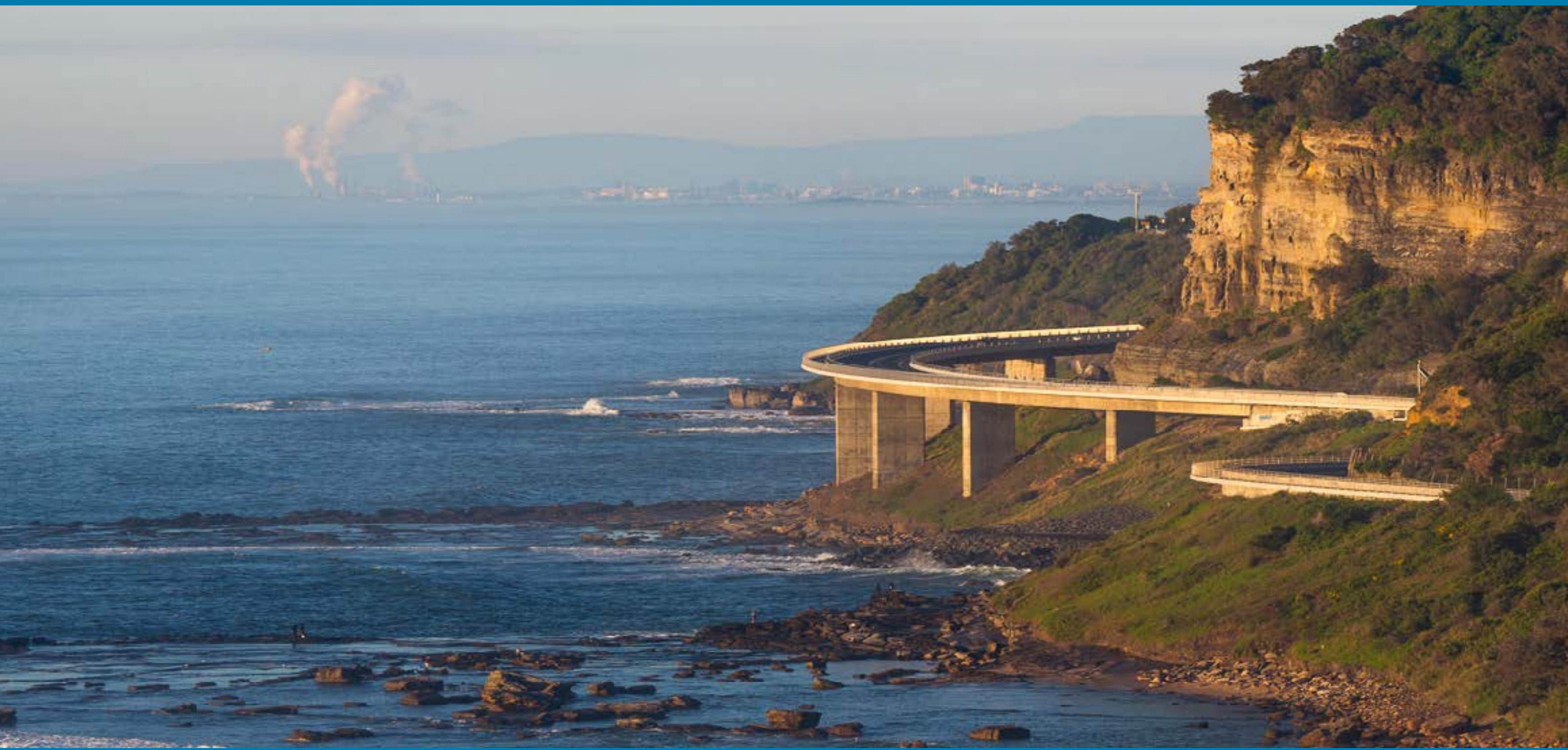
Sources of air pollution in NSW

Air Emissions Inventory for the Greater Metropolitan Region of NSW – 2013



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Cover photo: Wide view of Seacliff Bridge at sunrise,
Port Kembla industry in background /Caz Nowaczyk/EPA

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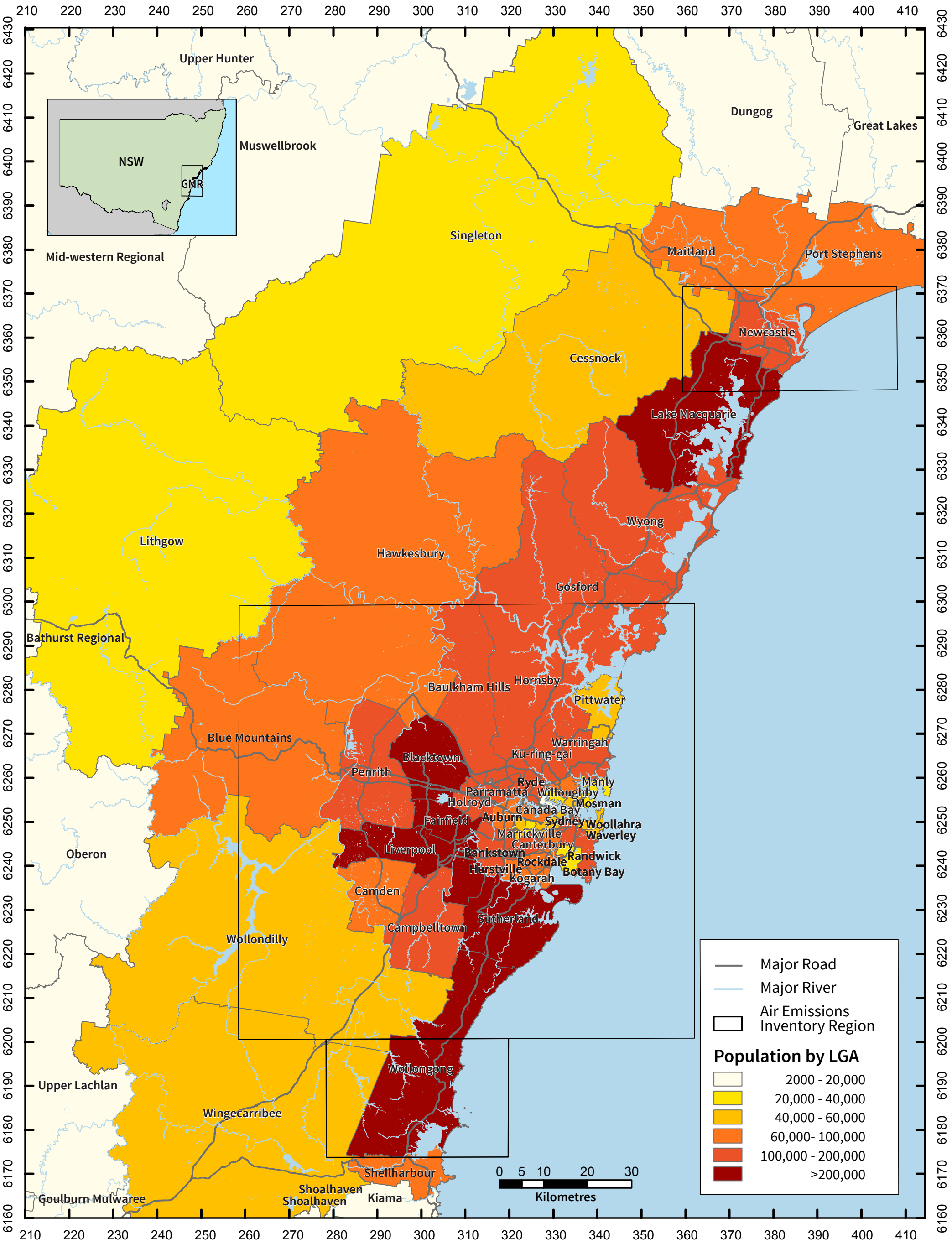
Introduction

This brochure is a summary of the information contained in the *2013 Air Emissions Inventory for the NSW Greater Metropolitan Region* (GMR). More detailed information about activity data, emission estimation methodologies, sources, or emissions of other air pollutants included in the inventory can be found on the EPA website[1].

Purpose of the inventory

Air pollution comes from many sources. To find the best ways to manage air quality we need to know the contribution made by each source. The previous inventory for the NSW GMR was completed in 2012 and provides information for the 2008 calendar year. This publication summarises inventory data for the 2013 calendar year to support air quality research, policies and programs based on up-to-date information.

Figure 1: Definition of GMR and the Sydney, Newcastle and Wollongong regions, and population density in each LGA



[1] https://www.epa.nsw.gov.au/your-environment/air/air-emissions-inventory.

Description of the inventory

The inventory is a detailed listing of pollutants discharged into the atmosphere by each source type during a given time period and at a specific location. The study area covers 57,330 km^2, which includes the greater Sydney, Newcastle and Wollongong regions, known collectively as the Greater Metropolitan Region (GMR). About 78% of the NSW population resides in the GMR. The GMR and the Sydney, Newcastle and Wollongong regions are shown in Figure 1, along with the population in each local government area (LGA)[2] .

The inventory includes emissions from biogenic (natural and living), geogenic (natural non-living) and anthropogenic (human-made) sources as follows:

- Natural – biogenic and geogenic (e.g. bushfires, marine aerosols and vegetation).
- Commercial – non-EPA-licensed premises (e.g. printers, quarries and service stations).
- Domestic-Commercial – domestic activities (e.g. residential lawn mowing, wood heaters and portable fuel containers) and non-premises based commercial activities (e.g. public open space lawn mowing).
- Industrial – EPA licensed premises (e.g. coal mines, oil refineries and power stations).
- Off-Road Mobile – unregistered non-road vehicles and equipment (e.g. dump trucks, bulldozers, locomotives and marine vessels).
- On-Road Mobile – road registered vehicles (e.g. registered cars, trucks and buses).

The inventory covers more than 1,000 substances, including:

- common pollutants, such as ammonia, carbon monoxide (CO), lead, oxides of nitrogen (NO_x), particulate matter ≤ 10µm[3] (PM_{10}), particulate matter ≤ 2.5µm ($PM_{2.5}$), sulfur dioxide (SO_2) and total volatile organic compounds (VOC)
- organic compounds, such as 1,3-butadiene, benzene and formaldehyde
- metals, such as cadmium, manganese and nickel
- polycyclic aromatic hydrocarbons (PAH), polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF).
- greenhouse gases (carbon dioxide, methane and nitrous oxide).

Air emissions data can be presented for the whole GMR, for the Sydney, Newcastle or Wollongong regions, for each of the 64 LGAs within the GMR or by postcode. Emissions vary by month, day of week and hour of day so they can be presented on an annual, monthly, daily or hourly basis.

Development of the inventory

Estimation techniques

Emission estimation techniques for all sources have been based on published state-of-the-art methodologies, such as those used by the California Air Resources Board (CARB), the European Environment Agency or the United States Environmental Protection Agency (USEPA).

The base year of the inventory represents activities that took place in the 2013 calendar year.

All emissions have been calculated within six source-specific relational databases, which include all the data needed to estimate emissions to air from natural and human-made sources. These databases contain activity data; emission factors; particulate matter (PM) and VOC speciation profiles; spatial allocation data; hourly, daily and monthly temporal variation data; and emission projection factors.

Activity, spatial and temporal data have been acquired through a domestic survey of residential households and an industrial survey of EPA-licensed premises. They have also been supplied by a number of government departments and service providers.

Air emissions have been estimated by combining activity data with emission factors. Where available, source emission test data has been used in preference to emission factors for industrial and commercial sources.

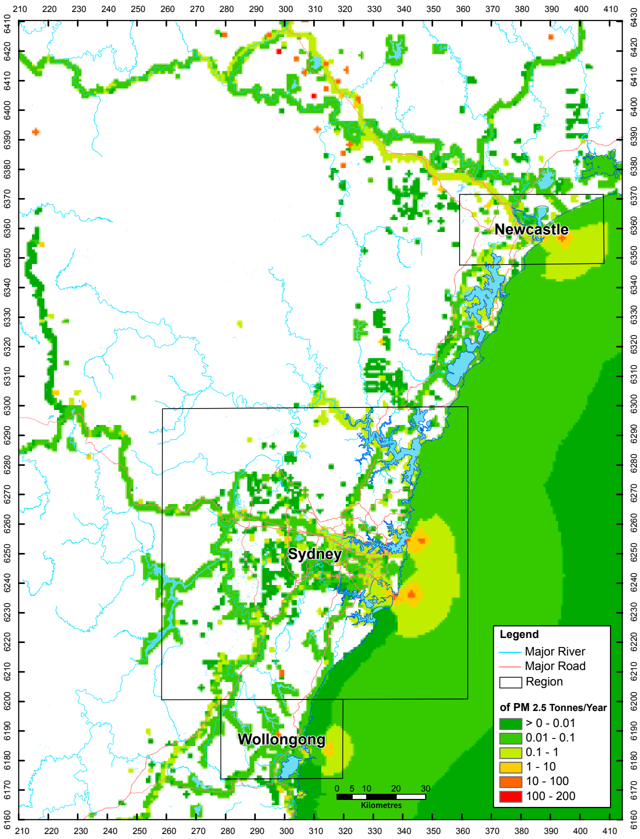
[2] Inventory data was allocated to the LGAs as they existed in 2013, prior to amalgamations that occurred from 2016, and are consistent with 2008 LGAs.

[3] µm = one millionth of a metre = one thousandth of a mm.

The emissions have been assigned to map coordinates for industrial and commercial point sources, or 1km by 1km grid cells for natural, domestic, off-road and on-road area sources and industrial and commercial fugitive sources. As an example, Figure 2 shows the spatial distribution of emissions from off-road vehicles and equipment (including marine emissions).

Emissions are then calculated for each month, day of week and hour of day by using factors derived from the activity data.

Figure 2: Example of the spatial distribution of off-road vehicles and equipment emissions (including marine)



Storage of the inventory data

The air emissions inventory data are stored in a Microsoft® SQL Server™ 2012 relational database (EDMS v2.0) which includes a number of features such as:

- emissions charting by air pollutant, source, LGA and region
- emissions data visualisation using geographical information systems
- emissions forecasting up to 2041
- emissions modelling to test policy scenarios
- environmental reporting by air pollutant, source, LGA and region.

The database can be used to produce output data to facilitate:

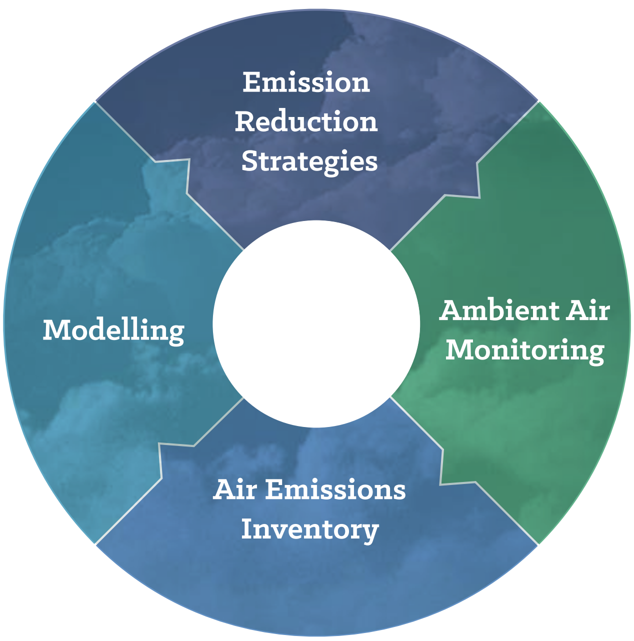
- air pollution modelling using models developed by the California Institute of Technology, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and USEPA
- source and pollutant prioritisation using CARB facility prioritisation guidelines and the USEPA RSEI (risk screening environmental indicators) methodology
- VOC prioritisation based on photochemical smog forming potential, using the CARB MIR (maximum incremental reactivity) methodology.

Using the inventory in air quality management

National air quality standards

Ambient air quality monitoring provides assessment of compliance with standards set out in the National Environment Protection (Ambient Air Quality) Measure (NEPM). The inventory is used to identify priority sources of key air pollutants. Airshed modelling identifies the amount of air pollutant reductions required and cost-effective emissions reduction strategies are then developed to improve air quality. Figure 3 shows the role of the air emissions inventory within the air quality management cycle.

Figure 3: Air emissions inventory role in air quality management



Priority air pollutants

In 1998, ambient air quality standards and goals for six common pollutants – CO, lead, nitrogen dioxide (NO_2), ozone (O_3), PM_{10} and SO_2 – were included in the Ambient Air Quality NEPM. In May 2003, governments varied the Ambient Air Quality NEPM to include advisory reporting standards for $PM_{2.5}$. In February 2016 the $PM_{2.5}$ standards were adopted as reporting standards. GMR ambient concentrations of CO, lead, NO_2 and SO_2 are all consistently below the relevant national standards. However, concentrations of O_3, and sometimes PM_{10} and $PM_{2.5}$, can exceed national standards. NO_x, PM_{10}, $PM_{2.5}$ and VOC are the air pollutants of primary concern in the GMR and Sydney region.

NO_x and VOC are photochemical smog precursors and, when emitted in the presence of sunlight, undergo a series of complex reactions that cause photochemical smog to form. Ground-level ozone is an indicator of photochemical smog, which is characterised by a white atmospheric haze in warmer months of the year.

PM_{10} and $PM_{2.5}$ emissions are responsible for primary particulate matter pollution, which is characterised by a brown atmospheric haze in cooler months of the year.

NO_x, VOC, SO_2 and ammonia react in the atmosphere to form secondary organic aerosols, nitrate and sulfate compounds, which are collectively known as secondary particulate matter pollution.

Fine particulate matter pollution is made up of both primary emissions and secondary organic and inorganic aerosols, which are formed through atmospheric reactions.

Figure 4 illustrates air pollution sources, their transport and transformation, and the parts of the environment that are affected by air pollution.

Figure 4: Sources of air pollution, their transport and transformation and the parts of the environment that are affected by air pollution

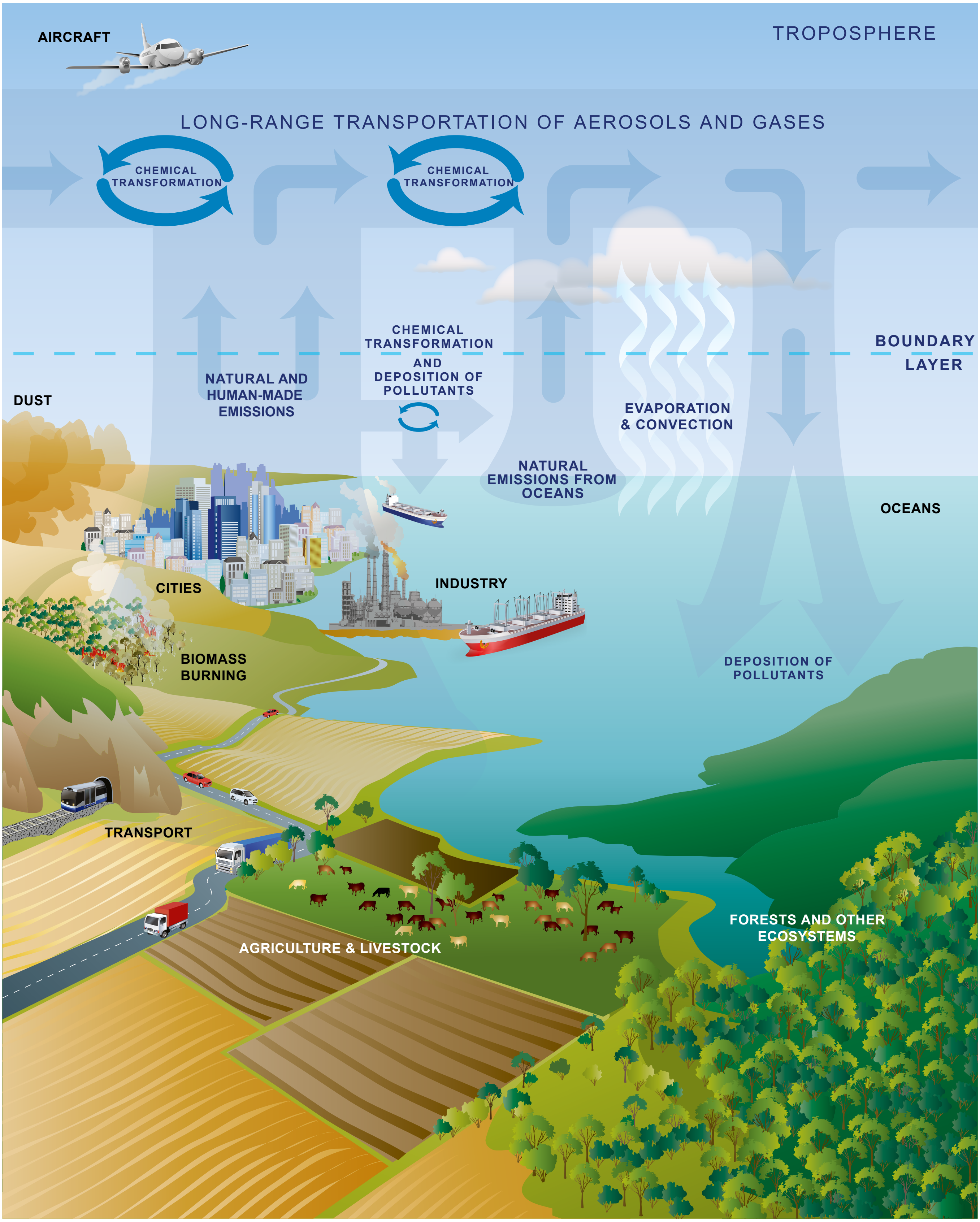


Figure 5: Sources of air pollution, their transport and transformation and the parts of the environment that are affected by air pollution

2013 inventory data

Major natural and human-made sources in the GMR

Table 1 presents annual emissions of common pollutants from natural and human-made sources in the GMR. Human-made sources are the major contributors to NO_x (88%) and SO_2 (97%), while natural sources are significant contributors to CO (65%), PM_{10} (51%), $PM_{2.5}$ (73%) and VOC (60%) emissions. Hazard reduction burns and bushfires were major contributors to natural emissions of CO, PM_{10} and $PM_{2.5}$ in 2013.

Table 1: Total estimated annual emissions from natural and human-made sources in the GMR

	Emissions (tonnes/year)						
Substance	**Natural**	**Commercial**	**Domestic-Commercial**	**Industrial**	**Off-Road Mobile**	**On-Road Mobile**	**Total**
CO	874,147	378	119,664	171,147	61,628	115,262	1,342,226
NO_x	35,920	562	3,473	160,966	58,920	45,085	304,927
PM_{10}	103,547	1,287	7,734	86,422	3,263	2,505	204,758
$PM_{2.5}$	76,965	433	7,429	16,530	3,086	1,750	106,194
SO_2	7,955	192	165	214,112	10,757	126	233,306
VOC	205,021	10,330	73,828	12,628	21,300	16,124	33 9,230

Using the data from Table 1, Figures 6 to 9 show the proportions of annual emissions for the priority pollutants NO_x, VOC, PM_{10} and $PM_{2.5}$ from natural and human-made sources in the GMR.

Figure 6: Human-made and natural NO_x in the GMR

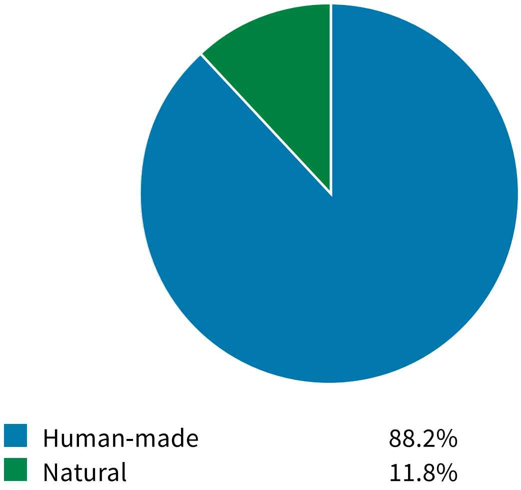


Figure 7: Human-made and natural VOC in the GMR

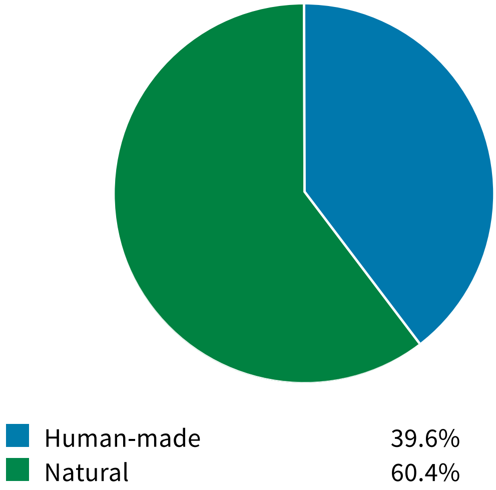


Figure 8: Human-made and natural PM_{10} in the GMR

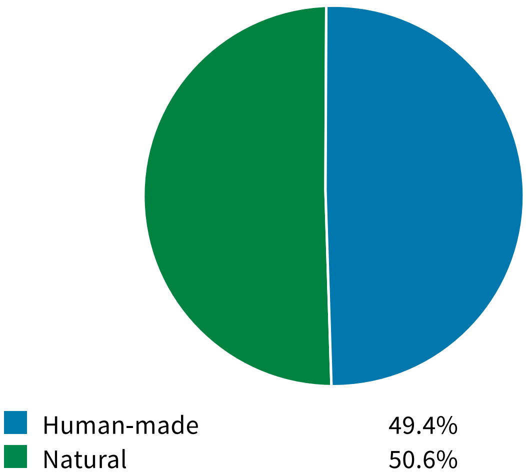
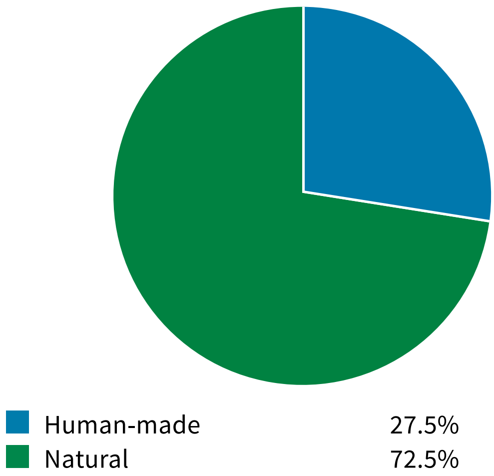
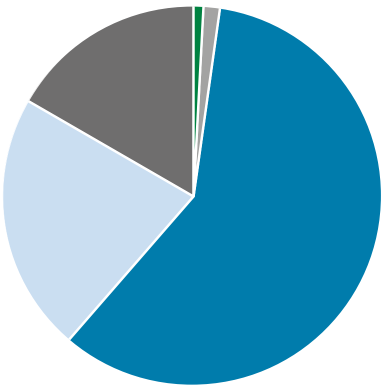


Figure 9: Human-made and natural $PM_{2.5}$ in the GMR



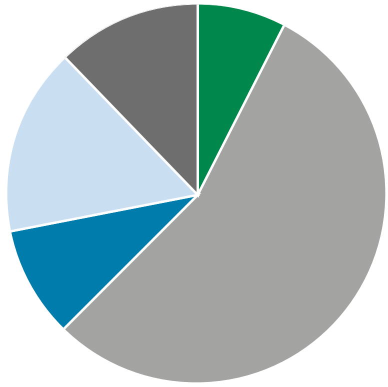
Using the data from Table 1, Figures 10 to 13 show the proportions of annual emissions for the priority pollutants NO_x, VOC, PM_{10} and $PM_{2.5}$, from each type of human-made source in the GMR. NO_x emissions from industrial (59.8%), off-road mobile (21.9%) and on-road mobile (16.8%) sources are the most significant and together make up over 98% of human-made emissions. For VOC emissions, domestic-commercial (55.0%), off-road mobile (15.9%) and on-road mobile (12.0%) sources are the most significant and together make up nearly 83% of human-made emissions. PM_{10} emissions are dominated by industrial sources (85.4%), with domestic-commercial sources (7.6%) the next largest contributor. Nearly 93% of human-made $PM_{2.5}$ emissions are made up of industrial (56.6%), domestic-commercial (25.4%) and off-road mobile (10.6%) sources.

Figure 10: Human-made NO_x in the GMR



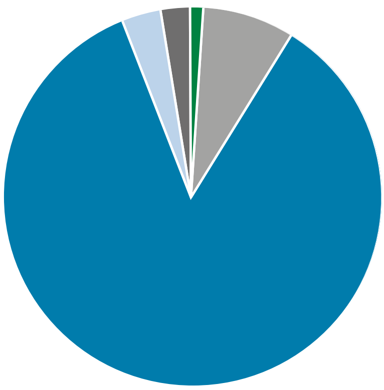
Commercial	0.2%
Domestic-Commercial	1.3%
Industrial	59.8%
Off-Road Mobile	21.9%
On-Road Mobile	16.8%

Figure 11: Human-made VOC in the GMR



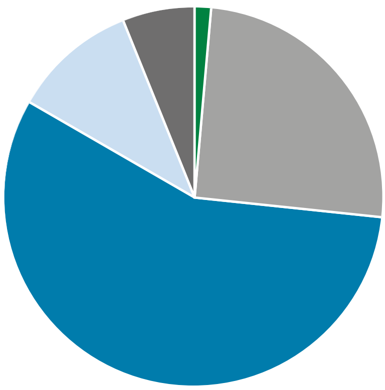
Commercial	7.7%
Domestic-Commercial	55.0%
Industrial	9.4%
Off-Road Mobile	15.9%
On-Road Mobile	12.0%

Figure 12: Human-made PM_{10} in the GMR



Commercial	1.3%
Domestic-Commercial	7.6%
Industrial	85.4%
Off-Road Mobile	3.2%
On-Road Mobile	2.5%

Figure 13: Human-made $PM_{2.5}$ in the GMR



Commercial	1.5%
Domestic-Commercial	25.4%
Industrial	56.6%
Off-Road Mobile	10.6%
On-Road Mobile	6.0%

Major natural and human-made sources in the Sydney region

Table 2 presents annual emissions of common pollutants from natural and human-made sources in the Sydney region. Human-made sources are the major contributors to CO (83.3%), NO_x (95.7%), PM_{10} (72.7%), $PM_{2.5}$ (72.3%), SO_2 (96.4%) and VOC (75.2%) emissions.

Using the data from Table 2, Figures 14 to 17 show the proportions of annual emissions for the priority pollutants NO_x, VOC, PM_{10} and $PM_{2.5}$ from natural and human-made sources in the Sydney region.

Table 2: Total estimated annual emissions from natural and human-made sources in the Sydney region

Emissions (tonnes/year)							
Substance	**Natural**	**Commercial**	**Domestic-Commercial**	**Industrial**	**Off-Road Mobile**	**On-Road Mobile**	**Total**
CO	42,008	320	90,299	5,968	22,465	91,239	252,299
NO_x	2,605	359	2,701	7,387	15,734	32,496	61,282
PM_{10}	5,786	682	5,744	6,040	1,111	1,838	21,200
$PM_{2.5}$	3,816	291	5,517	1,824	1,034	1,279	13,761
SO_2	382	79	124	3,057	6,790	97	10,530
VOC	31,785	9,561	57,399	9,369	7,552	12,641	128,306

Figure 14: Human-made and natural NO_x in the Sydney region

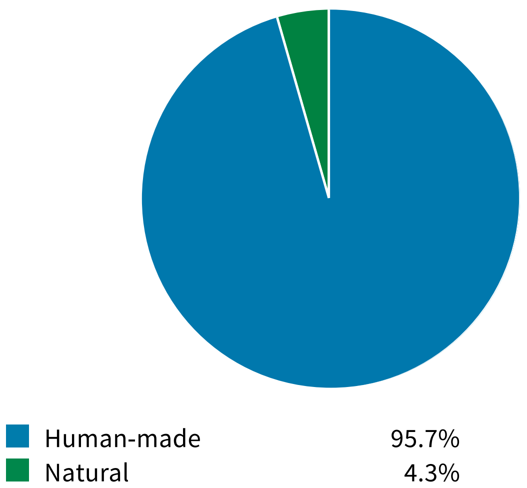


Figure 15: Human-made and natural VOC in the Sydney region

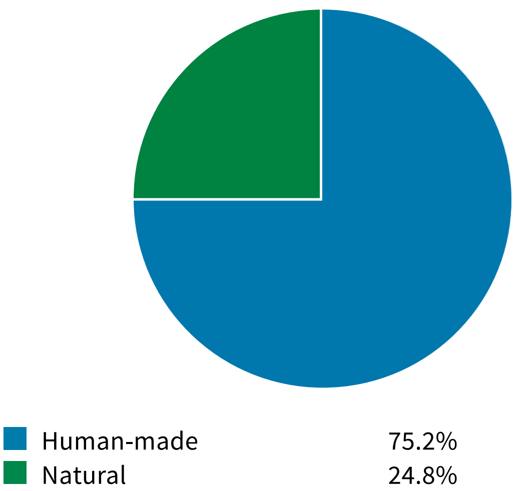


Figure 16: Human-made and natural PM_{10} in the Sydney region

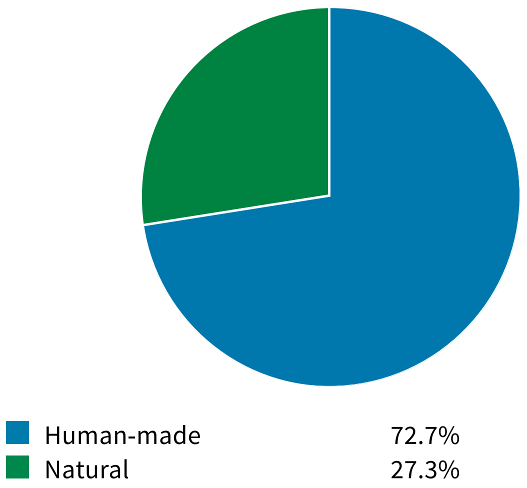
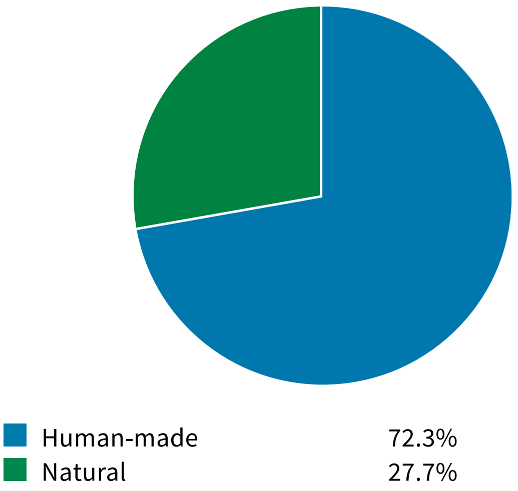


Figure 17: Human-made and natural $PM_{2.5}$ in the Sydney region

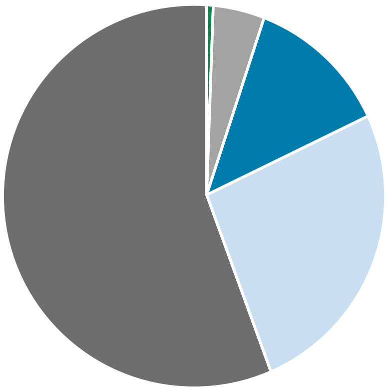


Using the data from Table 2, Figures 18 to 21 show the proportions of annual emissions for the priority pollutants NO_x, VOC, PM_{10} and $PM_{2.5}$, from each type of human-made source in the Sydney region. NO_x emissions from on-road mobile (55.4%), off-road mobile (26.8%) and industrial (12.6%) sources are the most significant and together make up nearly 95% of human-made emissions.

For VOC emissions, domestic-commercial (59.5%) and on-road mobile (13.1%) sources are the most significant and together make up nearly 73% of human-made emissions. PM_{10} emissions from industrial (39.2%) and domestic-commercial (37.3%) sources are the largest contributors, while on-road mobile sources (11.9%) are also significant.

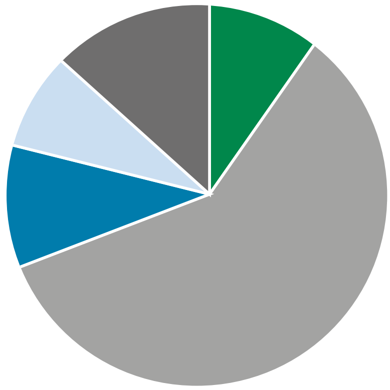
Nearly 87% of human-made $PM_{2.5}$ emissions are made up of domestic-commercial (55.5%), industrial (18.3%) and on-road mobile (12.9%) sources.

Figure 18: Human-made NO_x in the Sydney region



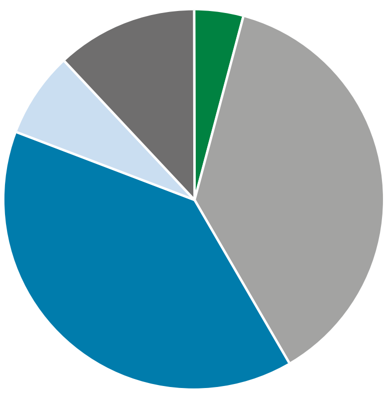
Commercial	0.6%
Domestic-Commercial	4.6%
Industrial	12.6%
Off-Road Mobile	26.8%
On-Road Mobile	55.4%

Figure 19: Human-made VOC in the Sydney region



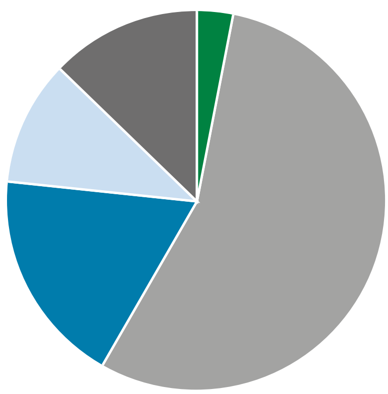
Commercial	9.9%
Domestic-Commercial	59.5%
Industrial	9.7%
Off-Road Mobile	7.8%
On-Road Mobile	13.1%

Figure 20: Human-made PM_{10} in the Sydney region



Commercial	4.4%
Domestic-Commercial	37.3%
Industrial	39.2%
Off-Road Mobile	7.2%
On-Road Mobile	11.9%

Figure 21: Human-made $PM_{2.5}$ in the Sydney region



Commercial	2.9%
Domestic-Commercial	55.5%
Industrial	18.3%
Off-Road Mobile	10.4%
On-Road Mobile	12.9%

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