the Adelaide airshed.

The resultant emissions of each NPI substance contained in solvent kerosene were determined from the total airshed consumption figure. The mass of solvent kerosene was calculated from the volume by multiplying by the density of the solvent. This resultant mass was then multiplied by the corresponding emission factors listed in the cutback bitumen EET manual[19] to determine the emissions of each NPI substance.

Total emissions estimates from the use of kerosene in the process of cutback bitumen in the Adelaide airshed are presented in Table 16. Spatial distribution of emissions within the airshed was calculated by apportioning the emissions data according to the gridded road traffic data (VKT data; see Section 2.2).

3.2.2 Regional airsheds—cutback bitumen emissions

The emissions resulting from the application of cutback bitumen within regional airsheds were estimated assuming that the solvent kerosene consumed in an airshed is emitted during the inventory period. As a result, regional consumption of solvent kerosene applied to surfaced roads was estimated to be 284,000 L, 71% of the State's total. Kerosene use within each regional airshed was further estimated by apportioning the regional total consumption figure by each airshed's VKT data. Emissions were calculated by multiplying the kerosene use by emission factors listed in the Cutback bitumen EET manual[19].

Resultant emission estimates for each major regional airshed are presented in Table 16, while minor regional airshed emissions are presented in Table 17. Spatial distribution of total emissions within each airshed was calculated by apportioning emissions according to the gridded VKT data.

Table 16 Cutback bitumen emissions in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†					
Substance	**Adelaide**	**Barossa**	**Port Lincoln**	**Riverland**	**South East**	**Spencer Gulf**
Benzene	3.4	0.15	0.070	0.22	0.41	0.23
Biphenyl (1,1′-biphenyl)	10	0.43	0.21	0.64	1.2	0.68
Cumene (1-methylethylbenzene)	2,400	100	49	150	290	160
Cyclohexane	0.15	0.0063	0.0030	0.0094	0.018	0.0099
Ethylbenzene	160	7.0	3.4	10	20	11
n-Hexane	0.15	0.0063	0.0030	0.0094	0.018	0.0099
Polycyclic aromatic hydrocarbons	190	8.1	3.9	12	23	13
Styrene (ethenylbenzene)	0.47	0.020	0.0097	0.030	0.057	0.032
Toluene (methylbenzene)	100	4.3	2.1	6.4	12	6.8
Total volatile organic compounds	59,000	2,500	1,200	3,800	7,100	4,000
Xylenes (individual or mixed isomers)	840	36	17	53	100	56

† Emissions to 2 significant figures

Table 17 Cutback bitumen emissions in the minor regional airsheds

	Emissions per airshed (kg/yr)†										
	BAROSSA		**RIVERLAND**				**SOUTH EAST**		**SPENCER GULF**		
Substance	**Lyndoch**	**Nuriootpa**	**Barmera**	**Berri**	**Loxton**	**Renmark**	**Millicent**	**Mount Gambier**	**Port Augusta**	**Port Pirie**	**Whyalla**
Benzene	0.016	0.075	0.024	0.012	0.028	0.033	0.023	0.13	0.048	0.040	0.045
Biphenyl (1,1′-biphenyl)	0.046	0.22	0.072	0.035	0.081	0.099	0.069	0.39	0.14	0.12	0.13
Cumene (1-methylethylbenzene)	11	53	17	8.4	19	24	16	93	34	28	32
Cyclohexane	0.00068	0.0033	0.0011	0.00052	0.0012	0.0015	0.0010	0.0057	0.0021	0.0017	0.0019
Ethylbenzene	0.76	3.6	1.2	0.58	1.3	1.6	1.1	6.4	2.3	1.9	2.2
n-Hexane	0.00068	0.0033	0.0011	0.00052	0.0012	0.0015	0.0010	0.0057	0.0021	0.0017	0.0019
Polycyclic aromatic hydrocarbons	0.87	4.2	1.4	0.66	1.5	1.9	1.3	7.3	2.7	2.2	2.5
Styrene (ethenylbenzene)	0.0022	0.010	0.0034	0.0017	0.0038	0.0046	0.0032	0.018	0.0067	0.0055	0.0062
Toluene (methylbenzene)	0.47	2.2	0.72	0.35	0.82	0.99	0.69	3.9	1.4	1.2	1.3
Total volatile organic compounds	270	1,300	420	210	480	580	400	2,300	840	690	780
Xylenes (individual or mixed isomers)	3.9	19	6.0	2.9	6.8	8.3	5.7	32	12	9.8	11

† Emissions to 2 significant figures

3.3 Domestic and commercial solvent and aerosol use

Domestic and commercial solvents and aerosols estimated in this section refer to a range of domestic and commercial products. Solvents within these products include many NPI substances that are emitted to the atmosphere with use. The following groups of solvent and aerosol products are covered by the estimations in this section:

- personal care products
- household cleaners
- motor vehicle aftermarket products
- adhesives and sealants
- insecticides and herbicides
- coatings and related products
- miscellaneous products.

Not included in this section are emissions from the use of architectural surface coatings, motor vehicle refinishing and sub-reporting threshold facility solvents, which are covered in other sections of this report. Also not included in this section are emissions from broadacre and horticultural applications of pesticides. The pesticide products covered in this section relate only to domestic and commercial applications.

The solvents used in these domestic and commercial products contain VOCs that act either as active ingredients themselves or as carriers for the active ingredients. The emissions of VOCs occur during product use by immediate evaporation (aerosol spray), evaporation after application (product drying) and direct release in the gaseous phase[23].

Emissions calculated from the use of domestic and commercial solvents and aerosols were determined by applying emission factors listed in the *NPI Emissions Estimation Technique Manual for Aggregated Emissions from Domestic/Commercial Solvent and Aerosol Use* (Solvent EET manual)[24].

3.3.1 Adelaide airshed—domestic and commercial solvent emissions

Emissions estimated in the Adelaide airshed reflect the quantity of products consumed by the population of that area. Emission factors listed in the EET manual for domestic and commercial solvent and aerosol use are based on per capita usage of the various product groups. These factors have been derived in the United States and are considered to give estimates of reasonable and acceptable accuracy for Australian conditions[24].

Domestic and commercial solvent and aerosol emissions (Table 18) were calculated by multiplying the per capita usage emission factors in the Solvent EET manual[24] by the population of the Adelaide airshed. Total emissions presented in Table 18 were spatially disaggregated to individual grid squares, according to the population of each grid square within the Adelaide airshed.

3.3.2 Regional airsheds—domestic and commercial solvent emissions

Emissions estimated in regional airsheds were calculated according to the methodology described in Section 3.3.1. In brief, per capita emission factors related to the use of solvents and aerosols were multiplied by the airshed's population.

Total emissions listed in Table 18 are for each of the major regional airsheds. Emissions presented in Table 19 represent those estimated for each of the minor regional airsheds. Emission totals were spatially distributed according to the population of each grid square within each airshed.

Table 18 Domestic and commercial solvent and aerosol emissions in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†					
Substance	**Adelaide**	**Barossa**	**Port Lincoln**	**Riverland**	**South East**	**Spencer Gulf**
Acrylic acid	0.0019	0.000027	0.000022	0.000047	0.000068	0.000099
Benzene	2.2	0.032	0.026	0.056	0.081	0.12
Chloroform (trichloromethane)	470	6.7	5.5	12	17	25
1,2-Dichloroethane	2.2	0.032	0.026	0.055	0.08	0.12
Dichloromethane	17,000	250	200	430	630	910
Ethylbenzene	980	14	12	25	36	52
Ethylene oxide	7,100	100	84	180	260	380
Ethylene glycol (1,2-ethanediol)	43,000	620	510	1,100	1,600	2,300
Fluoride compounds	6.7	0.096	0.079	0.17	0.24	0.35
Formaldehyde (methyl aldehyde)	600	8.6	7.1	15	22	32
n-Hexane	41,000	580	480	1,000	1,500	2,200
Hydrochloric acid	0.83	0.012	0.010	0.021	0.030	0.044
Methanol	330,000	4,800	3,900	8,400	12,000	18,000
Methyl ethyl ketone	24,000	340	280	600	870	1,300
Methyl isobutyl ketone	3,600	51	42	90	130	190
Tetrachloroethylene	13,000	190	160	340	490	710
Toluene (methylbenzene)	200,000	2,900	2,400	5,100	7,400	11,000
Trichloroethylene	230	3.3	2.7	5.8	8.4	12
Xylenes (individual or mixed isomers)	96,000	1,400	1,100	2,400	3,500	5,100
Total volatile organic compounds	5,400,000	77,000	64,000	130,000	200,000	280,000

† Emissions to 2 significant figures

Table 19 Domestic and commercial solvent and aerosol emissions in the minor regional airsheds

	Emissions per airshed (kg/yr)†										
	BAROSSA		RIVERLAND				SOUTH EAST		SPENCER GULF		
Substance	**Lyndoch**	**Nuriootpa**	**Barmera**	**Berri**	**Loxton**	**Renmark**	**Millicent**	**Mount Gambier**	**Port Augusta**	**Port Pirie**	**Whyalla**
Acrylic acid	0.0000025	0.000020	0.0000037	0.0000078	0.0000079	0.000012	0.0000083	0.000042	0.000025	0.000026	0.000042
Benzene	0.0030	0.024	0.0043	0.0092	0.0094	0.014	0.0099	0.051	0.030	0.031	0.050
Chloroform (trichloromethane)	0.63	5.0	0.90	1.9	2.0	2.9	2.1	11	6.2	6.5	10
1,2-Dichloroethane	0.0029	0.023	0.0042	0.0091	0.0093	0.014	0.0098	0.050	0.029	0.031	0.050
Dichloromethane	23	180	33	71	73	110	77	390	230	240	380
Ethylbenzene	1.3	10	1.9	4.0	4.1	6.1	4.4	22	13	14	22
Ethylene oxide	9.5	76	14	29	30	44	32	160	95	100	160
Ethylene glycol (1,2-ethanediol)	58	460	83	180	180	270	190	980	580	600	970
Fluoride compounds	0.0090	0.071	0.013	0.028	0.028	0.042	0.030	0.15	0.089	0.094	0.15
Formaldehyde (methyl aldehyde)	0.80	6.4	1.2	2.5	2.5	3.7	2.7	14	8.0	8.4	13
n-Hexane	54	430	78	170	170	250	180	930	540	570	910
Hydrochloric acid	0.0011	0.0088	0.0016	0.0034	0.0035	0.0051	0.0037	0.019	0.011	0.012	0.019
Methanol	440	3,500	640	1,400	1,400	2,100	1,500	7,600	4,400	4,600	7,400
Methyl ethyl ketone	32	250	46	98	100	150	110	540	320	330	530
Methyl isobutyl ketone	4.8	38	6.9	15	15	22	16	82	48	50	80
Tetrachloroethylene	18	140	26	55	57	83	60	300	180	190	300
Toluene (methylbenzene)	270	2,200	390	840	860	1,300	900	4,600	2,700	2,800	4,500
Trichloroethylene	0.31	2.4	0.44	0.95	0.97	1.4	1.0	5.2	3.1	3.2	5.1
Xylenes (individual or mixed isomers)	130	1,000	180	400	410	600	430	2,200	1,300	1,300	2,200
Total volatile organic compounds	7,200	57,000	10,000	22,000	23,000	33,000	24,000	120,000	72,000	75,000	120,000

† Emissions to 2 significant figures

3.4 Domestic gas fuel

This source category includes the use of domestic natural gas, town gas and/or liquefied petroleum gas. A combination of each of these fuels can be used throughout the metropolitan and country areas. Natural gas and town gas supplies are limited by the extent of the distribution system, while LPG for domestic applications (primarily propane) is supplied in the form of large portable bottles. Domestic gas fuel is burned for cooking, space heating and hot water heating.

Emissions from the use of domestic gas fuel depend on the amount and type of gaseous fuel burnt and also on the temperature and efficiency of the combustion process. The temperature and efficiency of the domestic combustion process is generally uncontrolled. Emission factors used to estimate emissions in this report, were based on work carried out in the United States on firing emissions from natural gas[25] and LPG[26]. Emissions were calculated according to the methodology described in the *NPI Emissions Estimation Technique Manual for Aggregated Emissions from Domestic Gaseous Fuel Burning* (Gas EET manual)[28].

3.4.1 Adelaide airshed—domestic gas fuel emissions

The consumption statistics for natural gas and LPG within the Adelaide airshed were provided by various independent sources. Natural gas data was provided by the major domestic supplier, Origin Energy and cross-referenced with domestic consumption figures reported by ABARE[16] and the Australian Natural Gas Association (AGA)[27]. This data was consequently used to determine natural gas emissions in the Adelaide airshed.

LPG is less commonly used in metropolitan areas where the majority of homes are connected to mains gas. However, data collected by the Australian Bureau of Statistics (ABS) showed that 22% of the metropolitan area uses bottled gas as a main source of fuel. The total consumption of LPG was based on national data collected by the AGA and the Australian LPG Association (ALPGA).

Emissions from domestic gas fuel use were calculated according to the methodology described in the Gas EET manual[28]. Emissions were calculated by multiplying an emission factor by the total consumption of natural gas and LPG respectively. Total emissions of natural gas and LPG calculated for the Adelaide airshed are presented in Table 20.

Natural gas emissions within the Adelaide airshed were spatially distributed according to the distribution of homes in the region of the airshed between the ground and 200 metres above sea level. Homes connected to bottled LPG were assumed to be in areas with no available mains gas. Therefore emission estimates relating to the use of LPG fuel were distributed among homes in regions of the airshed more than 200 metres above sea level.

3.4.2 Regional airsheds—domestic gas fuel emissions

The natural gas consumption within regional airsheds was provided by Origin energy[29]. The Port Augusta and Port Lincoln airsheds do not have mains natural gas available. Therefore emissions in these airsheds were estimated according to the estimated use of LPG fuel only.

The use of LPG fuel within the regional airsheds was determined from the total consumption data provided by the AGA and cross-referenced with data provided by the ALPGA and LPG suppliers. The apportioning of total fuel consumption statistics, to determine regional consumption, was made according to statistical information provided by the ABS. This domestic survey information collected by the ABS identified that 78% of total LPG use was in regional areas. LPG consumption within each of the regional airsheds was further apportioned according to the distribution of housing within each airshed.

Regional emissions were calculated according to the methodology described in the Gas EET manual[28]. Total domestic gas fuel emissions, representing the use of natural and/or LPG gas, are presented in Table 20 and Table 21 for each of the major and minor regional airsheds respectively. Total emissions were spatially disaggregated by apportioning emissions among grid squares according to the distribution of housing within the airshed.

Table 20 Domestic gas fuel emissions in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†					
Substance	**Adelaide**	**Barossa**	**Port Lincoln**	**Riverland**	**South East**	**Spencer Gulf**
Arsenic & compounds	0.62	0.0000073		0.000055	0.012	0.011
Benzene	25	3.7	3.2	6.5	9.7	14
Beryllium & compounds	0.019	0.00000022		0.0000016	0.00037	0.00034
Cadmium & compounds	3.4	0.00004		0.0003	0.068	0.062
Chromium (III) compounds	4.4	0.26	0.22	0.46	0.74	1.1
Chromium (VI) compounds	1.8	0.11	0.093	0.19	0.31	0.44
Carbon monoxide	130,000	310	270	570	3,300	3,500
Cobalt & compounds	6.8	1.3	1.1	2.3	3.5	5.2
Copper & compounds	2.8	0.033	0.029	0.058	0.14	0.18
Cyclohexane	340	0.98	0.85	1.7	9.3	10
Formaldehyde (methyl aldehyde)	280	8.6	7.5	15	27	38
n-Hexane	5,600	1.1	0.88	2.3	110	110
Lead & compounds	1.7	0.033	0.029	0.058	0.12	0.16
Manganese & compounds	1.3	0.033	0.029	0.058	0.11	0.15
Mercury & compounds	0.81	0.0000095		0.000071	0.016	0.015
Nickel & compounds	8.4	0.36	0.32	0.64	1.1	1.5
Oxides of nitrogen	300,000	2,300	2,000	4,100	12,000	14,000
Particulate matter < 10 µm	24,000	66	57	120	640	690
Polycyclic aromatic hydrocarbons	2.1	0.000025		0.00019	0.043	0.039
Selenium & compounds	1.8	0.36	0.32	0.64	0.95	1.4
Sulfur dioxide	1,600	0.019		0.14	32	30
Toluene (methylbenzene)	20	1.8	1.6	3.3	5.0	7.4
Total volatile organic compounds	17,000	49	43	90	470	500
Zinc and compounds	92	0.36	0.32	0.65	2.7	3.1

† Emissions to 2 significant figures

Table 21 Domestic gas fuel emissions in the minor regional airsheds

	Emissions per airshed (kg/yr)†										
	BAROSSA		RIVERLAND				SOUTH EAST		SPENCER GULF		
Substance	Lyndoch	Nuriootpa	Barmera	Berri	Loxton	Renmark	Millicent	Mount Gambier	Port Augusta	Port Pirie	Whyalla
Arsenic & compounds	0.00000071	0.0000055	0.0000050	0.0000096	0.0000093	0.000014	0.0015	0.0073		0.0044	0.0069
Benzene	0.35	2.8	0.58	1.1	1.1	1.6	1.2	5.9	3.5	14	14
Beryllium & compounds	0.000000021	0.00000015	0.00000014	0.00000027	0.00000019	0.0000004	0.000046	0.00022		0.00013	0.00021
Cadmium & compounds	0.0000038	0.000030	0.000027	0.000052	0.000051	0.000075	0.0085	0.041		0.024	0.038
Chromium (III) compounds	0.025	0.2	0.041	0.080	0.078	0.11	0.093	0.45	0.25	1.0	1.0
Chromium (VI) compounds	0.010	0.083	0.017	0.033	0.032	0.047	0.039	0.19	0.10	0.43	0.43
Carbon monoxide	30	240	51	100	97	140	410	2,000	300	2,100	2,600
Cobalt & compounds	0.12	0.98	0.21	0.400	0.39	0.57	0.44	2.1	1.3	5.2	5.2
Copper & compounds	0.0031	0.025	0.0052	0.01	0.0099	0.015	0.018	0.085	0.032	0.15	0.16
Cyclohexane	0.093	0.74	0.16	0.30	0.29	0.43	1.2	5.7	0.94	6.2	7.6
Formaldehyde (methyl aldehyde)	0.81	6.5	1.4	2.6	2.5	3.7	3.4	16	8.3	35	36
n-Hexane	0.10	0.81	0.21	0.40	0.39	0.57	14	67	0.98	43	66
Lead & compounds	0.0031	0.025	0.0052	0.010	0.0099	0.015	0.015	0.072	0.032	0.14	0.15
Manganese & compounds	0.0031	0.025	0.0052	0.010	0.0099	0.014	0.014	0.067	0.032	0.14	0.14
Mercury & compounds	0.00000092	0.0000072	0.0000064	0.000012	0.000012	0.000018	0.002	0.0097		0.0057	0.009
Nickel & compounds	0.034	0.27	0.058	0.11	0.11	0.16	0.14	0.66	0.35	1.5	1.5
Oxides of nitrogen	220	1,700	370	720	700	1,000	1,500	7,200	2,200	11,000	12,000
Particulate matter < 10 µm	6.3	50	11	21	21	30	80	390	64	430	520
Polycyclic aromatic hydrocarbons	0.0000023	0.000019	0.000017	0.000033	0.000032	0.000047	0.0054	0.026		0.015	0.024
Selenium & compounds	0.034	0.27	0.058	0.11	0.11	0.16	0.12	0.58	0.35	1.4	1.4
Sulfur dioxide	0.0018	0.014	0.013	0.024	0.024	0.035	4.0	19		11	18
Toluene (methylbenzene)	0.17	1.4	0.30	0.57	0.56	0.82	0.63	3.0	1.8	7.3	7.3
Total volatile organic compounds	4.6	37	8.1	16	15	22	59	290	48	310	380
Zinc and compounds	0.034	0.27	0.058	0.11	0.11	0.16	0.34	1.6	0.35	2.1	2.4

† Emissions to 2 significant figures

3.5 Dry cleaning

Dry cleaning emissions arise from the use of cleaning solvents, trichloroethylene—also known as perchloroethylene (perc)—and small amounts of white spirit. White spirit contains the chemicals xylene and toluene. Tetrachloroethylene, xylene and toluene are individually considered as NPI substances and collectively as VOCs.

Volatile NPI substances are emitted during dry cleaning operations. Solvent is given off by washer, drier, solvent still, cooker, still residue and filter cake storage areas, as well as by leaky pipes, flanges and pumps. These emissions are found to vary depending on equipment type as well as age. Most tetrachloroethylene machines are fitted with recovery plants to recycle solvent, increasing cost savings and worker safety. Emission control can also be improved by good housekeeping (maintaining all equipment and using good operating practices). White spirit machines do not generally employ solvent recovery, because of the already low cost of these petroleum-based solvents as well as the fire hazards associated with collecting the vapours[30].

Dry cleaning emissions of VOCs and individual NPI substances were calculated in accordance with the methodology presented in the *NPI Emissions Estimation Technique Manual for Aggregated Emissions from Dry Cleaning* (Dry cleaning EET manual)[30].

3.5.1 Adelaide airshed—dry cleaning emissions

The activities associated with dry cleaning facilities were determined by conducting a survey of the industry and communicating with the industry president. The dry cleaning survey provided information on the number of active machines at each site, number of active sites, types of machines, solvent type used, volume of solvent and the number of employees. Over 33% of dry cleaning facilities returned completed survey responses. Advice was also sought from the Dry Cleaning Association to determine the accuracy of the estimated number of machines at individual sites[31]. The average volume of perc and white spirit used per machine was determined from the returned survey responses.

Emissions from dry cleaning activities were calculated according to the dry cleaning EET manual[30], which employs a mass balance approach, assuming that all solvent used is eventually emitted to the air during the year, even if it is initially recycled or subjected to other processes. This approach required known volumes of solvent used per facility to be converted to a mass, based on the specific gravity of each solvent. Tetrachloroethylene and white spirits contribute entirely to the total VOCs listed in Table 22. White spirit also contains smaller amounts of the NPI substances toluene and xylene. Total emissions of each NPI substance emitted in the Adelaide airshed from dry cleaning activities are presented in Table 22. Spatial distribution of emissions was made to grid squares according to the location of each dry cleaning facility within the airshed.

3.5.2 Regional airsheds—dry cleaning emissions

Dry cleaning emissions were calculated according to the methodology outlined in Section 3.5.1 for each of the regional airsheds with active dry cleaning facilities. Total emissions from dry cleaning activities within the major regional airsheds are presented in Table 23. Minor regional airsheds have at least one dry cleaning facility. Lyndoch airshed was excluded from the data presented in Table 23 since no active facilities were identified.

Table 22 Dry cleaning emissions in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†					
Substance	**Adelaide**	**Barossa**	**Port Lincoln**	**Riverland**	**South East**	**Spencer Gulf**
Tetrachloroethylene	120,000	700	700	2,800	1,400	2,200
Toluene (methylbenzene)	260	0	0	0	0	0
Xylenes (individual or mixed isomers)	9,600	0	0	0	0	0
Total volatile organic compounds	170,000	700	700	2,800	1,400	2,200

† Emissions to 2 significant figures

Table 23 Dry cleaning emissions in the minor regional airsheds

	Emissions per airshed (kg/yr)†								
	BAROSSA	**RIVERLAND**				**SOUTH EAST**	**SPENCER GULF**		
Substance	**Nuriootpa**	**Barmera**	**Berri**	**Loxton**	**Renmark**	**Mount Gambier**	**Port Augusta**	**Port Pirie**	**Whyalla**
Tetrachloroethylene	700	700	700	700	700	1,400	480	970	700
Toluene (methylbenzene)	0	0	0	0	0	0	0	0	0
Xylenes (individual or mixed isomers)	0	0	0	0	0	0	0	0	0
Total volatile organic compounds	700	700	700	700	700	1,400	480	970	700

† Emissions to 2 significant figures

3.6 Lawn mowing

This section considers domestic lawn mowing only. This includes mowing of the household lawn by individual residents or small contractors. Lawn mowing of parks, schools, and other open spaces is not included in these estimates.

Lawn mowing is considered to contribute a significant amount of VOCs, emitted as exhaust fumes from the mower's engine. There are four types of lawn mowers used in Australia—2-stroke engined mowers, 4-stroke engined mowers, electric mowers and push mowers. Only the first two types emit pollutants to the atmosphere at the point of use[32].

Four-stroke mowers have lower emissions of VOCs, carbon monoxide (CO) and particulate matter less than 10 µm (PM10) than two-stroke mowers, but have higher emissions of oxides of nitrogen (NOx). Fuel type (leaded or unleaded petrol) can also affect emissions, especially for lead and sulfur dioxide (SO_2)[32].

Emissions resulting from lawn mowing will vary depending on factors such as climate, land use, lot size, population demographics and the availability of water in more arid regions[33]. The methodology to estimate emissions in the Adelaide and regional airsheds was in accordance with the *NPI Emissions Estimation Technique Manual for Aggregated Emissions from Domestic Lawn Mowing* (Lawn mowing EET manual)[32].

3.6.1 Adelaide airshed—lawn mowing emissions

Domestic lawn mowing emissions are known to vary by regions due to a variety of factors. A domestic survey, completed by high school students, was used to determine the frequency, duration, lawn mower type and the volume of fuel used for lawn mowing per household annually. These responses were compiled to estimate the average mowing time in hours per household and the volume of fuel used per household for each mower type, 2-stroke or 4-stroke.

The results of the survey found that the use of 2-stroke mowers was greater than that of 4-stroke in all regions. In the Adelaide metropolitan area, over 57% of responses indicated using 2-stroke mowers compared to 31% using 4-stroke. These survey responses were used to estimate the total annual hours of operation of 2-stroke and 4-stroke mowers in the Adelaide airshed. The total annual hours of mower usage were further divided into 2-stroke and 4-stroke, leaded and unleaded fuel respectively.

Emissions were calculated by multiplying the annual hours of operation of each mower type, using leaded or unleaded fuel, by lawn mower emission factors listed in the lawn mowing EET manual[32]. Emission factors were derived from Australian testing data of 29 in-use mowers[32]. The total emissions from domestic lawn mowing, calculated for the Adelaide airshed, are presented in Table 24. Total emissions were disaggregated among the airshed according to the number of homes within each one kilometre square grid.

3.6.2 Regional airsheds—lawn mowing emissions

Lawn mowing emissions within the regional airsheds were calculated as in Section 3.6.1. The activity associated with domestic lawn mowing within the regional airsheds was considered to be significantly different to those in the Adelaide area, especially since the average plot size and water supply would be the major distinguishing factors. Therefore the total hours of operation of each lawn mower type were determined from domestic survey responses received from regional areas only. The regional responses were further segregated into two categories—semi-arid and arid. Survey responses from the areas of Barossa, Riverland and South East were grouped together to estimate the total hours of mower operation in the semi-arid region. The arid region included responses from areas of Spencer Gulf as well as Port Lincoln. Responses from airshed regions individually were insufficient to provide an accurate estimate due to their limited number. Combining the groups into the two categories, arid and semi-arid, provided a more representative estimate.

The annual hours of mower operation per household in the arid and semi-arid regions was used to determine total annual hours of mower operation in each regional airshed. These figures were derived from 71 and 127 survey responses from the semi-arid and arid regions respectively. Total emissions were calculated by multiplying emission factors by the total annual hours of mower operation in each airshed. Table 24 presents the total emissions from lawn mowing calculated for the major regional airsheds; emissions calculated for the minor regional airsheds are listed in Table 25. Total emissions were spatially distributed according to the number of homes in each grid square within the airshed.

Table 24 Lawn mowing (domestic) in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†					
Substance	**Adelaide**	**Barossa**	**Port Lincoln**	**Riverland**	**South East**	**Spencer Gulf**
Benzene	100,000	2,600	4,200	4,600	6,800	19,000
1,3-Butadiene (vinyl ethylene)	13,000	330	530	580	860	2,400
Carbon monoxide	5,600,000	160,000	200,000	280,000	420,000	880,000
Chromium (III) compounds	20	0.48	0.81	0.84	1.2	3.7
Chromium (VI) compounds	8.2	0.20	0.34	0.35	0.52	1.5
Cobalt & compounds	28	0.67	1.1	1.2	1.8	5.2
Copper & compounds	28	0.67	1.1	1.2	1.8	5.2
Cyclohexane	3,200	78	130	140	210	580
Ethylbenzene	24,000	600	980	1,100	1,600	4,400
Formaldehyde (methyl aldehyde)	18,000	460	700	820	1,200	3,200
n-Hexane	5,300	160	160	290	430	720
Lead & compounds	350	9.6	12	17	25	56
Manganese & compounds	28	0.67	1.1	1.2	1.8	5.2
Nickel & compounds	28	0.67	1.1	1.2	1.8	5.2
Oxides of nitrogen	23,000	790	540	1,400	2,100	2,400
Particulate matter < 10 µm	46,000	1,100	1,900	2,000	2,900	8,600
Polycyclic aromatic hydrocarbons	5,500	140	220	240	360	1,000
Styrene (ethenylbenzene)	1,900	46	75	82	120	340
Sulfur dioxide	4,600	130	160	230	340	730
Toluene (methylbenzene)	180,000	4,300	7,100	7,700	11,000	32,000
Total volatile organic compounds	1,900,000	46,000	75,000	82,000	120,000	340,000
Xylenes (individual or mixed isomers)	130,000	3,200	5,200	5,600	8,400	23,000
Zinc and compounds	28	0.67	1.1	1.2	1.8	5.2

† Emissions to 2 significant figures

Table 25 Lawn mowing (domestic) in the minor regional airsheds

	Emissions per airshed (kg/yr)†										
	BAROSSA		**RIVERLAND**				**SOUTH EAST**		**SPENCER GULF**		
Substance	**Lyndoch**	**Nuriootpa**	**Barmera**	**Berri**	**Loxton**	**Renmark**	**Millicent**	**Mount Gambier**	**Port Augusta**	**Port Pirie**	**Whyalla**
Benzene	240	1,900	410	790	780	1,100	850	4,100	4,700	5,000	7,900
1,3-Butadiene (vinyl ethylene)	31	250	52	100	99	140	110	520	590	630	1,000
Carbon monoxide	15,000	120,000	25,000	49,000	48,000	70,000	52,000	250,000	220,000	230,000	370,000
Chromium (III) compounds	0.045	0.36	0.076	0.15	0.14	0.21	0.16	0.76	0.9	0.96	1.5
Chromium (VI) compounds	0.019	0.15	0.032	0.061	0.06	0.087	0.065	0.32	0.37	0.40	0.63
Cobalt & compounds	0.063	0.51	0.11	0.21	0.20	0.30	0.22	1.1	1.3	1.4	2.1
Copper & compounds	0.063	0.51	0.11	0.21	0.20	0.30	0.22	1.1	1.3	1.4	2.1
Cyclohexane	7.4	59	13	24	24	35	30	130	140	150	240
Ethylbenzene	57	450	96	180	180	270	200	960	1,100	1,200	1,800
Formaldehyde (methyl aldehyde)	43	350	74	140	140	200	150	740	780	830	1,300
n-Hexane	15	120	26	51	49	73	54	260	180	190	300
Lead & compounds	0.90	7.2	1.5	2.9	2.9	4.2	3.2	15	14	15	23
Manganese & compounds	0.063	0.51	0.11	0.21	0.20	0.30	0.22	1.1	1.3	1.4	2.1
Nickel & compounds	0.063	0.51	0.11	0.21	0.20	0.30	0.22	1.1	1.3	1.4	2.1
Oxides of nitrogen	74	590	130	240	240	350	260	1,300	590	630	1,000
Particulate matter < 10 µm	110	840	180	340	340	490	370	1,800	2,100	2,300	3,600
Polycyclic aromatic hydrocarbons	13	100	22	42	41	60	45	220	240	260	410
Styrene (ethenylbenzene)	4.0	35	7.4	14	14	20	15	74	83	89	140
Sulfur dioxide	12	98	21	40	39	57	43	210	180	190	300
Toluene (methylbenzene)	410	3,300	690	1,300	1,300	1,900	1,400	6,900	7,800	8,300	13,000
Total volatile organic compounds	4,300	35,000	7,400	14,000	14,000	20,000	15,000	74,000	83,000	89,000	140,000
Xylenes (individual or mixed isomers)	300	2,400	510	980	960	1,400	1,100	5,100	5,700	6,100	9,700
Zinc and compounds	0.063	0.51	0.11	0.21	0.20	0.30	0.22	1.1	1.3	1.4	2.1

† Emissions to 2 significant figures

3.7 Motor vehicle refinishing

Motor vehicle refinishing applies to all paint applications subsequent to those applied by the original manufacturer. Hence emissions result from the use of paints and solvents by spray painters, crash repairers and panel beaters. Primers, topcoats and hardeners used for motor vehicle refinishing contain solvents containing VOCs as well as other NPI identified substances. This source category does not include emissions from motor vehicle manufacturing plants as these are considered to exceed the NPI threshold and are required to provide their own emission estimates.

Most work of motor refinishing is carried out within garages and workshops. However, VOCs are emitted during the application of coatings, the drying phase and from the cleaning of equipment such as spray guns. Chemical reactions may also cause emissions to occur during the refinishing, drying, curing and hardening phases. Particle emissions were considered comparatively small in relation to other emissions since most are generally confined to the workshop or booth. Booths are often fitted with water curtain scrubbers or filter pads that remove most of the particulate matter, therefore particulate emissions were not estimated for this source. However, these filtering techniques are of little benefit in removing VOC emissions.

3.7.1 Adelaide airshed—motor vehicle refinishing emissions

Emissions from motor vehicle refinishing were estimated according to the methodology described in the *NPI Emissions Estimation Technique Manual for Aggregated Emissions from Motor Vehicle Refinishing* (Refinishing EET manual)[34]. The technique for estimating emissions is based on a mass balance approach, which assumes that all solvent purchased in a year is used in that year and that all VOCs in the coating formulation evaporate and are emitted to the atmosphere. This methodology requires that the total consumption and composition of automotive surface coatings within each of the airsheds be known.

The consumption of automotive paints for motor vehicle refinishing was estimated from data provided by the APMF, which compiled a national Automotive Refinishing Sales survey to estimate the consumption and surface coating types over a quarterly period during 1997–98. The total consumption of automotive refinishing paints in the Adelaide airshed was then determined by apportioning from the national total to the airshed according to its population. The total volume of paint used in the Adelaide airshed was estimated as 839,000 L.

The emissions of each NPI substance were calculated by multiplying the volume of each paint type consumed by the corresponding emission factors listed in the EET manual. Table 26 presents the total emissions from motor vehicle refinishing facilities within the Adelaide airshed. These emissions were spatially distributed among the airshed according to the average volume of paint used by each motor refinishing facility, 523 of which were identified using telephone directory listings. Facilities were allocated to grid squares within the Adelaide airshed.

A survey of the motor refinishing facilities within the Adelaide airshed revealed the volume and type of automotive paints used among 12% of the facilities. The survey identified average consumption of automotive refinishing paints and solvents at 1609 L per facility, which correlated well with the average figure of 1604.5 L per facility calculated from the APMF data. The average volume determined from the APMF data was used to apportion the airshed’s emissions among motor refinishing facilities, except for facilities with reported consumption volumes of automotive paints and solvents; these were allocated emissions according to that data.

3.7.2 Regional airshed—motor vehicle refinishing emissions

Emissions for the regional airsheds were calculated according to the methodology in the EET manual[34] and outlined in Section 3.7.1 above. In brief, national automotive refinishing paint consumption data provided by APMF was apportioned according to the population of each airshed. Emissions were calculated from the apportioned paint data and spatially allocated to grid squares depending on the location of each motor refinishing facility. A voluntary survey was administered to motor refinishing facilities within the regional airsheds to determine the total volume of paints and solvents used annually. The 14.5% of respondents were allocated emissions reflecting the reported use of paints and solvents; the remaining facilities were allocated an average volume of paints and solvents, based on the APMF data, for the apportioning of annual emissions of VOC and NPI substances.

The total emissions of VOC and NPI substances in each of the airsheds were calculated by multiplying airshed consumption of automotive paints by the corresponding emission factors listed in the refinishing EET manual. Table 26 presents the total emissions for each of the major regional airsheds. Minor regional airshed emissions are presented in Table 27. As no motor vehicle refinishing activities were located in the minor airshed of Lyndoch, this airshed was excluded from data presented in Table 27.

Table 26 Motor vehicle refinishing emissions in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†					
Substance	**Adelaide**	**Barossa**	**Port Lincoln**	**Riverland**	**South East**	**Spencer Gulf**
Acetone	5,500	79	66	140	200	290
Cyclohexane	840	12	9.9	21	31	44
Ethyl acetate	6,600	94	78	160	240	350
Ethylbenzene	870	12	10	22	32	46
Methyl ethyl ketone	4,500	64	53	110	160	240
Methyl isobutyl ketone	1,600	23	19	41	60	87
Toluene (methylbenzene)	230,000	3,300	2,800	5,900	8,500	12,000
Total volatile organic compounds	600,000	8,600	7,100	15,000	22,000	32,000
Xylenes (individual or mixed isomers)	45,000	640	530	1,100	1,600	2,400

† Emissions to 2 significant figures

Table 27 Motor vehicle refinishing emissions in the minor regional airsheds

	Emissions per airshed (kg/yr)†									
	BAROSSA	**RIVERLAND**				**SOUTH EAST**		**SPENCER GULF**		
Substance	**Nuriootpa**	**Barmera**	**Berri**	**Loxton**	**Renmark**	**Millicent**	**Mount Gambier**	**Port Augusta**	**Port Pirie**	**Whyalla**
Acetone	79	10	41	26	41	52	140	40	110	130
Cyclohexane	12	1.6	6.1	3.9	6.2	7.8	21	6.1	16	19
Ethyl acetate	94	12	47	30	47	64	160	47	130	150
Ethylbenzene	12	1.6	6.5	4.1	6.5	8.2	22	6.3	17	20
Methyl ethyl ketone	64	8.3	33	20	33	42	110	32	89	100
Methyl isobutyl ketone	23	3.0	12	7.6	12	15	41	12	32	38
Toluene (methylbenzene)	3,300	430	1,800	1,100	1,700	2,200	5,800	1,700	4,400	5,200
Total volatile organic compounds	8,600	1,100	4,400	2,800	4,400	5,600	15,000	4,300	12,000	14,000
Xylenes (individual or mixed isomers)	640	84	330	200	330	420	1,100	330	890	1,000

† Emissions to 2 significant figures

3.8 Paved roads

Paved and unpaved roads are considered a major source of atmospheric particulate matter within an airshed[35] due to the suspension or resuspension of loose material on the road surface. The high uncertainty associated with the sparseness of emission factors and activity data for unpaved roads means that even small errors in the estimation technique may have a relatively large impact on the overall particulate emissions inventory[36]. Unpaved roads are generally present within regional airsheds, where road traffic information is often limited. Due to the relatively large uncertainties in estimating particulate emissions and following discussions with other jurisdictions at the Aggregate Air Emission Workshop in Tasmania[37], estimation of unpaved road emissions was excluded from this source category.

The source category of paved roads includes all public road surfaces that have a covering of bitumen or pavers to help reduce base road surface dust. However, when a vehicle travels over a paved road it generates emission of dust and particulate matter by suspension or resuspension of loose material on the road's surface. This material is introduced onto the roads from a variety of activities such as dust fall, litter, erosion from adjacent areas and spillage.

Particulate emissions from paved roads are continually moved and removed; however, due to the size of the particulates, deposition processes lead to a constant supply of loose material. Additionally, particulate matter also arises from exhaust and other emissions directly associated with motor vehicles, but these are included in the total annual emissions from motor vehicles, covered in Section 2.2.

Emissions from paved road surfaces presented in this section were calculated according to the recommended methodology outlined in the *NPI Emissions Estimation Technique Manual for Aggregated Emissions from Paved and Unpaved Roads* (Roads EET manual)[36].

3.8.1 Adelaide airshed—paved road emissions

Paved road emissions within the Adelaide airshed were calculated according to the methodology described in the Roads EET manual[36]. In brief, emissions were calculated by multiplying empirical factors for particle size by the road surface silt loading, the average vehicle weight, and the VKT. The VKT data used in these calculations was derived for estimating motor vehicle emissions in Section 2.2. The average vehicle weight was calculated by averaging the product of average vehicle weight by the VKT fraction for all vehicle classes. The silt loading applied to all paved roads within the Adelaide airshed was based on normal conditions and assuming average daily traffic to be at least 5000 vehicles per day.

Table 28 presents the total annual load of particulate matter and NPI substances from paved roads in the Adelaide airshed. The spatial allocation of emissions was made by apportioning emissions according to the VKTs per grid square within the airshed.

3.8.2 Regional airsheds—paved road emissions

Regional emissions from paved roads were calculated according to the methodology described in the EET manual[36] and detailed in Section 3.8.1. VKT data for each regional airshed was calculated from locally available data or estimated on the basis of road category, as described in regional motor vehicle emissions, Section 2.2.2. Emissions were calculated based on the average weight of vehicles, as determined for the Adelaide airshed, and the silt loading for normal conditions based on high or low average daily traffic, depending on the location. The Barossa and Port Lincoln airsheds were assumed to have average daily traffic of less than 5000 vehicles per day, while the Riverland, South East and Spencer Gulf were assumed to have a high daily traffic (greater than 5000 vehicles per day).

Total annual emissions from paved roads for each of the major regional airsheds are presented in Table 28. Table 29 summarises the emissions from paved roads in each of the minor regional airsheds. Allocation of emissions to grid squares in each airshed was made according to the apportioned VKT data in each grid square.

Table 28 Paved road emissions in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†					
Substance	**Adelaide**	**Barossa**	**Port Lincoln**	**Riverland**	**South East**	**Spencer Gulf**
Antimony & compounds	380	19	8.9	11	21	12
Arsenic & compounds	440	21	10	13	24	14
Cadmium & compounds	560	27	13	16	31	17
Cobalt & compounds	3,400	165	79	100	190	110
Copper & compounds	4,700	230	110	140	260	150
Lead & compounds	28,000	1,400	650	820	1,500	870
Manganese & compounds	23,000	1,100	550	690	1,300	720
Mercury & compounds	470	23	11	14	26	15
Nickel & compounds	2,000	97	47	59	110	62
Particulate matter < 10 µm	5,600,000	270,000	130,000	170,000	310,000	170,000
Selenium & compounds	59	2.9	1.4	1.7	3.3	1.8
Zinc and compounds	28,000	1,300	640	810	1,500	850

† Emissions to 2 significant figures

Table 29 Paved road emissions in the minor regional airsheds

	Emissions per airshed (kg/yr)†										
	BAROSSA		RIVERLAND				SOUTH EAST		SPENCER GULF		
Substance	**Lyndoch**	**Nuriootpa**	**Barmera**	**Berri**	**Loxton**	**Renmark**	**Millicent**	**Mount Gambier**	**Port Augusta**	**Port Pirie**	**Whyalla**
Antimony & compounds	2.0	9.6	0.62	1.3	1.6	1.7	1.2	6.8	2.5	2.1	2.3
Arsenic & compounds	2.3	11	0.71	1.5	1.8	2.0	1.4	7.9	2.9	2.4	2.7
Cadmium & compounds	2.9	14	0.90	1.8	2.3	2.5	1.8	10	3.6	3.0	3.4
Cobalt & compounds	18	85	5.5	11	14	15	11	61	22	18	21
Copper & compounds	25	120	7.6	16	19	21	15	84	31	25	29
Lead & compounds	150	700	45	92	120	130	88	500	180	150	170
Manganese & compounds	120	590	38	77	96	110	74	420	150	130	140
Mercury & compounds	2.5	12	0.76	1.6	1.9	2.1	1.5	8.4	3.1	2.5	2.9
Nickel & compounds	10	50	3.2	6.6	8.2	9.0	6.3	36	13	11	12
Particulate matter < 10 µm	29,000	140,000	9,100	19,000	23,000	26,000	18,000	100,000	37,000	30,000	34,000
Selenium & compounds	0.31	1.5	0.095	0.19	0.24	0.27	0.19	1.0	0.38	0.32	0.36
Zinc and compounds	140	690	44	91	110	120	87	490	180	150	170

† Emissions to 2 significant figures

3.9 Printing and graphic arts

The predominant emissions from the printing and graphic arts industry are VOCs contained in the printing inks, fountain and cleaning solutions. Emissions from the printing industry can also originate from presses, cleaning operations, ink mixing operations and ink storage tanks. However, emissions from storage tanks were not estimated in the studied airsheds.

The term printing includes five basic operations of the printing industry—gravure, offset lithographic, letterpress, flexographic and screen-printing. In the Adelaide airshed the use of gravure and flexographic printing is limited to one and three sites respectively. Offset lithographic and screen-printing were identified as the predominant techniques employed throughout the Adelaide and regional airsheds.

The composition of inks used for each of the printing processes determines the quantity of VOCs and other NPI substances that are emitted. Unfortunately, there is a serious lack of reliable speciation data for the other NPI substances from either local or overseas data[38]. Therefore until more comprehensive and accurate data becomes available emissions estimated in this study reflect total VOCs only.

3.9.1 Adelaide airshed—printing and graphic arts emissions

Printing and graphic arts emissions within the Adelaide airshed were calculated according to the employee-based emission factor approach as described in the *NPI Emissions Estimation Technique Manual for Aggregated Emissions from Printing and Graphic Arts* (Printing EET manual)[38]. The employee-based emission factor was derived locally through a survey of the printing industry that determined local consumption of inks, solvents and cleaning solutions. The survey required participants to indicate the type of process carried out at their facility and describe the solvents used annually. Some survey responses (14%) provided quantities of solvents and inks used together with material safety data sheets as to the composition of these. This information gave the basis for calculating an employee-based emission factor for the printing industry. The employee-based emission factor included the two main printing processes, offset lithographic and screen-printing, which use a range of solvents and inks high in VOCs but also include the use of UV cured inks, which are considerably lower in VOC emissions.

The employee-based emission factor was based on detailed responses from six facilities, three offset lithographic and three screen printers, representing only 6% of the total industry. Other survey responses were not included in this calculation because they were limited or incomplete. The facilities using lithographic printing were all of relatively the same size with a mean and standard deviation of 75±3 employees. Screen-printing facilities were significantly smaller than the lithographic facilities, with 1, 3 and 21 employees respectively. The average emission factor per employee for printing and graphic arts emissions was determined as 193 kg/yr.

The employee-based emission factor derived from local data was found to be 14% higher than the default employee-based emission factor quoted in the Printing EET manual (169 kg/yr)[38]. However, in view of the fact that the default factor was derived from survey information in south-east Queensland and also subject to similar limitations, it may not be the best representation of the South Australian printing industry. Therefore the locally derived employee-based emission factor will be used until more information becomes available.

The employee-based emission factor, together with the average number of printing and graphic arts employees per facility, was used to estimate total airshed emissions. Employee numbers were provided by the ABS for the printing industry during the 1998–99 year. Employee data, together with the number of facilities located within the Adelaide metropolitan area, was used to determine the average number of employees per facility as 9.5 employees. All printing and graphic arts facilities were geo-coded to grid squares within the Adelaide airshed, then emissions were calculated by multiplying the employee-based emission factor by the number of employees per grid square.

Table 30 presents the total emissions of VOCs within the Adelaide airshed. These emission estimates represent the sum of all printing and graphic arts facilities located throughout the airshed.

3.9.2 Regional airsheds—printing and graphic arts emissions

Regional emissions from the printing and graphic art industry were calculated according to the employee-based emission factor technique described in the Printing EET manual[38] and outlined in Section 3.9.1. The same employee-based emission factor used in the Adelaide airshed was applied to all regional airsheds. Employee numbers were estimated from the total reported employee statistics published by the ABS. Printing facilities were identified using telephone listings and located using GIS software to grid squares within each airshed.

Table 30 presents the resulting VOC emissions calculated for each of the major regional airsheds. Total VOC emissions for the minor regional airshed are presented in Table 31. The Lyndoch airshed, with no listed printing and graphic arts facilities was excluded from the data presented in Table 31.

Table 30 Printing and graphic arts emissions in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†					
Substance	**Adelaide**	**Barossa**	**Port Lincoln**	**Riverland**	**South East**	**Spencer Gulf**
Total volatile organic compounds	450,000	36,000	1,500	16,000	18,000	14,000

† Emissions to 2 significant figures

Table 31 Printing and graphic arts emissions in the minor regional airsheds

	Emissions per airshed (kg/yr)†								
	BAROSSA	RIVERLAND			SOUTH EAST		SPENCER GULF		
Substance	**Nuriootpa**	**Berri**	**Loxton**	**Renmark**	**Millicent**	**Mount Gambier**	**Port Augusta**	**Port Pirie**	**Whyalla**
Total volatile organic compounds	36,000	7,100	3,900	4,700	4,300	14,000	2,800	5,600	6,100

† Emissions to 2 significant figures

3.10 Service stations

Service stations are the main suppliers of petrol and related products to road vehicles. These petroleum products contain a mixture of VOCs, including hydrocarbons, oxygenates and halocarbons. Air emissions are generated during the unloading of petrol from tankers to underground storage tanks, by underground storage tank breathing losses and during vehicle refuelling.

The air emissions of various NPI substances were estimated according to the best practice technique described in the *NPI Emissions Estimation Technique Manual for Aggregated Emissions from Service Stations* (Service station EET manual)[39]. These emission estimates reflect fuel sales, fuel composition, fuel handling practices, and vapour control methods employed.

3.10.1 Adelaide airshed—service station emissions

Petrol consumption within the Adelaide airshed was estimated from the 1998–99 national petroleum sales figures supplied by the Australian Institute of Petroleum (AIP)[40]. These figures provided an estimate of leaded, unleaded, premium unleaded, diesel and LPG fuels sold throughout Australia. South Australia's consumption and the consumption of petrol fuels in each airshed were determined by apportioning the national consumption figures, based on population, for each fuel type.

Air emissions of total VOCs from each fuel type were determined using emission factors in the Service station EET manual[39] and the volume of each fuel sold within the airshed. VOC emissions were calculated for all evaporative emissions associated with fuel delivery. Tank refuelling was initially assumed as 100% submerged without vapour recovery. Vapour recovery is a process whereby vapours are returned to the refuelling tanker rather than vented to air. Within the Adelaide airshed, vapour recovery facilities are available at newer service stations and used where available to speed up the process of refuelling. However, since a vapour recovery unit has not yet been installed in South Australia[40], vapours are consequently vented from the tanker to the atmosphere at the tanker depot. Only 30–40% of Mobil-operated service stations use a submerged-with-vapour-recovery filling technique, and venting emissions at the terminal have been included in point source industry emissions calculated by Mobil. Therefore a combination of filling techniques, submerged and submerged-with-vapour-recovery, were included in the current fuel VOC emission estimates. For diesel and LPG fuels, the total throughput was multiplied by the corresponding emission factor in the service station EET manual[39], which accounts for the different filling and venting methods.

The composition of NPI substances in each fuel type was sourced through communications with the major local supplier Mobil[41] and the AIP. Local compositions of petrol were preferred over national data, since petrol products do vary between jurisdictions due to the requirements to regulate volatility to compensate for climate variations[39]. However, local data for all substances was limited and was supplemented by national data. These composition data were provided as a weight fraction of the total VOC emissions of each fuel.

The liquid and vapour composition of petrol fuels was determined in the first instance from the local data provided by Mobil. Some fuel compositions were sourced from AIP, which provided an average of all fuel types used nationally. Vapour compositions of styrene and lead compounds were calculated according to Equation 2 in the Service station EET manual from liquid composition data. The speciation of cyclohexane was determined in a previous study[42]. These compositions were used to determine the amount of each NPI substance in the total volume of fuel used within each airshed.

The total air emissions of each NPI substance were then divided by the total apportioned airshed petrol sales to provide a throughput emission factor for each substance in kg/yr/kL. This enabled simple spatial allocation of emissions among service stations with estimated throughput of fuel. The throughput of fuel at each service station in the Adelaide airshed was calculated by equally dividing the total airshed apportioned petrol sales figure, for all fuels combined, among all operating service stations. Some petroleum distributors provided total throughput for each owned and operated service station as well as the tank filling methods. These were included in the average throughput calculation. Service stations were identified through telephone listings and located using GIS software to each 1 x 1 km square grid. Spatial allocation of air emissions was then determined by multiplying the total throughput in each grid by the calculated throughput emission factor of each NPI substance (kg/yr/kL).

Table 32 presents the total evaporative emissions of petrol product sales from service stations in the Adelaide airshed.

3.10.2 Regional airshed—service station emissions

Regional emissions were calculated using the methodology and data described in Section 3.10.1. The consumption of petrol products within each airshed was determined by apportioning the State petrol sales figures according to the population of each airshed. Emissions were allocated within each airshed assuming that only submerged filling with no vapour recovery was used. The emission estimates of total VOCs and speciated NPI substances were calculated according to the methodology in the EET manual, for the various petrol types used.

The total emissions of each NPI substance were divided by the total petrol sold in each airshed to determine a throughput emission factor in kg/yr/kL, as described in section 3.10.1. The total of all petroleum products sold within each airshed was equally distributed among the operating service stations. However, service stations with reported volumes were assigned known throughput rather than an average. The corresponding throughput data for each service station were allocated to grids within each airshed using GIS software.

Service station emission estimates of NPI substances were calculated by multiplying the total throughput in each grid by the throughput emission factor of each NPI substance (kg/yr/kL). Total emission estimates (Table 32) reflect evaporative emissions from the sales of petrol products from service stations within each of the major regional airsheds. Table 33 lists total air emissions estimated in the various minor regional airsheds.

Table 32 Service stations emissions in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†					
Substance	**Adelaide**	**Barossa**	**Port Lincoln**	**Riverland**	**South East**	**Spencer Gulf**
Benzene	27,000	390	320	690	1,000	1,400
Cumene (1-methylethylbenzene)	2,500	35	29	62	89	130
Cyclohexane	1,700	25	21	44	64	92
Ethylbenzene	1,600	23	19	40	58	84
Lead & compounds	0.41	0.0060	0.0049	0.010	0.015	0.022
n-Hexane	4,300	63	52	110	160	230
Styrene (ethenylbenzene)	45	0.65	0.54	1.1	1.7	2.4
Toluene (methylbenzene)	24,000	350	290	610	890	1,300
Total volatile organic compounds	1,600,000	23,000	19,000	41,000	60,000	86,000
Xylenes (individual or mixed isomers)	8,600	120	100	220	320	460

† Emissions to 2 significant figures

Table 33 Service station emissions in the minor regional airsheds

	Emissions per airshed (kg/yr)†										
	BAROSSA		RIVERLAND				SOUTH EAST		SPENCER GULF		
Substance	**Lyndoch**	**Nuriootpa**	**Barmera**	**Berri**	**Loxton**	**Renmark**	**Millicent**	**Mount Gambier**	**Port Augusta**	**Port Pirie**	**Whyalla**
Benzene	59	330	120	150	110	170	180	630	580	380	320
Cumene (1-methylethylbenzene)	5.3	30	11	14	9.6	15	16	56	54	35	30
Cyclohexane	3.7	21	7.6	9.8	6.8	11	12	40	38	25	21
Ethylbenzene	3.4	19	6.9	8.9	6.2	9.9	11	37	35	23	19
Lead & compounds	0.00089	0.0051	0.0017	0.0022	0.0016	0.0025	0.0028	0.0095	0.0091	0.0059	0.0051
n-Hexane	9.4	53	19	24	17	27	30	100	95	62	53
Styrene (ethenylbenzene)	0.097	0.55	0.19	0.24	0.18	0.27	0.31	1.1	0.99	0.64	0.55
Toluene (methylbenzene)	52	300	110	140	95	150	160	560	540	350	300
Total volatile organic compounds	3,500	20,000	7,100	9,100	6,400	10,000	11,000	38,000	35,000	23,000	20,000
Xylenes (individual or mixed isomers)	19	110	38	49	34	55	59	200	190	120	110

† Emissions to 2 significant figures

3.11 Solid fuel burning (domestic)

Domestic solid fuel burning can significantly contribute to area-based emissions of a range of particulate matter and VOCs. In Australia, the main solid fuel used is wood. Coal and briquettes are also used but to a lesser degree. The quantity and composition of emissions from domestic wood combustion is highly variable and dependent on the type of wood heater used, the characteristics of the wood burnt and the operating methods[43].

There are three main types of wood heaters and stoves used in Australia—open fireplaces, conventional heaters and controlled combustion heaters. Open fireplaces are the least efficient and have the highest emissions; controlled combustion heaters are the most efficient and have the lowest emissions. Emissions from all three heater types were estimated in the Adelaide and regional airsheds.

The density and rates of release of volatile gases can vary significantly from one species of wood to another. It is generally accepted that softwoods (e.g. pine) produce higher particulate emissions than hardwoods (e.g. eucalyptus). However, emission factors for different species of wood are not readily available and therefore general emission factors need to be used.

Emissions from solid fuel combustion are strongly seasonal, and can also vary by the time of day, distance from coast, altitude, age of residence and economic factors. Emissions calculated for this inventory source represent domestic survey responses indicating annual use of solid fuel for heating purposes in metropolitan and regional areas of South Australia. The seasonal and geographical factors have been integrated into the average annual consumption of solid fuel.

3.11.1 Adelaide airshed—solid fuel burning emissions

Domestic solid fuel emissions were calculated according to methodologies described in the *NPI Emissions Estimation Technique Manual for Aggregated Emissions from Domestic Solid Fuel Burning* [43] (Burning EET manual). The information for calculating emissions was sourced through the domestic survey described in Section 1.3 which provided data on the type of solid fuel heating used in the home (open fireplace, pot belly, slow combustion) and the weight of hard wood, soft wood and briquettes burnt annually. The 1387 household surveys returned from participants in the Adelaide metropolitan area indicated that 30% of households used one of the defined solid fuel heaters—open fire (13%), pot belly (3%) or slow combustion (14%). None of the households reported using more than one solid fuel heating type. These responses were transposed to the entire population as a number of solid fuel heaters per household within the Adelaide airshed, giving 56,925 open fires, 11,322 pot belly stoves and 61,013 slow combustion heaters, in the 436,214 households in the Adelaide airshed. Annual emissions were determined from the mass of firewood and briquettes used by the corresponding number of appliances in each airshed.

Total annual solid fuel burning emissions calculated for the Adelaide airshed are presented in Table 34. Annual emissions were spatially allocated to grids on the basis of household distribution data collected during the 1996 census year.

3.11.2 Regional airshed—solid fuel burning emissions

Regional emissions from solid fuel burning were calculated according to the methodologies described in the Burning EET manual[43] and outlined in Section 3.11.1. Regional survey results were used to determine the number and type of appliances used throughout each airshed. The 211 surveys returned indicated that the use of solid fuel heating among the survey population was 74%, 23% using open fires, 7% pot bellies and 45% slow combustion heaters. These statistics together with the quantity of firewood burnt were used to determine the total consumption of firewood per appliance and per household.

The total airshed consumption of hardwoods and softwoods by appliance type was computed with corresponding emission factors relating to the three different heater types. Annual air emissions estimated from solid fuel burning in each of the major regional airsheds are presented in Table 34. Table 35 lists substances annually emitted from solid fuel burning in each of the minor regional airsheds. Spatial allocation of annual emissions was assigned to grids within the airsheds on the basis of housing distribution data.

Table 34 Solid fuel burning (domestic) emissions in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†					
Substance	**Adelaide**	**Barossa**	**Port Lincoln**	**Riverland**	**South East**	**Spencer Gulf**
1,3-Butadiene (vinyl ethylene)	15,000	550	480	980	1,500	2,200
Acetaldehyde	450,000	20,000	17,000	36,000	53,000	79,000
Acetone	330,000	15,000	13,000	26,000	39,000	58,000
Antimony & compounds	9.1	0.50	0.44	0.90	1.3	2.0
Arsenic & compounds	6.8	0.34	0.30	0.60	0.89	1.3
Benzene	85,000	6,300	5,400	11,000	16,000	25,000
Beryllium & compounds	1.2	0.0049	0.0042	0.0086	0.013	0.019
Cadmium & compounds	5.4	0.23	0.20	0.40	0.60	0.89
Carbon disulfide	0.50	0.0020	0.0018	0.0036	0.0054	0.0080
Carbon monoxide	15,000,000	840,000	730,000	1,500,000	2,200,000	3,300,000
Chromium (VI) compounds	110	0.44	0.39	0.79	1.2	1.7
Cobalt & compounds	1.5	0.084	0.073	0.15	0.22	0.33
Cyanide (inorganic) compounds	9.5	0.039	0.034	0.070	0.10	0.15
Di-(2-Ethylhexyl) phthalate (DEHP)	0.28	0.0011	0.0010	0.0020	0.0030	0.0045
Dichloromethane	2.0	0.0083	0.0072	0.015	0.022	0.033
Ethylbenzene	0.36	0.0015	0.0013	0.0026	0.0039	0.0058
Fluoride compounds	570	2.4	2.0	4.2	6.2	9.2
Formaldehyde (methyl aldehyde)	490,000	22,000	19,000	38,000	57,000	85,000
Lead & compounds	58	1.5	1.3	2.6	3.9	5.8
Manganese & compounds	45	1.5	1.3	2.6	3.9	5.8
Mercury & compounds	0.50	0.0020	0.0018	0.0036	0.0054	0.0080
Methyl ethyl ketone	5,200	439	380	780	1,200	1,700
n-Hexane	0.26	0.0011	0.00092	0.0019	0.0028	0.0041
Nickel & compounds	2.1	0.079	0.069	0.14	0.21	0.31
Oxides of nitrogen	180,000	11,000	9,300	19,000	28,000	42,000
Particulate matter < 10 μm	1,500,000	82,000	71,000	140,000	210,000	320,000
Phenol	0.061	0.00025	0.00022	0.00045	0.00066	0.00098
Polycyclic aromatic hydrocarbons	30,000	2,200	1,900	3,900	5,800	8,600
Selenium & compounds	6.5	0.10	0.091	0.19	0.27	0.41
Styrene (ethenylbenzene)	7,400	270	230	480	710	1,100
Sulfur dioxide	60,000	2,000	1,800	3,600	5,300	8,000
Tetrachloroethylene	0.16	0.00067	0.00059	0.0012	0.0018	0.0026
Toluene (methylbenzene)	80,000	4,100	3,500	7,200	11,000	16,000
Total volatile organic compounds	6,000,000	260,000	230,000	470,000	690,000	1,000,000
Xylenes (individual or mixed isomers)	41,000	1,800	1,600	3,300	4,900	7,200
Zinc and compounds	770	39	34	69	100	150

† Emissions to 2 significant figures

Table 35 Solid fuel burning (domestic) emissions in the minor regional airsheds

	Emissions per airshed (kg/yr)†										
	BAROSSA		RIVERLAND				SOUTH EAST		SPENCER GULF		
Substance	**Lyndoch**	**Nuriootpa**	**Barmera**	**Berri**	**Loxton**	**Renmark**	**Millicent**	**Mount Gambier**	**Port Augusta**	**Port Pirie**	**Whyalla**
1,3-Butadiene (vinyl ethylene)	52	420	88	170	170	240	180	880	530	570	900
Acetaldehyde	1,900	15,000	3,200	6,200	6,000	8,900	6,600	32,000	19,000	21,000	33,000
Acetone	1,400	11,000	2,400	4,600	4,500	6,600	4,900	24,000	14,000	15,000	24,000
Antimony & compounds	0.048	0.38	0.081	0.16	0.15	0.22	0.17	0.81	0.49	0.52	0.82
Arsenic & compounds	0.032	0.26	0.054	0.10	0.10	0.15	0.11	0.54	0.33	0.35	0.55
Benzene	590	4,700	1,000	1,900	1,900	2,800	2,100	10,000	6,000	6,400	10,000
Beryllium & compounds	0.00046	0.0037	0.00078	0.0015	0.0015	0.0022	0.0016	0.0078	0.0047	0.005	0.0079
Cadmium & compounds	0.021	0.17	0.036	0.07	0.068	0.10	0.080	0.36	0.22	0.23	0.37
Carbon disulfide	0.00019	0.0015	0.00033	0.00063	0.00061	0.0009	0.00067	0.0033	0.0020	0.0021	0.0033
Carbon monoxide	79,000	630,000	130,000	260,000	250,000	370,000	280,000	1,300,000	810,000	860,000	1,400,000
Chromium (VI) compounds	0.042	0.33	0.071	0.14	0.13	0.20	0.15	0.71	0.43	0.46	0.72
Cobalt & compounds	0.0079	0.063	0.013	0.026	0.025	0.037	0.028	0.13	0.081	0.086	0.14
Cyanide (inorganic) compounds	0.0037	0.030	0.0063	0.012	0.012	0.017	0.013	0.063	0.038	0.040	0.064
Di-(2-Ethylhexyl) phthalate (DEHP)	0.00011	0.00086	0.00018	0.00035	0.00034	0.00051	0.00038	0.0018	0.0011	0.0012	0.0019
Dichloromethane	0.00078	0.0063	0.0013	0.0026	0.0025	0.0037	0.0027	0.013	0.0080	0.0085	0.013
Ethylbenzene	0.00014	0.0011	0.00024	0.00045	0.00044	0.00065	0.00049	0.0024	0.0014	0.0015	0.0024
Fluoride compounds	0.22	1.8	0.38	0.72	0.71	1.0	0.78	3.8	2.3	2.4	3.8
Formaldehyde (methyl aldehyde)	2,000	16,000	3,400	6,600	6,500	9,500	7,100	34,000	21,000	22,000	35,000
Lead & compounds	0.14	1.1	0.24	0.46	0.45	0.66	0.49	2.4	1.4	1.5	2.4
Manganese & compounds	0.10	1.1	0.24	0.46	0.45	0.65	0.49	2.4	1.4	1.5	2.4
Mercury & compounds	0.00019	0.0015	0.00033	0.00063	0.00061	0.00090	0.00067	0.0033	0.0020	0.0021	0.0033
Methyl ethyl ketone	42	330	70	140	130	200	150	710	430	450	720
n-Hexane	0.000099	0.00079	0.00017	0.00032	0.00032	0.00047	0.00035	0.0017	0.001	0.0011	0.0017
Nickel & compounds	0.0074	0.0599	0.013	0.024	0.024	0.035	0.026	0.13	0.076	0.081	0.13
Oxides of nitrogen	1,000	8,000	1,700	3,300	3,200	4,700	3,500	17,000	10,000	11,000	17,000
Particulate matter < 10 µm	7,700	62,000	13,000	25,000	25,000	36,000	27,000	130,000	79,000	84,000	130,000
Phenol	0.000024	0.00019	0.00004	0.000077	0.000076	0.00011	0.000083	0.00040	0.00024	0.00026	0.00041
Polycyclic aromatic hydrocarbons	210	1,700	350	680	660	970	730	3,500	2,100	2,300	3,600
Selenium & compounds	0.0098	0.079	0.017	0.032	0.031	0.046	0.034	0.17	0.10	0.11	0.17
Styrene (ethenylbenzene)	25	200	43	83	81	120	89	430	260	280	440
Sulfur dioxide	190	1,500	320	620	610	900	670	3,200	2,000	2,100	3,300
Tetrachloroethylene	0.000064	0.00051	0.00011	0.00021	0.00020	0.00030	0.00022	0.0011	0.00065	0.00069	0.0011
Toluene (methylbenzene)	380	3,100	650	1,200	1,200	1,800	1,300	6,500	3,900	4,200	6,600
Total volatile organic compounds	25,000	200,000	42,000	81,000	79,000	120,000	87,000	420,000	250,000	270,000	430,000
Xylenes (individual or mixed isomers)	170	1,400	290	570	560	820	610	3,000	1,800	1,900	3,000
Zinc and compounds	3.7	30	6.2	12	12	17	13	62	38	40	64

† Emissions to 2 significant figures

Section 4: Sub-reporting threshold facilities

Sub-reporting threshold facilities represent industrial and commercial facilities that were below the NPI reporting threshold in the reporting year or were above the threshold but did not report because:

- NPI manuals were not published for their industry sector (NPI does not require facilities to report unless a relevant handbook is published)
- the facility elected not to report (1998–99 reporting was not compulsory).

4.1 Fuel combustion

Fuel combustion from sub-reporting threshold facilities includes industrial and commercial facilities that:

- burn less than 400 tonnes of fuel or waste in a year (i.e. facilities that do not trigger the NPI Category 2 thresholds)
- trigger the NPI Category 2a and/or 2b thresholds but fail to submit an annual report.

The consumption of fuels was determined from data provided by local suppliers or compiled by ABARE[16]. The manufacturing and electricity generation industries are the main fuel consumers in urban airsheds when the consumption of residential and commercial sectors is excluded. Electricity generation can also be excluded since operators have reported NPI emissions as part of the above thresholds requirements. This leaves the manufacturing sector as the principal source of aggregated emissions from fuel combustion to be estimated.

Fuel use among the industrial manufacturing sector was assessed according to the market share of each fuel. Black coal, coke and coal by-products all have a market share of more than 10%; however, nearly all of these products have been accounted for by reporting facilities. Natural gas and electricity also exceed 10% of the market fuel share, but only natural gas is considered in this section since emissions occur at place of use. LPG, used to a lesser degree with a market share of around 3%, was also considered a combustion product among the industry sector particularly in airsheds where natural gas is unavailable. Fuel oil combustion emissions were estimated even though the market share of this fuel among the industrial sector was less than 1%.

The commercial sector was defined according to the Australian energy report[16] classification including the total of Divisions F, G, H, J, K, L, M, N, O, P and Q. The dominance of each fuel in the commercial sector was assessed according to each fuel's share of the market. Excluding electricity, natural gas and LPG were considered the dominant fuels with a market share of 84% and 8% respectively. Fuel oil and wood waste both had a market share of less than 1%; however, fuel oil was still estimated using emission factors provided in the *NPI Emissions Estimation Technique Manual for Aggregated Emissions from Fuel Combustion (Sub-Threshold)* (Fuel combustion EET manual)[44].

Manufacturing plants are located in industrial zones, while commercial facilities are usually located near residential areas. Emissions from the industrial and commercial sectors were therefore calculated and allocated to grid squares separately to provide a better representation of area-based emissions. The spatial surrogate for allocating emissions from sub-threshold industrial facilities was the portion of industry within each grid cell (industry density). Overlaying industry numbers by postcode, provided by the ABS, created the gridded industry data per airshed. The industry density for each grid square was calculated by dividing the cell industry total by the total number of industry within the airshed. Commercial emissions were allocated according to the commercial density of each grid square. This data was determined in the same way as the industry density.

4.1.1 Adelaide airshed—fuel combustion emissions

Emissions from sub-reporting threshold facility fuel combustion were calculated using emission factors, according to the methodology described in the fuel combustion EET manual[44].

Natural gas consumption data for the Adelaide and regional airsheds were provided by Origin Energy[29,45]. LPG and fuel oil consumption data were sourced from ABARE[16], and required further computation to apportion data to the respective airshed before calculating emissions. The apportioning of LPG and fuel oil consumption data was made on the basis of the number of commercial and industrial sites within each airshed. Approximately 76% of commercial and industrial sites were located within the Adelaide airshed, thus corresponding to 76% of the total LPG and fuel oil consumed in South Australia. The total consumption of natural gas, LPG and fuel oil within the Adelaide airshed, excludes consumption data accounted for by industry reporters in 1999–2000.

Emission factors from the fuel combustion EET manual[44] were applied to natural gas and fuel oil consumption figures. Emission factors listed in the NPI industrial handbook for combustion in boilers[46] for propane LPG fuel were used to calculate industrial and commercial boiler emissions. Industrial and commercial fuel combustion emissions were spatially allocated according to industrial and commercial zones respectively within the Adelaide airshed. Table 36 presents the total calculated emissions of individual NPI substances from fuel combustion processes of sub-threshold reporting facilities within the Adelaide airshed during 1998–99.

4.1.2 Regional airshed—fuel combustion emissions

The sub-threshold fuel combustion emissions estimated in each of the regional airsheds were made according to the methodology described in the fuel combustion EET manual[44] and reviewed in Section 4.1.1 above.

The data on state consumption of LPG and fuel oil provided by ABARE was allocated to regional airsheds according to the proportion of commercial and industrial sites respectively. Natural gas data supplied to the major regional airsheds was provided by Origin energy. The natural gas pipeline network does not extend to the airsheds of Port Augusta and Port Lincoln, so these airsheds were classified as 'without mains natural gas' and excluded from subsequent natural gas emissions calculation.

A total of 3772 industrial facilities and 10,067 commercial facilities were located outside the Adelaide metropolitan region. These facilities were classified as regional but only a proportion of them were located within the regional airsheds. Of the total regional commercial and industrial facilities only 3.6% and 4.5% respectively were located in the Barossa airshed, 4.5% and 5.3% in the Port Lincoln airshed, 4.9% and 4.9% in the Riverland airshed and 10.3% and 10.8% in the South East airshed. The largest proportion of commercial and industrial facilities was located in the Spencer airshed, with 14.4% and 11.3% respectively. Subsequent fuel consumption data was apportioned to each airshed based on these distributions.

The total annual emissions from fuel combustion at sub-threshold facilities estimated for each of the major regional airsheds is presented in Table 36. Table 37 lists total emissions of all NPI substances estimated in each of the minor airsheds for 1998–99.

Table 36 Sub-threshold fuel combustion emissions in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†					
Substance	**Adelaide**	**Barossa**	**Port Lincoln**	**Riverland**	**South East**	**Spencer Gulf**
Antimony & compounds	2.1	0.0082	0.0097	0.0093	0.020	0.023
Arsenic & compounds	5.7	0.50	0.0025	0.044	3.0	0.078
Benzene	82	9.4	4.9	5.2	41	12
Beryllium & compounds	0.32	0.030	0.000051	0.0025	0.18	0.0044
Cadmium & compounds	29	2.8	0.00074	0.24	17	0.41
Carbon monoxide	2,100,000	200,000	720	18,000	1,200,000	31,000
Chromium (VI) compounds	11	1.0	0.00046	0.087	6.1	0.15
Chromium (III) compounds	24	2.3	0.0011	0.20	14	0.34
Cobalt & compounds	4.5	0.21	0.011	0.028	1.2	0.056
Copper & compounds	23	2.2	0.0032	0.19	13	0.32
Cyclohexane	2,300	220	1.2	19	1,300	35
Ethylbenzene	0.026	0.00010	0.00012	0.00011	0.00024	0.00028
Fluoride compounds	15	0.059	0.069	0.066	0.14	0.16
Formaldehyde (methyl aldehyde)	2,000	200	9.9	25	1,100	51
n-Hexane	47,000	4,500	1.4	380	27,000	660
Hydrochloric acid	140	0.55	0.65	0.62	1.4	1.5
Lead & compounds	13	1.2	0.0028	0.11	7.4	0.19
Manganese & compounds	11	0.95	0.0055	0.085	5.7	0.15
Mercury & compounds	6.8	0.65	0.00022	0.055	3.9	0.095
Nickel & compounds	89	5.4	0.15	0.59	32	1.1
Oxides of nitrogen	2,600,000	250,000	4,500	25,000	1,500,000	47,000
Particulate matter < 10 µm	200,000	19,000	180	1,700	110,000	3,100
Polycyclic aromatic hydrocarbons	18	1.7	0.0022	0.14	10	0.25
Selenium & compounds	0.89	0.060	0.0013	0.0062	0.36	0.012
Sulfur dioxide	200,000	990	880	860	3,300	2,100
Toluene (methylbenzene)	100	10	2.5	3.1	55	7.1
Total volatile organic compounds	140,000	14,000	120	1,300	82,000	2,300
Xylenes (individual or mixed isomers)	0.044	0.00017	0.00020	0.00019	0.00042	0.00047
Zinc and compounds	760	72	0.054	6.1	430	11

† Emissions to 2 significant figures

Table 37 Sub-threshold fuel combustion emissions in the minor regional airsheds

	Emissions per airshed (kg/yr)†										
	BAROSSA		RIVERLAND				SOUTH EAST		SPENCER GULF		
Substance	Lyndoch	Nuriootpa	Barmera	Berri	Loxton	Renmark	Millicent	Mount Gambier	Port Augusta	Port Pirie	Whyalla
Antimony & compounds	0.00019	0.0029	0.00010	0.00085	0.00045	0.00052	0.00011	0.015	0.0055	0.0063	0.0067
Arsenic & compounds	0.012	0.18	0.00048	0.0039	0.0022	0.0026	0.015	2.2	0.0014	0.039	0.036
Benzene	0.22	3.3	0.058	0.50	0.26	0.29	0.21	31	2.9	3.6	3.9
Beryllium & compounds	0.00069	0.010	0.000028	0.00022	0.00012	0.00015	0.00085	0.13	0.000029	0.0023	0.0021
Cadmium & compounds	0.066	0.98	0.0026	0.021	0.012	0.014	0.083	12	0.00042	0.21	0.19
Carbon monoxide	4,700	71,000	190	1,600	860	1,000	6,000	890,000	390	16,000	14,000
Chromium (VI) compounds	0.024	0.36	0.00095	0.0076	0.0042	0.0051	0.030	4.5	0.00026	0.078	0.071
Chromium (III) compounds	0.055	0.82	0.0021	0.017	0.0096	0.012	0.069	10	0.00061	0.18	0.16
Cobalt & compounds	0.0050	0.074	0.00031	0.0025	0.0014	0.0016	0.0061	0.91	0.0063	0.023	0.022
Copper & compounds	0.051	0.77	0.0020	0.016	0.0091	0.011	0.064	9.6	0.0018	0.17	0.15
Cyclohexane	5.1	77	0.21	1.7	0.95	1.1	6.4	960	0.71	17	16
Ethylbenzene	0.0000023	0.000035	0.0000013	0.000010	0.0000055	0.0000063	0.0000015	0.00019	0.000067	0.000076	0.000081
Fluoride compounds	0.0014	0.021	0.00074	0.0061	0.0033	0.0037	0.00075	0.11	0.039	0.045	0.048
Formaldehyde (methyl aldehyde)	4.6	69	0.28	2.3	1.2	1.5	5.6	840	5.7	21	20
n-Hexane	110	1,600	4.2	33	19	22	130	20,000	0.79	340	310
Hydrochloric acid	0.013	0.19	0.0069	0.057	0.031	0.035	0.0069	1.0	0.37	0.42	0.45
Lead & compounds	0.029	0.44	0.0012	0.0095	0.0052	0.0063	0.037	5.5	0.0016	0.096	0.088
Manganese & compounds	0.022	0.34	0.00093	0.0075	0.0042	0.0050	0.028	4.2	0.0032	0.076	0.070
Mercury & compounds	0.015	0.23	0.00060	0.0049	0.0027	0.0032	0.019	2.9	0.00012	0.050	0.045
Nickel & compounds	0.13	1.9	0.0065	0.053	0.029	0.034	0.16	24	0.087	0.50	0.47
Oxides of nitrogen	5,900	89,000	280	2,200	1,200	1,500	7,400	1,100,000	2,500	22,000	20,000
Particulate matter < 10 µm	440	6,600	19	150	85	100	550	83,000	99	1,500	1,400
Polycyclic aromatic hydrocarbons	0.040	0.60	0.0016	0.013	0.0071	0.0086	0.050	7.6	0.0012	0.13	0.12
Selenium & compounds	0.0014	0.021	0.000068	0.00055	0.00030	0.00036	0.0018	0.26	0.00072	0.0053	0.0050
Sulfur dioxide	23	350	9.6	79	42	48	17	2,500	500	590	630
Toluene (methylbenzene)	0.25	3.7	0.034	0.28	0.15	0.17	0.27	41	1.4	2.3	2.3
Total volatile organic compounds	320	4,800	14	110	62	74	400	61,000	72	1,100	1,000
Xylenes (individual or mixed isomers)	0.0000040	0.000060	0.0000021	0.000018	0.0000095	0.000011	0.0000020	0.00032	0.00011	0.00013	0.00014
Zinc and compounds	1.7	25	0.067	0.54	0.30	0.36	2.1	320	0.031	5.5	5.0

† Emissions to 2 significant figures

4.2 Industrial solvents

The air emissions generated from this source category are derived from the use of solvents for degreasing and surface cleaning in the industrial sector. Uses of solvents for other purposes have been estimated under their respective sections such as architectural surface coatings, motor vehicle refinishing, and printing and graphic arts.

Degreasing and surface cleaning prepares the surface for subsequent surface protection processes. The only solvent considered for this purpose is trichloroethylene, which in itself is a NPI substance as well as a total VOC.

Trichloroethylene is used in most industries as a solvent degreaser although its primary use is in the metal working industry. The typical uses of trichloroethylene include:

- airframe and automotive manufacturing
- electronics manufacturing and assembling
- glass fabrication and finishing
- machine parts manufacturing
- mechanical workshops
- repair, overhaul and equipment maintenance.

Three processes of degreasing are generally employed—vapour degreasing, cold degreasing and conveyorised degreasing. For the purpose of these emission calculations, the mass balance method is used to calculate emissions, assuming that total volume of trichloroethylene consumed in an airshed will totally evaporate to the atmosphere, regardless of the degreasing method applied. This approach is further discussed in the *NPI Emissions Estimation Technique Manual for Aggregated Emissions from Use of Industrial Solvents (Sub-Threshold)* (Solvents EET manual)[47].

4.2.1 Adelaide airshed—industrial solvent emissions

Industrial solvent emissions within the Adelaide airshed were calculated in accordance with the Solvents EET manual[47]. Total sales of trichloroethylene solvent for the South Australia market were sourced through two of the major suppliers, Orica Australia Pty Ltd[48] and Consolidated Chemicals Company[49]. The use of trichloroethylene reported by industries providing their own emission calculations was subtracted from the total South Australian supply.

The use of trichloroethylene was attributed to those industries with ANZSIC codes 27 and 28, corresponding to metal product, machinery and equipment manufacture. The proportion of these two industry sectors within the Adelaide airshed was used to scale down State use of trichloroethylene. Assuming the mass balance approach, the entire annual consumption of trichloroethylene solvent was used to estimate the total airshed emissions of each NPI substance.

Total air emissions of trichloroethylene and VOC calculated for the Adelaide airshed are listed in Table 38. Emissions were spatially distributed throughout the airshed among grid squares corresponding to industrial densities for the manufacturing industry only, using GIS software.

4.2.2 Regional airshed—industrial solvent emissions

Regional emissions from the use of trichloroethylene as a degreasing solvent were calculated according to the best practice method described in the Solvents EET manual[47] and outlined in Section 4.2.1.

In brief, the consumption of trichloroethylene within each regional airshed was apportioned according to the number of facilities involved with metal product, machinery and equipment manufacture. Annual emissions were calculated assuming a mass balance approach to determine the total air emissions of trichloroethylene and VOC within each airshed.

Table 38 presents annual emissions estimated from the use of trichloroethylene in each of the major regional airsheds. Minor airshed emissions of NPI substances relating to degreasing solvent use are presented in Table 39. Emissions from this source were spatially distributed to each grid square, in proportion to the located manufacturing industry within each airshed.

Table 38 Sub-threshold industrial solvent emissions in the Adelaide and major regional airsheds

	Emissions per airshed (kg/yr)†					
Substance	**Adelaide**	**Barossa**	**Port Lincoln**	**Riverland**	**South East**	**Spencer Gulf**
Trichloroethylene	100,000	1,400	1,300	2,100	2,800	3,200
Total volatile organic compounds	100,000	1,400	1,300	2,100	2,800	3,200

† Emissions to 2 significant figures

Table 39 Sub-threshold industrial solvent emissions in the minor regional airsheds

	Emissions per airshed (kg/yr)†										
	BAROSSA		RIVERLAND				SOUTH EAST		SPENCER GULF		
Substance	**Lyndoch**	**Nuriootpa**	**Barmera**	**Berri**	**Loxton**	**Renmark**	**Millicent**	**Mount Gambier**	**Port Augusta**	**Port Pirie**	**Whyalla**
Trichloroethylene	33	490	23	180	100	130	14	2,100	890	700	790
Total volatile organic compounds	33	490	23	180	100	130	14	2,100	890	700	790

† Emissions to 2 significant figures

Section 5: Results summary

The results presented in this section provide an overview of all NPI substance emissions by each aggregated source type. The information is provided in the form of tables indicating actual and percentage contributions. Comparisons have been made between airsheds, sources and NPI substances emitted in the Adelaide and each of the major regional airsheds. These are presented according to the following category types: mobile (motor vehicles), mobile (other), area-based, sub-threshold reporting and industry reported sources. Some comparisons are made for the three basic source categories—mobile, area-based and industry.

5.1 Results

5.1.1 Total emissions of NPI substances

The total inventory of NPI substances in the Adelaide airshed is presented in Table 40. This table provides a summary of emissions estimated from aggregate sources as well as industry reported emissions for 1999–2000. The aggregate emissions consist of emissions estimated for 1998–99 from the three main source categories—mobile, area-based and sub-threshold facilities. For comparison purposes, industry reported emissions for 1999–2000 are included as opposed to the 1998–99 data. These were considered more complete than the early version that consisted of preliminary data collected during the implementation period of the NPI. For the latest industry reported data, please refer to the NPI Internet database directly: www.npi.ea.gov.au.

The NPI provides emission estimates for 59 substances in the Adelaide airshed, 58 substances in the South East airshed and 56 substances in the remaining airsheds—Barossa, Port Lincoln, Riverland and Spencer Gulf—from the total list of 90 substances. However, NPI substance emissions were only calculated for those substances where emission factors were available. Substances with no emission data are either not related to the sources studied or emission factors for their estimation were unavailable.

The total NPI substance estimates for the Adelaide airsheds are presented in Table 40. Table 41 indicates the percentage contribution made by individual sources to the total annual emissions of each NPI substance in the Adelaide airshed. These include all aggregate and industry emission sources and the totals for each of the grouped source categories—motor vehicles, other mobile, area-based, sub-threshold and industry reported. The list of substances presented includes only those with actual estimates.

The complete list of NPI substances emitted in the Barossa is presented in Table 42. Emissions from aggregate source emissions are provided separate to those reported by NPI reporting facilities. The percentage contribution made by individual sources to the annual total of each NPI substance is presented in Table 43.

Similarly, total annual estimates of NPI substances for the remaining regional airsheds of Port Lincoln, Riverland, South East and Spencer Gulf are presented in Table 44, Table 46, Table 48 and Table 50 respectively. The proportion each source contributes to the total emissions of each substance within these airsheds is presented in Table 45, Table 47, Table 49 and Table 51.

Table 40 Total emissions of NPI substances in the Adelaide airshed

	NPI substance	Aggregated emissions TOTAL (kg/yr)	Industry reported (1999-2000) TOTAL (kg/yr)	TOTAL (kg/yr†)
1	Carbon monoxide	170,758,037	2,630,353	170,000,000
2	Total volatile organic compounds	36,779,465	2,830,390	40,000,000
3	Oxides of nitrogen	22,010,320	7,713,902	30,000,000
4	Particulate matter < 10 µm	8,138,951	2,907,117	11,000,000
5	Sulfur dioxide	1,186,069	2,059,224	3,200,000
6	Toluene (methylbenzene)	2,578,478	343,699	2,900,000
7	Xylenes (individual or mixed isomers)	1,910,713	511,585	2,400,000
8	Formaldehyde (methyl aldehyde)	989,561	1,204	990,000
9	n-Hexane	882,443	109,416	990,000
10	Benzene	903,316	25,034	930,000
11	Acetaldehyde	588,034		590,000
12	Acetone	525,699	16,010	540,000
13	Cyclohexane	504,703	10,993	520,000
14	Methanol	421,658	21	420,000
15	Ammonia (total)	255,952	14,000	270,000
16	Ethylbenzene	263,525	4,738	270,000
17	Polycyclic aromatic hydrocarbons	63,938	190,175	250,000
18	1,3-Butadiene (vinyl ethylene)	159,792	14	160,000
19	Trichloroethylene	102,222	35,700	140,000
20	Tetrachloroethylene	131,153	61	130,000
21	Methyl ethyl ketone	33,565	72,487	110,000
22	Lead & compounds	64,655	463	65,000
23	Ethylene glycol (1,2-ethanediol)	59,426		59,000
24	Dichloromethane	45,967	110	46,000
25	Styrene (ethenylbenzene)	44,735	600	45,000
26	Fluoride compounds	592	43,471	44,000
27	2-Ethoxyethanol acetate	29,619	8,400	38,000
28	Zinc and compounds	29,656	272	30,000
29	Ethanol	13,670	11,000	25,000
30	Manganese & compounds	23,086	17	23,000
31	Methyl isobutyl ketone	18,853	19	19,000
32	Carbon disulfide	0.50	13,000	13,000
33	Ethylene oxide	7,137		7,100
34	Ethyl acetate	6,600		6,600
35	Cumene (1-methylethylbenzene)	4,900	1,026	5,900
36	Copper & compounds	4,757	13	4,800
37	Cobalt & compounds	3,442	0.0043	3,400
38	Nickel & compounds	2,318	440	2,800
39	Hydrogen sulfide	1,554		1,600
40	Arsenic & compounds	1,342	44	1,400
41	Cadmium & compounds	683	32	720
42	Chromium (III) compounds	668		670
43	Mercury & compounds	479	12	490
44	Chloroform (trichloromethane)	468		470
45	Chromium (VI) compounds	399	30	430
46	Sulfuric acid		424	420
47	Antimony & compounds	394	27	420
48	1,2-Dichloroethane	2.2	350	350
49	Hydrochloric acid	143	173	320
50	Phenol	131	53	180
51	Selenium & compounds	69	4.0	73
52	Biphenyl (1,1′-biphenyl)	10		10
53	Cyanide (inorganic) compounds	9.5		9.5
54	Nickel carbonyl		4.8	4.8
55	Beryllium & compounds	3.3	0.00093	3.3
56	1,2-Dibromoethane		3.2	3.2
57	Nickel subsulfide		0.60	0.60
58	Di-(2-Ethylhexyl) phthalate (DEHP)	0.28		0.28
59	Acrylic acid	0.0019		0.0019

† Total emissions to 2 significant figures

Table 41 Percentage contribution by source to the total emission of NPI substances in the Adelaide airshed

ADELAIDE AIRSHED	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)
		OTHER MOBILE																				
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL SUB-THRESHOLD	Reporting Facilities 1999-2000
Acetaldehyde	22.6	0.4	0.1	0.2	0.1	0.9											76.5	76.5				
Acetone	21.4	0.2				0.2	13.5						1.0				60.9	75.4				3.0
Acrylic acid									100.0									100.0				
Ammonia (total)	94.8																					5.2
Antimony & compounds			0.4		0.2	0.6								90.4			2.2	92.5	0.5		0.5	6.4
Arsenic & compounds		64.0	<0.1		0.1	64.1					<0.1			31.8			0.5	32.3	0.4		0.4	3.2
Benzene	73.8	0.1	<0.1	0.2	<0.1	0.5	0.2		<0.1		<0.1	10.8				2.9	9.2	23.0	<0.1		<0.1	2.7
Beryllium & compounds					54.0	54.0					0.6						36.0	36.6	9.5		9.5	<0.1
Biphenyl (1,1′-biphenyl)								100.0										100.0				
1,3-Butadiene (vinyl ethylene)	81.1	0.6	0.2	0.3	0.2	1.4						8.1					9.4	17.5				<0.1
Cadmium & compounds		11.7	0.1		<0.1	11.9					0.5			78.3			0.8	79.5	4.1		4.1	4.5
Carbon disulfide																	<0.1	<0.1				100.0
Carbon monoxide	84.6	0.5	<0.1	0.1	<0.1	0.7					<0.1	3.2					8.7	12.0	1.2		1.2	1.5
Chloroform (trichloromethane)									100.0									100.0				
Chromium (III) compounds		92.6	<0.1	<0.1	<0.1	92.7					0.7	3.0						3.6	3.6		3.6	
Chromium (VI) compounds		62.4	<0.1	<0.1	<0.1	62.4					0.4	1.9					25.6	28.0	2.5		2.5	7.1
Cobalt & compounds			<0.1	<0.1	<0.1	<0.1					0.2	0.8		98.8			<0.1	99.8	0.1		0.1	<0.1
Copper & compounds			<0.1	<0.1	<0.1	<0.1					<0.1	0.6		98.5				99.2	0.5		0.5	0.3
Cumene (1-methylethylbenzene)								40.5								42.2		82.7				17.3
Cyanide (inorganic) compounds																	100.0	100.0				
Cyclohexane	4.8						91.5	<0.1			<0.1	0.6	0.2			0.3		92.6	0.4		0.4	2.1
1,2-Dibromoethane																						100.0
1,2-Dichloroethane									0.6									0.6				99.4
Dichloromethane							62.4		37.3								<0.1	99.8				0.2
Ethanol							55.4											55.4				44.6
2-Ethoxyethanol acetate							77.9											77.9				22.1
Ethyl acetate													100.0					100.0				
Ethylbenzene	87.7	<0.1	<0.1	0.2	<0.1	0.2		<0.1	0.4			8.9	0.3			0.6	<0.1	10.3	<0.1		<0.1	1.8
Ethylene glycol (1,2-ethanediol)							27.4		72.6									100.0				
Ethylene oxide									100.0									100.0				

Table 41 (cont) Aggregate source contribution to total emissions (%) in the Adelaide airshed

ADELAIDE AIRSHED	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)
		OTHER MOBILE																				
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic / Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL SUB-THRESHOLD	Reporting Facilities 1999-2000
Di-(2-Ethylhexyl) phthalate (DEHP)																	100.0	100.0				
Fluoride compounds									<0.1								1.3	1.3	<0.1		<0.1	98.7
Formaldehyde (methyl aldehyde)	46.9	0.8	0.2	0.2	0.2	1.4			<0.1		<0.1	1.8					49.5	51.4	0.2		0.2	0.1
n-Hexane	31.0		<0.1	<0.1	<0.1	0.1	47.6	<0.1	4.1		0.6	0.5				0.4	<0.1	53.2	4.7		4.7	11.0
Hydrochloric acid									0.3									0.3	42.4		42.4	57.3
Hydrogen sulfide	100.0																					
Lead & compounds	54.2	1.4	<0.1	<0.1	<0.1	1.4					<0.1	0.5		43.0		<0.1	<0.1	43.6	<0.1		<0.1	0.7
Manganese & compounds			<0.1	<0.1	<0.1	<0.1					<0.1	0.1		99.6			0.2	99.9	<0.1		<0.1	<0.1
Mercury & compounds			<0.1		<0.1	<0.1					0.2			95.8			0.1	96.0	1.4		1.4	2.5
Methanol							21.1		78.9									100.0				<0.1
Methyl ethyl ketone									22.5				4.2				4.9	31.6				68.4
Methyl isobutyl ketone							72.4		19.0				8.5					99.9				<0.1
Nickel & compounds		3.0	<0.1	<0.1	3.9	6.9					0.3	1.0		72.5			<0.1	73.9	3.2		3.2	16.0
Nickel carbonyl																						100.0
Nickel subsulfide																						100.0
Oxides of nitrogen	60.0	0.7	1.8	<0.1	1.0	3.5					1.0	<0.1					0.6	1.7	8.8		8.8	26.0
Particulate matter < 10 µm	5.1	1.5	0.1	<0.1	0.2	1.8					0.2	0.4		50.7			13.6	64.9	1.8		1.8	26.3
Phenol		71.2				71.2											<0.1	<0.1				28.8
Polycyclic aromatic hydrocarbons	10.8	0.2	<0.1	<0.1	<0.1	0.3		<0.1			<0.1	2.2					11.8	14.0	<0.1		<0.1	74.8
Selenium & compounds			<0.1		1.5	1.6					2.5			80.4			8.9	91.8	1.2		1.2	5.5
Styrene (ethenylbenzene)	77.4	0.5		0.1	<0.1	0.6		<0.1				4.2				<0.1	16.3	20.6				1.3
Sulfur dioxide	19.7	1.3	0.7	<0.1	6.7	8.8					<0.1	0.1					1.8	2.0	6.0		6.0	63.5
Sulfuric acid																						100.0
Tetrachloroethylene									10.2	89.8							<0.1	100.0				<0.1
Toluene (methylbenzene)	59.3	<0.1	<0.1	0.2	<0.1	0.3	4.1	<0.1	6.9	<0.1	<0.1	6.2	7.9			0.8	2.7	28.6	<0.1		<0.1	11.8
Total volatile organic compounds	43.9	0.1	<0.1	0.1	<0.1	0.4	7.1	0.1	13.5	0.4	<0.1	4.8	1.5		1.2	4.0	15.1	47.9	0.4	0.3	0.6	7.1
Trichloroethylene									0.2									0.2		73.9	73.9	25.9
Xylenes (individual or mixed isomers)	62.6	<0.1	<0.1	<0.1	<0.1	0.2	2.4	<0.1	4.0	0.4		5.4	1.9			0.4	1.7	16.1	<0.1		<0.1	21.1
Zinc and compounds			<0.1	<0.1	<0.1	<0.1					0.3	<0.1		93.6			2.6	96.5	2.5		2.5	0.9
TOTAL SUBSTANCE COUNT (N)	20	22	27	23	30	32	13	10	20	4	24	23	9	12	1	10	36	53	29	1	29	48

Table 42 Total emissions of NPI substances in the Barossa airshed

NPI substance		Aggregated emissions TOTAL (kg/yr)	Industry reported (1999-2000) TOTAL (kg/yr)	TOTAL (kg/yr†)
1	Carbon monoxide	4,036,560	89,000	4,100,000
2	Oxides of nitrogen	735,428	1,134,350	1,900,000
3	Particulate matter < 10 µm	388,064	1,182,760	1,600,000
4	Total volatile organic compounds	863,394	130	860,000
5	Toluene (methylbenzene)	51,813		52,000
6	Xylenes (individual or mixed isomers)	38,770		39,000
7	Formaldehyde (methyl aldehyde)	32,340		32,000
8	Sulfur dioxide	18,098	7,900	26,000
9	Benzene	23,253		23,000
10	Acetaldehyde	22,793	170	23,000
11	Acetone	18,519		19,000
12	n-Hexane	18,371		18,000
13	Cyclohexane	7,638		7,600
14	Methanol	6,070		6,100
15	Ethylbenzene	5,428		5,400
16	Ammonia (total)	5,170		5,200
17	1,3-Butadiene (vinyl ethylene)	3,535		3,500
18	Polycyclic aromatic hydrocarbons	2,917	2.8	2,900
19	Lead & compounds	2,085	28	2,100
20	Trichloroethylene	1,403		1,400
21	Zinc and compounds	1,448		1,400
22	Manganese & compounds	1,137		1,100
23	Styrene (ethenylbenzene)	1,030		1,000
24	Tetrachloroethylene	890		890
25	Ethylene glycol (1,2-ethanediol)	852		850
26	Methyl ethyl ketone	843		840
27	Fluoride compounds	2.6	790.37	790
28	Dichloromethane	660		660
29	2-Ethoxyethanol acetate	430		430
30	Methyl isobutyl ketone	268		270
31	Copper & compounds	233		230
32	Ethanol	194		190
33	Cobalt & compounds	168		170
34	Cumene (1-methylethylbenzene)	138		140
35	Ethylene oxide	100		100
36	Nickel & compounds	104		100
37	Ethyl acetate	94		94
38	Hydrogen sulfide	32		32
39	Mercury & compounds	24	7.4	31
40	Cadmium & compounds	30		30
41	Arsenic & compounds	22	2.3	25
42	Antimony & compounds	19		19
43	Chromium (VI) compounds	1.8	16	18
44	Chloroform (trichloromethane)	6.7		6.7
45	Selenium & compounds	3.4		3.4
46	Chromium (III) compounds	3.1		3.1
47	Nickel carbonyl		1.9	1.9
48	Hydrochloric acid	0.56		0.56
49	Biphenyl (1,1′-biphenyl)	0.43		0.43
50	Cyanide (inorganic) compounds	0.039		0.039
51	Beryllium & compounds	0.035		0.035
52	1,2-Dichloroethane	0.032		0.032
53	Carbon disulfide	0.0020		0.0020
54	Di-(2-Ethylhexyl) phthalate (DEHP)	0.0011		0.0011
55	Phenol	0.00025		0.00025
56	Acrylic acid	0.000027		0.000027

† Total emissions to 2 significant figures

Table 43 Percentage contribution by source to the total emission of NPI substances in the Barossa airshed

BAROSSA AIRSHED (TOTAL)	MOBILE SOURCES (%)						AREA BASED SOURCES (%)													SUB-THRESHOLD FACILITIES (%)			(%)
		OTHER MOBILE																					
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL SUB-THRESHOLD	Reporting Facilities 1999-2000
Acetaldehyde	12.4	-	0.2	-	-	0.2											86.7	86.7				0.7
Acetone	13.5	-		-	-		5.6						0.4				80.5	86.5				
Acrylic acid		-		-	-				100.0									100.0				
Ammonia (total)	100.0	-		-	-																	
Antimony & compounds		-	0.7	-	-	0.7								96.7			2.6	99.3	<0.1		<0.1	
Arsenic & compounds		-	<0.1	-	-						<0.1			87.2			1.4	88.6	2.0		2.0	9.4
Benzene	60.0	-	0.1	-	-	0.1	<0.1		<0.1		<0.1	11.1				1.7	26.9	39.7	<0.1		<0.1	
Beryllium & compounds		-		-	-						<0.1						14.2	14.2	85.8		85.8	
Biphenyl (1,1′-biphenyl)		-		-	-			100.0										100.0				
1,3-Butadiene (vinyl ethylene)	74.6	-	0.7	-	-	0.7						9.3					15.4	24.7				
Cadmium & compounds		-	0.2	-	-	0.2					<0.1			89.8			0.8	90.5	9.3		9.3	
Carbon disulfide		-		-	-												100.0	100.0				
Carbon monoxide	68.7	-	0.1	-	-	0.1					<0.1	3.9					20.2	24.1	4.9		4.9	2.1
Chloroform (trichloromethane)		-		-	-				100.0									100.0				
Chromium (III) compounds		-	0.2	-	-	0.2					8.4	15.6						24.0	75.8		75.8	
Chromium (VI) compounds		-	<0.1	-	-						0.6	1.1					2.5	4.2	5.8		5.8	90.0
Cobalt & compounds		-	<0.1	-	-						0.8	0.4		98.6			<0.1	99.8	0.1		0.1	
Copper & compounds		-	<0.1	-	-						<0.1	0.3		98.7				99.0	0.9		0.9	
Cumene (1-methylethylbenzene)		-		-	-			74.5								25.5		100.0				
Cyanide (inorganic) compounds		-		-	-												100.0	100.0				
Cyclohexane	6.6	-		-	-		89.0	<0.1			<0.1	1.0	0.2			0.3		90.5	2.9		2.9	
1,2-Dichloroethane		-		-	-				100.0									100.0				
Dichloromethane		-		-	-		62.1		37.9								<0.1	100.0				
Ethanol		-		-	-		100.0											100.0				
2-Ethoxyethanol acetate		-		-	-		100.0											100.0				
Ethyl acetate		-		-	-								100.0					100.0				
Ethylbenzene	88.0	-	<0.1	-	-			0.1	0.3			11.0	0.2			0.4	<0.1	12.0	<0.1		<0.1	
Ethylene glycol (1,2-ethanediol)		-		-	-		27.2		72.8									100.0				
Ethylene oxide		-		-	-				100.0									100.0				

Table 43 (cont) Percentage contribution by source to the emissions of NPI substances in the Barossa airshed

BAROSSA AIRSHED (TOTAL)	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)
		OTHER MOBILE																				
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL SUB-THRESHOLD	Reporting Facilities 1999-2000
Di-(2-Ethylhexyl) phthalate (DEHP)		-		-	-												100.0	100.0				
Fluoride compounds		-		-	-				<0.1								0.3	0.3	<0.1		<0.1	99.7
Formaldehyde (methyl aldehyde)	30.0	-	0.4	-	-	0.4			<0.1		<0.1	1.4					67.5	68.9	0.6		0.6	
n-Hexane	34.1	-	0.1	-	-	0.1	36.9	<0.1	3.1		<0.1	0.9				0.3	<0.1	41.2	24.5		24.5	
Hydrochloric acid		-		-	-				2.1									2.1	97.9		97.9	
Hydrogen sulfide	100.0	-		-	-																	
Lead & compounds	34.1	-	<0.1	-	-						<0.1	0.5		64.0		<0.1	<0.1	64.4	<0.1		<0.1	1.3
Manganese & compounds		-	<0.1	-	-						<0.1	<0.1		99.7			0.1	99.9	<0.1		<0.1	
Mercury & compounds		-	<0.1	-	-						<0.1			73.9			<0.1	73.9	2.1		2.1	23.9
Methanol		-		-	-		20.9		79.1									100.0				
Methyl ethyl ketone		-		-	-				40.3				7.6				52.1	100.0				
Methyl isobutyl ketone		-		-	-		72.4		19.0				8.6					100.0				
Nickel & compounds		-	<0.1	-	-						0.3	0.6		93.7			<0.1	94.7	5.2		5.2	
Nickel carbonyl		-		-	-																	100.0
Oxides of nitrogen	23.0	-	2.1	-	-	2.1					0.1	<0.1					0.6	0.7	13.5		13.5	60.7
Particulate matter < 10 µm	0.7	-	<0.1	-	-						<0.1	<0.1		17.4			5.2	22.6	1.2		1.2	75.3
Phenol		-		-	-												100.0	100.0				
Polycyclic aromatic hydrocarbons	19.1	-	0.4	-	-	0.4		0.3			<0.1	4.8					75.2	80.3	<0.1		<0.1	0.1
Selenium & compounds		-	0.1	-	-	0.1					10.7			84.5			3.0	98.1	1.8		1.8	
Styrene (ethenylbenzene)	69.5	-		-	-			<0.1				4.4				<0.1	26.0	30.5				
Sulfur dioxide	51.1	-	6.5	-	-	6.5					<0.1	0.5					7.7	8.2	3.8		3.8	30.4
Tetrachloroethylene		-		-	-				21.3	78.7							<0.1	100.0				
Toluene (methylbenzene)	68.1	-	<0.1	-	-		3.2	<0.1	5.6		<0.1	8.2	6.3			0.7	7.9	31.9	<0.1		<0.1	
Total volatile organic compounds	40.9	-	0.2	-	-	0.2	4.6	0.3	8.9	<0.1	<0.1	5.3	1.0		4.1	2.7	30.1	57.0	1.6	0.2	1.8	<0.1
Trichloroethylene		-		-	-				0.2									0.2		99.8	99.8	
Xylenes (individual or mixed isomers)	79.4	-	<0.1	-	-		2.2	<0.1	3.6			8.2	1.6			0.3	4.6	20.5	<0.1		<0.1	
Zinc and compounds		-	<0.1	-	-						<0.1	<0.1		92.2			2.7	94.9	5.0		5.0	
TOTAL SUBSTANCE COUNT (N)	20	-	27	-	-	27	13	10	20	2	24	23	9	12	1	10	36	53	29	2	30	13

(-) source not available in airshed

Table 44 Total emissions of NPI substances in the Port Lincoln airshed

	NPI substance	Aggregated emissions TOTAL (kg/yr)	Industry reported (1999-2000) TOTAL (kg/yr)	TOTAL (kg/yr†)
1	Carbon monoxide	2,201,640		2,200,000
2	Total volatile organic compounds	589,937	27,370	620,000
3	Oxides of nitrogen	247,625		250,000
4	Particulate matter < 10 µm	219,055		220,000
5	Sulfur dioxide	46,526		47,000
6	Toluene (methylbenzene)	32,712	590	33,000
7	Formaldehyde (methyl aldehyde)	24,535		25,000
8	Xylenes (individual or mixed isomers)	22,183	166	22,000
9	Acetaldehyde	18,448		18,000
10	Benzene	16,018	639	17,000
11	Acetone	14,947		15,000
12	n-Hexane	8,997	355	9,400
13	Cyclohexane	5,972	14	6,000
14	Methanol	4,950		5,000
15	Ethylbenzene	3,041	14	3,100
16	Polycyclic aromatic hydrocarbons	2,401		2,400
17	1,3-Butadiene (vinyl ethylene)	2,255	2.2	2,300
18	Ammonia (total)	2,131		2,100
19	Trichloroethylene	1,303		1,300
20	Tetrachloroethylene	986		990
21	Lead & compounds	860		860
22	Methyl ethyl ketone	713		710
23	Ethylene glycol (1,2-ethanediol)	706		710
24	Styrene (ethenylbenzene)	678		680
25	Dichloromethane	619		620
26	Zinc and compounds	547		550
27	Manganese & compounds	540		540
28	2-Ethoxyethanol acetate	348		350
29	Methyl isobutyl ketone	226		230
30	Ethanol	165		170
31	Ethylene oxide	112		110
32	Copper & compounds	78	12	90
33	Cumene (1-methylethylbenzene)	84		84
34	Ethyl acetate	82		82
35	Chromium (VI) compounds	78		78
36	Nickel & compounds	75		75
37	Cobalt & compounds	71		71
38	Arsenic & compounds	34		34
39	Chromium (III) compounds	17		17
40	Hydrogen sulfide	16		16
41	Cadmium & compounds	13		13
42	Mercury & compounds	11.0		11.0
43	Phenol	9.6		9.6
44	Antimony & compounds	7.9		7.9
45	Chloroform (trichloromethane)	5.5		5.5
46	Fluoride compounds	2.1		2.1
47	Selenium & compounds	2.0		2.0
48	Hydrochloric acid	0.66		0.66
49	Beryllium & compounds	0.41		0.41
50	1,2-Dibromoethane		0.3	0.30
51	Biphenyl (1,1′-biphenyl)	0.21		0.21
52	Cyanide (inorganic) compounds	0.034		0.034
53	1,2-Dichloroethane	0.026		0.026
54	Carbon disulfide	0.0018		0.0018
55	Di-(2-Ethylhexyl) phthalate (DEHP)	0.0010		0.0010
56	Acrylic acid	0.000022		0.000022

† Total emissions to 2 significant figures

Table 45 Percentage contribution by source to the total emission of NPI substances in the Port Lincoln airshed

PORT LINCOLN AIRSHED (TOTAL)	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)
		OTHER MOBILE																				
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL SUB-THRESHOLD	Reporting Facilities 1999-2000
Acetaldehyde	6.2	0.8	<0.1	0.5	0.5	1.9											91.9	91.9				
Acetone	6.6	0.5				0.5	5.7						0.4				86.6	92.8				
Acrylic acid									100.0									100.0				
Ammonia (total)	100.0																					
Antimony & compounds			0.3		1.9	2.2								93.1			4.6	97.7	0.1		0.1	
Arsenic & compounds		67.2	<0.1		1.4	68.6								30.5			0.9	31.4	<0.1			
Benzene	34.6	0.4	<0.1	1.1	0.5	2.0	0.1		<0.1		<0.1	25.1				1.9	32.3	59.5	<0.1			3.8
Beryllium & compounds					99.0	99.0											1.0	1.0	<0.1			
Biphenyl (1,1′-biphenyl)								100.0										100.0				
1,3-Butadiene (vinyl ethylene)	48.2	2.6	0.3	2.0	2.2	7.1						23.4					21.2	44.6				0.1
Cadmium & compounds		14.2	<0.1		0.8	15.0								83.6			1.3	84.9	<0.1			
Carbon disulfide																	100.0	100.0				
Carbon monoxide	54.1	2.6	<0.1	0.8	0.4	3.8					<0.1	9.1					33.0	42.1	<0.1			
Chloroform (trichloromethane)									100.0									100.0				
Chromium (III) compounds		93.4	<0.1	<0.1	0.7	94.1					1.3	4.7						5.9	<0.1			
Chromium (VI) compounds		98.8	<0.1	<0.1	<0.1	98.8					0.1	0.5					0.6	1.2	<0.1			
Cobalt & compounds			<0.1	<0.1	0.4	0.4					1.3	1.3		96.8			<0.1	99.5	<0.1			
Copper & compounds			<0.1	<0.1	0.5	0.5					<0.1	1.0		98.5				99.5	<0.1			
Cumene (1-methylethylbenzene)								54.5								32.2		86.7				13.3
Cyanide (inorganic) compounds																	100.0	100.0				
Cyclohexane	3.5				<0.1		93.5	<0.1			<0.1	2.2	0.2			0.4		96.2	<0.1			0.2
1,2-Dibromoethane																						100.0
1,2-Dichloroethane									100.0									100.0				
Dichloromethane							63.0		37.0								<0.1	100.0				
Ethanol							100.0											100.0				
2-Ethoxyethanol acetate							100.0											100.0				
Ethyl acetate													100.0					100.0				
Ethylbenzene	64.6	0.2	<0.1	1.2	0.2	1.6		0.1	0.4			31.9	0.3			0.6	<0.1	33.4	<0.1			0.5
Ethylene glycol (1,2-ethanediol)							27.8		72.2									100.0				
Ethylene oxide									100.0									100.0				

Table 43 (cont) Percentage contribution by source to the emissions of NPI substances in the Port Lincoln airshed

PORT LINCOLN AIRSHED (TOTAL)	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)
		OTHER MOBILE																				
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL SUB-THRESHOLD	Reporting Facilities 1999-2000
Di-(2-Ethylhexyl) phthalate (DEHP)																	100.0	100.0				
Fluoride compounds									3.7								93.1	96.8	3.2		3.2	
Formaldehyde (methyl aldehyde)	16.0	2.1	0.1	0.6	1.2	4.0			<0.1		<0.1	2.8					77.1	79.9	<0.1			
n-Hexane	27.6		<0.1	0.4	0.9	1.4	59.8	<0.1	5.1		<0.1	1.7				0.6	<0.1	67.1	<0.1			3.8
Hydrochloric acid									1.5									1.5	98.5		98.5	
Hydrogen sulfide	100.0																					
Lead & compounds	30.2	2.4	<0.1	0.1	<0.1	2.5					<0.1	1.2		65.9		<0.1	0.1	67.2	<0.1			
Manganese & compounds			<0.1	<0.1	<0.1						<0.1	0.2		99.6			0.2	100.0	<0.1			
Mercury & compounds			<0.1		0.1	0.1								99.8			<0.1	99.8	<0.1			
Methanol							21.2		78.8									100.0				
Methyl ethyl ketone									39.3				7.4				53.3	100.0				
Methyl isobutyl ketone							73.0		18.6				8.4					100.0				
Nickel & compounds		2.9	<0.1	<0.1	33.1	36.1					0.4	1.5		61.7			<0.1	63.6	0.2		0.2	
Oxides of nitrogen	67.9	0.6	3.5	<0.1	21.4	25.4					0.8	0.2					3.8	4.8	1.8		1.8	
Particulate matter < 10 µm	2.1	1.9	<0.1	<0.1	2.6	4.5					<0.1	0.9		59.9			32.4	93.2	<0.1			
Phenol		100.0				100.0											<0.1					
Polycyclic aromatic hydrocarbons	9.5	1.5	0.1	0.4	<0.1	2.0		0.2				9.2					79.1	88.5	<0.1			
Selenium & compounds			<0.1		12.3	12.3					15.7			67.4			4.5	87.6	<0.1			
Styrene (ethenylbenzene)	47.7	2.1		0.8	<0.1	2.9		<0.1				12.1				<0.1	37.2	49.3				
Sulfur dioxide	11.2	0.2	0.8	<0.1	81.7	82.7					<0.1	0.3					3.9	4.2	1.9		1.9	
Tetrachloroethylene									18.6	81.4							<0.1	100.0				
Toluene (methylbenzene)	43.8	<0.1	<0.1	1.8	0.3	2.1	4.2	<0.1	7.2		<0.1	21.2	8.4			0.9	10.5	52.3	<0.1			1.8
Total volatile organic compounds	23.6	0.5	<0.1	0.8	0.5	1.8	5.3	0.2	10.4	0.1	<0.1	12.1	1.2		0.3	3.1	37.3	69.9	<0.1	0.2	0.2	4.4
Trichloroethylene									0.2									0.2		99.8	99.8	
Xylenes (individual or mixed isomers)	56.9	<0.1	<0.1	0.8	0.2	1.0	3.2	<0.1	4.9			23.2	2.4			0.4	7.1	41.2	<0.1			0.7
Zinc and compounds			<0.1	<0.1	0.1	0.1					<0.1	0.2		94.6			5.0	99.8	<0.1			
TOTAL SUBSTANCE COUNT (N)	20	22	27	23	30	32	13	10	20	2	19	23	9	12	1	10	36	53	29	2	30	10

Table 46 Total emissions of NPI substances in the Riverland airshed

	NPI substance	Aggregated emissions TOTAL (kg/yr)	Industry reported (1999-2000) TOTAL (kg/yr)	TOTAL (kg/yr†)
1	Carbon monoxide	5,566,215	1,000	5,600,000
2	Total volatile organic compounds	1,442,457	22,500	1,500,000
3	Oxides of nitrogen	638,428	3,400	640,000
4	Particulate matter < 10 µm	324,743	93	320,000
5	Toluene (methylbenzene)	94,435	314	95,000
6	Sulfur dioxide	23,415	22,006	45,000
7	Xylenes (individual or mixed isomers)	56,906	83	57,000
8	Formaldehyde (methyl aldehyde)	56,887		57,000
9	Acetaldehyde	43,751		44,000
10	Benzene	40,346	300	41,000
11	Acetone	31,114		31,000
12	n-Hexane	22,445	320	23,000
13	Cyclohexane	12,599	22	13,000
14	Methanol	10,620		11,000
15	Ethylbenzene	8,239	12	8,300
16	1,3-Butadiene (vinyl ethylene)	6,529	0.4	6,500
17	Ammonia (total)	5,933		5,900
18	Polycyclic aromatic hydrocarbons	5,218	1	5,200
19	Tetrachloroethylene	3,140		3,100
20	Trichloroethylene	2,106		2,100
21	Lead & compounds	1,705		1,700
22	Styrene (ethenylbenzene)	1,578		1,600
23	Ethylene glycol (1,2-ethanediol)	1,510		1,500
24	Methyl ethyl ketone	1,490		1,500
25	Dichloromethane	1,150		1,200
26	Zinc and compounds	884		880
27	2-Ethoxyethanol acetate	750		750
28	Manganese & compounds	690		690
29	Methyl isobutyl ketone	477		480
30	Ethanol	346		350
31	Cumene (1-methylethylbenzene)	215	2.2	220
32	Ethylene oxide	180		180
33	Ethyl acetate	160		160
34	Copper & compounds	140		140
35	Cobalt & compounds	104		100
36	Nickel & compounds	61		61
37	Hydrogen sulfide	36		36
38	Cadmium & compounds	17		17
39	Mercury & compounds	14		14
40	Arsenic & compounds	14		14
41	Chloroform (trichloromethane)	12		12
42	Antimony & compounds	12		12
43	Fluoride compounds	4.4		4.4
44	Selenium & compounds	2.6		2.6
45	Chromium (VI) compounds	1.5	0.21	1.7
46	Chromium (III) compounds	1.6		1.6
47	Biphenyl (1,1′-biphenyl)	0.64		0.64
48	Hydrochloric acid	0.64		0.64
49	1,2-Dibromoethane		0.10	0.10
50	Cyanide (inorganic) compounds	0.070		0.070
51	1,2-Dichloroethane	0.055		0.055
52	Beryllium & compounds	0.011		0.011
53	Carbon disulfide	0.0036		0.0036
54	Di-(2-Ethylhexyl) phthalate (DEHP)	0.0020		0.0020
55	Phenol	0.00045		0.00045
56	Acrylic acid	0.000047		0.000047

† Total emissions to 2 significant figures

Table 47 Percentage contribution by source to the total emission of NPI substances in the Riverland airshed

RIVERLAND AIRSHED (TOTAL)	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)
		OTHER MOBILE																				
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL: OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL: SUB-THRESHOLD	Reporting Facilities 1999-2000
Acetaldehyde	8.0	-	<0.1	6.6	3.0	9.6											82.3	82.3				
Acetone	10.0	-					5.8						0.5				83.7	90.0				
Acrylic acid		-							100.0									100.0				
Ammonia (total)	100.0	-																				
Antimony & compounds		-	0.1			0.1								92.4			7.4	99.8	<0.1		<0.1	
Arsenic & compounds		-	<0.1			<0.1					<0.1			95.3			4.4	99.7	0.3		0.3	
Benzene	39.8	-	<0.1	13.4	6.1	19.6	<0.1		<0.1		<0.1	11.2				1.7	26.9	39.9	<0.1		<0.1	0.7
Beryllium & compounds		-									<0.1						77.3	77.3	22.7		22.7	
Biphenyl (1,1′-biphenyl)		-						100.0										100.0				
1,3-Butadiene (vinyl ethylene)	46.6	-	<0.1	20.4	9.3	29.7						8.8					14.9	23.7				<0.1
Cadmium & compounds		-	<0.1			<0.1					<0.1			96.2			2.3	98.6	1.4		1.4	
Carbon disulfide		-															100.0	100.0				
Carbon monoxide	55.8	-	<0.1	8.4	3.7	12.1					<0.1	5.0					26.7	31.7	0.3		0.3	<0.1
Chloroform (trichloromethane)		-							100.0									100.0				
Chromium (III) compounds		-	<0.1	5.4	2.2	7.7					28.4	51.8						80.2	12.1		12.1	
Chromium (VI) compounds		-	<0.1	2.2	0.9	3.1					11.3	20.9					47.1	79.2	5.1		5.1	12.5
Cobalt & compounds		-	<0.1	0.1	<0.1	0.2					2.2	1.2		96.3			0.1	99.8	<0.1		<0.1	
Copper & compounds		-	<0.1	<0.1	<0.1	0.1					<0.1	0.9		98.8				99.7	0.1		0.1	
Cumene (1-methylethylbenzene)		-						70.4								28.6		99.0				1.0
Cyanide (inorganic) compounds		-															100.0	100.0				
Cyclohexane	4.6	-					93.4	<0.1			<0.1	1.1	0.2			0.3		95.1	0.2		0.2	0.2
1,2-Dibromoethane		-																				100.0
1,2-Dichloroethane		-							100.0									100.0				
Dichloromethane		-					62.6		37.4								<0.1	100.0				
Ethanol		-					100.0											100.0				
2-Ethoxyethanol acetate		-					100.0											100.0				
Ethyl acetate		-											100.0					100.0				
Ethylbenzene	66.6	-	<0.1	13.2	5.7	18.9		0.1	0.3			13.2	0.3			0.5	<0.1	14.3	<0.1		<0.1	0.1
Ethylene glycol (1,2-ethanediol)		-					27.2		72.8									100.0				
Ethylene oxide		-							100.0									100.0				

Table 47 (cont) Percentage contribution by source to the emissions of NPI substances in the Riverland airshed

RIVERLAND AIRSHED (TOTAL)	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)
		OTHER MOBILE																				
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL SUB-THRESHOLD	Reporting Facilities 1999-2000
Di-(2-Ethylhexyl) phthalate (DEHP)		-															100.0	100.0				
Fluoride compounds		-							3.8								94.7	98.5	1.5		1.5	
Formaldehyde (methyl aldehyde)	20.6	-	<0.1	7.6	3.5	11.1			<0.1		<0.1	1.4					66.8	68.3	<0.1		<0.1	
n-Hexane	31.7	-	<0.1	5.2	2.4	7.6	51.5	<0.1	4.4		<0.1	1.3				0.5	<0.1	57.7	1.7		1.7	1.4
Hydrochloric acid		-							3.3									3.3	96.7		96.7	
Hydrogen sulfide	100.0	-																				
Lead & compounds	48.3	-	<0.1	2.8	<0.1	2.9					<0.1	1.0		47.6		<0.1	0.2	48.8	<0.1		<0.1	
Manganese & compounds		-	<0.1	<0.1	<0.1	<0.1					<0.1	0.2		99.4			0.4	100.0	<0.1		<0.1	
Mercury & compounds		-	<0.1			<0.1					<0.1			99.6			<0.1	99.6	0.4		0.4	
Methanol		-					20.9		79.1									100.0				
Methyl ethyl ketone		-							40.3				7.4				52.3	100.0				
Methyl isobutyl ketone		-					72.5		18.9				8.6					100.0				
Nickel & compounds		-	<0.1	0.2	<0.1	0.3					1.0	2.0		95.5			0.2	98.7	1.0		1.0	
Oxides of nitrogen	90.3	-	0.9	0.5	<0.1	1.4					0.6	0.2					3.0	3.8	3.9		3.9	0.5
Particulate matter < 10 µm	4.7	-	<0.1	<0.1	<0.1	0.1					<0.1	0.6		50.9			43.1	94.6	0.5		0.5	<0.1
Phenol		-															100.0	100.0				
Polycyclic aromatic hydrocarbons	12.2	-	<0.1	5.7	2.5	8.3		0.2			<0.1	4.6					74.7	79.6	<0.1		<0.1	<0.1
Selenium & compounds		-	<0.1			<0.1					25.0			67.3			7.4	99.7	0.2		0.2	
Styrene (ethenylbenzene)	51.5	-		8.9	3.9	12.8		<0.1				5.2				<0.1	30.4	35.7				
Sulfur dioxide	38.8	-	0.5	1.5	0.4	2.4					<0.1	0.5					7.9	8.4	1.9		1.9	48.4
Tetrachloroethylene		-							10.8	89.2							<0.1	100.0				
Toluene (methylbenzene)	42.9	-	<0.1	17.8	8.2	26.0	3.1	<0.1	5.3		<0.1	8.1	6.2			0.6	7.5	30.8	<0.1		<0.1	0.3
Total volatile organic compounds	27.8	-	<0.1	9.6	4.2	13.8	4.8	0.3	8.9	0.2	<0.1	5.6	1.0		1.1	2.8	32.1	56.7	<0.1	0.1	0.2	1.5
Trichloroethylene		-							0.3									0.3		99.7	99.7	
Xylenes (individual or mixed isomers)	62.1	-	<0.1	9.0	4.2	13.2	2.6	<0.1	4.2			9.7	1.9			0.4	5.7	24.6	<0.1		<0.1	0.1
Zinc and compounds		-	<0.1	<0.1	<0.1	<0.1					<0.1	0.1		91.3			7.8	99.3	0.7		0.7	
TOTAL SUBSTANCE COUNT (N)	20	-	27	23	23	28	13	10	20	2	24	23	9	12	1	10	36	53	29	2	30	16

Table 48 Total emissions of NPI substances in the South East airshed

	NPI substance	Aggregated emissions TOTAL (kg/yr)	Industry reported (1999-2000) TOTAL (kg/yr)	TOTAL (kg/yr†)
1	Carbon monoxide	10,003,038	2,518,690	13,000,000
2	Oxides of nitrogen	2,507,604	381,400	2,900,000
3	Total volatile organic compounds	2,108,955	35,300	2,100,000
4	Particulate matter < 10 µm	669,264	448,880	1,100,000
5	Sulfur dioxide	40,674	215,380	260,000
6	Methanol	15,200	117,000	130,000
7	Toluene (methylbenzene)	123,036	256	120,000
8	Xylenes (individual or mixed isomers)	89,576	65	90,000
9	Formaldehyde (methyl aldehyde)	82,000		82,000
10	n-Hexane	59,900	280	60,000
11	Acetaldehyde	59,917		60,000
12	Benzene	55,505	258	56,000
13	Acetone	47,608		48,000
14	Cyclohexane	19,526	17	20,000
15	Ethylbenzene	12,433	10	12,000
16	Ammonia (total)	11,477		11,000
17	Polycyclic aromatic hydrocarbons	7,472	2,464	9,900
18	1,3-Butadiene (vinyl ethylene)	8,378		8,400
19	Lead & compounds	3,187	41	3,200
20	Trichloroethylene	2,808		2,800
21	Styrene (ethenylbenzene)	2,426		2,400
22	Methyl ethyl ketone	2,230		2,200
23	Ethylene glycol (1,2-ethanediol)	2,190		2,200
24	Zinc and compounds	2,059		2,100
25	Tetrachloroethylene	1,890		1,900
26	Dichloromethane	1,630		1,600
27	Manganese & compounds	1,305		1,300
28	2-Ethoxyethanol acetate	1,080		1,100
29	Methyl isobutyl ketone	690		690
30	Ethanol	500		500
31	Cumene (1-methylethylbenzene)	377	1.2	380
32	Copper & compounds	277	10	290
33	Ethylene oxide	260		260
34	Ethyl acetate	240		240
35	Cobalt & compounds	196	2.0	200
36	Nickel & compounds	148	2.0	150
37	Arsenic & compounds	52	40.9	93
38	Fluoride compounds	6.6	85	92
39	Chromium (VI) compounds	79	7.3	86
40	Hydrogen sulfide	70		70
41	Cadmium & compounds	51	3.0	54
42	Chromium (III) compounds	32	3.1	35
43	Mercury & compounds	30	0.61	31
44	Antimony & compounds	22		22
45	Chloroform (trichloromethane)	17		17
46	Selenium & compounds	4.8		5.0
47	Nickel subsulfide		4.2	4.2
48	Phenol	2.9		2.9
49	Nickel carbonyl		2.0	2.0
50	Hydrochloric acid	1.4		1.4
51	Biphenyl (1,1′-biphenyl)	1.20790481		1.2
52	Beryllium & compounds	0.19		0.19
53	Cyanide (inorganic) compounds	0.10		0.10
54	1,2-Dichloroethane	0.080		0.080
55	Carbon disulfide	0.0054		0.0054
56	Di-(2-Ethylhexyl) phthalate (DEHP)	0.0030		0.0030
57	Polychlorinated dioxins and furans		0.0018	0.0018
58	Acrylic acid	0.000068		0.000068

† Total emissions to 2 significant figures

Table 49 Percentage contribution by source to the total emission of NPI substances in the South East airshed

SOUTH EAST AIRSHED (TOTAL)	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)
		OTHER MOBILE																				
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL: SUB-THRESHOLD	Reporting Facilities 1999-2000
Acetaldehyde	11.4	<0.1		0.6	<0.1	0.6											87.9	87.9				
Acetone	12.8	<0.1					5.5						0.4				81.2	87.1				
Acrylic acid									100.0									100.0				
Ammonia (total)	100.0																					
Antimony & compounds					<0.1									94.1			5.8	99.9	<0.1			
Arsenic & compounds		25.2			<0.1	25.2					<0.1			26.4			1.0	27.3	3.2		3.2	44.2
Benzene	55.6	<0.1		1.2	0.1	1.3	0.1		<0.1		<0.1	12.1				1.8	28.5	42.5	<0.1			0.5
Beryllium & compounds					2.3	2.3					0.2						6.7	6.9	90.8		90.8	
Biphenyl (1,1′-biphenyl)								100.0										100.0				
1,3-Butadiene (vinyl ethylene)	69.6	0.3		1.9	0.2	2.4						10.2					17.8	28.0				
Cadmium & compounds		4.1			<0.1	4.1					0.1			57.8			1.1	59.0	31.3		31.3	5.6
Carbon disulfide																	100.0	100.0				
Carbon monoxide	48.5	0.5		0.5	<0.1	0.9					<0.1	3.3					17.5	20.8	9.6		9.6	20.0
Chloroform (trichloromethane)									100.0									100.0				
Chromium (III) compounds		46.2		<0.1	<0.1	46.2					2.1	3.4						5.5	39.5		39.5	8.8
Chromium (VI) compounds		82.0		<0.1	<0.1	82.0					0.4	0.6					1.4	2.4	7.1		7.1	8.5
Cobalt & compounds				<0.1	<0.1						1.8	0.9		95.6			0.1	98.4	0.6		0.6	1.0
Copper & compounds				<0.1	<0.1						<0.1	0.6		91.3				91.9	4.5		4.5	3.5
Cumene (1-methylethylbenzene)								76.1								23.5		99.7				0.3
Cyanide (inorganic) compounds																	100.0	100.0				
Cyclohexane	5.7						85.9	<0.1			<0.1	1.1	0.2			0.3		87.5	6.7		6.7	0.1
1,2-Dichloroethane									100.0									100.0				
Dichloromethane							61.3		38.6								<0.1	100.0				
Ethanol							100.0											100.0				
2-Ethoxyethanol acetate							100.0											100.0				
Ethyl acetate													100.0					100.0				
Ethylbenzene	84.9	<0.1		1.0	0.1	1.1		0.2	0.3			12.8	0.3			0.5	<0.1	13.9	<0.1			0.1
Ethylene glycol (1,2-ethanediol)							26.9		73.1									100.0				
Ethylene oxide									100.0									100.0				

Table 49 (cont) Percentage contribution by source to the emissions of NPI substances in the South East airshed

SOUTH EAST AIRSHED (TOTAL)	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)
		OTHER MOBILE																				
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL: SUB-THRESHOLD	Reporting Facilities 1999-2000
Di-(2-Ethylhexyl) phthalate (DEHP)																	100.0	100.0				
Fluoride compounds									0.3								6.8	7.0	0.2		0.2	92.8
Formaldehyde (methyl aldehyde)	27.4	0.2		0.6	<0.1	0.8			<0.1		<0.1	1.4					68.8	70.2	1.4		1.4	
n-Hexane	23.0			0.2	<0.1	0.2	27.9	<0.1	2.5		0.2	0.7				0.3	<0.1	31.5	44.7		44.7	0.5
Hydrochloric acid									2.2									2.2	97.8		97.8	
Hydrogen sulfide	100.0																					
Lead & compounds	49.0	0.7		0.1	<0.1	0.9					<0.1	0.8		47.7		<0.1	0.1	48.6	0.2		0.2	1.3
Manganese & compounds				<0.1	<0.1						<0.1	0.1		99.1			0.3	99.6	0.4		0.4	
Mercury & compounds					<0.1						<0.1			85.2			<0.1	85.2	12.8		12.8	2.0
Methanol							2.4		9.1									11.5				88.5
Methyl ethyl ketone									39.0				7.2				53.8	100.0				
Methyl isobutyl ketone							72.5		18.8				8.7					100.0				
Nickel & compounds		1.5		<0.1	<0.1	1.5					0.7	1.2		73.8			0.1	75.8	21.3		21.3	1.3
Nickel carbonyl																						100.0
Nickel subsulfide																						100.0
Oxides of nitrogen	33.5	<0.1		<0.1	<0.1						0.4	<0.1					1.0	1.4	51.8		51.8	13.2
Particulate matter < 10 µm	2.5	0.4		<0.1	<0.1	0.4					<0.1	0.3		27.9			18.8	46.9	10.0		10.0	40.1
Phenol		100.0				100.0											<0.1					
Polychlorinated dioxins and furans																						100.0
Polycyclic aromatic hydrocarbons	12.3	0.1		0.4	<0.1	0.5		0.2			<0.1	3.6					58.4	62.2	0.1		0.1	24.8
Selenium & compounds					<0.1						19.7			67.3			5.6	92.6	7.4		7.4	
Styrene (ethenylbenzene)	64.8	0.2		0.7	<0.1	0.9		<0.1				4.9				<0.1	29.3	34.2				
Sulfur dioxide	12.3	<0.1		<0.1	<0.1						<0.1	0.1					2.1	2.2	1.3		1.3	84.1
Tetrachloroethylene									25.9	74.1							<0.1	100.0				
Toluene (methylbenzene)	63.2	<0.1		1.6	0.2	1.8	3.5	<0.1	6.0		<0.1	8.9	6.9			0.7	8.9	34.8	<0.1			0.2
Total volatile organic compounds	36.5	<0.1		0.8	<0.1	0.8	4.8	0.3	9.3	<0.1	<0.1	5.6	1.0		0.9	2.8	32.2	56.9	3.8	0.1	4.0	1.6
Trichloroethylene									0.3									0.3		99.7	99.7	
Xylenes (individual or mixed isomers)	75.9	<0.1		0.7	<0.1	0.7	2.4	0.1	3.9			9.3	1.8			0.4	5.4	23.3	<0.1			0.1
Zinc and compounds				<0.1	<0.1						0.1	<0.1		74.0			4.9	78.9	21.0		21.0	
TOTAL SUBSTANCE COUNT (N)	20	22	0	23	29	31	13	10	20	2	24	23	9	12	1	10	36	53	29	2	30	27

Table 50 Total emissions of NPI substances in the Spencer Gulf airshed

	NPI substance	Aggregated emissions TOTAL (kg/yr)	Industry reported (1999-2000) TOTAL (kg/yr)	TOTAL (kg/yr†)
1	Carbon monoxide	7,631,626	99,519,000	110,000,000
2	Sulfur dioxide	290,622	60,571,000	61,000,000
3	Oxides of nitrogen	1,305,641	18,997,000	20,000,000
4	Particulate matter < 10 µm	572,057	4,007,500	4,600,000
5	Total volatile organic compounds	2,443,507	15,160	2,500,000
6	Toluene (methylbenzene)	131,264	5,308	140,000
7	Formaldehyde (methyl aldehyde)	106,695		110,000
8	Benzene	65,907	28,227	94,000
9	Acetaldehyde	85,985		86,000
10	Xylenes (individual or mixed isomers)	79,331	2,372	82,000
11	Acetone	65,676		66,000
12	Fluoride compounds	10	58,463	58,000
13	n-Hexane	37,048	219	37,000
14	Lead & compounds	1,766	28,151	30,000
15	Cyclohexane	26,307	22	26,000
16	Methanol	22,700		23,000
17	Polycyclic aromatic hydrocarbons	10,606	2,513	13,000
18	Ethylbenzene	10,704	8.6	11,000
19	1,3-Butadiene (vinyl ethylene)	9,051	0.20	9,100
20	Ammonia (total)	5,676		5,700
21	Methyl ethyl ketone	3,240		3,200
22	Trichloroethylene	3,212		3,200
23	Ethylene glycol (1,2-ethanediol)	3,160		3,200
24	Tetrachloroethylene	2,910		2,900
25	Dichloromethane	2,410		2,400
26	Styrene (ethenylbenzene)	2,354		2,400
27	Arsenic & compounds	64	1,638	1,700
28	2-Ethoxyethanol acetate	1,540		1,500
29	Zinc and compounds	1,027		1,000
30	Methyl isobutyl ketone	997		1,000
31	Manganese & compounds	735		730
32	Ethanol	720		720
33	Ethylene oxide	380		380
34	Cumene (1-methylethylbenzene)	291	3.1	290
35	Ethyl acetate	350		350
36	Nickel & compounds	235		230
37	Chromium (VI) compounds	144	64.442	210
38	Cobalt & compounds	118	41	160
39	Copper & compounds	155		150
40	Cadmium & compounds	24	103.95	130
41	Chromium (III) compounds	38		38
42	Hydrogen sulfide	34		34
43	Mercury & compounds	15	14.75	30
44	Chloroform (trichloromethane)	25		25
45	Antimony & compounds	16		16
46	Phenol	15		15
47	Selenium & compounds	5.1		5.1
48	Beryllium & compounds	2.3		2.3
49	Hydrochloric acid	1.6		1.6
50	Biphenyl (1,1′-biphenyl)	0.68		0.68
51	Cyanide (inorganic) compounds	0.15		0.15
52	1,2-Dichloroethane	0.12		0.12
53	1,2-Dibromoethane		0.10	0.10
54	Carbon disulfide	0.0080		0.0080
55	Di-(2-Ethylhexyl) phthalate (DEHP)	0.0045		0.0045
56	Acrylic acid	0.000099		0.000099

† Total emissions to 2 significant figure

Table 51 Percentage contribution by source to the total emission of NPI substances in the Spencer Gulf airshed

SPENCER GULF AIRSHED (TOTAL)	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)
		OTHER MOBILE																				
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL SUB-THRESHOLD	Reporting Facilities 1999-2000
Acetaldehyde	4.1	0.3	0.4	1.0	2.1	3.8											92.1	92.1				
Acetone	4.7	0.2				0.2	6.0						0.4				88.6	95.0				
Acrylic acid									100.0									100.0				
Ammonia (total)	100.0																					
Antimony & compounds			5.0		7.0	12.0								75.1			12.7	87.8	0.1		0.1	
Arsenic & compounds		2.7	<0.1		0.2	2.9					<0.1			0.8			<0.1	0.8	<0.1			96.2
Benzene	16.6	0.1	0.2	1.8	3.2	5.3	<0.1		<0.1		<0.1	20.1				1.5	26.5	48.1	<0.1			29.9
Beryllium & compounds					99.0	99.0					<0.1						0.8	0.8	0.2		0.2	
Biphenyl (1,1′-biphenyl)								100.0										100.0				
1,3-Butadiene (vinyl ethylene)	32.4	1.2	1.8	4.6	9.5	17.2						26.3					24.1	50.4				0.0
Cadmium & compounds		3.4	0.3		0.6	4.3					<0.1			13.5			0.7	14.2	0.3		0.3	81.2
Carbon disulfide																	100.0	100.0				
Carbon monoxide	2.7	0.1	<0.1	0.1	0.3	0.5					<0.1	0.8					3.1	3.9	<0.1			92.8
Chloroform (trichloromethane)									100.0									100.0				
Chromium (III) compounds		84.4	<0.1	<0.1	2.1	86.5					2.8	9.7						12.5	0.9		0.9	
Chromium (VI) compounds		67.1	<0.1	<0.1	0.1	67.2					0.2	0.7					0.8	1.7	<0.1			31.0
Cobalt & compounds			<0.1	<0.1	1.3	1.3					3.2	3.3		66.2			0.2	72.9	<0.1			25.7
Copper & compounds			0.1	<0.1	1.6	1.7					0.1	3.4		94.6				98.1	0.2		0.2	
Cumene (1-methylethylbenzene)								54.7								44.2		98.9				1.1
Cyanide (inorganic) compounds																	100.0	100.0				
Cyclohexane	2.1				<0.1		94.9	<0.1			<0.1	2.2	0.2			0.3		97.6	0.1		0.1	0.1
1,2-Dibromoethane																						100.0
1,2-Dichloroethane									100.0									100.0				
Dichloromethane							62.2		37.8								<0.1	100.0				
Ethanol							100.0											100.0				
2-Ethoxyethanol acetate							100.0											100.0				
Ethyl acetate													100.0					100.0				
Ethylbenzene	49.4	<0.1	<0.1	3.1	5.0	8.1		0.1	0.5			40.5	0.4			0.8	<0.1	42.3	<0.1			0.1
Ethylene glycol (1,2-ethanediol)							27.2		72.8									100.0				
Ethylene oxide									100.0									100.0				

Table 51 (cont) Percentage contribution by source to the emissions of NPI substances in the Spencer Gulf airshed

SPENCER GULF AIRSHED (TOTAL)	MOBILE SOURCES (%)						AREA BASED SOURCES (%)												SUB-THRESHOLD FACILITIES (%)			(%)
		OTHER MOBILE																				
NPI substance %	Motor vehicles	Aeroplanes	Railways	Recreational boating	Shipping	TOTAL OTHER MOBILE	Architectural surface coatings	Cutback Bitumen	Domestic/ Commercial solvents/ aerosols	Dry Cleaning	Gaseous fuel burning (domestic)	Lawn Mowing	Motor Vehicle Refinishing	Paved Roads	Print Shops / Graphic Arts	Service stations	Solid fuel burning (domestic)	TOTAL AREA BASED	Fuel Combustion	Solvent Use	TOTAL SUB-THRESHOLD	Reporting Facilities 1999-2000
Di-(2-Ethylhexyl) phthalate (DEHP)																	100.0	100.0				
Fluoride compounds									<0.1								<0.1		<0.1			100.0
Formaldehyde (methyl aldehyde)	10.8	0.9	0.9	1.3	3.2	6.2			<0.1		<0.1	3.0					79.9	82.9	<0.1			
n-Hexane	18.7		0.4	1.0	2.2	3.6	66.8	<0.1	5.9		0.3	1.9				0.6	<0.1	75.4	1.8		1.8	0.6
Hydrochloric acid									2.8									2.8	97.2		97.2	
Hydrogen sulfide	100.0																					
Lead & compounds	2.7	0.2	<0.1	<0.1	<0.1	0.2					<0.1	0.2		2.9		<0.1	<0.1	3.1	<0.1			94.0
Manganese & compounds			<0.1	<0.1	<0.1						<0.1	0.7		98.4			0.8	99.9	<0.1			
Mercury & compounds			0.5		0.3	0.8					<0.1			49.1			<0.1	49.1	0.3		0.3	49.7
Methanol							20.7		79.3									100.0				
Methyl ethyl ketone									40.1				7.4				52.5	100.0				
Methyl isobutyl ketone							72.2		19.1				8.7					100.0				
Nickel & compounds		1.9	<0.1	<0.1	68.2	70.1					0.7	2.2		26.4			0.1	29.4	0.5		0.5	
Oxides of nitrogen	3.1	<0.1	1.2	<0.1	1.6	2.8					<0.1	<0.1					0.2	0.2	0.2		0.2	93.6
Particulate matter < 10 µm	0.3	0.2	0.1	<0.1	0.8	1.1					<0.1	0.2		3.8			7.0	11.0	<0.1			87.5
Phenol		100.0				100.0											<0.1					
Polycyclic aromatic hydrocarbons	4.6	0.5	0.6	0.7	1.1	2.9		<0.1			<0.1	7.6					65.6	73.2	<0.1			19.2
Selenium & compounds			0.5		27.5	28.0					28.0			35.8			8.1	71.8	0.2		0.2	
Styrene (ethenylbenzene)	32.9	1.0		1.8	2.9	5.8		<0.1				14.4				0.1	46.7	61.3				
Sulfur dioxide	<0.1	<0.1	<0.1	<0.1	0.4	0.4					<0.1	<0.1					<0.1		<0.1			99.5
Tetrachloroethylene									24.4	75.6							<0.1	100.0				
Toluene (methylbenzene)	28.7	<0.1	0.1	3.9	6.4	10.4	4.5	<0.1	8.0		<0.1	23.3	8.7			0.9	11.6	57.0	<0.1			3.9
Total volatile organic compounds	15.9	0.3	0.4	1.7	3.3	5.7	6.0	0.2	11.4	<0.1	<0.1	13.8	1.3		0.6	3.5	40.7	77.5	<0.1	0.1	0.1	0.6
Trichloroethylene									0.4									0.4		99.6	99.6	
Xylenes (individual or mixed isomers)	41.7	<0.1	<0.1	2.0	3.3	5.3	3.8	<0.1	6.2			27.8	2.9			0.6	8.7	50.0	<0.1			2.9
Zinc and compounds			0.2	<0.1	0.4	0.6					0.3	0.5		82.9			14.6	98.4	1.0		1.0	
TOTAL SUBSTANCE COUNT (N)	20	22	27	23	30	32	13	10	20	2	24	23	9	12	1	10	36	53	29	2	30	22

5.1.2 Spatial distribution of emissions

The distribution of total VOC emissions presented in this section exemplifies the spatial distribution surrogates of the four broad aggregate source category types—motor vehicles, other mobile, area-based and sub-threshold facilities within each airshed studied.

Total VOCs emitted by all aggregate sources, with the exception of paved roads, are an example of the spatial distribution of surrogates common to a range of sources within each airshed. These include VKT, road networks, housing distributions, population distributions, industry distributions, shipping channels or flight paths. Although these spatial distribution surrogates used to apportion total emissions are similar for other NPI substances, the quantity of emissions from each source type will vary.

The Adelaide airshed VOC emissions derived from motor vehicles and other mobile sources are presented in Figure 12 and Figure 13 respectively. Motor vehicle VOC emissions were assigned to the airshed according to the distribution of the road network and the relative VKT on each road type. In Figure 13, the distribution of VOC emissions from other mobile sources, which includes aircraft, railways, recreational boating, shipping and commercial boating, represents the distribution surrogates relative to each source such as flight tracks, railway tracks, coast and shipping channels respectively. Figure 14 represents emissions of VOCs derived from a range of area-based sources that were generally distributed among grid squares in proportion to the relative population or housing density. The distribution of VOC emissions from sub-threshold facilities, presented in Figure 15, was attributed to areas within the airshed zoned as industrial to light commercial.

From these distribution maps the similarity in distribution of area-based source emissions and motor vehicle emissions is clearly evident. Further, the above-mentioned spatial distribution maps indicate the cumulative contribution of each source category to the total inventory emissions estimate, since most sources can coexist in the 1 km square grids.

The principles of spatial distribution of emissions within the regional airsheds is similar to those described for the Adelaide airshed and therefore these are not presented in this report; they can be viewed on the Internet NPI database[1]. The spatial resolution of the major regional airsheds was to 5 km grid squares; this further increases the overlap between sources and the corresponding emission contributions. Minor regional airshed grids, representing the regional townships, provide for greater resolution of emissions, especially those relating to area-based, population distribution surrogates, and are therefore based on 1 km square grids.

[1] www.npi.ea.gov.au

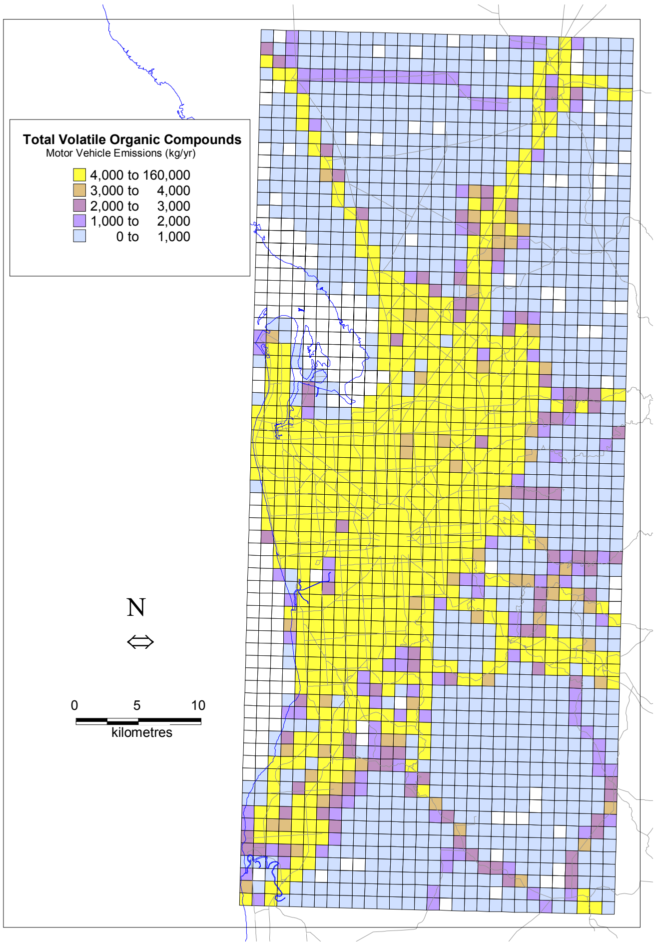


Figure 12 Adelaide airshed—motor vehicle VOC emissions

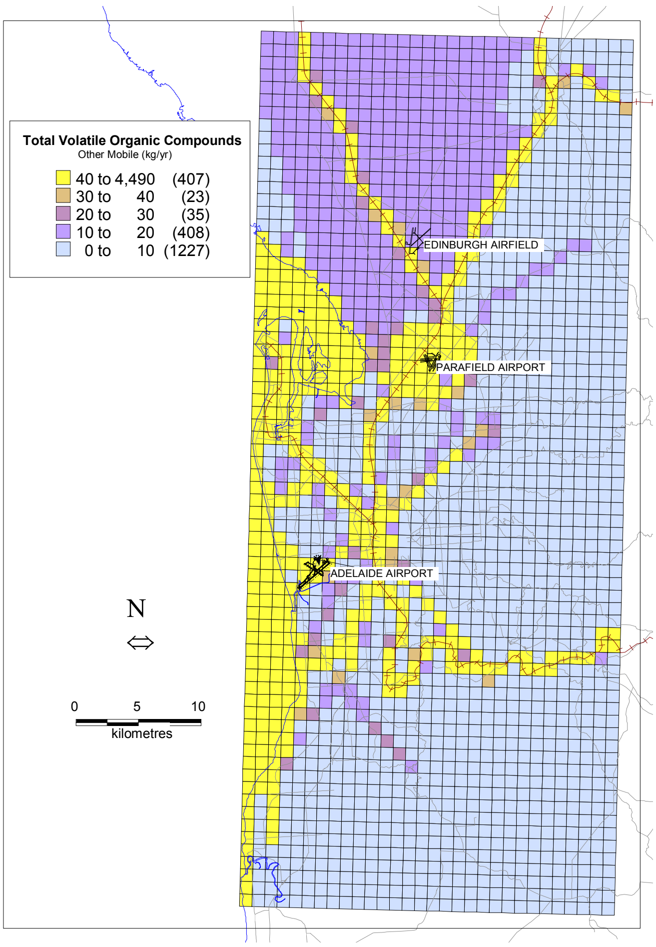


Figure 13 Adelaide airshed—other mobile VOC emissions

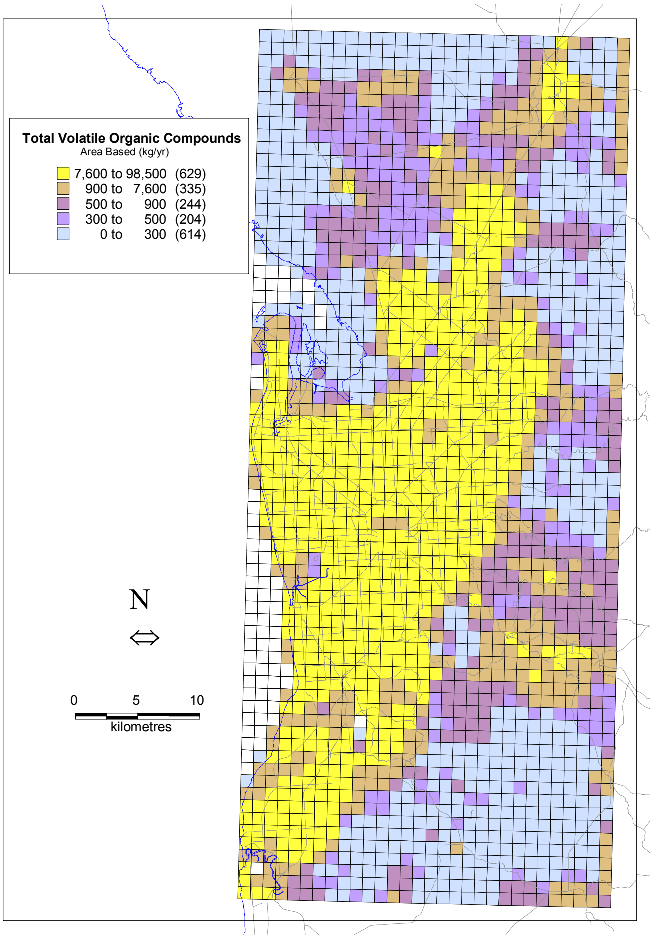


Figure 14 Adelaide airshed—area-based VOC emissions

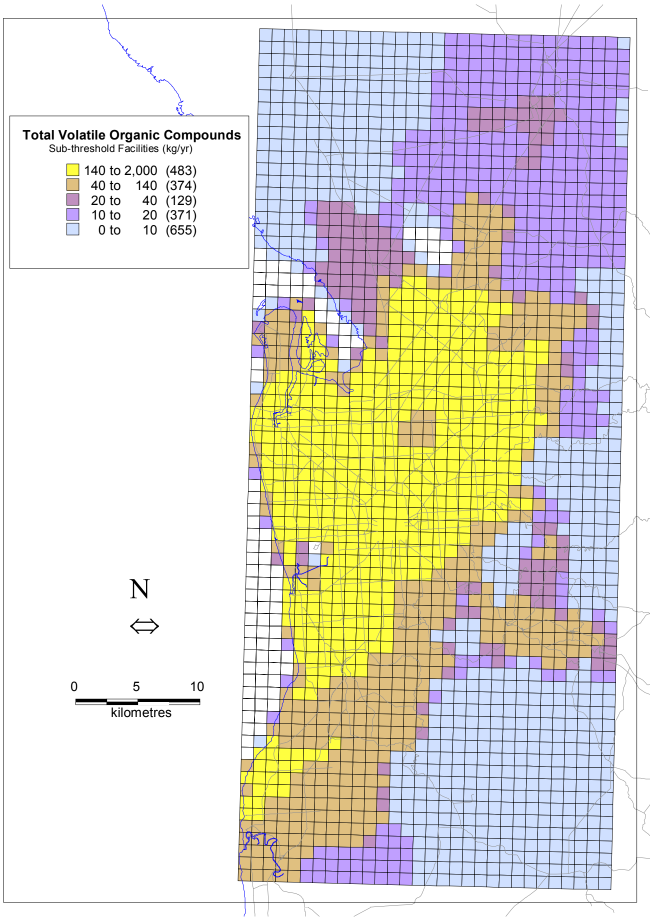


Figure 15 Adelaide airshed—sub-threshold facilities VOC emissions

5.1.3 NPI emission comparisons between emission sources

Emissions of NPI substances ranged over up to 11 orders of magnitude from CO to acrylic acid. The emissions of CO were identified as the highest in each airshed, followed by total volatile organic compounds, NOx, PM10 and SO_2. The order of these substances, in terms of magnitude of substance emitted, varied between airsheds as a result of the dominance of individual sources. For comparative purposes, these contributing sources were grouped according to the following five categories:

- *Mobile – motor vehicles*: includes emissions from all passenger vehicles, four-wheel drives, light vehicles, rigid trucks, articulated trucks, buses, motor cycles and other vehicles.
- *Mobile – other*: includes aircraft and watercraft operating within the airshed. Watercraft include ships, commercial boats and recreational boats.
- *Area-based*: includes emissions from domestic and commercial activities as well as activities associated with road traffic such as cutback bitumen and paved roads.
- *Sub-threshold facilities*: includes emissions from fuel combustion and solvent use by those facilities which were below the reporting threshold.
- *Industry-reported:* includes emissions reported by industries operating above the NPI thresholds. This data is valid for the 1999–2000 reporting year and is used in place of the preliminary 1998–99 data since it includes a more representative sample of the reporting facilities.

In Table 52 the contribution by these five source categories is presented in terms of the percentage of occurrences where each source was the single largest contributor to the emission of NPI substances in an airshed, relative to the number of NPI substances estimated for that source. For example, for motor vehicles in the Adelaide airshed, '60%(20)' means that 60% of the 20 substances emitted by that source were the single largest contributors to the total amount emitted of that substance. This standardisation was necessary to account for the variation in the number of substances emitted by each source.

On a percentage basis and depending on the airshed, more than half of the substances emitted from area-based sources were identified as the largest contributors to the total emissions in all airsheds (Table 52). Motor vehicles were consistently the most dominant single source category, contributing between 25% and 60% of the emitted substances as the single largest contributor to the total emissions in each airshed. The dominance of industry emissions was most seen in the Barossa and Spencer Gulf airsheds, where the combined sources sub-threshold and reporting facilities collectively contributed to largest proportion with more than 40% of the substances emitted by them.

Table 52 Percentage of occurrences where the source was the single largest contributor †

Source category	Adelaide airshed % (N)	Barossa airshed % (N)	Port Lincoln airshed % (N)	Riverland airshed % (N)	South East airshed % (N)	Spencer Gulf airshed % (N)
Mobile – motor vehicles	60% (20)	45% (20)	40% (20)	50% (20)	45% (20)	25% (20)
Mobile – other	16% (32)	0% (27)	16% (32)	0% (28)	10% (31)	16% (32)
Area based	57% (53)	72% (53)	74% (53)	79% (53)	64% (53)	66% (53)
Sub-threshold facilities	3% (30)	13% (30)	10% (30)	7% (30)	17% (30)	7% (30)
Industry reported 1999-2000	23% (48)	38% (13)	10% (13)	13% (16)	26% (27)	41% (22)

† relative to the number of substances emitted by source

(N) number of substances estimated in each source category

The contribution by each source type identified in Table 52 is further compared by airshed in Figure 16, which again demonstrates the dominance of motor vehicle emissions in the Adelaide airshed and area-based emissions in each of the regional airsheds. Within motor vehicles, passenger vehicles were responsible for over 50% of the total emissions estimated. However, a number of substances were dominated by contributions from the diesel fuelled vehicle fleet[7]. For those substances where the area-based source was identified as the largest contributor, the contribution by the subcategory sources is examined in Figure 17. The dominance of the single subcategory source type 'paved roads' was identified in each airshed. While solvent emissions from architectural surface coatings, domestic and commercial solvents and dry cleaning facilities, collectively make up between 43% and 52% of the contributions in each airshed.

Selected substances emitted by the three main source types, mobile, area-based and industry sources, were compared. The area-based source was unchanged from that described previously. However, the sources mobile and industry were constructed by combining mobile—motor vehicles with mobile—other, and sub-threshold with reporting facilities respectively. NPI substances selected for these comparisons include CO, NOx, PM10, SO_2, total VOCs, benzene-toluene-ethylbenzene-xylene (BTEX) compounds and metallic compounds. These substances categorise the complete NPI substance list, as well as individually being significant air pollutants that are monitored by air programs such as the Air NEPM or the Air Toxics Program. BTEX compounds are one group of substances currently being investigated by the Living Cities Air Toxics program. NPI substances included in the group metallic compounds include all those with metalloid properties.

The comparison of percentages of substances emitted within each source shown in Figure 18 indicates a similar profile for mobile and area-based sources in the Adelaide and combined regional airsheds. Industry emissions show the greatest variations in substances emitted in the two airsheds. CO was the dominant substance emitted from all sources except industry in the Adelaide airshed, where NOx was dominant. SO_2 was a major industry emission in both airsheds.

Further comparison between the three sources and their relative contribution to the total emission of each of the selected substances (Figure 19) indicates the difference in contribution between the Adelaide and combined regional airsheds (Figure 20). Comparisons for the five major regional airsheds—Barossa, Port Lincoln, Riverland, South East and Spencer Gulf—are presented in Figure 21 to Figure 25. The profiles of the relative contributions presented in the combined regional airshed closely reflect those identified in Figure 25 of the Spencer Gulf airshed. This indicates the significant contribution of this airshed to the total regional emissions and in particular the dominance of industry emissions of CO, NOx, PM10, SO_2 and metallic compounds on the overall regional totals.

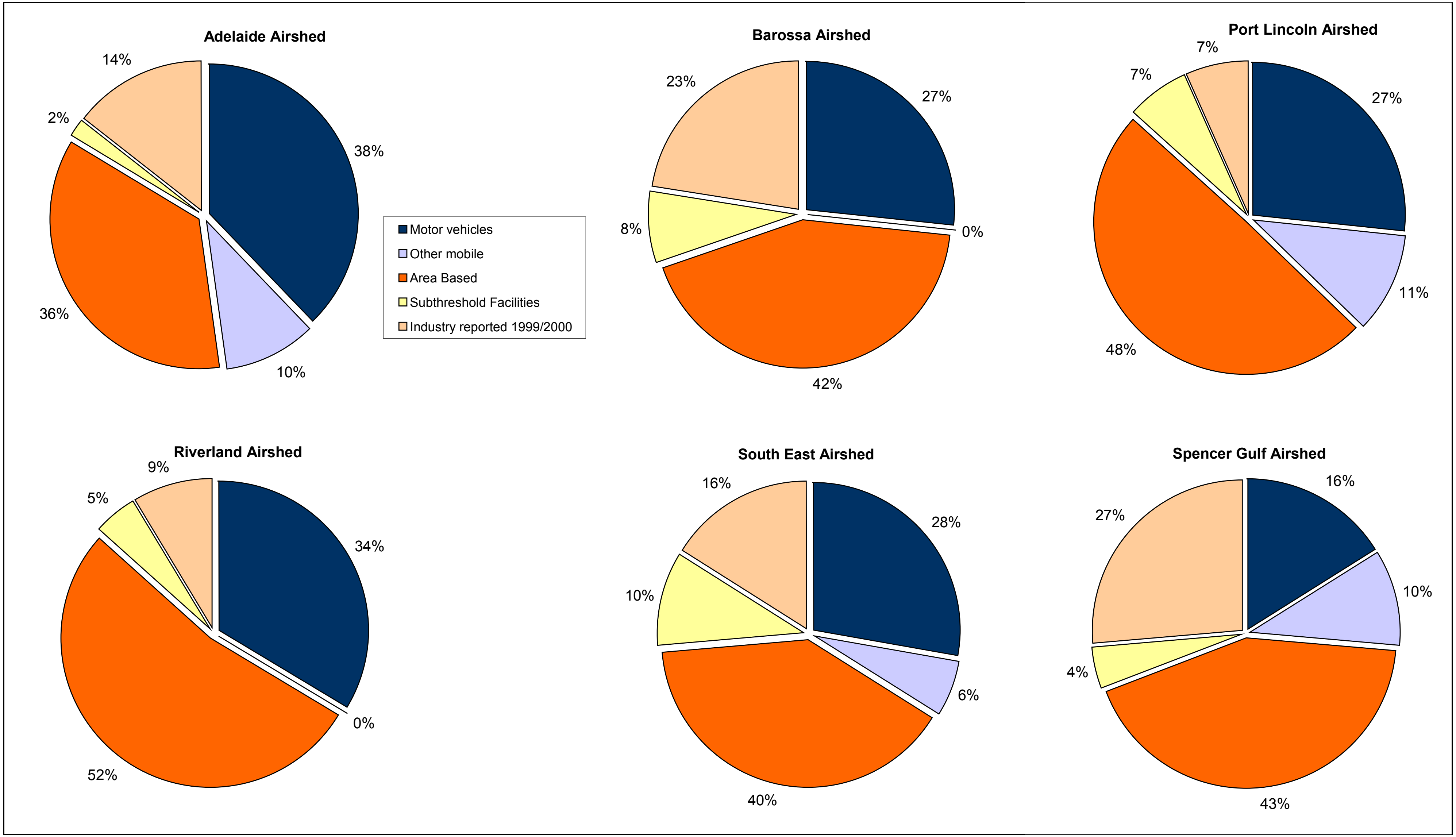
The largest emitters of CO, NOx and BTEX compounds in the Adelaide airshed and some of the regional airsheds were mobile sources. Industry emissions of the selected substances were found to vary between airsheds, with the most dominant sources located in the Adelaide, Barossa, South East and Spencer Gulf airsheds. Emissions of SO_2 in the Adelaide airshed were mostly due to industry and mobile sources; however, the relative contributions of these two sources in the regional airsheds varied significantly, with industry contributions significantly outweighing mobile in the Spencer Gulf airshed. Area-based sources were still the largest source of PM10, VOC and metallic compounds in all airsheds except the Barossa and Spencer Gulf.

In summary, mobile sources were the dominant source of NPI substance emissions in the Adelaide airshed, particularly for CO, NOx and BTEX. Area-based sources were the dominant source of PM10, VOC and metallic compound emissions in the Adelaide and regional airsheds. The contribution from industry in the Adelaide airshed was significantly less than identified in the regional airsheds. Mobile and area-based sources were the dominant source of NPI substances in the Port Lincoln and Riverland airsheds. The contribution from industry in the emission of NOx and PM10 substances was high in the Barossa airshed and SO_2 in South East airsheds. However, the highest contribution by industrial facilities was identified in the Spencer Gulf airsheds, for the total emission estimates of CO, NOx, PM10, SO_2 and metallic compounds.

5.1.4 NPI emission comparisons between airsheds

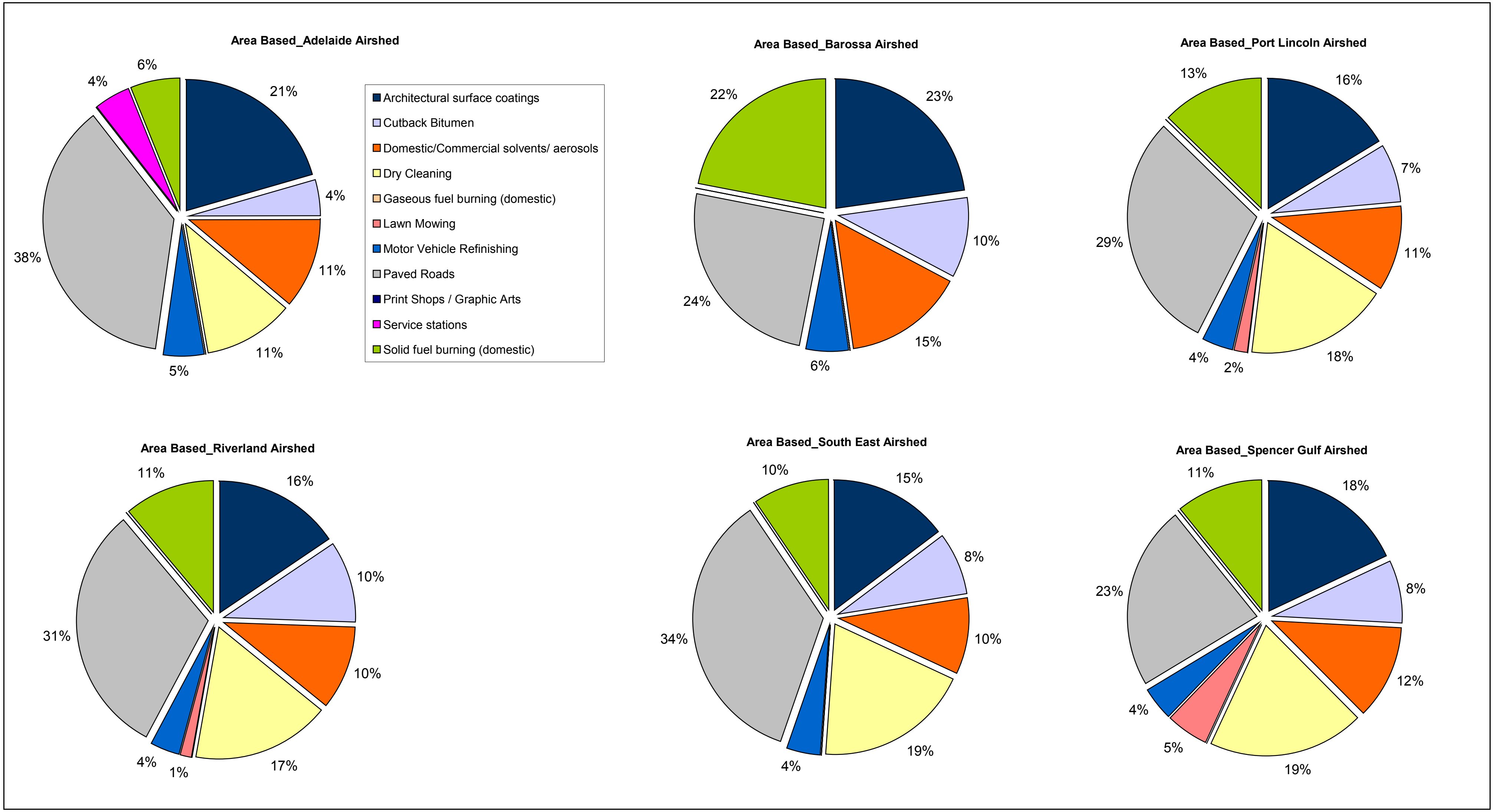
NPI air emissions for the South Australian airsheds have not been compared with those of other jurisdictions in this report. Early comparisons with the Perth NPI Emissions Study[2] showed Perth emissions to be within the range of emissions estimated for the six South Australian airsheds, including the Adelaide airshed, although variations of the annual emissions loads were found to be relatively large. The authors identified the need to standardise estimation methodologies, recommending the use of standard methodologies such as the NPI Aggregate EET manuals produced by Environment Australia. This move would eliminate some variation and allow emission differentials due to local data and the level of activity to be analysed. However, small variations in emissions will also be due to the assumptions made in deriving local data, which remains a limiting factor for some aggregate emission sources even with the use of the NPI EET manuals. A comparison of the assumptions made by jurisdictions may help identify the significance of this limitation.

This section graphically compares total emissions estimated for selected substances in the Adelaide and the regional airsheds (Figure 26). Bars, on a logarithmic scale, represent total emissions in each airshed on a per-capita basis to standardise for differences in population related activities. Emissions per capita for the Adelaide, Port Lincoln, Riverland and South East airsheds were of similar magnitude. However, estimates identified for the Barossa and Spencer Gulf airsheds were significantly higher than other airsheds. Similarity between the Adelaide and all regional airsheds was most evident for VOC, BTEX and metallic compounds that were mostly related to area-based and mobile-motor vehicle sources. The observed differences in emission estimates for some airsheds indicate the dominance of industry sources. In the absence of industry dominance, there is a close agreement in the per-capita emissions between the regional airsheds and the Adelaide airshed, suggesting the possibility of transposing data to other regions of the State on a population basis. However, inventory estimates must be validated against actual monitoring data to confirm these findings.



† where the source was the single largest contributor relative to the number of substances emitted

Figure 16 Comparisons of emission sources based on the relative percentage of occurrence in each airshed†



† where the source was the single largest contributor relative to the number of substances emitted

Figure 17 Comparison of individual source emissions within the area-based source category†

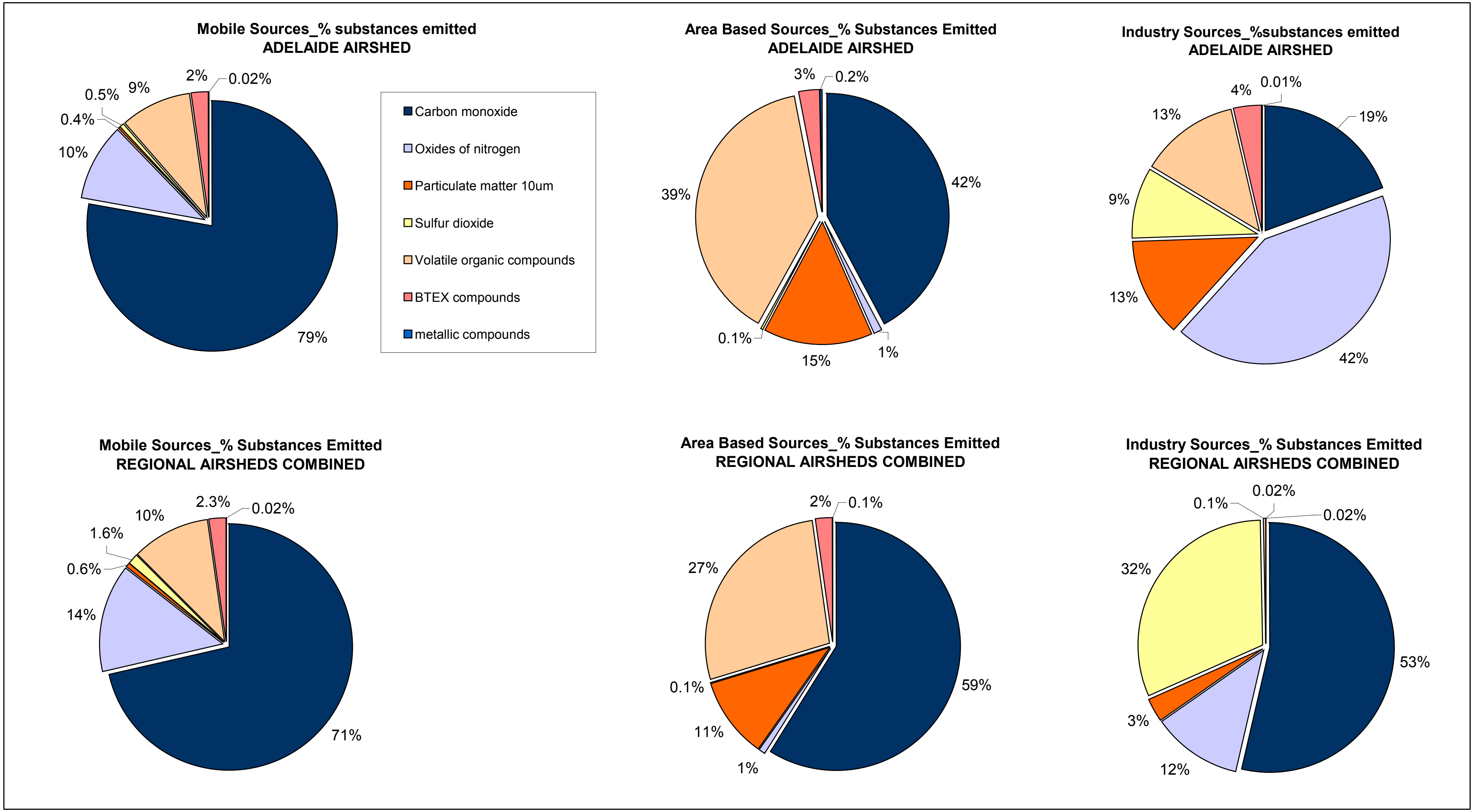


Figure 18 Comparison of substances emitted by the three main source category types: mobile, area-based and industry

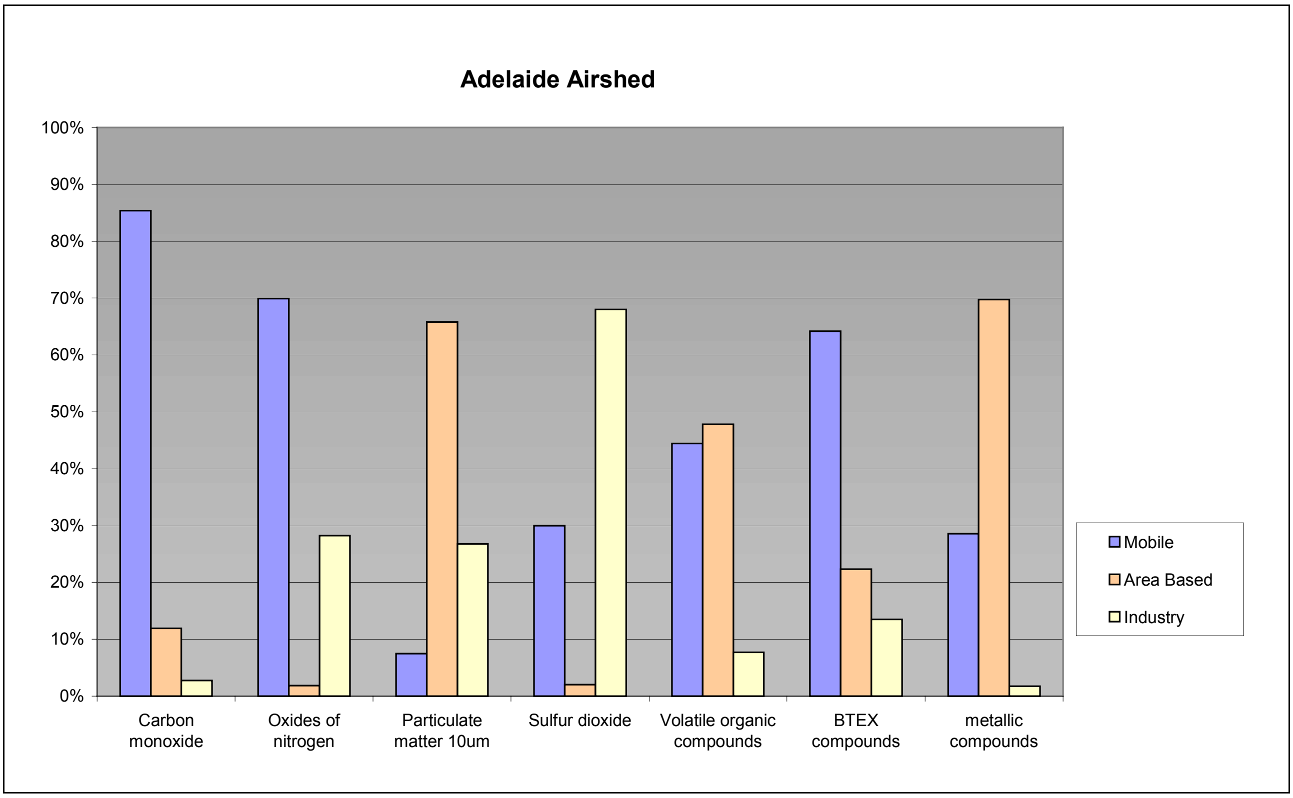


Figure 19 Comparison of NPI substance emissions by source in the Adelaide airshed

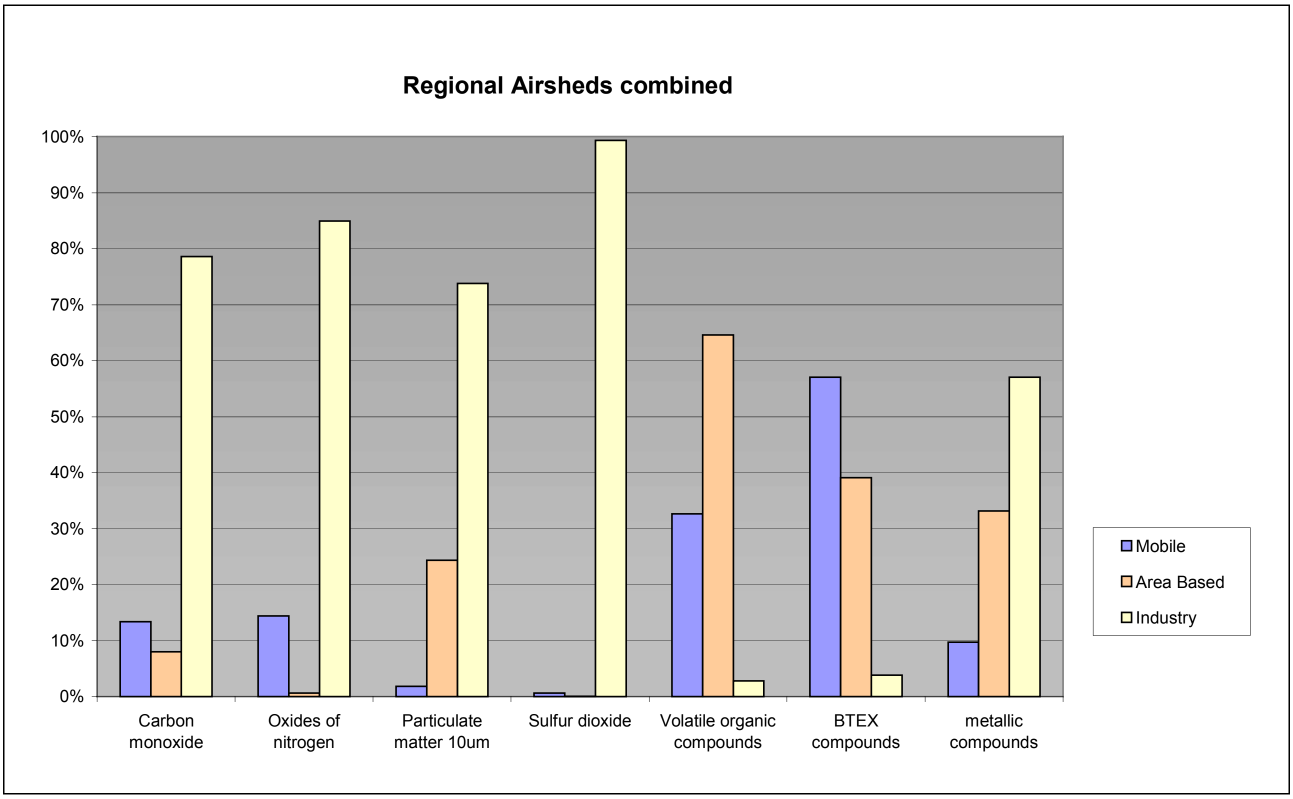


Figure 20 Comparison of NPI substance emissions by source in all regional airsheds combined

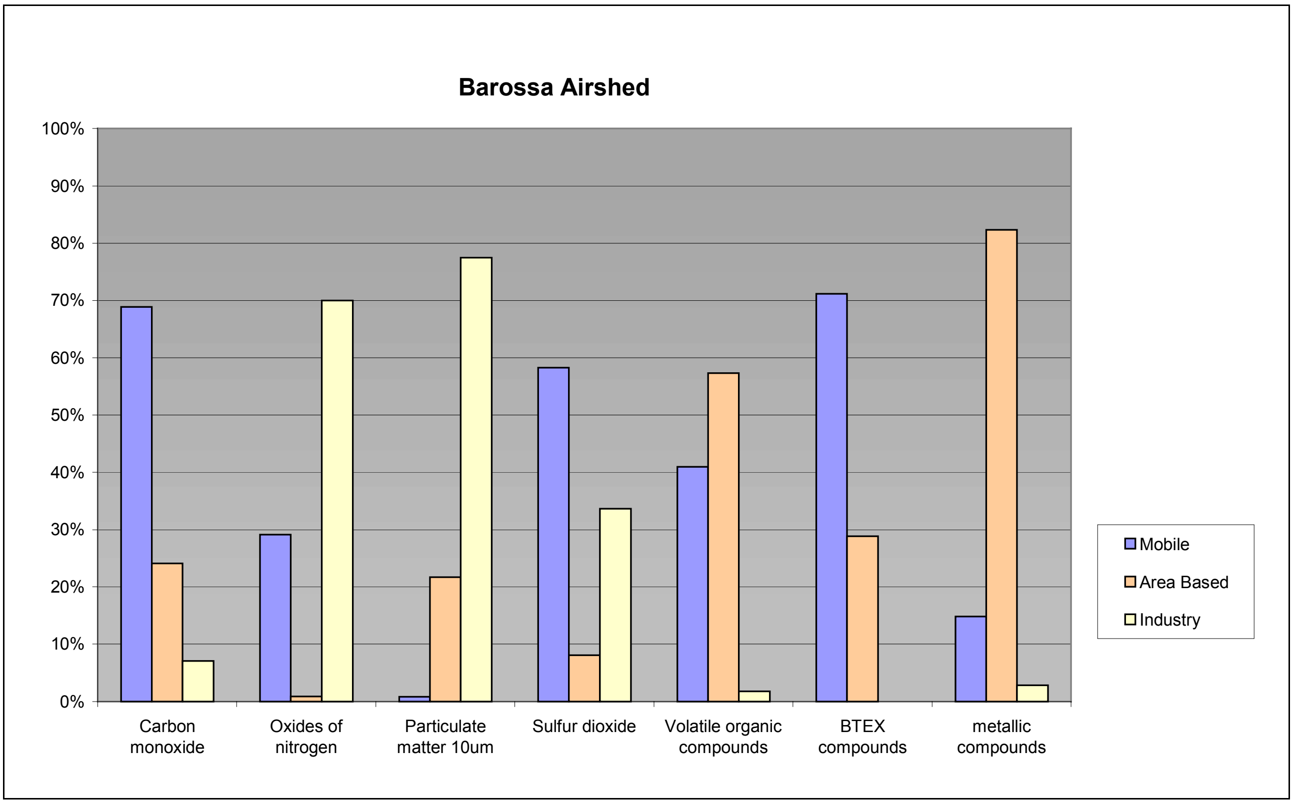


Figure 21 Comparison of NPI substance emissions by source in the Barossa airshed

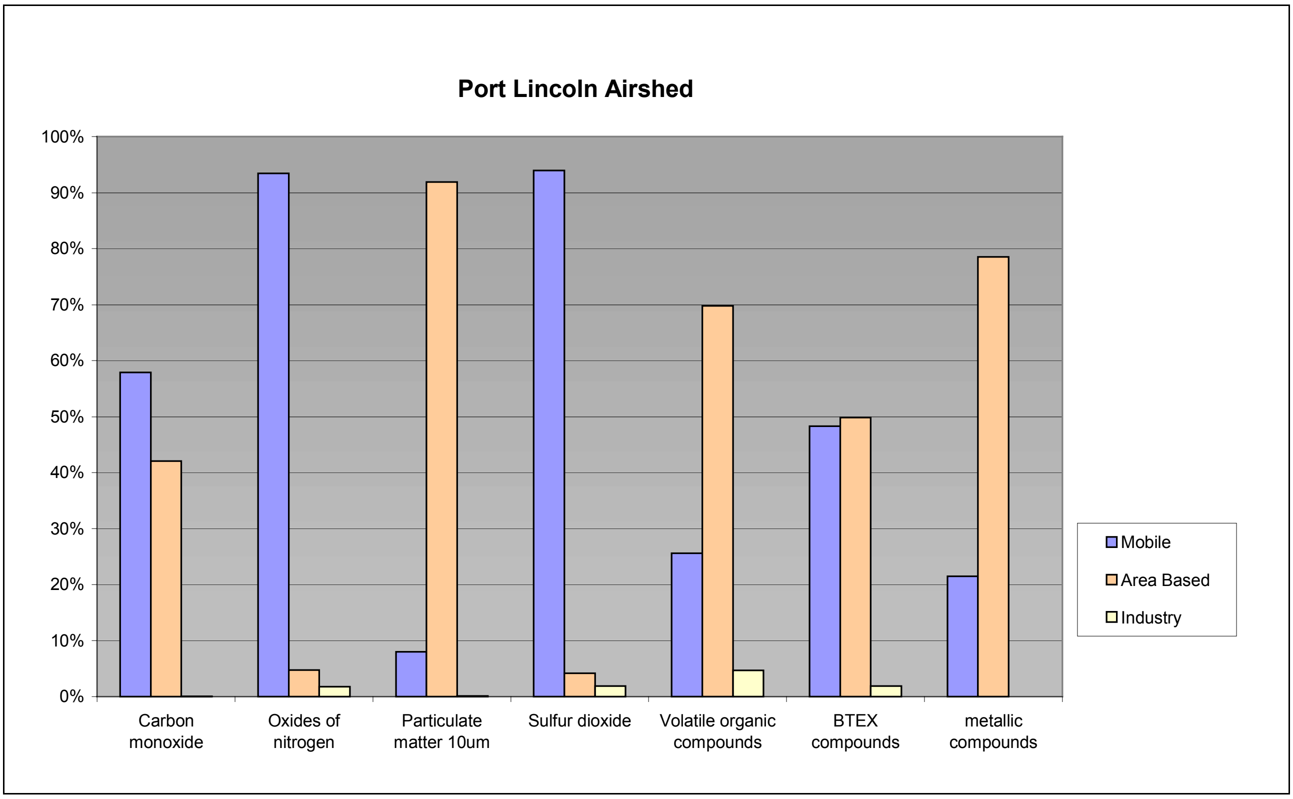


Figure 22 Comparison of NPI substance emissions by source in the Port Lincoln airshed

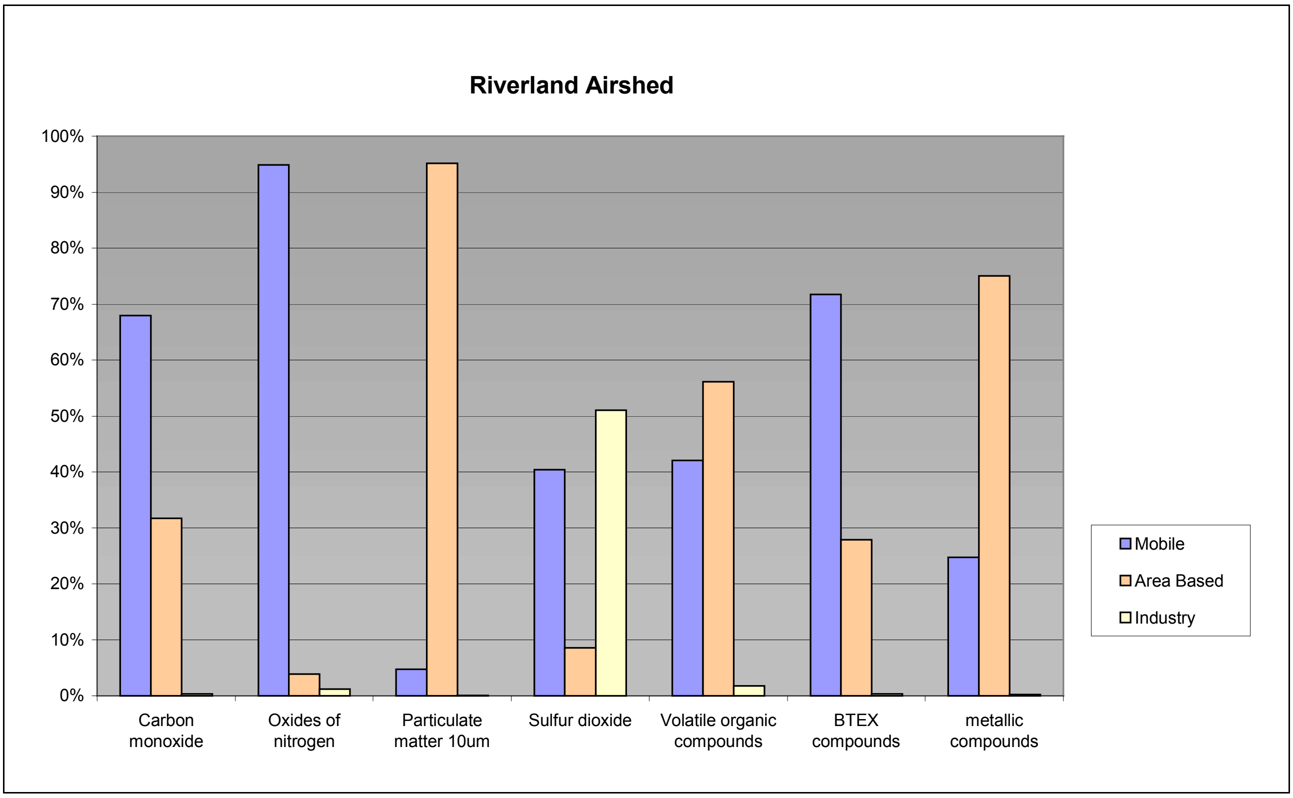


Figure 23 Comparison of NPI substance emissions by source in the Riverland airshed

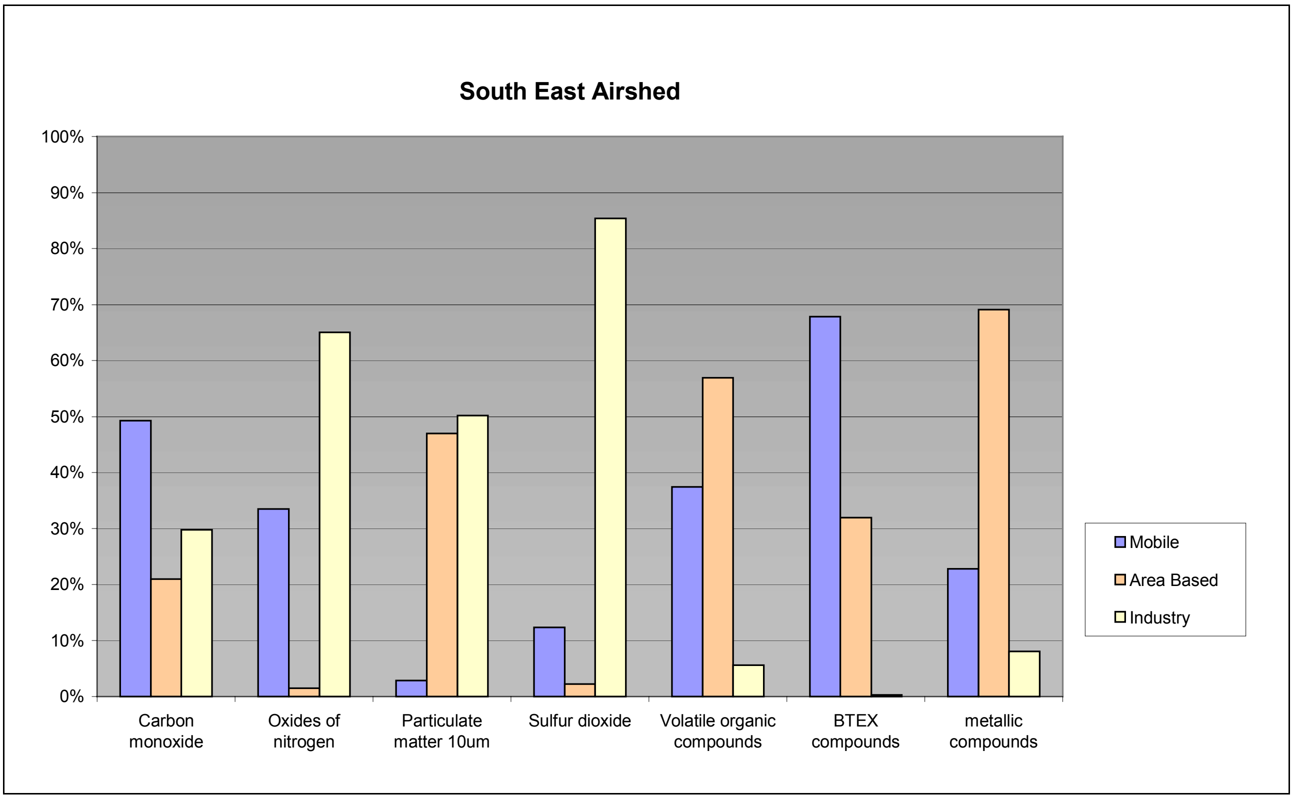


Figure 24 Comparison of NPI substance emissions by source in the South East airshed

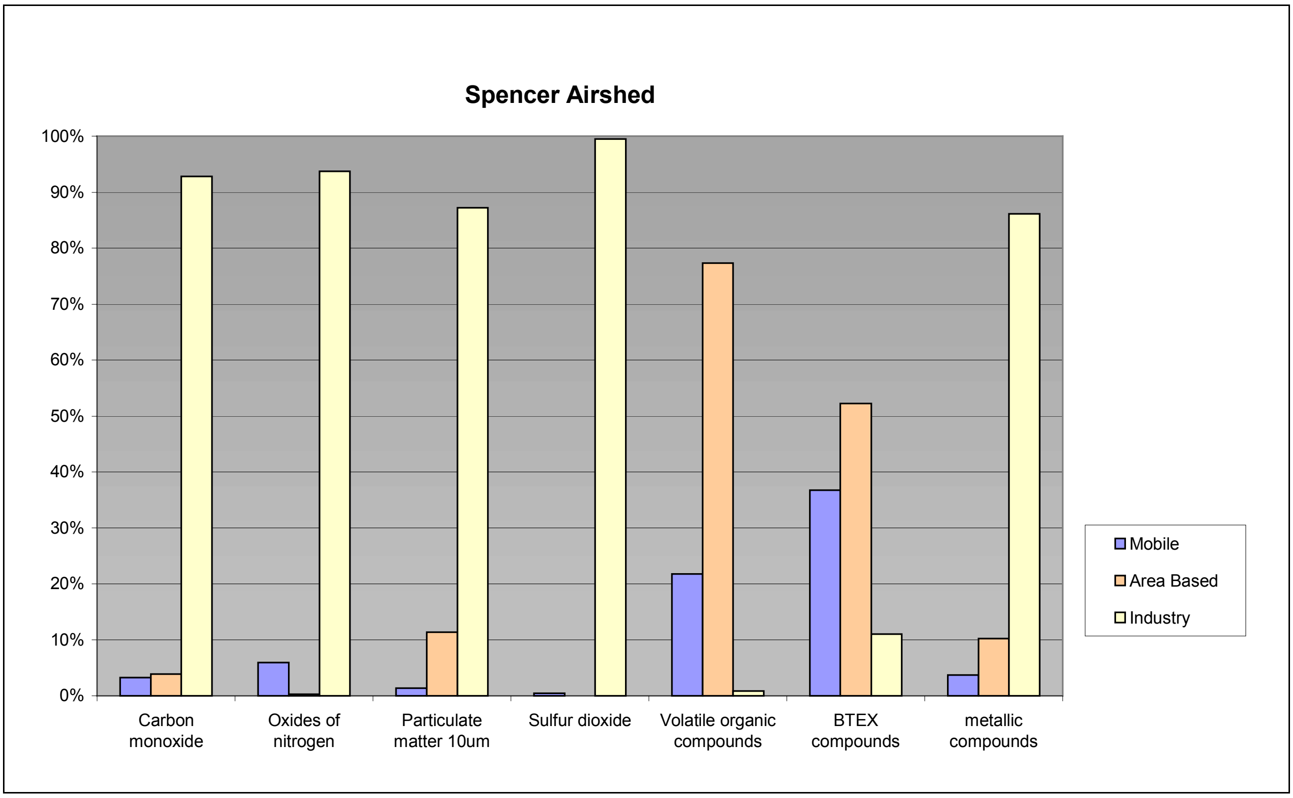


Figure 25 Comparison of NPI substance emissions by source in the Spencer airshed

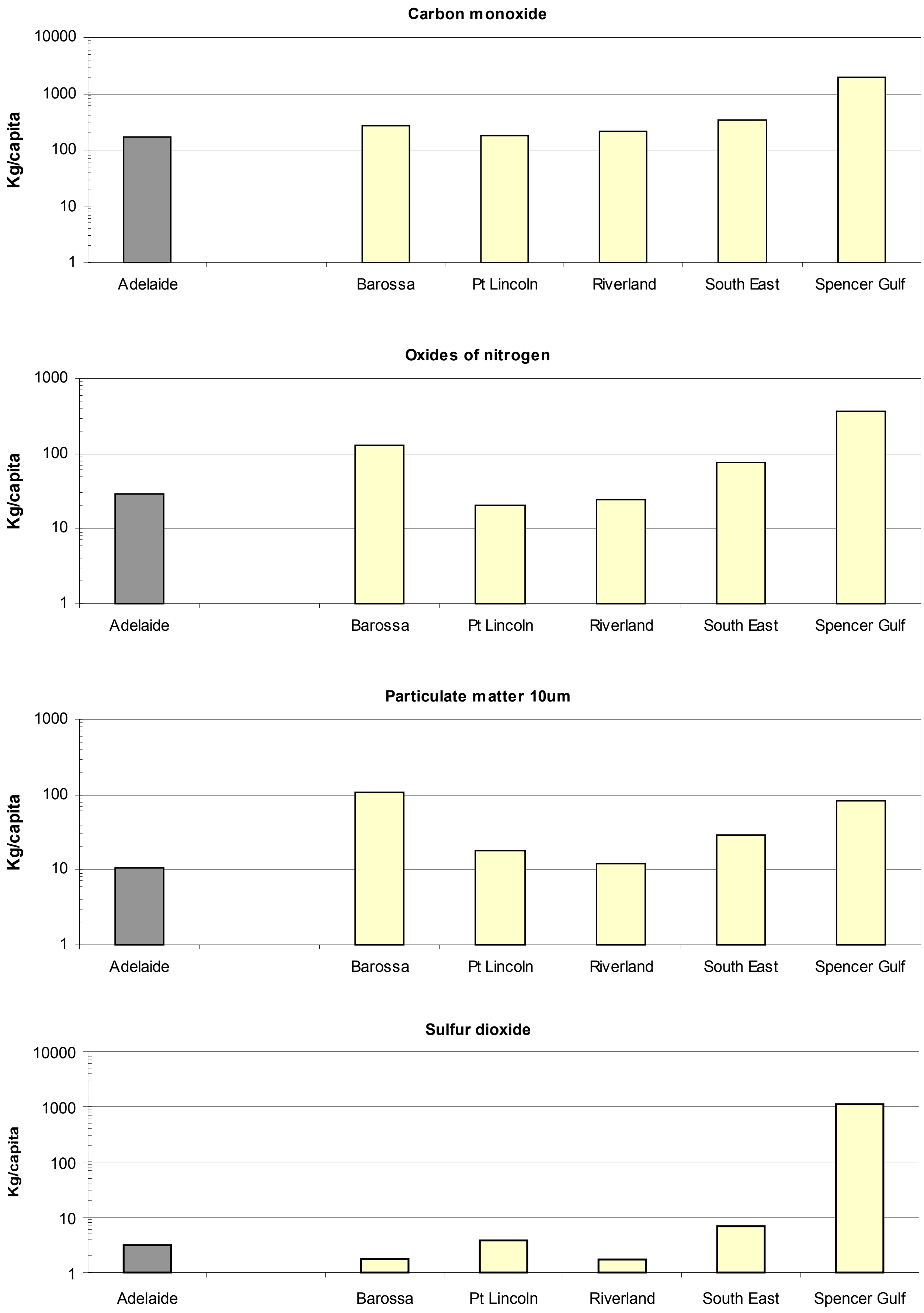


Figure 26 Annual airshed emissions of selected NPI substances, in kilograms per capita

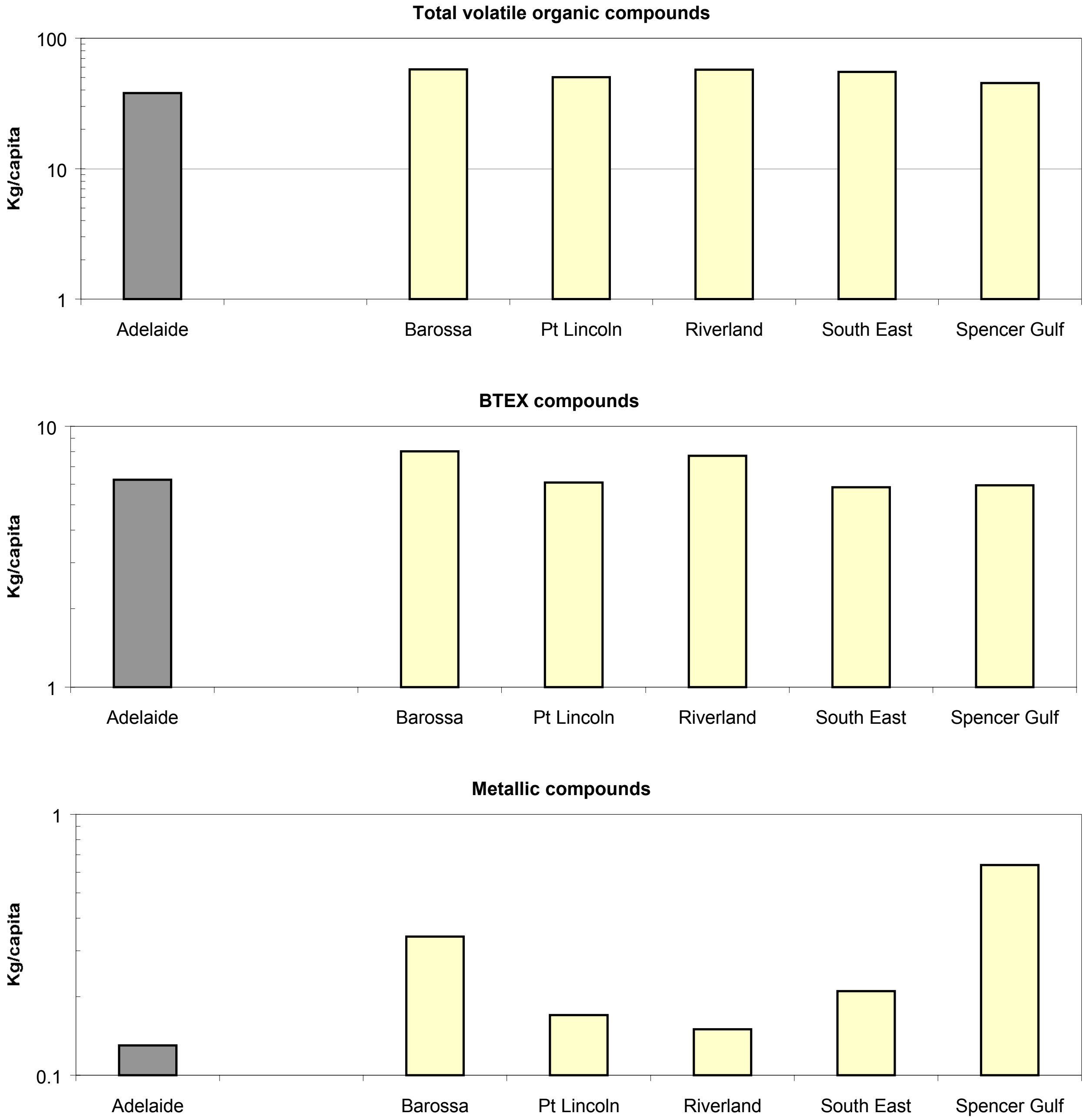


Figure 26 (cont) Annual airshed emissions of selected NPI substances, in kilograms per capita

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