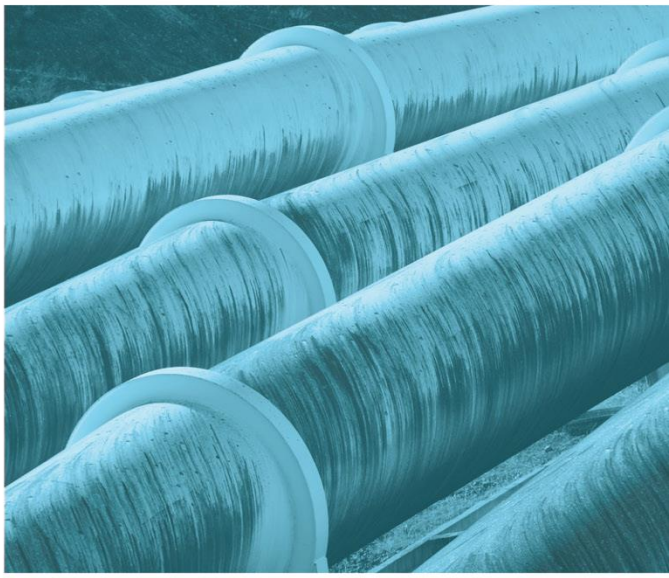



WestConnex New M5

Options for smoky vehicle enforcement in the New M5 tunnels

Prepared for Transport for NSW
January 2020

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T 03 9993 1900

PERTH
Level 6, 191 St Georges Terrace
Perth WA 6000

CANBERRA
PO Box 9148
Deakin ACT 2600

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EMM Sydney
Ground floor, 20 Chandos Street
St Leonards NSW 2065

T 02 9493 9500
E info@emmconsulting.com.au

www.emmconsulting.com.au

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Appendices

1 Introduction

1.1 Background and objectives

The WestConnex New M5 project, which is currently under construction, will feature twin nine-kilometre motorway tunnels between Kingsgrove and St Peters interchange at the site of the old Alexandria landfill. The project also includes connections to the future Sydney Gateway and WestConnex M4-M5 Link, and local streets and intersections in St Peters are being upgraded. The New M5 was declared by the NSW Minister for Planning to be critical State Significant infrastructure (SSI), and was approved by the Minister in April 2016, subject to conditions of approval.

This report provides information to assist Transport for NSW in addressing the conditions of approval for the New M5 project, and specifically the requirements with respect to the management of smoky vehicles (condition of approval E30).

In recent decades, specific programs and measures have been introduced to permit the visual identification and reporting of smoky vehicles on NSW roads. These programs and measures have been based on the so-called '10-second rule', whereby a vehicle must emit smoke that is visible for a period of at least 10 seconds. There has been a particular focus on Sydney's M5 East tunnel, where various programs have been devised in response to community concern about the large numbers of smoky heavy vehicles using the tunnel. Notably, the M5 East tunnel has been equipped with a camera-based[1] identification system for smoky vehicles, and the environmental impact statement for the New M5 project proposed that a similar system would be installed in its tunnels.

This report discusses potential options for smoky vehicle enforcement in the New M5 tunnels, based on visual identification and the 10-second rule. The report provides some context, and briefly summarises the smoky vehicle programs in place in NSW and elsewhere with reference to the available data. The viability of a smoky vehicle enforcement program for the New M5 project, as well as some potential alternatives to visual identification, are considered.

1.2 Features of the New M5 project

The key features of the New M5 project include the following:

- Twin, nine-kilometre motorway tunnels between the existing M5 East Motorway and St Peters;
- tunnel stubs to allow for future connections to WestConnex M4-M5 Link and the F6 Extension;
- surface road widening works along the M5 East Motorway;
- a new road interchange at St Peters;
- new bridge crossings over Alexandra Canal;
- closure and remediation of the Alexandria Landfill site;
- works to enhance and upgrade local streets and intersections near the St Peters interchange; and

[1] It should be noted that a human operator is still required to actually identify smoky vehicles from the camera footage.

- ancillary facilities such as electronic tolling, signage, ventilation structures, fire and life safety systems, emergency evacuation and smoke extraction infrastructure, and a motorway control centre.

The New M5 tunnel ventilation system has been designed, and would be operated, to comply with some of the most stringent limits in the world for in-tunnel air quality. The ventilation system will also be effective at maintaining local air quality, and will ensure zero portal emissions. The ventilation system will be automatically controlled using real-time data on traffic, and feedback from air quality sensors in the tunnel, to ensure in-tunnel conditions are managed effectively in accordance with the agreed limits. Furthermore, specific ventilation modes have been developed to manage breakdowns, congestion, and emergency situations.

1.3 Condition E30

The relevant condition of approval for smoky vehicles (condition E30) is summarised below:

> Prior to operation, the Proponent must investigate, in consultation with the EPA [NSW Environment Protection Authority][2], the measures for smoky vehicle enforcement in the New M5 tunnels, taking into consideration cost effectiveness. Any measures implemented as a result of investigation recommendations must be in accordance with current RMS [NSW Roads and Maritime Services] smoky vehicle enforcement programs. The effectiveness of the smoky vehicle enforcement measures must be documented in the Independent Environmental Audit required under condition E51.

The aims and scope of condition E30 are somewhat open to interpretation, and EMM's interpretation is summarised below.

EMM has assumed that the broad aims of condition E30 are to assist with the following: (i) maintaining visibility in the New M5 tunnels ('tunnel user safety'), and (ii) maintaining in-tunnel air quality ('tunnel user health'). Another, more general, intention of the condition may be to reduce vehicle emissions on surface roads. These aims are similar to those of the existing smoky vehicle enforcement programs for the M5 East tunnel.

With respect to the scope of condition E30, EMM has assumed that it is restricted to *visible* smoke from vehicle exhaust, and specifically the '10-second' rule (see section 2.4.1). This clearly influences the content of the report, as it excludes other pollutants and any methods involving the measurement of emissions. It is worth adding that the inherent assumption here is that visible smoke from vehicle exhaust is an appropriate surrogate for all other exhaust pollutants, which is generally not the case.

1.4 Structure of this report

The subsequent sections of this report contain the following:

- the context of the study, including a summary of road vehicle emissions in Sydney, the causes of smoke in vehicle exhaust, and the mechanisms for reporting of visible exhaust smoke (section 2);
- a review of smoky vehicle enforcement programs in Australia and other countries, based on the 10-second rule or similar (section 3);
- an assessment of the options that are available for smoky vehicle enforcement, according to the 10-second rule or similar (section 4); and
- a summary of the findings of the study, and the resulting conclusions (section 5).

[2] Roads and Maritime Services consulted with the EPA during 2018. Although the consultation was framed in the context of the WestConnex M4 East project, it was equally relevant to other tunnels in NSW.

2 Context

2.1 Road vehicle emissions in Sydney

The most detailed and comprehensive source of information on current and future emissions in the Sydney area is the emissions inventory[3] that is compiled periodically by NSW EPA. A comprehensive inventory was published in 2012. This inventory has a base year 2008 and projections are available for 2011, 2016, 2021, 2026, 2031 and 2036 (NSW EPA 2012)[4]. The importance of road transport as a source of pollution in Sydney can be illustrated by reference to sectoral emissions in the EPA inventory. The data for anthropogenic and biogenic emissions in Sydney, as well as a detailed breakdown of emissions from road transport, are presented here.

Figure 2.1 shows that, in 2016, road transport was responsible for 9% of PM_{10} emissions and 10% of $PM_{2.5}$ emissions. The most important sources of PM_{10} and $PM_{2.5}$ were the domestic-commercial sector and industry, which together accounted for 62% of PM_{10} and 69% of $PM_{2.5}$. The contribution to particulate matter from the domestic sector in Sydney was due largely to wood burning for heating in winter. Emissions from natural sources, such as bushfires, dust storms and marine aerosol, will have contributed significantly to ambient particulate matter concentrations. The projections of sectoral emissions in Figure 2.2 show that the road transport contribution to emissions of PM_{10} and $PM_{2.5}$, is projected to decrease between 2011 and 2036 due to improvements in emission-control technology. However, the relatively small contribution of road transport to emissions of PM_{10} and $PM_{2.5}$ means that the decreases would have only a minor impact on total emissions.

The breakdown of emissions in 2016 from the road transport sector by process and vehicle type is presented in Figure 2.3. Petrol passenger vehicles (mainly cars) accounted for a large proportion of the vehicle kilometres travelled (VKT) in Sydney[5]. Exhaust emissions from these vehicles were a minor source of PM_{10} (3%) and $PM_{2.5}$ (4%). Non-exhaust processes[6] were the largest source of road transport PM_{10} (71%) and $PM_{2.5}$ (57%). This is a larger proportion than in, say, European countries, as there are relatively few diesel cars in Australia. It is also a cause for concern, as there are currently no controls for road, brake and tyre wear particles (and no legislation), and emissions would increase in line with projected traffic growth. Heavy-duty diesel vehicles are disproportionate contributors to particulate matter emissions due to their inherent combustion characteristics, high operating mass (and hence high fuel usage), and level of emission control technology (NSW EPA 2012). The projections of road transport emissions are broken down by process and vehicle group in Figure 2.4. There are projected to be reductions in exhaust emissions of PM_{10} and $PM_{2.5}$ but a growing contribution from road, brake and tyre wear particles.

To summarise, whilst exhaust emissions of PM_{10} and $PM_{2.5}$ from road transport have decreased as vehicle emission legislation has tightened, over the longer term it is anticipated that emission levels would start to rise again as increases in annual VKT would start to offset the reductions achieved by the current emission standards and vehicle technologies. However, the contribution from road, brake and tyre wear sources will be increasingly important in the future.

[3] An emissions inventory defines the amount (in tonnes per year) of pollution that is emitted from each source in a given area.

[4] An updated inventory, with a base year of 2013, was published by NSW EPA in 2019 (https://www.epa.nsw.gov.au/your-environment/air/air-emissions-inventory). However, the projections for future years are not yet publicly available, and hence the data from the older inventory have been used in this report. This would not affect the conclusions of the report.

[5] Diesel passenger vehicles have historically represented a small (but growing) proportion of the total passenger vehicle fleet.

[6] Road surface wear, brake wear and tyre wear.

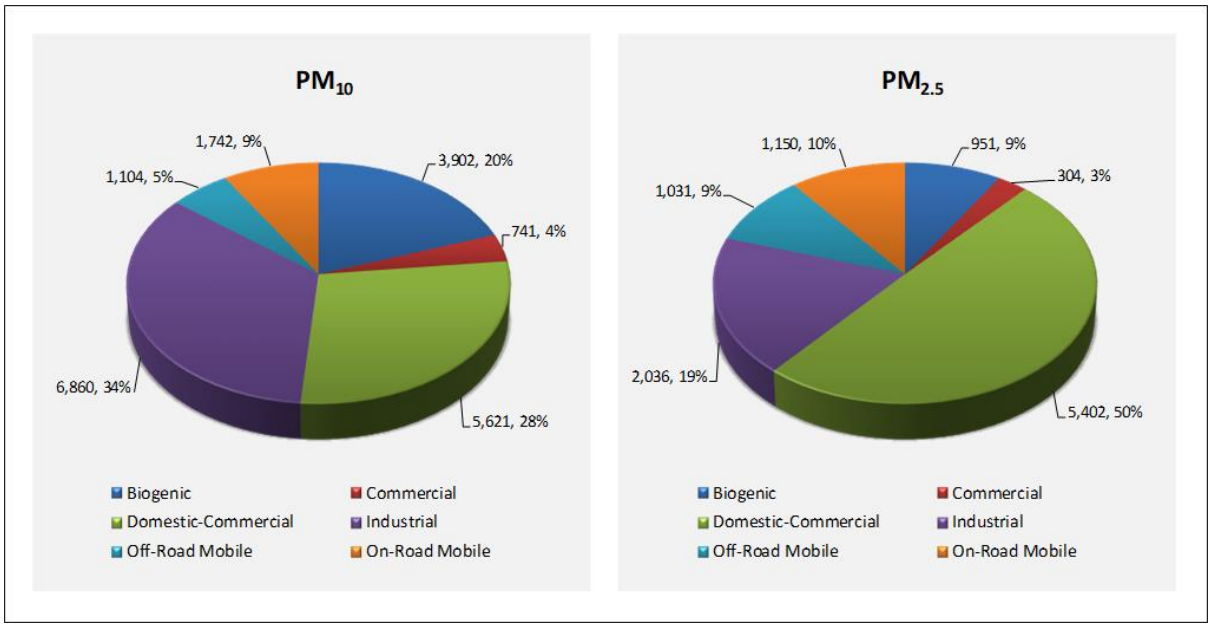

Figure 2.1 **Sectoral emissions of PM_{10} and $PM_{2.5}$ in Sydney, 2016 (tonnes per year and percentage of total)**

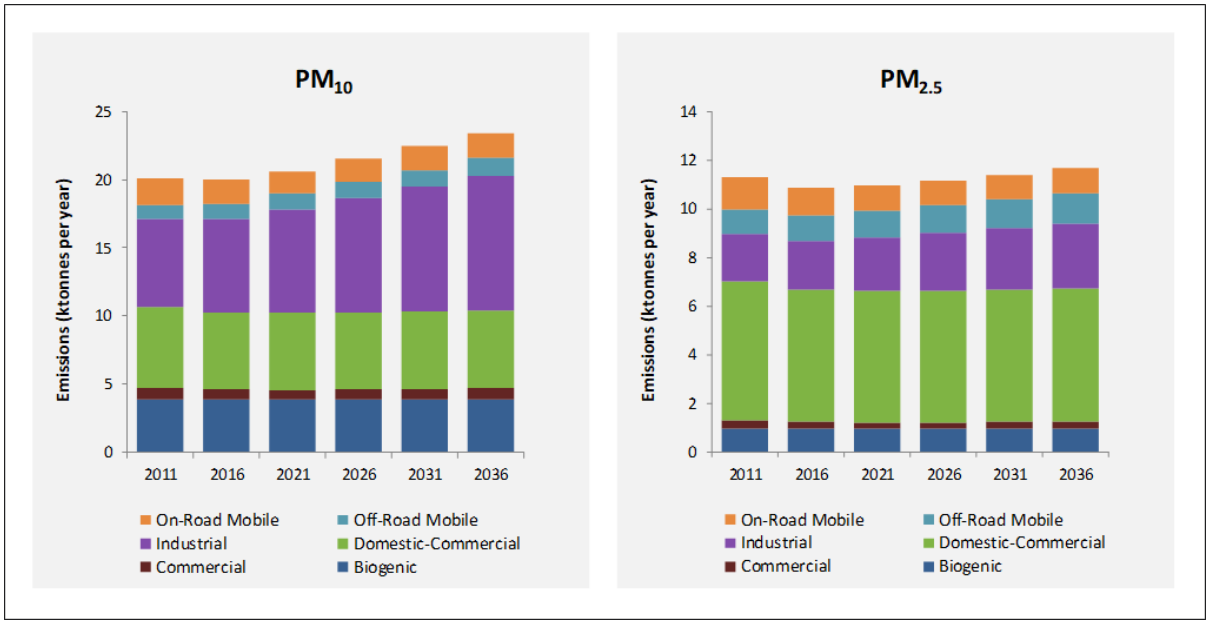

Figure 2.2 **Projections of sectoral emissions of PM_{10} and $PM_{2.5}$ in Sydney, 2011-2036**

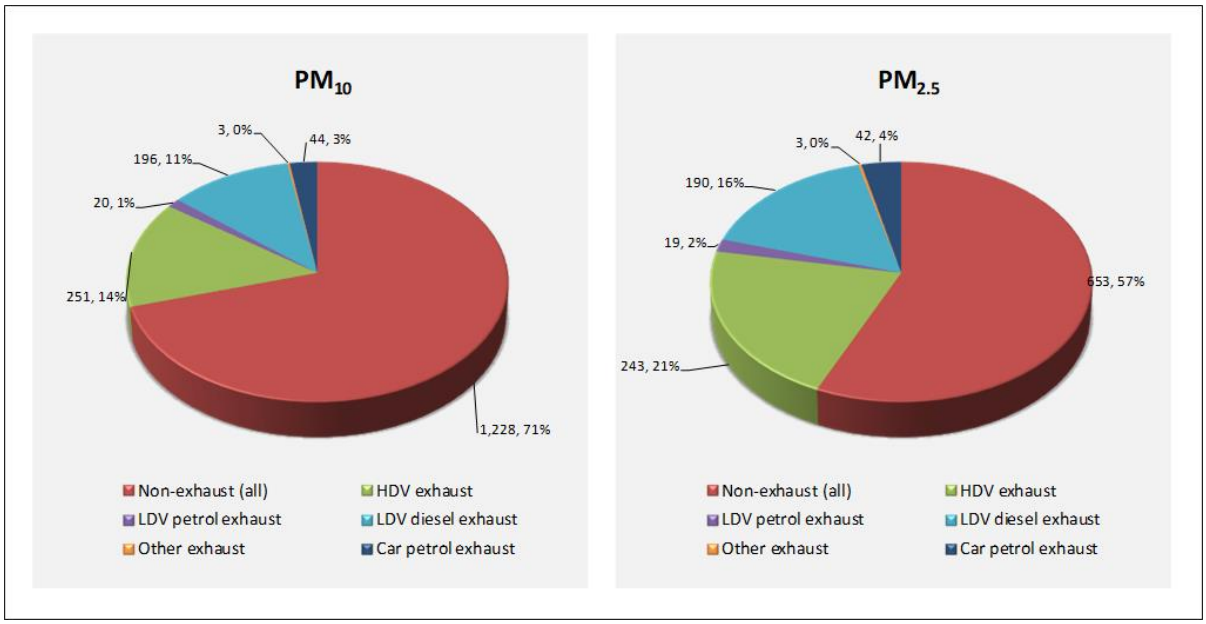

Figure 2.3 **Breakdown of road transport emissions of PM_{10} and $PM_{2.5}$ in Sydney, 2016 (tonnes per year and percentage of total)**

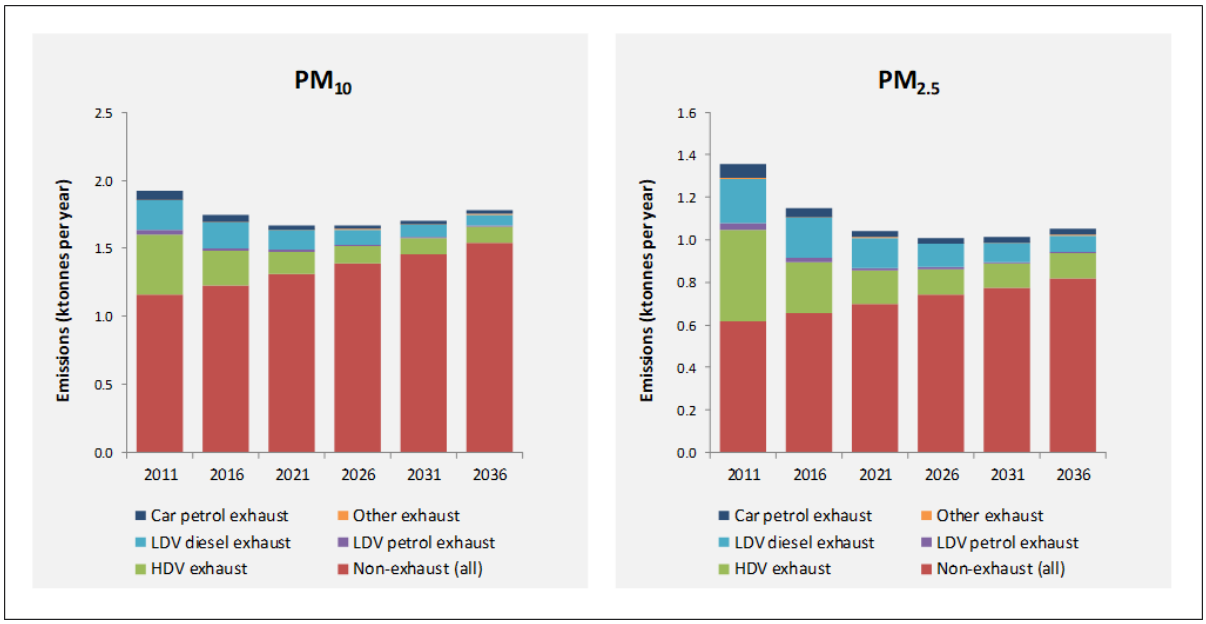

Figure 2.4 **Projections of road transport emission of PM_{10} and $PM_{2.5}$ in Sydney, 2011-2036**

2.2 High emitters and smoky vehicles

Various studies have shown that, for some pollutants, relatively small numbers of vehicles have particularly high emission levels, and that these high emitters have a disproportionately large contribution to overall emissions.

In the EPA's inventory the contribution of high emitters is only calculated for light-duty petrol vehicles. Assumptions are made concerning the emission factors for high emitters and the proportion of these vehicles in the fleet. However, it can be seen from Figure 2.2 that light-duty petrol vehicles are only responsible for a small percentage of PM_{10} and $PM_{2.5}$ emissions from road transport in Sydney.

Excessive emissions of smoke from vehicle exhaust are visually intrusive, odorous, and potentially a risk to public health. Some smoky vehicles may also be high emitters. However, as noted in section 1.3, the correlations between emissions of visible smoke and emissions of other pollutants are weak. Therefore, a smoky vehicle program which uses the 10-second smoke rule cannot ensure detection of vehicles with excess emissions of particulate matter mass, or of gaseous pollutants such as oxides of nitrogen (NO_X), hydrocarbons (HC) and carbon monoxide (CO).

2.3 Causes of visible smoke

There are three basic types of smoke that can be emitted from petrol and diesel vehicles: white smoke, blue smoke and black/grey smoke. Some common causes of these are summarised in Table 2.1.

Smoke from petrol-engine vehicles is mainly due to excessive wear. Blue smoke may be emitted from the exhaust pipe or the crankcase, and normally signifies engine wear or damage. It is emitted from the exhaust pipe when oil finds its way into the combustion chamber and is burnt. Black smoke results from an excessively rich fuel mixture, which can result from, for example, a faulty engine management system or faulty fuel injectors.

Diesel-engine vehicles have historically been more prone to smoke emissions than petrol-engine vehicles. Any diesel engine that is in good condition should produce no visible smoke from the exhaust under most operating conditions. However, for some older diesel vehicles a brief puff of smoke may be released when the engine is placed under heavy load (eg during accelerations or when travelling uphill). This is due to the lag before the turbocharger speed and air flow is able to match the volume of diesel injected into the cylinders. This should not be the case for modern diesel vehicles. Smoke from a modern diesel engine is therefore indicative of a fault.

In diesel vehicles white smoke occurs when raw, unburned diesel is present in the exhaust. Some causes of this include faulty or damaged injectors, incorrect injection timing, low cylinder compression, and cylinder wear. Water entering combustion spaces can also create white smoke[7]. Faulty head gaskets and cracked cylinder heads are common causes. Blue smoke from diesel engines indicates that oil is being burnt, and normally means engine wear or damage. The oil can enter the combustion chamber for several reasons, including worn valve seals, cylinders, and piston rings. Black smoke is the most common smoke emitted from diesel engines. It indicates poor and incomplete combustion of the diesel fuel, and the smoke is high in carbon or soot. There are many causes, including incorrect timing, dirty or worn injectors, over-fuelling, and a faulty turbocharger.

[7] Water vapour (condensation) in vehicle exhaust can commonly be mistaken for smoke during cold weather. Water vapour is a normal product of combustion, and is not considered to be vehicle smoke.

Table 2.1 Common causes of smoke from vehicle exhaust (Oregon DEQ 2015)

Colour of smoke	Diagnosis	Probable causes
Petrol engines		
White	Coolant or water leaking into combustion chamber	• Bad head gasket • Cracked block or cylinder head • Damaged head gasket
Blue	Engine oil being burned	• Oil leaking into combustion chamber • Worn piston rings, valves or cylinders, damaged head gasket, oil contacting the hot exhaust
Black/grey	Incomplete fuel combustion	• Clogged air filter • Carburettor choke malfunction, dirty fuel injectors, or emission system malfunction • Ignition timing off • Low compression due to engine wear
Diesel engines		
White	Improper air/fuel mixture	• Faulty fuel injection system • Incorrect fuel injection and valve timing • Engine overheating • Faulty fuel pump and/or injection pump
Blue	Engine oil being burned	• Excess engine oil • Worn piston rings, valves or cylinders
Black/grey	Incomplete fuel combustion	• Damaged or clogged air filter • Faulty fuel injection system • Wrong grade of fuel • Incorrect fuel injection pump timing • Engine overheating • Low compression ratio

2.4 Reporting of visible smoke in Australia

2.4.1 The ’10-second’ rule

Emission standards at the vehicle type approval stage are defined in Australian Design Rules (ADRs). In 1976, ADR 30/00 introduced a smoke emission requirement for vehicles with four or more wheels powered by a diesel engine. Given the expectation that there will be some level of deterioration with vehicle age, a ’10-second smoke rule’ was developed to provide a means for regulating in-service vehicle smoke emissions. That is, smoky vehicles are those that are visually identified as emitting smoke continuously for a period of 10 seconds or more. As suggested in section 2.3, a properly maintained and inspected vehicle will emit smoke only briefly, which is why a period of 10 seconds is used to classify smoky vehicles on the road.

2.4.2 National Environment Protection (Diesel Vehicle Emissions) Measure

The National Environment Protection (Diesel Vehicle Emissions) Measure ('Diesel NEPM') was made in June 2001. The goal of the Diesel NEPM is to reduce exhaust emissions from diesel vehicles by facilitating compliance with in-service emissions standards. Under the NEPM, several Australian jurisdictions run smoky vehicle reporting programs and diesel vehicle emission testing and repair programs. In these programs the 10-second rule is applied.

2.4.3 Heavy Vehicle (Vehicle Standards) National Regulation

For heavy vehicles (those above 4.5 tonnes) to be considered roadworthy in Australia, they must comply with the Heavy Vehicle (Vehicle Standards) National Regulation. Part 8, section 95 of Schedule 2 of the Regulation specifies that heavy vehicles must not emit visible smoke for a continuous period of 10 seconds or more. The National Heavy Vehicle Regulator (NHVR) was established in 2013, and has published a manual to provide consistent criteria for in-service inspections (NHVR 2018). Section 11.3 of the manual applies the 10-second smoke rule.

2.4.4 Role of the jurisdictions – smoky vehicle programs

In some Australian jurisdictions there has been a smoky vehicle program in place, in one form or another, since the 1970s. These programs are intended to provide a means of detecting vehicles that have deteriorated to a point where excessive emissions can be visually observed. Smoky vehicle programs may require the owner to repair the vehicle and/or encourage them to make repairs to reduce smoke. Currently, several jurisdictions run a smoky vehicle reporting program in which the 10-second rule is applied by authorised personnel. There is also normally provision for the general public to report smoky vehicles. The programs in the various Australian jurisdictions, as well as those in some other countries, have been reviewed in section 3.

3 Review of smoky vehicle enforcement programs

This section of the report contains a review of the smoky vehicle enforcement programs in Australia and in other countries, and summarises the trends in the available data. Given that the report is concerned with the New M5 project in Sydney, this section focuses mainly on the programs in NSW. The review is restricted to programs based on the application of the 10-second rule (or similar).

3.1 Australia

3.1.1 New South Wales

i Legislation

a Protection of the Environment Operations Act

The *Protection of the Environment Operations Act 1997* (POEO Act) is a key piece of environment protection legislation in NSW, and provides a statutory framework for managing air emissions. The POEO Act, which is administered by NSW EPA, is supported by the following:

- the Protection of the Environment Operations (Clean Air) Regulation 2010, which provides regulatory measures to control emissions from industry, motor vehicles and fuels, domestic solid fuel heaters and open burning; and

- the Protection of the Environment Operations (General) Regulation 2009, which establishes a licensing scheme for major industrial premises and provides economic incentives for licensed businesses and industry to reduce pollution, including emissions to air.

Part 4, Division 2, Clause 15 of the Clean Air Regulation 2010 defines excessive air impurities with respect to motor vehicles propelled by a spark-ignition or diesel engine:

- for the purposes of section 154 (2) (a) of the POEO Act, a motor vehicle emits excessive air impurities if, when in operation, it emits air impurities in excess of such a standard of concentration that air impurities are visible for a continuous period of more than 10 seconds when determined in accordance with Test Method 31 (see below); and

- for the purposes of section 154 (2) (b) of the POEO Act, a motor vehicle emits excessive air impurities if, when tested in accordance with Test Method 31, it emits air impurities in excess of an amount per test that results in air impurities being visible for a continuous period of more than 10 seconds.

As noted above, in NSW, the procedure by which the 10-second rule is applied is defined in Test Method 31 of the Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales (DEC 2007). Test Method 31 is summarised in Appendix A.

b Other legislation

The Heavy Vehicle (Vehicle Standards) National Regulation (see section 2.4.3) is implemented in NSW law, and is a key piece of legislation for managing air emissions from heavy vehicles.

With regard to light vehicles, Part 9 section 130 of Schedule 2 of the Road Transport (Vehicle Registration) Regulation 2017 specifies that vehicles must not emit visible smoke for more than 10 seconds.

ii EPA smoky vehicle program

NSW EPA is responsible for maintaining a smoky vehicle program to fulfil its regulatory responsibilities under the POEO Act[8]. EPA officers, who have been trained in smoky vehicle observation according to the 10-second rule, patrol roads in NSW. Vehicles judged to emit excessive smoke are required to undergo maintenance and be submitted for inspection. Various sanctions and penalties may be applied, and an officer may automatically issue the owner of a smoky vehicle used for commercial purposes with a $400 fine. Commercial vehicles often travel far greater distances each year than privately owned vehicles, and have the potential to emit more pollution if they have smoky exhausts. They are therefore a particular target for enforcement action.

A Defective Vehicle Notices can be issued to the owner of vehicle who fails to repair it as directed, or a vehicle which is observed to be smoky on a number of occasions. A Defective Vehicle Notice requires the owner to carry out any necessary repairs so that the vehicle no longer emits excessive smoke, and to provide evidence to the EPA that the repairs were carried out. Failure to provide evidence that the vehicle is no longer emitting excessive smoke may result in the vehicle registration being suspended.

iii The M5 East Air Quality Improvement Plan (2006-2012)

In June 2006 the NSW Minister for Roads announced plans by the NSW Government to improve air quality in the M5 East tunnel (RTA 2006). This was in response to community concern about the level of haze caused by the high numbers of smoky heavy vehicles using the tunnel.

This Air Quality Improvement Plan included the following for the tunnel:

- installing a smoky vehicle camera/video system;
- increased ventilation flows with an extra 12 jet fans; and
- a trial of filtration technology.

iv The M5 East Air Quality Improvement Program (2012)

The 2012 M5 East Air Quality Improvement Program was delivered jointly by Roads and Maritime Services and EPA. The Program adopted a wide-ranging approach to reduce the impact of existing older heavy diesel trucks, both in the M5 East tunnel and elsewhere. The main elements of the Program were:

- a ‘Smoky Vehicle Enforcement Project’;
- a ‘Vehicle Emissions Enforcement System’, involving a smoky vehicle camera/video system; and
- a ‘Diesel Retrofit and Repair Initiative’.

More details of these elements are provided below.

a Smoky Vehicle Enforcement Project

The Smoky Vehicle Enforcement Project started in March 2013. It included increased fines for the operators of smoky vehicles. Vehicle operators faced a fine of $2,000 for the first two offences, and a third offence attracted a

[8] https://www.epa.nsw.gov.au/your-environment/air/ninair/smoky-vehicle-program

$2,000 fine as well as an automatic three-month suspension of vehicle registration. However, the Project was suspended in January 2018 due to a decline in the number of penalty notices being issued.

b Vehicle Emissions Enforcement System

Roads and Maritime Services has developed a Vehicle Emissions Enforcement System (VEES) for the M5 East tunnel to reduce haze, improve overall air quality, and reduce exposure to air pollution in and around the tunnel. The VEES is designed to detect, identify and record smoky vehicles using smoke detectors, video cameras, and still cameras with optical character recognition software. It includes a camera detection device[9] that captures video images of vehicles emitting continuous visible smoke for analysis by an adjudicator. The system was initially installed in June 2006 as part of the Air Quality Improvement Plan, and upgraded in 2012 as part of the Air Quality Improvement Program. The upgrade allowed a broader range of vehicles to be detected.

The VEES is installed on the steep incline near the exit of the westbound tube of the M5 East tunnel, where the gradient (up to around 8%) has the effect of reducing the speed of some heavy vehicles as they climb out of the tunnel, and increasing the amount of visible smoke that some vehicles can emit due to the high engine load. The video camera footage covers a distance of around 200 m.

A Memorandum of Understanding (MOU) relating to the VEES has been established between Roads and Maritime Services and EPA. Roads and Maritime Services is responsible for operating the VEES, with EPA being responsible for issuing penalty notices in conjunction with offences. The process of smoky vehicle detection and notification is as follows:

- the M5 East cameras generate video image recordings ('potential offence files') of motor vehicles travelling through the tunnel and emitting smoke;
- the potential offence files are sent for adjudication by Roads and Maritime Services officers and, if a breach has been identified, are referred to the EPA for enforcement action;
- an EPA officer determines whether the vehicle is compliant or not; and
- if non-compliant, EPA sends advisory letter to vehicle owner. The EPA may then issue a penalty notice in relation to the incident. The recipient may elect to pay a fine, request a review of the penalty notice, or contest the penalty notice in court. The majority of vehicles are checked and repaired.

It is current policy that penalty notices are not issued if the EPA officer reports that the visible emission was continuous for less than 15 seconds. This is to allow uncertainty in the observed duration of the smoke emission.

The VEES does have some limitations, notably:

- the system only captures visible smoke from heavy vehicles with vertical exhausts, and is not suitable for the detection of smoke from heavy vehicles with horizontal exhausts[10]. Horizontal exhaust pipes can be obscured by other vehicle components, making it more difficult to pinpoint the source of any visible smoke; and
- due to the lighting conditions in the M5 East tunnel, camera adjudicators have occasionally been unable to confirm that emissions were continuous for more than 15 seconds;
- because of traffic conditions, camera adjudicators have occasionally been unable to identify the offending vehicle; and

[9] For the purposes of Test Method 31 the VEES hardware and software constitutes an approved system.

[10] EPA removed the requirement for vertical exhausts on vehicles that comply with ADR 80/01 (Euro 4), allowing for underbody exhausts on 2007 and later heavy vehicles.

- the system is designed for vehicles travelling at a relatively low speed. This means that a significant fraction of the traffic in the tunnel cannot be captured. For example, because the video camera footage only covers a distance of around 200 m, and the smoke emission has to be continuous for at least 15 seconds, then only vehicles with a speed of less than around 50 km/h (30 mph) can be captured. The field of view can actually cover a distance of more than 200 m, but the corresponding speeds are still low.

As a result of the declining number of smoky vehicles being reported to EPA (see below) and a reduction in funding, the program was suspended in December 2017.

c Diesel Retrofit and Repair Initiative

Roads and Maritime Services introduced the M5 East Tunnel Diesel Retrofit and Repair Initiative in March 2013. The aim of the initiative is to reduce the levels of PM_{10} in the tunnel by identifying and repairing smoky vehicles Smoky vehicles are identified using a camera system (see below). Operators of these vehicles are offered a 50% subsidy (up to a $10,000 cap) to repair emissions-related engine faults and to install particle traps in the exhaust systems of these vehicles.

v Public reporting of smoky vehicles

The public may report smoky vehicles via the EPA's Environment Line, website, or mobile phone app.

vi Trends in smoky vehicle reporting

Figure 3.1 shows the annual numbers of smoky vehicles reported in NSW over the period 1989-2018, with the results grouped by type of reporting:

- **Public.** This group relates to reporting by members of the public via the EPA's online smoky vehicle portal. The portal provides advice regarding the application of the 10-second rule. Users should only try to submit reports when the visible emission is continuous for more than 10 seconds. If the user does not report that the visible emission is continuous for more than 10 seconds, the report will not be accepted.

- **M5 East tunnel camera system.** This group relates to smoky vehicles detected by the cameras and adjudicators in the M5 East tunnel. The EPA policy for reporting smoky vehicle offences has also been adopted for the M5 East system. That is to say, penalty notices are only issued when Roads and Maritime Services camera adjudicators report that a smoke emission is continuously visible for 15 seconds or more. EPA officers provided training to the camera adjudicators in the application of Test Method 31.

- **Roads and Maritime Services officers.** This group relates to smoky vehicles reported by Roads and Maritime Services officers in the field.

- **Environment Protection Authority officers.** This group relates to smoky vehicles reported by EPA officers in the field. Under the EPA's current policy, penalty notices are only issued based on reports submitted by EPA officers who have undergone training in the application of Test Method 31.

For 2018, data were only available for public reporting, and only to the end June. This explains the dotted line between 2017 and 2018 in the first plot of Figure 3.1.

Public reporting of smoky vehicles increased after 1990, and dramatically between 1995 and 1996, to a peak of 8,400 per year. There was then a systematic decrease between 1996 and 2011, with a levelling off of observations thereafter. In recent years, public reports have remained relatively stable, at between 1,500 and 1,800 per year. The data for 2018 are incomplete, but suggest that there would have been a further reduction in reporting during this year.

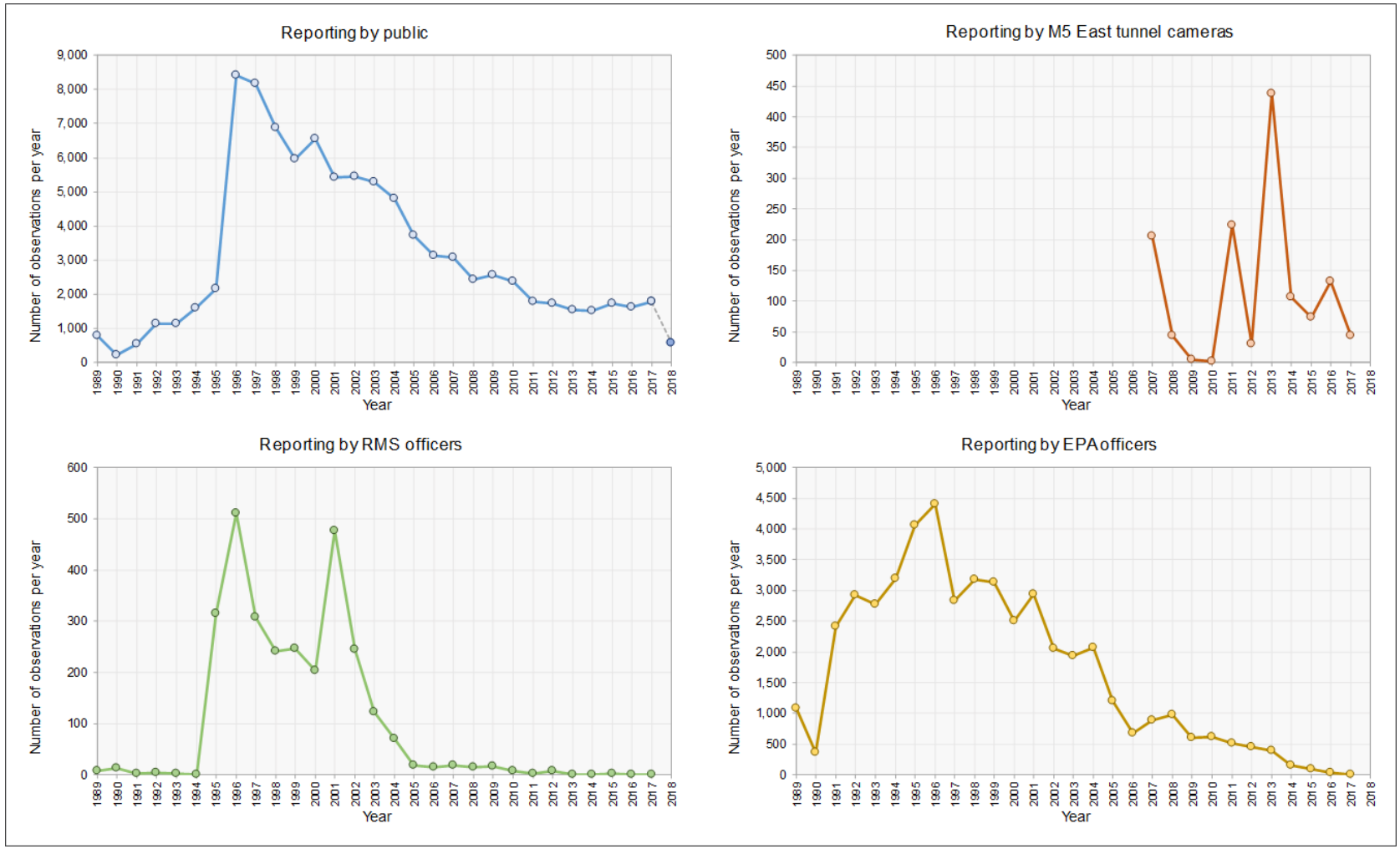

Figure 3.1 Smoky vehicle observations in NSW between 1989 and 2018, by type of report

For the M5 East tunnel there has been no systematic trend in smoky vehicle observations. In most years there have been fewer than 250 observations. In one year (2013) there were around 440 observations, and this may be explained in part by the upgrade of the VEES that took place in 2012. Fines for smoky vehicles also increased in March of 2013, and this may have resulted in some drivers avoiding the tunnel after this date. The M5 East smoky vehicle program has been suspended since January 2018 due to the significant decline in the number of penalty notices being issued.

There were very few observations by Roads and Maritime Services officers prior to 1995 and after 2004. There was a sharp increase in observations between 1994 and 1996, followed by a general decrease between 1996 and 2005, although there were peaks in 2001 and 2002. From 2005 onwards the number of observations has been low.

The number of observations by EPA officers increased from 1990 to a peak in 1996. There was then a steady decrease between 1996 and 2017. By 2017 the number of observations was very low

Additional monthly data from the M5 East VEES during 2016 and 2017 are summarised in Figure 3.2 (Sarkar 2018). This graph shows the number of VEES images that were adjudicated each month by Roads and Maritime Services, and the corresponding number of referrals to EPA (note different scales). It can be seen that very few reports (less than five per month) were issued to EPA after February 2017.

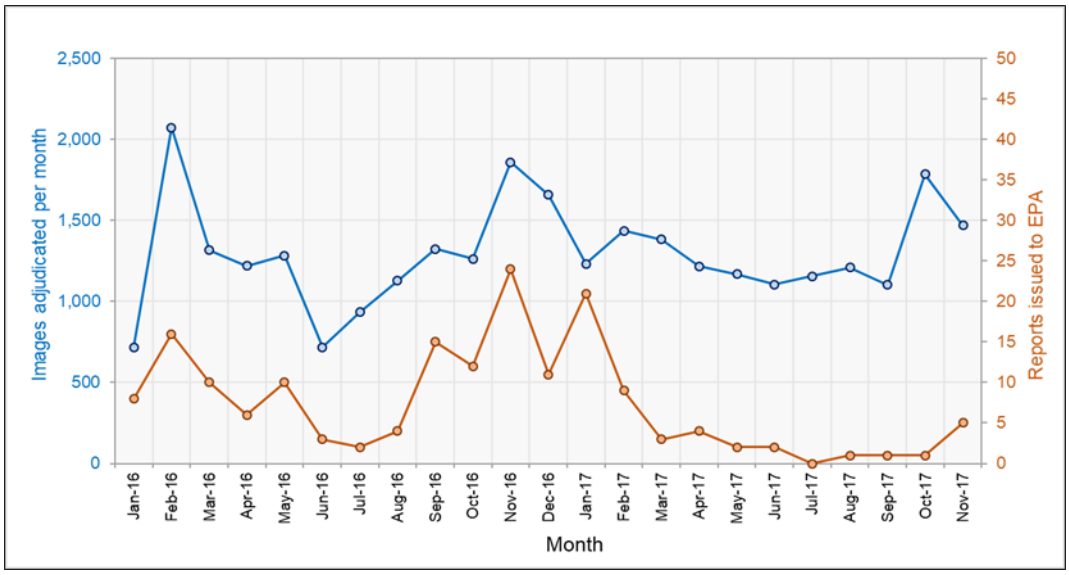

Figure 3.2 Results from the VEES in 2016 and 2017

Figure 3.3 shows, for different years, the total numbers of vehicles that have been issued with a penalty notice by NSW EPA, and the proportion of those vehicles with a diesel engine (NEPC 2008-2017). In a reflection of the number of vehicles being reported, the number of penalty notices has declined markedly over the last 10-25 years. In 2015-16, EPA officers issued only around 90 penalty notices to the owners of smoky vehicles. The proportion of smoky vehicles with a diesel engine has generally remained quite steady at above 90%.

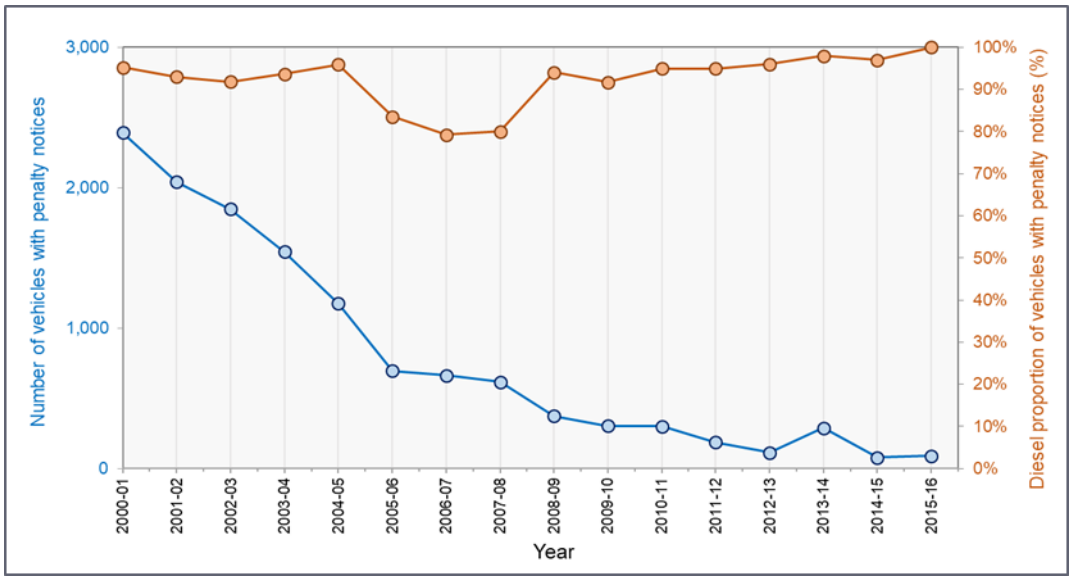

Figure 3.3 Penalty notices by year

The contributions of all reporting groups are shown in Figure 3.4. In percentage terms, the public contribution to smoky vehicle reports has increased with time, from around 20-40% in the 1990s to almost 100% in recent years. Public reporting has been the dominant mechanism for the last 10-15 years. In the 1990s and early 2000s, reporting by EPA officers was also a significant contributor, but this contribution has decreased substantially in recent years.

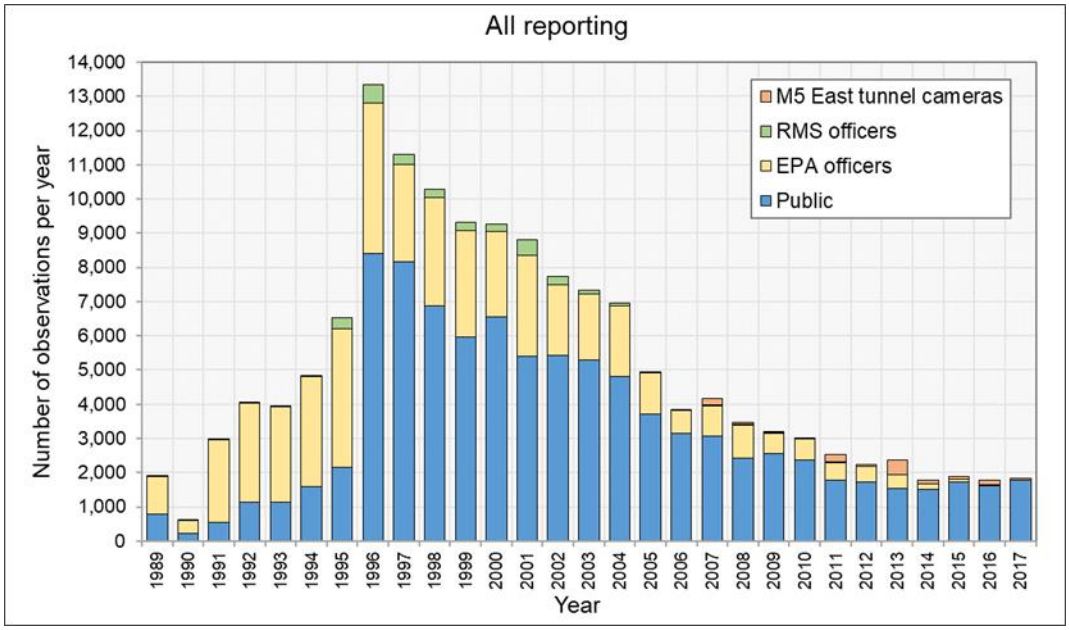

Figure 3.4 Contributions to smoky vehicle observations in NSW between 1989 and 2018

Little supporting information is available to explain the trends in the NSW data. The following factors may have exerted pressures on the number of smoky vehicle reports (these pressures could have acted in different directions at different points in time):

- the total number of vehicles on the road;
- the vehicle technology mix, and more specifically the prevalence of older-technology diesel vehicles in the fleet;
- for the M5 East tunnel, the possibility that old vehicles (or potential smoky vehicles) avoid the tunnel to avoid identification;
- the level of public awareness of the mechanism for reporting smoky vehicles;
- public satisfaction with the effectiveness of the smoky vehicle programs, and the willingness to submit reports; and
- the level of government funding for the smoky vehicle programs.

In Figure 3.5, the historical pattern in the *total* number of smoky vehicle observations is compared with the trends (normalised to 2003) in some indicators that could have had a bearing on the number of smoky vehicles reported. These are:

- the population of NSW (ABS 2018a);
- the number of vehicles registered in NSW (Roads and Maritime Services 2018);
- the number of vehicle-kilometres travelled (VKT) in NSW (ABS 2018b; ABS 2011; ABS 2006; ABS 2001; BITRE 2011);
- the proportion of diesel vehicles (of all types) on main roads (the example is for highways); and
- the regulated sulfur content of automotive diesel. The estimated average exhaust emission factor[11] for $PM_{2.5}$ for vehicles on the road in NSW (no data available prior to 2003).

It is clear that the number of smoky vehicle reports has decreased considerably in spite of continuing increases in the population, the number of vehicles in the fleet, the amount of travel, and the proportion of diesel vehicles on main roads. However, there has been a reduction in the average $PM_{2.5}$ exhaust emission factor of the NSW fleet, as well as fuel sulfur content, which indicates that improvements in automotive fuel quality and emission-control technology are likely to have been important factors in the reduced reporting of smoky vehicles. The possibility that older vehicles may be avoiding the M5 East tunnel to avoid detection has little bearing on these total numbers of smoky vehicle reports for NSW, given that the contribution of the M5 East observations to the total is very small. There is no information to determine whether other factors, such as public satisfaction with the smoky vehicle programs, have influenced reporting.

[11] This was calculated using a model similar to that used in the NSW EPA's emission inventory. It was calculated for a typical traffic mix on arterial roads and an average traffic speed of 40 km/h. Emission factors were not available for years prior to 2003.

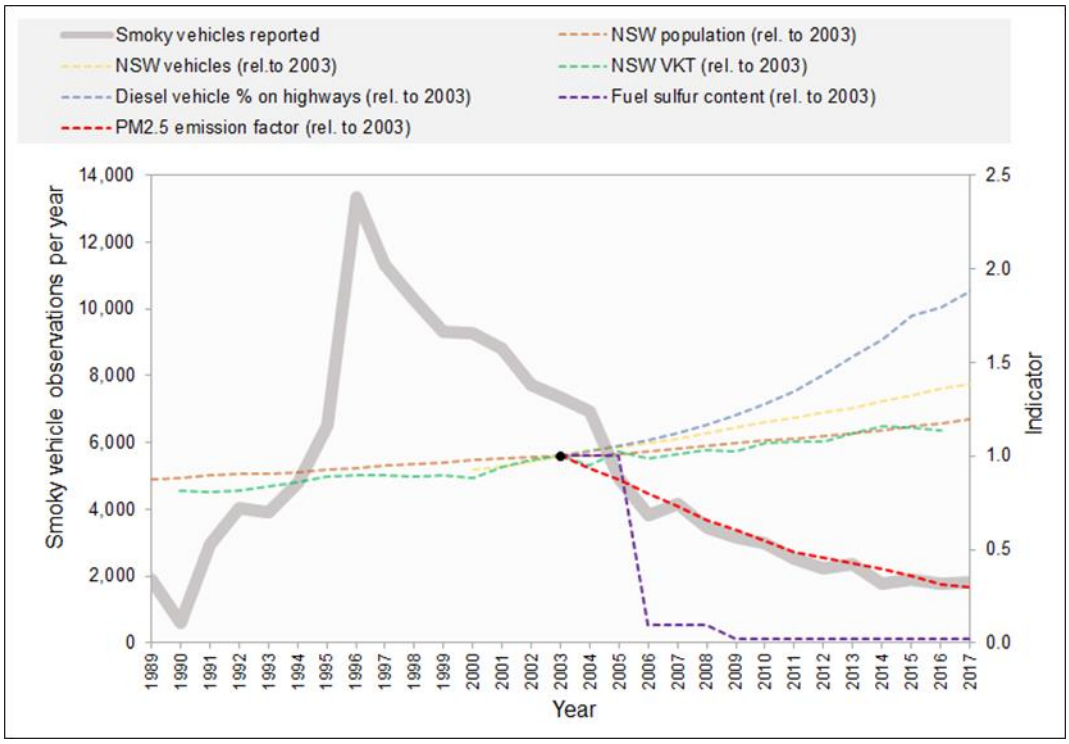

Figure 3.5 Smoky vehicle observations in NSW and other metrics

vii Program cost-effectiveness

The camera system in the M5 East tunnel was installed in June 2006 at a cost of $3 million, and upgraded in 2012 at a cost of $250,000. The MOU between Roads and Maritime Services and EPA had stated an operational fee of $110,000 every 6 months, to be paid by Roads and Maritime Services to EPA with regard to the issuing of penalty notices and the prosecution of offences. This fee was calculated based on approximately 300 offences per annum (in 2017, 44 smoky vehicles were identified in the tunnel).

Little information is available to determine the overall cost-effectiveness of the NSW smoky vehicle program (or indeed other programs). However, it seems unlikely that the NSW program would be particularly cost-effective given the relatively small numbers of smoky vehicles that are currently being identified. In an economic analysis to support the review of the Ambient Air Quality NEPM, Pacific Environment (2013) examined the costs and benefits of various pollution-reduction measures. Although the authors did not investigate smoky vehicle programs per se, they did consider targeted maintenance of high-emitting light-duty vehicles using remote sensing, as well as a penalty and incentive scheme for high emitters. These measures were found to give relatively low emission reductions at relatively high cost (with a benefit:cost ratio of less than one), especially when compared with other measures such as regulations for wood heaters and non-road diesel engines, and control measures for coal mines.

3.1.2 Victoria

The Environmental Protection Authority of Victoria (EPA Victoria) has operated a smoky vehicle reporting program for a number of years. The program allows members of the public to identify smoky vehicles (diesel, petrol or LPG) using the 10-second rule, and to report them to EPA Victoria. Public reporting is via the EPA Victoria web site[12]. EPA Victoria also operates an enforcement program, whereby EPA Victoria or Victoria Police officers can report vehicles

[12] https://www.epa.vic.gov.au/get-involved/report-smoky-vehicles

identified as emitting continuous smoke for at least 10 seconds. As a result of these reports, the owners of the offending vehicles are informed in writing (via a cautionary letter), and are requested to have the problem fixed. Owners are also informed of the penalties that may apply (NEPC 2017).

Some historical summary data on smoky vehicles in Victoria are available from the annual reports of the National Environment Protection Council (NEPC 2008-2017), and information for recent years was also provided by EPA Victoria (Tangtatco 2018). Figure 3.6 shows the number of smoky vehicles, of all types, reported by the public, and the number of cautionary letters issued by the police and EPA Victoria (note different scales), between 2005 and 2017. There has been a clear downward trend in both sets of data. The number of public reports decreased from around 10,500 in 2005-06 to around 2,000 in 2013-14. In recent years the number of reports has remained at around 2,000 per year. The number of cautionary letters being issued decreased from 1,500 in 2005-06 to between around 100 and 200 from 2013-14 onwards.

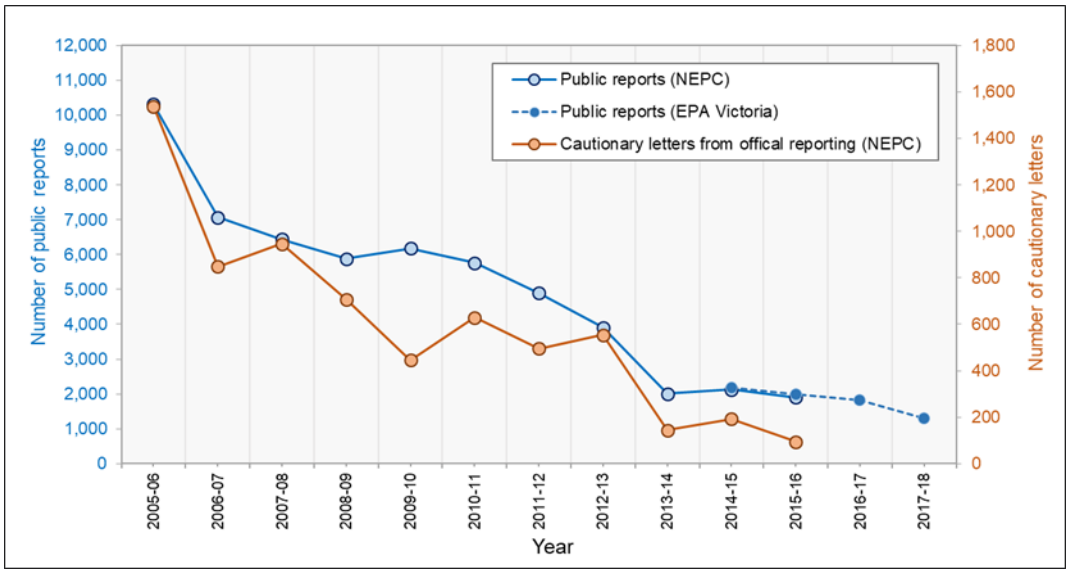

Figure 3.6 Numbers of smoky vehicle reported (publicly) and cautionary letters issued (from official reporting) under the EPA Victoria smoky vehicle program

It was noted by NEPC (2017) that, prior to the reporting of heavy vehicles to the National Heavy Vehicle Regulator, there was a significant decline in the proportion of diesel-engine vehicles heavier than 1.5 tonnes being reported. This could indicate that there are now fewer smoky diesel vehicles in this category.

3.1.3 Queensland

The Queensland Department of Transport and Main Roads operates a smoky vehicle web site and hotline[13]. This provides the public with an avenue for reporting vehicles that breach the 10-second rule. Following a data match of the information provided for a vehicle, a letter is sent to the owner advising them of the report and suggesting ways to identify and rectify the problem. If the vehicle is reported three times within a four-month period, the owner is issued with a Present Vehicle Order (PVO) which requires the vehicle to be checked for defects by a Transport Inspector.

[13]https://www.tmr.qld.gov.au/Community-and-environment/Environmental-management/How-you-can-make-a-difference/Report-a-smoky-vehicle

Some historical summary data for smoky vehicles in Queensland are available from the NEPC annual reports (NEPC 2008-2017). Figure 3.7 shows the numbers of all vehicles reported on the hotline, as well as the numbers of diesel vehicles reported. The total number of smoky vehicles reported decreased substantially between 2007 and 2011, but has been quite stable in recent years. The number of diesel vehicles reported has decreased more steadily. In recent years around 35% to 45% of all reported vehicles have been diesel. NEPC (2017) notes that Brisbane has experienced a residential construction boom which has seen an increase in heavy vehicles in urban areas, and there has also been a large increase in diesel light vehicles. These factors may have contributed to the upturn in the reporting of smoky vehicles in 2015-16.

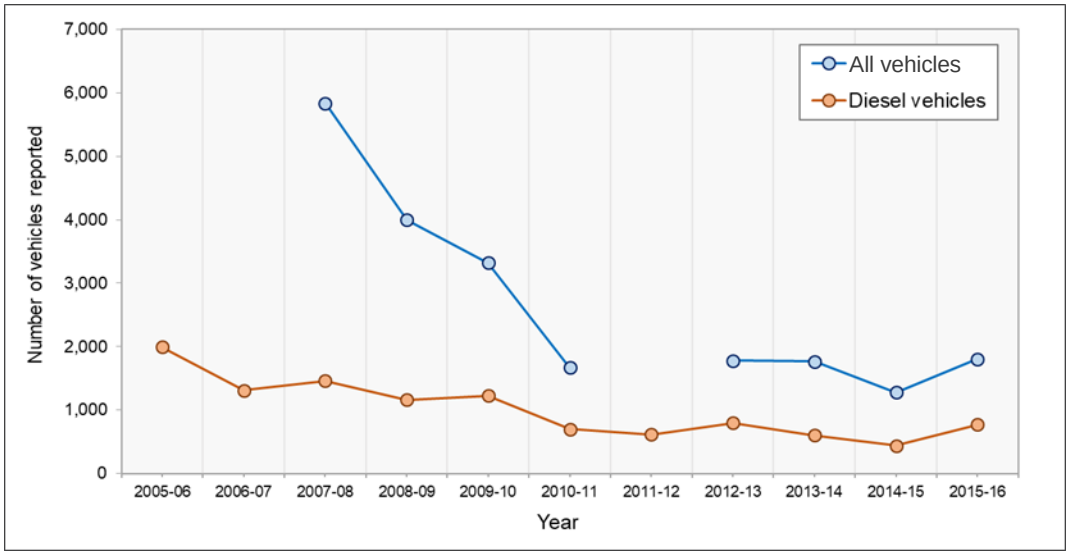

Figure 3.7 Numbers of smoky vehicles reported in Queensland

3.1.4 Western Australia

Western Australia's smoky vehicle program is operated by the Department of Water and Environmental Regulation (DWER)[14], with the support of the Department of Transport (DoT). The Program is a key initiative of the Diesel NEPM and the Perth Air Quality Management Plan. The first annual report for the program covered the period between July 2016 and June 2017, and summarised the objectives, mechanics and performance of the program (DWER 2018). Some historical summary data are also available from NEPC annual reports.

Members of the public who identify vehicles that emit smoke continuously for 10 seconds or more can submit reports to DWER. DWER and DoT then verify the details in the reports and notify the owners of the vehicles, who are given an opportunity to respond. The responses are collected, and statistical data on the reported vehicles are compiled. For example, in 2016–2017, the program received 480 reports of smoky vehicles. Of these, 424 were verified and a letter was issued to the vehicle owner. A total of 303 responses were received from the identified owners.

Figure 3.8 shows the number of smoky vehicles reported over a seven-year period. There is no systematic trend in the data, with typically around 400 vehicles being reported each year. In Figure 3.9 the actions reported by respondents are shown as a percentage of the total number of letters issued. Between around 40% and 50% of the responses received indicated that the vehicle owner had repaired their vehicle after being notified. Between 30%

[14] https://www.der.wa.gov.au/our-work/programs/172-smoky-vehicle-reporting-program

and 40% of responses advised that the owner considered the vehicle in question did not emit smoke, indicating different interpretations of what constitutes a smoky vehicle between reporters and vehicle owners. A notable change for 2016–2017 was the drop in the 'vehicle details incorrect' response. The verification process that compares reported vehicle make, model and colour against the DoT database was added February 2016, and has effectively eliminated this issue (DEWR 2018). From Figure 3.10 it can be seen that most of the vehicles reported (typically around 50-70%) had a diesel engine.

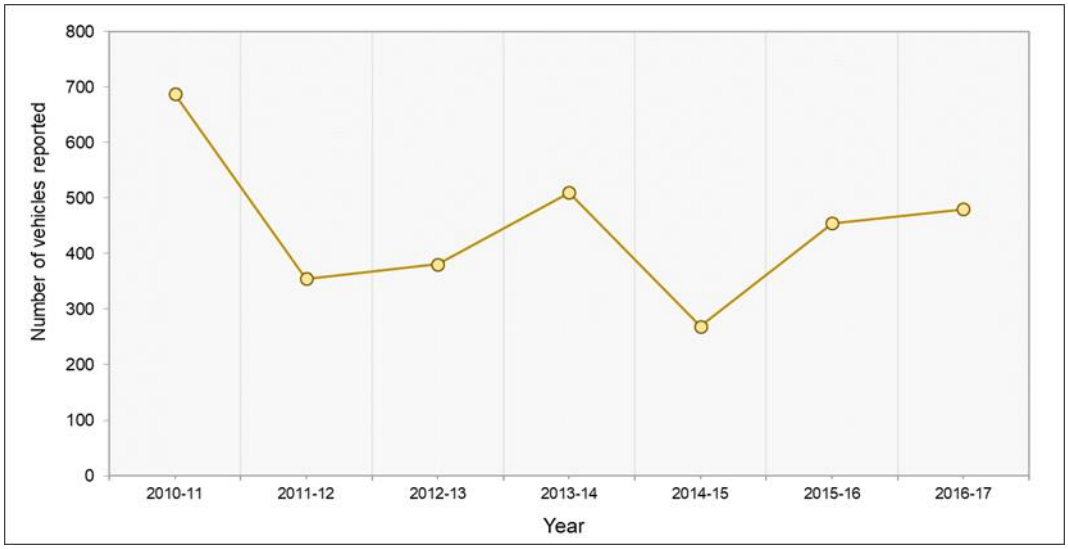

Figure 3.8 Number of smoky vehicles reported by year in Western Australia

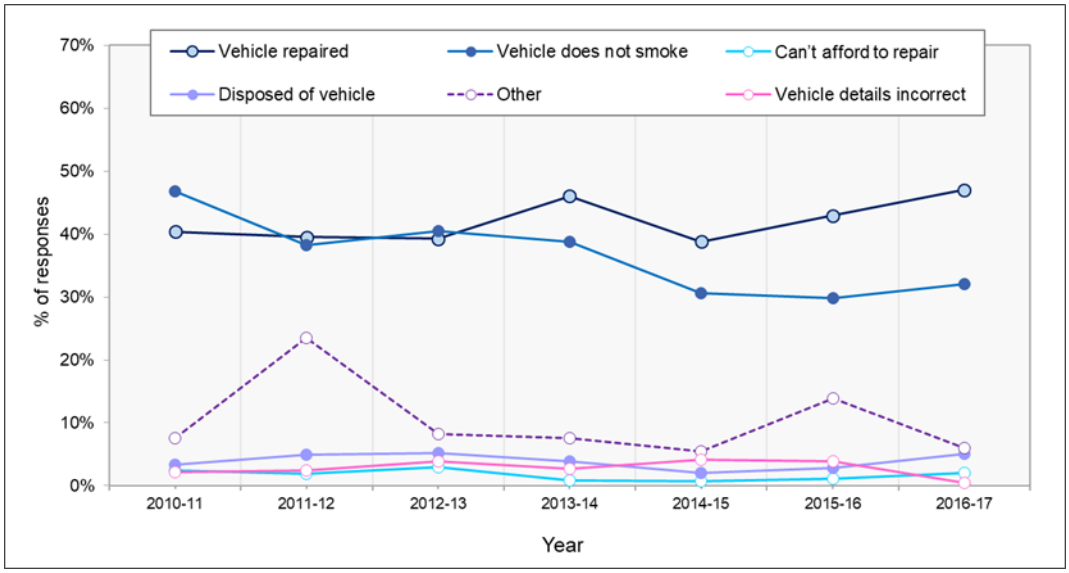

Figure 3.9 Actions reported by respondents in Western Australia

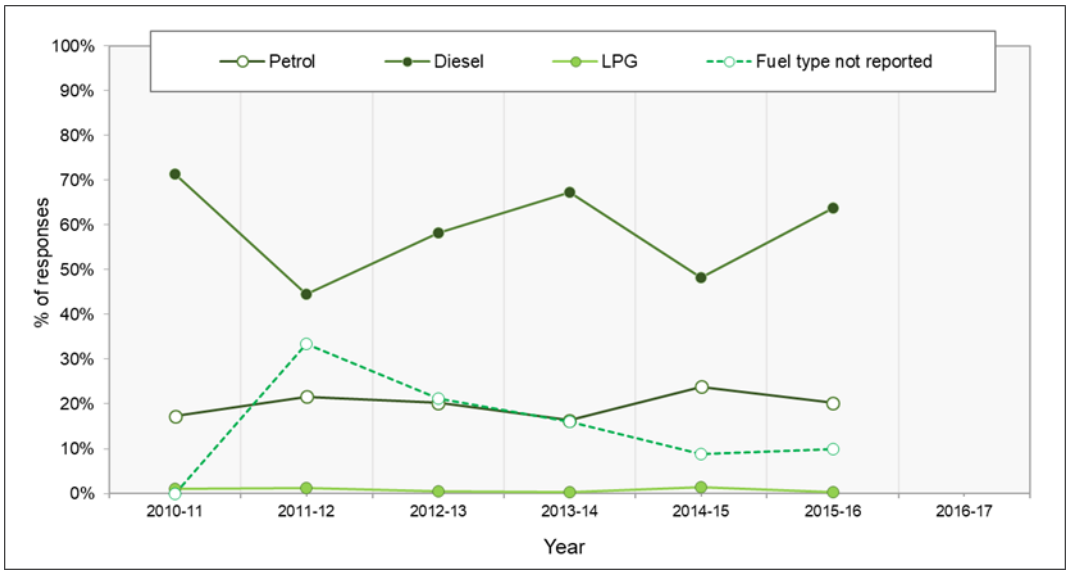

Figure 3.10 Fuel type reported by respondents in Western Australia

3.1.5 South Australia

South Australia does not have an active smoky vehicle program. The Department of Planning, Transport and Infrastructure participated in a three-month trial program with the South Australia EPA in 1996, and a smoky vehicle reporting program was introduced in 1997. This was based on the 10-second rule, and reporting was by selected government personnel (South Australia EPA inspectors and vehicle Inspectors). It did not include reporting by members of the general public. In 1999, and again in 2004, an enhanced scheme, involving reporting by members of the public, was proposed but not implemented given resourcing issues and concerns about public reporting. By this time, smoky vehicles had become comparatively rare and it was considered by the Department of Planning, Transport and Infrastructure that the likely benefits would not outweigh the gains (Smith 2018).

At present, police officers are authorised under the *Road Traffic Act 1961* to observe and report vehicles for alleged breaches of the 10-second rule. The police use this rule as the basis for issuing defect notices on the spot[15]. However, the police have not taught the use of the 10-second rule for some years, although they do teach that 'any undue/excessive smoke requires attention' (Smith 2018).

3.1.6 Tasmania

The Tasmanian government does not operate a smoky vehicle program as such. The Department of State Growth - Transport is responsible for vehicle emissions, and applies the 10-second rule for smoky exhausts, and issues Traffic Infringement Notices requiring identified vehicles to undergo servicing to reduce smoke emissions. For the public reporting of smoky vehicles, a contact number is provided on the Department's web site[16].

Traffic Infringement Notices for smoky exhausts are issued by Departmental Vehicle Inspection Officers, and can also be issued by the police. Records are not compiled showing the number of Traffic Infringement Notices issued for smoky vehicles.

[15] https://www.epa.sa.gov.au/community/air

[16] http://epa.tas.gov.au/epa/air/air-quality-in-tasmania/reducing-air-pollution/reduce-car-use

3.1.7 Northern Territory

Little information is available on the treatment of smoky vehicles in the Northern Territory. According to NEPC (2017), a smoky vehicle program is undertaken as part of the Territory's vehicle registration and roadworthiness testing procedures. Records of diesel vehicles issued with defect orders show that only a minor fraction of vehicles checked as part of the vehicle registration process receive a defect notice due to engine smoke. For the public reporting of smoky vehicles, a contact number is provided on the Northern Territory Environment Protection Authority's web site[17].

3.1.8 Australian Capital Territory

The ACT does not operate a smoky vehicle program.

3.1.9 The Australian Government

The Australian Government does not operate a smoky vehicle program.

3.2 Other countries

In the following sections several examples of smoky vehicle programs in other countries are briefly summarised. The selection is not intended to be comprehensive, but rather provides a cross-section of the approaches being used.

3.2.1 Canada (Ontario)

The Ministry of the Environment, Conservation and Parks of the Ontario Provincial Government has implemented a 'Drive Clean' program. Specialised government officials in the Vehicle Emissions Enforcement Unit can perform on-road emissions checks and can issue on-the-spot fines for vehicles that emit visible smoke. Additionally, members of the public are encouraged to contact a Drive Clean centre if they witness a smoky vehicle (Ontario Ministry of the Environment, Conservation and Parks 2018).

3.2.2 Hong Kong

The Environmental Protection Department (EPD) of Hong Kong has implemented a Smoky Vehicle Control Programme that mainly targets diesel vehicles emitting excessive smoke due to poor maintenance (Hong Kong Environmental Protection Department 2012). Smoky vehicle spotters, who are trained and accredited by the EPD, will report vehicles that emit excessive smoke. After verifying the information in the smoky vehicle reports, the EPD will issue an Emission Testing Notice (ETN) to the owner of each reported vehicle, requiring the owner to fix the smoke problem and pass an emission test within 12 working days. Vehicles failing the emission test have their licence cancelled by the Transport Department (Chen 2018). The number of ETNs issued between 2015 and 2017 decreased by around 50% (from 4,478 to 2,181). The Hong Kong Government attributes this to a scheme to progressively phase-out 82,000 pre-Euro IV diesel commercial vehicles, including goods vehicles, light buses and non-franchised buses. As of 30 June 2018, about 63,000 vehicles had been removed from the fleet (Chen 2018).

3.2.3 New Zealand

The regulation of in-service emissions was first introduced in New Zealand in 2001, with a 10-second rule for excessive smoke from on-road vehicles. This rule was later updated and extended by the following Rules:

[17] https://ntepa.nt.gov.au/waste-pollution/hotline

- the Road User Rule 2004, which prohibits a vehicle from emitting visible smoke for 10 or more seconds whilst being driven on the road (NZTA 2005). This is enforced by New Zealand Police, with officers issuing on-the-spot fines for offences; and

- the Vehicle Exhaust Emissions Rule 2007, which prohibits the removal of, or tampering with, a vehicle's emissions-control equipment and requires a vehicle to pass a five-second visible smoke check during a roadworthiness inspection (NZTA 2016).

Members of the public are also encouraged to report any incidents to a non-emergency traffic police line (New Zealand Police 2018).

New Zealand Police were unable to provide information on the numbers of smoky vehicles being reported. However, the numbers of warnings issued between 2013 and 2018 are shown, by type of warning, in Figure 3.11. Between 2013-14 and 2017-18, the number of vehicles with a warning issued for a defective exhaust system remained quite stable (there was a slight increase). The number of vehicles with excessive exhaust smoke had approximately halved by 2017-18 compared with pre-2016 levels.

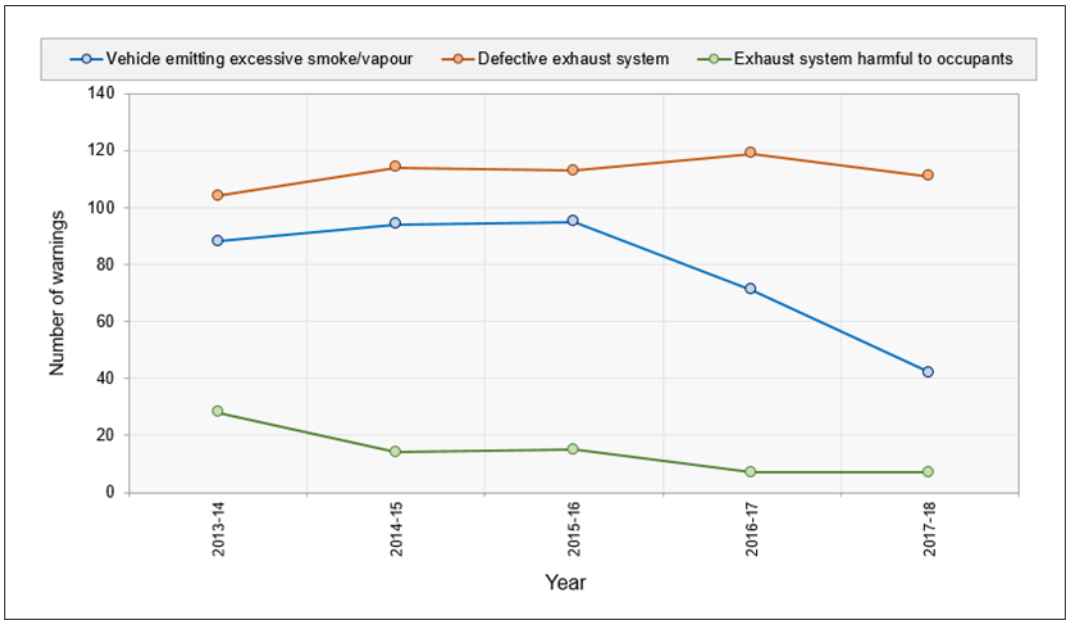

Figure 3.11 Smoky vehicle warnings issued by New Zealand police

3.2.4 Singapore

In Singapore, motor vehicle emissions are regulated by the National Environment Agency (NEA)[18]. Under the Environmental Protection and Management (Vehicular Emissions) Regulations, it is an offence for any vehicle to emit smoke while on the road. The regulations specify the following:

- 'no person shall use or cause or permit to be used on any road any motor vehicle from which any smoke or visible vapour is emitted';

[18] https://www.nea.gov.sg/our-services/pollution-control/air-pollution/air-pollution-regulations

- ‘every diesel driven motor vehicle that is in use shall not emit smoke of opacity greater than 40 Hartridge Smoke Units (HSU) or its equivalent’; and
- ‘every motor vehicle (whether petrol-engined or diesel-engined) must not emit any smoke or visible vapour when in use’.

Owners of smoky vehicles can be fined up to $2,000 for the first offence and $5,000 for subsequent offences.

To minimise smoky diesel vehicles, the smoke opacity limit was tightened from 50 HSU to 40 HSU on 1 January 2014. Furthermore, during the mandatory periodic vehicle inspections for road tax renewal, diesel vehicles are required to pass a more stringent chassis dynamometer test which measures the smoke emitted under simulated road driving conditions.

NEA takes stringent enforcement action against smoky vehicles on the roads. The owner of a smoky vehicle will be required to send their vehicle for inspection at an authorised centre, and the owner will be fined if the vehicle fails the inspection. In addition, the owner will be required to rectify and send their vehicle for a re-inspection which it must pass before the vehicle will be allowed back on the road.

Members of the public who identify smoky vehicles can report them to NEA via the web site, a hotline or a phone app. No details of the criteria for identifying smoky vehicles are available.

The NEA is also trialling a new camera system which can detect and identify smoky vehicles on the road. It has been reported that the system is similar to the one deployed in Sydney’s M5 East tunnel[19].

3.2.5 South Africa

The South African Government encourages the public to report smoky vehicles through a telephone hotline. The Health Department issues a letter to the owner of a reported vehicle, containing corrective actions and requesting that the vehicle be submitted for a free emissions test (African News Agency 2016).

In addition, roadside diesel vehicle emission testing is conducted on a daily basis in Cape Town in partnership with the city's traffic service. Between July and December of 2017, around 4,000 diesel vehicles were tested, with a total of 14 (<0.5%) failing to meet the diesel emission standards. This can be compared with the 17% failure rate when the city first started doing the diesel emissions tests in 2000. The drop has been attributed to visible policing, improvement in the quality of diesel (reduced sulfur content), continual improvement in emission-control technology, and improved vehicle maintenance.

3.2.6 United Kingdom

In the UK the Driver and Vehicle Standards Agency (DVSA) has a mechanism in place to allow the public to report an excessively smoky lorry or bus[20]. No reporting system is in place for other types of vehicle. The UK Government also administers roadside checks and inspections. If the vehicle is emitting visible smoke or exceeds emission limits, a prohibition notice will be issued, requiring corrective measures within 10 days or else the owner may face prosecution. Additionally, some boroughs have been designated as Air Quality Management Areas, and visible smoke emissions and emission test failures in these areas will result in on-the-spot fines/penalties (UK Government 2018).

[19] https://www.tnp.sg/news/singapore/smoky-vehicles-can-now-be-caught-camera

[20] https://www.gov.uk/report-smoky-vehicle

Various local authorities in the UK also have procedures in place for the public reporting of smoky vehicles. Examples include Coventry[21] , York[22] , Luton[23] , Cambridge[24] and Trafford[25].

3.2.7 United States

Smoky vehicle programs are operated in many US states, counties and cities, and it is beyond the scope of this report to review all of these. Some examples are summarised below.

i California

The California Air Resources Board (CARB) operates a Smoking Vehicle Complaint program. Members of the public are encouraged to report smoky vehicles to either CARB or the local Air Pollution Control District, and then advisory notices will be issued to the vehicle owners (CARB 2016). Fines for smoky vehicles can also be issued on the spot by California Highway Patrol, or issued based on a lack of response to written notification of excessive emissions (SCAQMD 2018). The South Coast Air Quality Managing District alone receives approximately 2,500 reports a year.

ii Colorado

Under Colorado's smoky vehicle law, police officers can issue on-the-spot fines for vehicles emitting visible smoke, and can order the owner to make repairs. Increased penalties and fines are issued for repeat offences. Members of the public are also encouraged to contact the government if they witness a smoky vehicle (Colorado Department of Public Health and Environment 2018).

iii Florida

In Broward County, Florida, any car, bus or truck that generates smoke continuously from the exhaust pipe for more than five seconds is in violation of the Broward County Code[26].

iv Nevada

Nevada's Department of Motor Vehicles (DMV) has a 'Smog Spotter' program in which members of the public are actively encouraged to report smoky vehicles. DMV investigates reports of any vehicle with a Nevada registration, including heavy-duty diesel trucks. After receiving a report, DMV sends an advisory letter to the owner of the vehicle. If the letter does not require the vehicle to be inspected at a DMV emission test facility, the owner must check the vehicle and make any necessary repairs to reduce emissions. Failure to comply can result in cancellation of the vehicle registration (Nevada DMV 2018).

The monthly numbers of reported vehicles and advisory letters between 2011 and 2017 are shown in Figure 3.12. There has been a gradual decrease in both statistics with time, and there was a marked drop in smoky vehicle numbers towards the end of 2017. There has also been a gradual reduction in the proportion of vehicles with letters, from around 50-60% in 2011 to 40-50% in 2017.

Police officers may also issue citations for excessive smoke under several laws, including NRS 484D.415: "The engine and power mechanism of every motor vehicle shall be so equipped and adjusted as to prevent the escape of excessive fumes or smoke."

[21] http://www.coventry.gov.uk/downloads/download/632/smoky_vehicles

[22] https://www.york.gov.uk/info/20059/air_pollution/187/smoky_vehicles

[23] https://www.luton.gov.uk/environment/environmental%20health/air_pollution_2/pages/pollution%20control%20-%20air_1_1.aspx

[24] https://www.camcycle.org.uk/newsletters/40/article13.html

[25] http://www.trafford.gov.uk/residents/environment/pollution/smoky-vehicles/polluting-vehicles-in-Trafford.aspx

[26] http://www.broward.org/Environment/AirQuality/EducationalPrograms/Pages/ReportSmokingVehicles.aspx

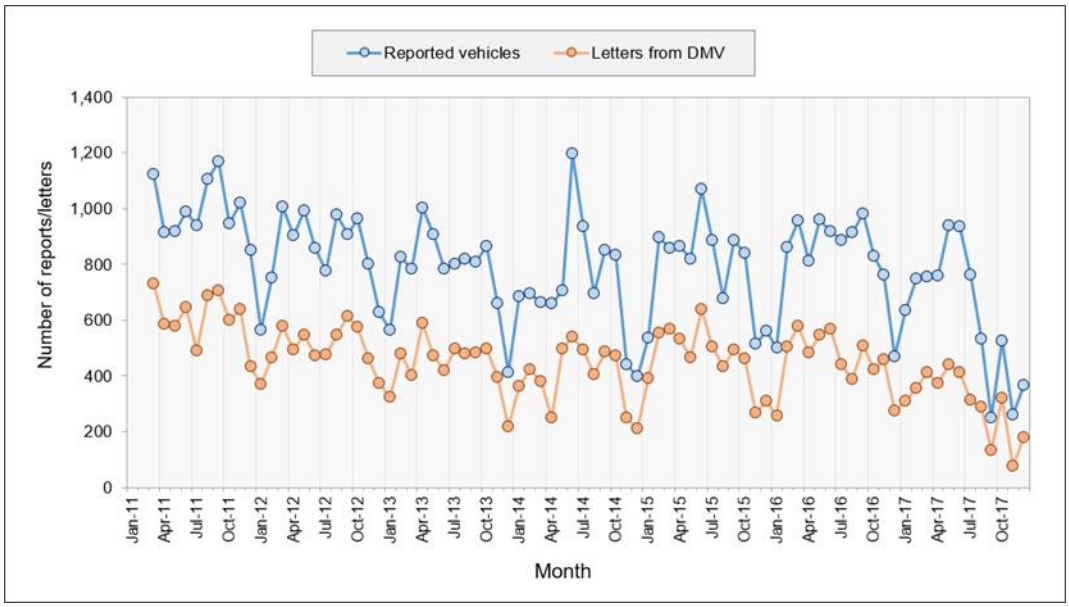

Figure 3.12 Reporting of smoky vehicles in Nevada between 2015 and 2017

v Oregon

In the state of Oregon, the public can report a smoky vehicle via a hotline or by completing a form on the web site of the Department of Environmental Quality (DEQ)[27]. This applies to cars or trucks that are identified as having visible exhaust smoke for more than 10 seconds. DEQ may contact the driver of the vehicle, but does not conduct formal enforcement activities. Any city, county or state police officer who witnesses excessive smoke from a motor-vehicle can issue the driver with a citation.

vi Texas

Texas has several initiatives to control emissions from motor vehicles, including smoky vehicle laws and programs.

Driving a vehicle with excessive smoke in Texas is a violation of the state's Smoking Vehicle Statute. This statute defines a smoky vehicle as one that either emits smoke for 10 or more consecutive seconds, or emits smoke which does not fully dissipate within 10 seconds. Texas law enforcement agencies may issue citations, punishable by fines of up to $1,000, to drivers operating a smoky vehicle on any roadway.

The Texas Commission on Environmental Quality (TCEQ) has set up a program to encourage the public to report smoky vehicles. The program is designed to encourage the citizens of Texas to voluntarily maintain and repair their cars, trucks and buses, and to promote public awareness regarding the harmful emissions and air pollution caused by smoky vehicles. The agency does not enforce any measures, and suggests corrective voluntary actions to the owner of a smoky vehicle. However, TCEQ notifies the owner that driving with excessive visible smoke is illegal under state law, and that law enforcement officials can issue an on-the-spot fine (TCEQ 2018).

The reporting of smoky vehicles in the Dallas-Fort Worth area of Texas is conducted through the North Central Texas Regional Smoking Vehicle Program Web Site. The North Central Texas Council of Governments[28] informs registered owners of vehicles suspected of emitting excessive smoke.

[27] https://www.oregon.gov/deq/Vehicle-Inspection/Pages/Smoking-Vehicles.aspx

[28] https://www.nctcog.org/trans/quality/air/for-everyone/hevp/rsvp

4 Smoky vehicle enforcement options for the New M5 project

4.1 Options relating to the 10-second rule

The following sections summarise the options that are available for smoky vehicle enforcement with respect to the New M5 project, based on the application of the 10-second rule for visible smoke.

4.1.1 Enforcement based on voluntary public reporting

Mechanisms for facilitating the public reporting of smoky vehicles have been established in several Australian jurisdictions, and are also common internationally. These usually involve a combination of a telephone hotline and an online form, with a request for the vehicle registration, the date and time of the observation, and other vehicle information. Other mechanisms, such as mobile phone applications, do not appear to be in common use, although there are some examples.

The criterion for the identification of a smoky vehicle varies from location to location. In Australia, the 10-second rule is generally applied, although this has been extended to 15 seconds in the M5 East tunnel. The 10-second rule is also applied in some US states (eg Oregon), but shorter periods are also used (eg five seconds in Broward County, Florida). Otherwise, the required duration of a smoky exhaust event is simply not specified.

Maintaining a public reporting mechanism for smoky vehicles is a relatively low-cost approach that is currently available through the EPA.

4.1.2 Enforcement based on agency and police reporting

In most Australian and overseas jurisdictions with smoky vehicle programs, public reporting is supplemented with reporting by government agencies or the police.

Given the recent decline in the number of smoky vehicles being reported (and the number of penalty notices) by government agencies in NSW, and the subsequent suspension of programs, it seems unlikely that there will be a useful role for agency officers to play in the visual identification of smoky vehicles for the New M5 project.

Similarly, some basic training of police officers should be sufficient to allow them to identify and report particularly smoky vehicles on an ad hoc basis.

4.1.3 Enforcement based on a M5 East-type camera system

The M5 East camera system contributes only a small fraction of the total number of smoky vehicle reports in NSW. Moreover, the system's limitations are relevant to the New M5 tunnels. For example, the existing system is designed for vehicles travelling at a relatively low speed (less than around 50 km/h). This means that a significant fraction of the traffic in a motorway tunnel cannot be captured under normal traffic conditions, where speeds are closer to 80 km/h. The design of a camera system for the New M5 tunnels would need to accommodate the prevailing travel speed, and the practicalities of this would have to be established. As noted earlier, the New M5 tunnels have been designed to have relatively shallow road gradients of 6% or less. The road gradient of around 8% near the exits of the M5 East tunnel is a contributing factor to vehicles producing visible smoke. As there are no significant gradients near the exits of the New M5 tunnels, a camera-based system may not detect many smoky vehicles.

4.2 Alternatives to the 10-second rule

Any approach to managing on-road emissions that relies solely on the visual observation of smoke in vehicle exhaust (as with the 10-second rule) is unlikely to be very successful in the future. Reasons for this include the following:

- there are no clear relationships between visible smoke in vehicle exhaust and the measurement metrics that provide more a meaningful description of vehicle emission behaviour. These metrics include the concentration of key pollutants in vehicle exhaust, or the mass emitted per unit time or distance;
- engine management and emission-control systems are becoming increasingly sophisticated and, with respect to the identification of faults, a simple visual observation cannot provide the same level of diagnostic information as a direct measurement or an interrogation using on-board diagnostics (OBD)[29]; and
- because visual observations do not provide quantitative data on emission levels, it is more difficult to evaluate the success or otherwise of any programs and policies that are designed to reduce on-road emissions.

In various countries the reporting of smoky vehicles complements a more rigorous program of inspection and maintenance that involves, in one form or another, the measurement of emissions. Most approaches that involve measurement are likely to provide a more reliable evidence base that purely visual approaches involving some degree of subjectivity. Nevertheless, some countries that have measurement-based emission checks still do have mechanisms in place for the public reporting of smoky vehicles. There may still be a place for visual observation in the future, as it could act as a simple initial screening stage in the process of rectifying (or scrapping) high-emitting vehicles. However, the data tend to indicate that visual observation is rather 'hit and miss', and its cost-effectiveness should be evaluated more thoroughly.

Some examples of measurement-based approaches are noted below. Clearly, for some of these approaches, such as scheduled inspection and maintenance, there is a very large body of information available internationally.

- routine inspection and maintenance with emission testing[30];
- routine inspection and maintenance with OBD;
- random roadside emission tests[31]; and
- remote sensing of vehicle emissions[32]

In the context of this report, the main issue with the above approaches is that there is currently no legislative mechanism in NSW to support the measurement of emissions from in-service vehicles. The legislation only supports visual observation and the 10-second rule. Consequently, changes to the law in NSW would be required to enable measurement-based enforcement of emission limits. This is beyond the scope of this report, and it could also be argued that it is beyond what could reasonably be expected of any given infrastructure project. Such approaches would be better administered at the state on a national level.

[29] OBD refers to the technology for monitoring modern engine and emission-control systems, as well as other key vehicle components. An OBD test is a quick and effective means of identifying vehicle faults, including emission-related faults. However, there are a number of drawbacks (see CITA, 2011).

[30] Various types of emission test are used in inspection and maintenance programs, ranging from simple idle tests to loaded chassis dynamometer tests.

[31] These typically involve only an idle or 'fast idle' test.

[32] In a remote sensing device (RSD) a light beam is directed through the exhaust plume of a passing vehicle, with exhaust concentrations being measured using spectroscopic methods. A camera captures the license plate to link the emissions data to vehicle registration information, and hence vehicle characteristics. One of the main benefits of remote sensing is the large number of measurements that can be made in a short space of time. Remote sensing has been used to screen for high emitters as part of wider inspection and maintenance programs. RSDs can also be used for defeat-device investigations and measuring emission system deterioration (Posada et al 2015). RSDs have not been widely used in Australia to date.

5 Summary and conclusions

5.1 Summary

Model projections indicate that future emissions of PM_{10} and $PM_{2.5}$ from road vehicles in Sydney (and NSW) will be dominated by non-exhaust processes rather than exhaust emissions. Consequently, the overall importance of identifying smoky vehicles ought to diminish.

In the last decade there have been significant reductions in numbers of smoky vehicle reports (and penalty notices) in NSW, Victoria and Queensland. In Western Australia the number of smoky vehicle reports has not reduced systematically, although the historical record is shorter than in the other states, and the overall number of reports is lower. South Australia does not have an active smoky vehicle program. Although public reporting has been considered in South Australia, smoky vehicles have become comparatively rare and it is considered that the likely benefits would not outweigh the gains. In the remaining Australian jurisdictions, there is either no official smoky vehicle program, or no data on smoky vehicles are available.

In NSW the reports of smoky vehicles (and penalty notices) have declined significantly in spite of a significant growth in population, road traffic and the diesel vehicle fleet over the last 15-20 years. There is some evidence to indicate that the reduced reporting of smoky vehicles – both in Australia and in other countries – is likely to be associated with improvements in automotive fuel quality and emission-control technology, with fewer smoky vehicle events occurring.

Various countries and local jurisdictions outside Australia have smoky vehicle enforcement programs in place, and these are broadly similar to the ones in Australia. Where data are available for other countries, they indicate that numbers of smoky vehicle reports are declining, as in Australia. However, the smoky vehicle programs in other countries are often not the only mechanism by which on-road vehicle exhaust emissions are managed. The visual observation of smoke in vehicle exhaust usually complements a more sophisticated inspection and maintenance regime involving some form of direct measurement of emissions.

5.2 Conclusions

In terms of smoky vehicle enforcement in the New M5 tunnels, the following conclusions have been drawn:

- the New M5 tunnels have been designed to minimise vehicle exhaust emissions as far as possible, such as through the use of relatively small road gradients, and this should also help to minimise the incidence of smoky vehicles; and
- the adoption of a comprehensive smoky vehicle enforcement program specifically for the New M5 tunnels – including extensive NSW government agency involvement, and an M5 East-style camera system in the tunnel – would entail significant cost but is unlikely to generate significant environmental benefits or in-tunnel benefits.

In more general terms with respect to the management of exhaust emissions from the on-road fleet in Australia:

- there are various reasons why vehicle exhaust emissions are better regulated at the state and/or national level than at the project level (centralisation of records, data protection, consistent application of regulations, etc);
- there may be some benefit in retaining state-wide mechanisms for the public reporting of smoky vehicles;

- testing for visible smoke by the National Heavy Vehicle Regulator will continue independently of any smoky vehicle programs in place;
- the 10-second rule appears to be declining in utility for managing in-service vehicle emissions; and
- the main barrier to a measurement-based approach for managing in-service emissions is that changes to state or national law would be required. An investigation of this is beyond the project level, and would requires a more detailed evaluation of alternative approaches, including a wider critique of the 10-second rule and alternatives based on measurement, a more thorough examination of the available data from Australia and overseas, and consideration of costs and benefits.

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Appendix A

Test Method 31

In NSW, the procedure by which the 10-second rule is applied is defined in Test Method 31 of the Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales (DEC 2007). Test Method 31 defines the 'observation procedure for excessive air impurities: visible emissions'. The method is described below.

When an observer is determining if a vehicle is being used in breach of the clause limiting visible emissions, the following principles apply:

- *The observer must be satisfied that the vehicle generating the visible emissions is correctly identified.*
- *The observer must be satisfied that the emissions are visible not just because of heat or the condensation of water vapour.*
- *The emissions must be continuously visible for more than 10 seconds.*

The following details of the observation must be recorded:

- *Length of time in seconds that the visible emissions were observed.*
- *Registration number of the motor vehicle under observation.*
- *Type of motor vehicle under observation.*
- *Colour and darkness, in the opinion of the observer, of the air impurities emitted.*
- *Location, date and approximate time of day that the observation was made.*

In the case of observation of digital imagery produced by an Approved Vehicle Emission Recording System (AVERS):

When an observer of digital imagery produced by an AVERS is determining if a vehicle is being used in breach of the clause limiting visible emissions, the following principles apply:

- *The observer must be satisfied that the vehicle generating the visible emissions is correctly identified.*
- *The observer must be satisfied that the visible emissions are visible not just because of heat or the condensation of water vapour.*
- *The emissions must be continuously visible on any digital video imagery produced by the AVERS for more than 10 seconds.*

The following details of the observation must be recorded:

- *Length of time in seconds that the visible emissions were observed.*
- *Registration number of the motor vehicle depicted in the digital imagery.*
- *Type of motor vehicle depicted in the digital imagery.*
- *Colour and darkness, in the opinion of the observer, of the air impurities which, by reference to the digital imagery, were emitted.*
- *Location, date and approximate time of day that the digital imagery was created.*