MAYOR OF LONDON

INNER LONDON ULTRA LOW EMISSION ZONE – ONE YEAR REPORT

February 2023

CONTENTS

Key Findings **5**
Introduction **9**
Number of vehicles and compliance rates **14**
Fleet compositions **27**
Traffic Impacts **32**
Emissions **36**
Air pollution concentrations **43**
Conclusion **56**
Appendix 1 ..... **57**
Appendix 2 ..... **66**
Appendix 3 ..... **80**

List of Figures

Figure 1: Timeline of successive emission-based charging schemes in London 10
Figure 2: Map of the central London ULEZ and the current ULEZ boundary 11
Figure 3: Map of the London-wide Low Emission Zone and the current ULEZ 12
Figure 4: Map showing the current congestion charge zone, ULEZ and the planned 2023 expansion of the ULEZ 13
Figure 5: Monthly average ULEZ compliance rates split by zone, for all ULEZ vehicles 25
Figure 6: Monthly average ULEZ compliance rates split by zone, for cars. 25
Figure 7: Monthly average ULEZ compliance rates split by zone, for vans. 26
Figure 8: Monthly average LEZ compliance rates split by zone, for HGVs. 26
Figure 9: Fleet composition for cars, split by engine type and London zone. 28
Figure 10: Fleet composition for private hire vehicles (PHVs), split by engine type and London zone. 29
Figure 11: Fleet composition for vans (LGVs), split by engine type and London zone. 30
Figure 12: Proportion of HGVs meeting the LEZ standards, split by engine type and London zone. 31
Figure 13: Traffic flows by London zone, all vehicles, 13 period moving average, 208/209- 2022/23. 35
Figure 14: Estimated Monthly vehicle kilometres, split by London zone 37
Figure 15: Trends in monthly NO_2 concentrations in London from 2010 to 2022 46
Figure 16: Trends in monthly average NO_2 concentrations with and without ULEZ policies 49
Figure 17: Monthly average NO_2 concentrations on ULEZ boundary roads 51

Figure 18: Trends in monthly average NO_2 concentrations at ULEZ boundary roads, with and without ULEZ. Group 1 is Brent Ikea and Hanger Lane. Group 2 includes the other 4 boundary sites. 52
Figure 19: Monthly average $PM_{2.5}$ concentrations across London 2010 to October 2022 54
Figure 20: Number of NO_2 monitoring sites in London per year 66
Figure 21: Trends in monthly average NO_2 roadside increment 78

List of Tables

Table 1: Vehicle types, emission limits and relevant scheme for compliance figures 15
Table 2 : Daily average and proportion of ULEZ compliant vehicles detected in the ULEZ 16
Table 3: Daily average number and proportion of ULEZ compliant vehicles detected in the zone per month (rounded to the nearest 1000 vehicles)† 16
Table 4: Changes in the daily average number and proportion of ULEZ compliant cars (M1 and PHV, excl. Taxis) detected in the zone† 18
Table 5: Changes in the daily average number and proportion of ULEZ compliant diesel cars (M1 and PHV, excl. Taxis) detected in the zone† 19
Table 6: Changes in the daily average number and proportion of ULEZ compliant vans (N1) detected in the zone† 20
Table 7: Changes in the daily average number and proportion of ULEZ compliant motorcycles (L) detected in the zone† 21
Table 8: London-wide Low Emission Zone compliance rate 23
Table 9: Percentage change in vehicle kilometres post-ULEZ expansion vs 2019 and post-ULEZ expansion vs pre-ULEZ expansion baseline, averaged by month and quarter. 34
Table 10: Estimated NOx emissions for the ULEZ area, by vehicle type and year . 38
Table 11: Estimated $PM_{2.5}$ emissions for the ULEZ area, by vehicle type and year . 40
Table 12: Estimated $PM_{2.5}$ emissions (exhaust only) for the ULEZ area, by vehicle type and year 41
Table 13: Estimated CO_2 emissions for the ULEZarea, by vehicle type and year 42
Table 14: Quarterly average NO_2 at roadside monitoring sites by zone based on the trends analysis in Figure 14 47
Table 15: Estimated reduction in NO_2 concentrations due to ULEZ policies 50
Table 16: Estimated reduction in NO_2 concentrations at boundary sites, as a result of ULEZ policies 53
Table 18: Quarterly average $PM_{2.5}$ at roadside monitoring sites by zone based on the trends analysis in Figure 21 55
Table 19: NOx emissions by London zone [tonnes per year] 57
Table 20: $PM_{2.5}$ emissions by London zone (includes non-exhaust) [tonnes per year] 59
Table 21: $PM_{2.5}$ emissions (exhaust only) by London zone [tonnes per year] 61
Table 22: CO_2 emissions by London zone [tonnes per year] 63
Table 23: Sites included in NO_2 trend analysis 67
Table 24: Heathrow sites excluded from this analysis 76
Table 25: Further sites excluded due to opening/closing in 2021 77

Table 26 Annual average NO_2 concentrations at monitoring stations across London, 2016-2022. 80
Table 27: Annual average $PM_{2.5}$ concentrations at monitoring stations across London, 2016-2022 90

Key Findings

On 8 April 2019 the Mayor of London launched the world's first 24-hour Ultra Low Emission Zone (ULEZ) in central London. On 25 October 2021 the zone was expanded across inner London, up to, but not including, the North and South Circular Roads. The ULEZ is now 18 times the size of the original area and covers four million people – around 44% of London's population.

The ULEZ does not operate in isolation. It operates in conjunction with the London-wide Low Emission Zone (LEZ), which was originally launched in 2008. It is the oldest of the capital's emission control schemes and applies to large and heavy vehicles. In March 2021 enforcement of tougher emission standards for the LEZ began. Prior to this, the standards hadn't changed since 2012. The LEZ standards are now the same as the ULEZ standards for most large and heavy vehicles.

In this report we evaluate the impacts of the ULEZ and the LEZ schemes, focusing on one year following the ULEZ expansion to inner London and for the LEZ, over a year and a half on from the enforcement of tighter LEZ standards. The report, including the methodology for assessing impacts on air pollutant concentrations, underwent independent peer review[1].

The analyses addressed the impacts of the overall ULEZ scheme, differentiating the impacts by inner and central London zone where the data permitted this. Compliance rates are presented for the zone as a whole with further analysis looking at the central, ULEZ area, and the boundary roads. Fleet composition data is analysed for central, inner and outer London. Traffic impacts have been summarised for the ULEZ area, outside the ULEZ area and for the ULEZ boundary roads. Emissions impacts have been estimated for central, inner and outer London separately and as an average for London as a whole. Air pollution concentrations have been analysed per London zone with additional analysis looking at the impacts on the boundary roads.

The findings indicate that the Mayor's air quality policies, and in particular the ULEZ and LEZ schemes, are having a significant impact reducing the number of older, more polluting vehicles seen driving in London and on reducing the levels of harmful air pollution that Londoners are exposed to. In summary, the key findings are:

Traffic and Vehicle Compliance

- **The vehicles traveling in London are increasingly cleaner**. The overall ULEZ compliance rates have continued to increase, with 94.4 per cent of vehicles[2] seen driving in the zone on an average day meeting the ULEZ standards a year following the expansion. This is an increase from just 39 per cent when the expansion was announced in 2017.

- **The number of older, more polluting vehicles in the zone has continued to reduce significantly.** There was an almost 60 per cent reduction in non-

[1] Peer reviewed by Dr Gary Fuller of Imperial College London
[2] This excludes taxis and vehicles under the LEZ scheme.

compliant vehicles detected in the zone since the expansion came into operation, an average reduction of 74,000 polluting vehicles per day.

- **The heavy vehicle fleet is cleaner because of the London LEZ.** The strengthening of emission standards resulted in a significant increase in compliance rates, such that compliance has now reached 97 per cent, increased from 90 per cent in February 2021, immediately prior to the tightening of the standards.

- **The proportion of diesel cars on London's roads has reduced.** In October 2022 the proportion of kilometres driven in London by diesel cars is estimated to have reduced from 32 per cent to about 25 per cent in inner London, showing the impact of the expansion in reducing diesel cars driving in inner London. In terms of private hire vehicles (PHVs), petrol hybrid electric vehicles comprise the largest proportion of this fleet. PHVs experienced an increase in the proportion of electric vehicles from October 2021 when the ULEZ was expanded, in both central and inner London. Changes to the composition of PHVs has been highly influenced by the additional licensing requirements for newly registered PHVs set by Transport for London to reduce emissions from these vehicles.

- **There has been an overall reduction in vehicles and traffic flows in the zone.** In October 2022, there were 47,000 fewer vehicles[3] seen in the zone on an average day (a reduction of almost 5 per cent) and data suggest traffic flows are around 3 per cent lower than in the weeks before the expansion. This is similar to the reduction in traffic flows observed following the introduction of the central London ULEZ. The COVID-19 pandemic also affected traffic levels. However, in outer London, traffic levels have largely returned to pre-pandemic levels but in central and inner London they remain below what they were in 2019.

Air Pollutant Emissions[4]

- **Pollution emissions have reduced dramatically.** Cumulatively since 2019, it is estimated the ULEZ led to nitrogen oxides (NO_x) emissions from road traffic reducing by 13,500 tonnes across London over the four-year period compared with what they would have been without the ULEZ, a reduction of 23 per cent. Within the ULEZ area NOx emissions are estimated to have reduced by 5,000 tonnes, a reduction of 26 per cent, over the same period. Reductions in NO_x emissions were seen across all vehicle types, but the greatest proportion was occurred in TfL busses at 70%. Cumulatively, emissions of fine particulate matter ($PM_{2.5}$) are estimated to have reduced by 180 tonnes across London since 2019, compared to without the ULEZ, a reduction of 7 per cent. Within the ULEZ area $PM_{2.5}$ emissions are estimated to have reduced by 80 tonnes, a reduction of 19 per cent, over the same period.

[3] This excludes taxis and vehicles under the LEZ scheme
[4] Emissions are the amount of pollution directly emitted from a particular source, e.g vehicles.

- **Carbon emissions from vehicles have also reduced.** Cumulatively since 2019 it is estimated the ULEZ has led to a reduction of around 800,000 tonnes of CO_2 emissions from vehicles across London over the four-year period compared to without the ULEZ, a saving of 3 per cent. Within the ULEZ area this is a saving of 290,000 tonnes, a reduction of 4 per cent over the same period.

Air Pollutant Concentrations[5]

- **The air in the zone is substantially cleaner.** The ULEZ expansion has led to four million people breathing cleaner air, including 1,362 more schools. Harmful nitrogen dioxide (NO_2) concentrations are estimated to be 21 per cent lower than they would have been in inner London without the ULEZ and 46 per cent lower than they would have been in central London. This is above what was predicted for the scheme. Substantial reductions in NO_2 concentrations were seen at roadside locations, with a 56 per cent reduction in central London, 47 per cent in inner London, and 37 per cent in outer London since 2017. Background monitoring sites away from the main road network also had significant reductions in NO_2 of 47 per cent in central and 45 per cent in inner London, since 2017. Unlike central and inner London sites, average concentrations at outer London background sites have remained constant since 2021.

- **The boundary roads have also benefited from cleaner air.** All air quality monitoring sites on the boundary roads recorded large reductions in NO_2 concentrations and there has been an estimated reduction of 19 - 27 per cent compared to a scenario without the ULEZ with the impact increasing over time. Showing therefore there has been no displacement of pollution to the boundary.

- **NO_2 levels have not returned to those experienced pre-pandemic**, indicating that even as traffic levels have risen; cleaner vehicles in the fleet caused by the ULEZ and its expansion, have had sustained and positive impacts on air pollution meaning concentrations continue to be far below what they would have been otherwise.

- **Particulate matter ($PM_{2.5}$) levels have also continued to reduce across London** with a 41 per cent reduction in average concentrations in central and inner London since 2017.

The findings set out in this report show that both the ULEZ and the LEZ continue to have a significant impact on the number of older, more polluting vehicles seen driving in London and on reducing harmful air pollution.

In September 2021, shortly before the expansion of the ULEZ to inner London, the World Health Organization (WHO) strengthened its ambient air quality guidelines (AQGs) in recognition of the growing body of health evidence that continued to show

[5] Concentration is the amount of pollution in the air at a certain location.

adverse health effects of air pollution in different ages, and even at low levels of air pollution. The latest WHO AQGs are more stringent than UK legal limits for air quality and show that further action will be needed to tackle emissions from both transport and non-transport sources of air pollution in order to meet the guidelines and protect health. This includes taking action in outer London given that average concentrations at background monitoring sites in outer London have remained constant since 2021. Further expansion of the ULEZ to outer London will help improve air quality for millions more Londoners.

Introduction

Toxic air pollution is a matter of life and death and affects Londoners in all stages of life.

Studies have long shown the many adverse health issues associated with elevated pollution levels, with toxic air contributing to the premature deaths of an estimated 4,000 Londoners in 2019[6] and to over 1,700 hospitalisations related to asthma and COPD[7] in 2017-2019, and to increasing the risk of dementia[8] and lung cancer[9]. Over 600,000 Londoners live with a lung condition and are more vulnerable to the impacts of air pollution, with more than half of these people living in outer London.

We also know that exposure to toxic air is disproportionally higher for those communities that have higher levels of deprivation, or a higher proportion of people from Black, Asian and Minority Ethnic backgrounds[10], though, due to air quality policies implemented since 2016, the gap is now narrowing.

Aimed at reducing the health impacts associated with high pollution levels in London, the Mayor of London introduced the world's first 24 hour Ultra Low Emission Zone (ULEZ) in central London on the 8 April 2019. The central London ULEZ delivered substantial impacts on air pollution, with nitrogen dioxide (NO_2) concentrations in central London reducing by 37 per cent, compared to a scenario without the ULEZ, in the first 10 months.

In order to increase the number of Londoners benefiting from the impacts of the ULEZ, on the 25 October 2021, the Mayor expanded the ULEZ to 18 times its original size, covering the area within the North and South Circular Roads and the four million people that reside within.

Six months following the expansion of the ULEZ, NO_2 concentrations had reduced by 44 per cent in central London and 20 per cent in inner London, compared with a scenario without the ULEZ.

The London Low Emission Zone (LEZ) was first introduced in 2008, applying to heavy vehicles. In the most recent change to the LEZ, the emission limits were tightened on 1 March 2021 and now align with the ULEZ standards for most affected vehicles.

Tackling air pollution is a matter of social justice and hence a key priority for the Mayor. The ULEZ is one of many bold policies implemented to address this and is recognised by independent experts as one of the most effective and speedy interventions. Expanding it is a key step towards a fairer society by reducing road

[6] London Health Burden of Current Air Pollution and Future Health Benefits of Mayoral Air Quality Policies
[7] Mayor Of London Press Release March 2022
[8] Air pollution: cognitive decline and dementia
[9] LBA1 Mechanism of action and an actionable inflammatory axis for air pollution induced non-small cell lung cancer: Towards molecular cancer prevention
[10] Air Pollution and Inequalities in London: 2019

transport emissions, tackling toxic pollution and protecting the health of the poorest and most marginalised Londoners.

This report evaluates the impacts of the October 2021 expansion of the ULEZ scheme in its first full year of operation, up to the end of October 2022.

What is the ULEZ?

The expansion of the ULEZ to Inner London is the latest in a progression of policies aimed at tackling harmful air pollution emissions from road transport, specifically nitrogen dioxide and particulate matter, by disincentivising the use of older, more polluting vehicles within the Ultra Low Emission Zone through applying a daily charge to vehicles that do not meet the emissions criteria. Emissions criteria are based on the Euro standards which regulate the emissions of pollutants from road vehicles as they are sold. The Euro standards emission limits have progressively reduced over time, meaning vehicles have become less polluting with each successive standard.

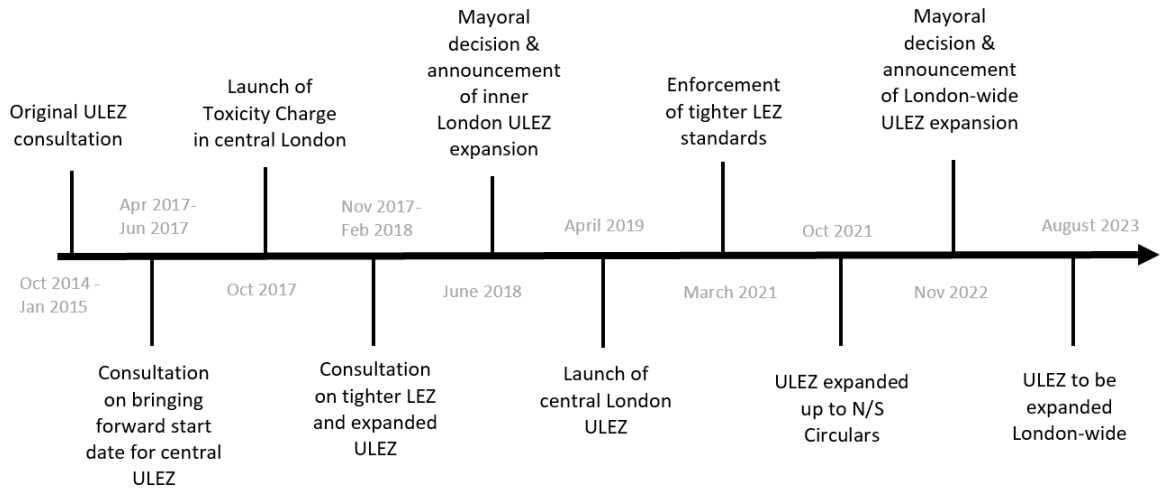

Figure 1: Timeline of successive emission-based charging schemes in London

Figure 1 above shows the timeline of emissions-based charge schemes in London including consultations, the T-charge which preceded the ULEZ, and the tightening of the LEZ standards.

The ULEZ operates 24 hours a day, every day of the year except Christmas Day (25 December). Vehicles must meet strict emission standards to drive in the ULEZ area:

- Euro 4 for petrol cars and small vans (registered new from January 2006)
- Euro 6 for diesel cars and small vans (registered new from September 2015)
- Euro 3 for motorcycles and other L-category vehicles (registered new from July 2007)

Vehicles that do not meet these standards must pay a charge of £12.50 per day to travel in the zone.

Figure 2 shows the area of London covered by the initial central ULEZ and the ULEZ expansion up to the North and South Circular roads.

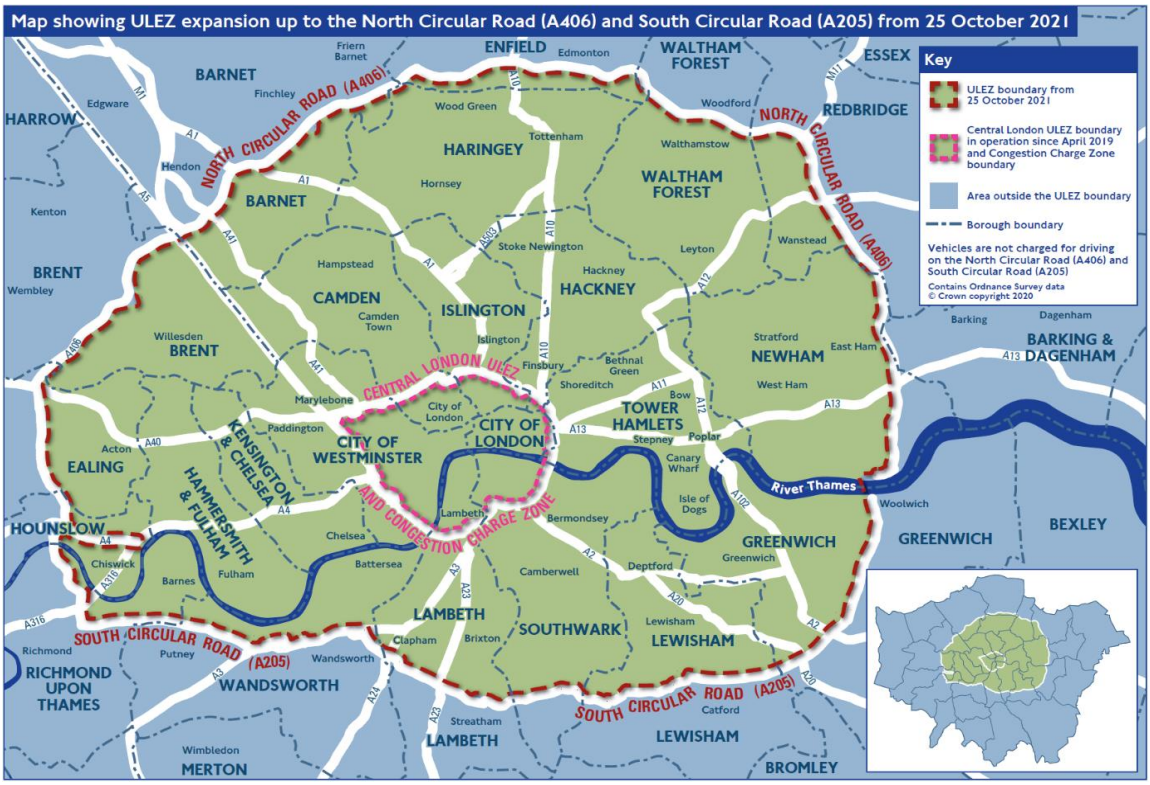

Figure 2: Map of the central London ULEZ and the current ULEZ boundary

What is the London-wide Low Emission Zone (LEZ)?

The London-wide Low Emission Zone was introduced in 2008 and operates 24 hours a day, every day of the year. On 1 March 2021 the emission standards for the LEZ were strengthened for heavy vehicles, the new standards are:

- Euro VI for buses, coaches and Heavy Goods Vehicles (HGVs)/vans over 3.5 tonnes (vehicles registered new from September 2016),
- Euro 3 for particulate matter only for vans between 1.2 tonnes and 3.5 tonnes and minibuses under 5t (vehicles registered new from January 2001).

Vehicles that do not meet these standards must pay a charge of £100 per day. Heavy vehicles that do not meet the lower Euro IV standard must pay a higher charge of £300 per day.

For most vehicles, the strengthening of the LEZ standards means that they are not separately subject to LEZ and ULEZ standards. The exception is for vans between 1.2t and 3.5t, and minibuses under 5t where the LEZ and ULEZ standards are different. These vehicles need to comply with both schemes if they drive within the ULEZ area or pay both sets of charges.

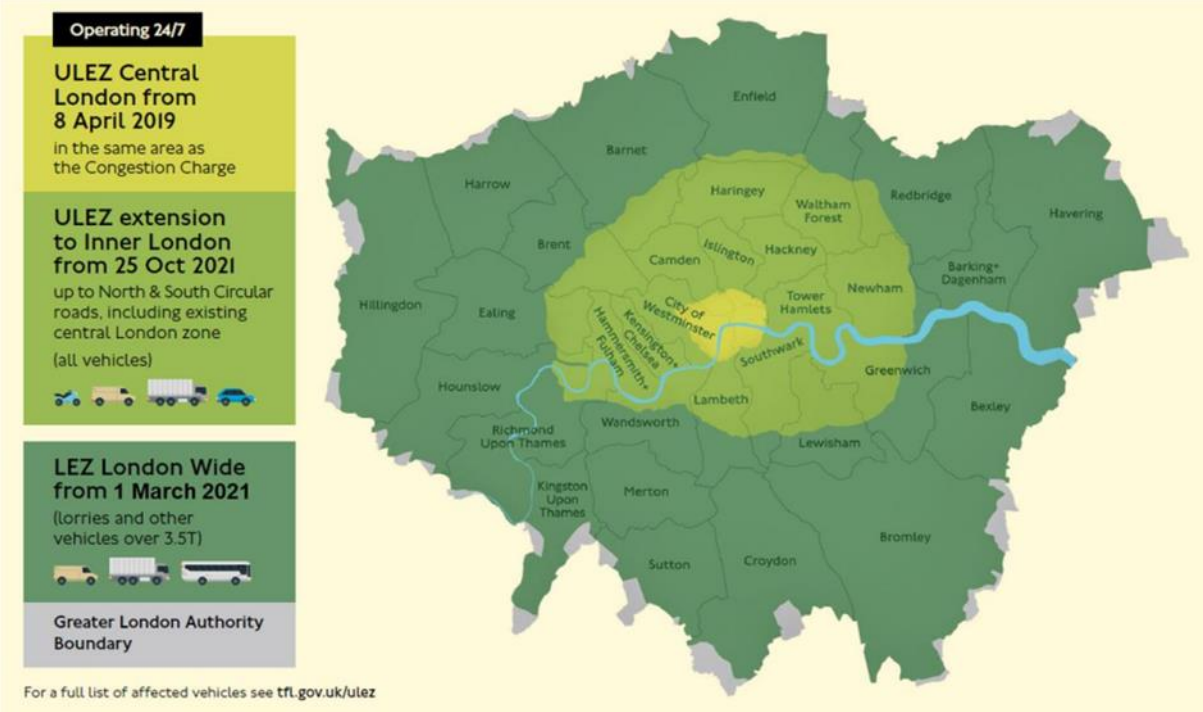

Figure 3: Map of the London-wide Low Emission Zone and the current ULEZ

Future changes to the ULEZ

On 25 November 2022 the Mayor announced he will expand the Ultra Low Emission Zone (ULEZ) London-wide to tackle the triple threats of air pollution, the climate emergency and congestion, and to ensure five million more Londoners can breathe cleaner air. The expansion will come into effect on Tuesday 29 August 2023 and will operate across all London boroughs up to the existing Low Emission Zone boundary. Figure 4 shows the extent of the planned expansion.

The emissions standards and daily charge will remain unchanged when the ULEZ is expanded London-wide.

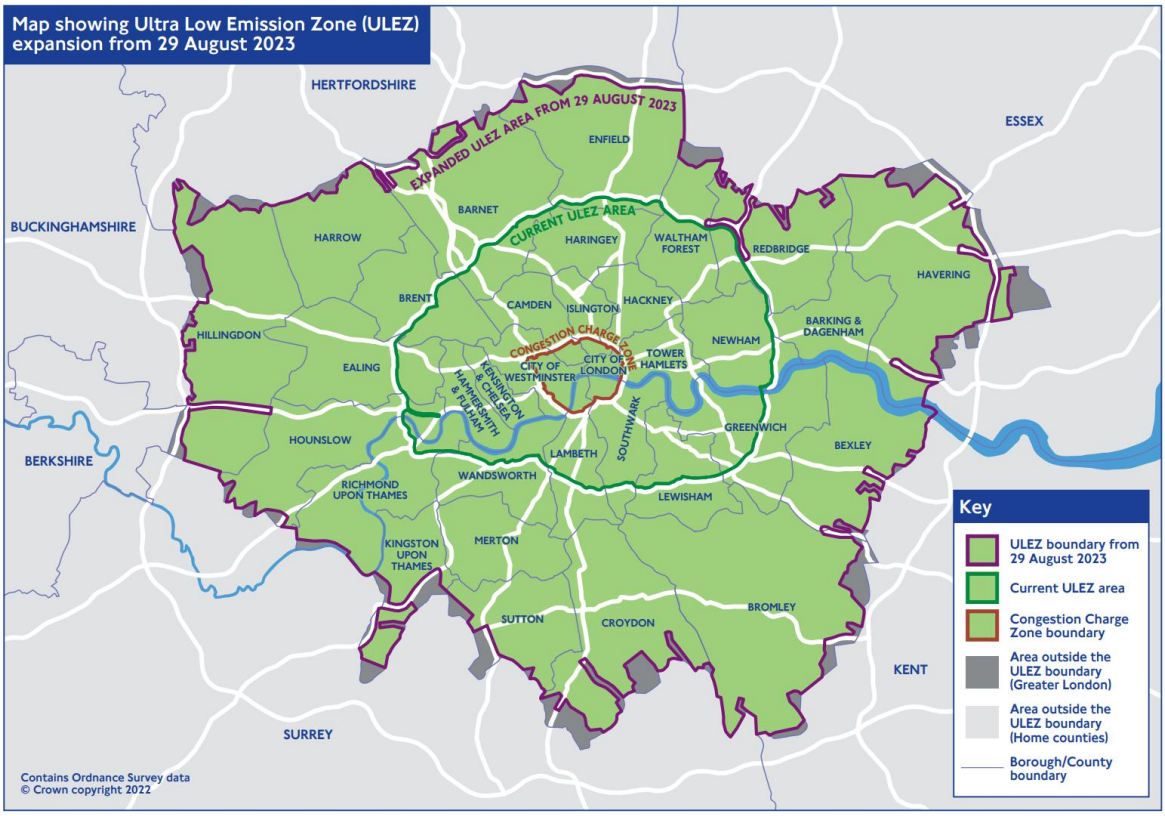

Figure 4: Map showing the current congestion charge zone, ULEZ and the planned 2023 expansion of the ULEZ

What to expect in this report

The expansion of the ULEZ across inner London took place on 25 October 2021. This report will look at the first full year of monitoring data and will provide the first analysis of the impact of the expanded ULEZ on air pollution emissions.

This is the latest in a series of reports evaluating the impact of the ULEZ and LEZ for heavy vehicles. Previous reports include:

- Central London Ultra Low Emission Zone – First Month Report
- Central London Ultra Low Emission Zone – Four Month Report
- Central London Ultra Low Emission Zone – Six Month Report
- Central London Ultra Low Emission Zone – Ten Month Report
- Central London Ultra Low Emission Zone 2020 Report
- London Low Emission Zone: Six Month Report
- Expanded Ultra Low Emission Zone – First Month Report
- Expanded Ultra Low Emission Zone – Six Month Report

Assessing the impacts of the expanded ULEZ and the LEZ

The aim of the ULEZ is to reduce pollution emissions by limiting the number of older more polluting vehicles on the roads. As such, the impacts of the ULEZ are rigorously monitored and the success of the ULEZ can be assessed through a number of different metrics:

- Number of vehicles and compliance rates
- Changes in fleet composition
- Traffic flow data
- Modelling of vehicle NOx and PM emissions
- Modelling of vehicle carbon emissions
- Air quality monitoring

Number of vehicles and compliance rates

Vehicle compliance rate refers to the proportion of vehicles that meet the ULEZ/LEZ emission standards. Vehicles that do not comply and are not exempt must pay the daily charge or be liable for enforcement action. The higher the compliance rate the more successful the scheme has been in terms of accelerating the transition to cleaner vehicles. This means compliance rates are a key metric in determining the success of the expanded ULEZ and the strengthened LEZ. Vehicles which do not meet the ULEZ/LEZ standards are described in this report as “non-compliant”.

Non-compliant vehicles do not meet the strict ULEZ emission standards and their drivers have either:

- Paid the daily charge
- Incurred a penalty charge
- Not been required to pay the daily ULEZ charge as they are eligible for a 100% discount or exemption

Table 1 details the emission standards for each vehicle type and which of the two schemes, ULEZ or LEZ, they fall under.

Table 1: Vehicle types, emission limits and relevant scheme for compliance figures

Vehicle type	Included in ULEZ compliance?	Emissions limits	Relevant scheme
Cars	Yes	Euro 4 (Petrol) Euro 6 (Diesel)	ULEZ
Motorbikes	Yes	Euro 3	ULEZ
Smaller vans	Yes	Euro 4 (Petrol) Euro 6 (Diesel)	ULEZ
Larger vans and minibuses (vans up to and including 3.5 t, minibuses up to and including 5t)	Yes	Euro 4 (Petrol) Euro 6 (Diesel)	ULEZ Diesel vehicles are additionally subject to a LEZ standard (Euro 3 for particulates) London-wide
Heavy diesel vehicles (incl. buses and coaches over 5t and HGVs and other heavy vehicles over 3.5t)	No	Euro VI	LEZ (London-wide)
Taxis (Black cabs)	No	All new taxis required to be "Zero Emission Capable" since 2018 and are subject to age limits and other restrictions to reduce emissions.	Taxi licensing

ULEZ compliance

The data in this section has been taken from TfL's camera network which detects vehicles using Automatic Number Plate Recognition (ANPR) cameras[11] as they enter the ULEZ and also travel within it.

Table 2 summarises the ULEZ compliance rates in the following moments:

- in February 2017 when the Mayor confirmed the T-Charge, the predecessor to the ULEZ;
- in October 2021, immediately prior to the expansion of the ULEZ on the 25th October, and
- one year on from expansion.

All tables in this section show the compliance rates for the whole current ULEZ, that is central London and the expanded zone up to the North and South Circular roads.

[11] For more information on how TfL gathers data, how it is used and protected please see the TfL website here: https://tfl.gov.uk/corporate/privacy-and-cookies/road-user-charging

The data shows that there has been a significant increase in the proportion of compliant vehicles driving in the zone since February 2017, with the average compliance rate now as high as 94 per cent for all vehicles and even higher at 95.8 per cent for cars.

Table 2 : Daily average and proportion of ULEZ compliant vehicles detected in the ULEZ

Vehicle type	Feb-17*	Oct – 21 (prior to launch) §	Oct-22 (one year after expansion)
All ULEZ vehicles	39%	86.9%	94.4%
Cars (incl. PHV, excl taxi)	44%	89.0%	95.8%
Vans (up to and incl. 3.5 tonnes)	12%	71.0%	85.0%
Motorcycles	50%	95.7%	97.3%

*****_February 2017 based on data from the London Atmospheric Emissions Inventory, except for Motorcycles which is based on Defra fleet composition data._

§ _Based on indicative data gathered from 12 to the 20 October_

Table 3: Daily average number and proportion of ULEZ compliant vehicles detected in the zone per month (rounded to the nearest 1000 vehicles)†

Date	Number of vehicles driving in the charging zone			Proportions of vehicles driving in the charging zone	
	Unique vehicles detected in zone*	Non-compliant vehicles	Compliant vehicles	Non-compliant vehicles	Compliant vehicles
October – 21 (prior to launch) §	950,000	124,000	826,000	13.1%	86.9%
Nov-21	941,000	75,000	866,000	8.0%	92.0%
Dec-21	886,000	66,000	820,000	7.4%	92.6%
Jan-22	862,000	57,000	806,000	6.6%	93.4%
Feb-22	909,000	61,000	848,000	6.7%	93.3%
Mar-22	931,000	61,000	869,000	6.6%	93.4%

Date	Number of vehicles driving in the charging zone			Proportions of vehicles driving in the charging zone	
	Unique vehicles detected in zone*	Non-compliant vehicles	Compliant vehicles	Non-compliant vehicles	Compliant vehicles
Apr-22	894,000	57,000	837,000	6.4%	93.6%
May-22	929,000	57,000	871,000	6.2%	93.8%
Jun-22	925,000	56,000	868,000	6.1%	93.9%
Jul-22	895,000	54,000	842,000	6.0%	94.0%
Aug-22	844,000	50,000	794,000	5.9%	94.1%
Sep-22	900,000	50,000	850,000	5.6%	94.4%
Oct-22	903,000	50,000	852,000	5.6%	94.4%
Change Oct 21–Oct 22	- 47,000	- 74,000	26,000	- 7.5 ppt^	7.5 ppt^
% Change	- 4.9%	- 59.7%	3.1%		

† Figures for vehicles subject to the ULEZ only, excluding vehicles subject to other schemes. Due to changes in scheme coverage over time these figures are not comparable with the central London ULEZ reports.

** "Unique vehicles" means that each vehicle is only counted one time each day even if it makes multiple journeys within the zone.*

§ *Based on indicative data gathered from 12 to the 20 October*

^ *Percentage points (ppt)*

Table 3 shows that compliance with the ULEZ is now over 94 per cent. This is extremely high and highlights the impact of the policy. Of the 5.6 per cent of non-compliant vehicles in September 2022, 28.8 per cent were non-chargeable. Non-chargeable vehicles include exemptions, vehicles benefitting from extended grace periods and those diverted into the zone. Exemptions apply to vehicles with 'disabled' or 'disabled passenger vehicle' tax class; minibuses used for community transport; wheelchair accessible private hire vehicles and historic vehicles[12] .

As seen in Table 3, the average number of non-compliant vehicles detected daily in the zone has continued to fall with a reduction of 74,000 vehicles from a daily average 124,000 in October 2021, prior to the expansion, to a daily average of just 50,000. This is an unprecedented reduction of almost 60 per cent of older more polluting vehicles detected the zone in a year.

We are seeing fewer vehicles driving in the zone overall, with some fluctuations showing seasonal variation and implying other factors such as the fuel price crisis

[12] TfL ULEZ Discounts and exemptions

and return to work following the pandemic are influencing vehicle numbers. Overall the daily average number of unique ULEZ vehicles in the zone has reduced from 950,000 immediately prior to the expansion in October 2021 to 903,000 in October 2022, a reduction of almost 5 percent.

Tables 4 to 7 show the monthly average compliance rates and vehicles driving in the zone for different ULEZ vehicle types including all cars, diesel cars, vans and motorbikes. Table 4 reports compliance rates for all cars, while Table 5 focuses on diesel cars only.

Table 4: Changes in the daily average number and proportion of ULEZ compliant cars (M1 and PHV, excl. Taxis) detected in the zone†

Date	Number of vehicles driving in the charging zone			Proportions of vehicles driving in the charging zone	
	Unique vehicles detected in zone*	Non-compliant vehicles	Compliant vehicles	Non-compliant vehicles	Compliant vehicles
Oct – 21 (prior to launch) §	792,000	87,000	706,000	11.0%	89.0%
Nov-21	784,000	47,000	737,000	6.0%	94.0%
Dec-21	756,000	44,000	712,000	5.8%	94.2%
Jan-22	730,000	36,000	694,000	4.9%	95.1%
Feb-22	762,000	38,000	724,000	5.0%	95.0%
Mar-22	775,000	37,000	738,000	4.8%	95.2%
Apr-22	751,000	35,000	715,000	4.7%	95.3%
May-22	778,000	35,000	742,000	4.6%	95.4%
Jun-22	775,000	35,000	739,000	4.6%	95.4%
Jul-22	748,000	34,000	714,000	4.5%	95.5%
Aug-22	702,000	31,000	671,000	4.4%	95.6%
Sep-22	748,000	31,000	718,000	4.1%	95.9%
Oct-22	753,000	31,000	721,000	4.2%	95.8%
Change Oct 21– Oct 22	- 39,000	- 56,000	15,000	-6.9 ppt^	6.9 ppt^
% Change	- 4.9%	- 64.4%	2.1%		

† Figures for vehicles subject to the ULEZ only, excluding vehicles subject to other schemes. Due to changes in scheme coverage over time these figures are not comparable with the central London ULEZ reports.

** "Unique vehicles" means that each vehicle is only counted one time each day even if it makes multiple journeys within the zone.*

§ *Based on indicative data gathered from 12 to the 20 October*

^ *Percentage points (ppt)*

Table 5: Changes in the daily average number and proportion of ULEZ compliant diesel cars (M1 and PHV, excl. Taxis) detected in the zone†

Date	Number of vehicles driving in the charging zone			Proportions of vehicles driving in the charging zone	
	Unique vehicles detected in zone*	Non-compliant vehicles	Compliant vehicles	Non-compliant vehicles	Compliant vehicles
Oct – 21 (prior to launch) §	216,000	79,000	138,000	36.4%	63.6%
Nov-21	186,000	43,000	143,000	23.0%	77.0%
Dec-21	177,000	40,000	137,000	22.5%	77.5%
Jan-22	164,000	32,000	131,000	19.8%	80.2%
Feb-22	173,000	34,000	139,000	19.9%	80.1%
Mar-22	175,000	34,000	141,000	19.4%	80.6%
Apr-22	167,000	32,000	135,000	19.2%	80.8%
May-22	172,000	32,000	140,000	18.6%	81.4%
Jun-22	172,000	32,000	140,000	18.6%	81.4%
Jul-22	164,000	30,000	134,000	18.5%	81.5%
Aug-22	152,000	28,000	123,000	18.6%	81.4%
Sep-22	162,000	28,000	134,000	17.2%	82.8%
Oct-22	164,000	29,000	136,000	17.4%	82.6%
Change Oct 21 – Oct 22	- 52,000	- 50,000	- 2,000	-19.0 ppt^	19.0 ppt^
% Change	- 24.1%	- 63.3%	- 1.4%		

† Figures for vehicles subject to the ULEZ only, excluding vehicles subject to other schemes. Due to changes in scheme coverage over time these figures are not comparable with the central London ULEZ reports.

** "Unique vehicles" means that each vehicle is only counted one time each day even if it makes multiple journeys within the zone.*

§ *Based on indicative data gathered from 12 to the 20 October*

^ *Percentage points (ppt)*

Table 6: Changes in the daily average number and proportion of ULEZ compliant vans (N1) detected in the zone†

Date	Number of vehicles driving in the charging zone			Proportions of vehicles driving in the charging zone	
	Unique vehicles detected in zone*	Non-compliant vehicles	Compliant vehicles	Non-compliant vehicles	Compliant vehicles
Oct – 21 (prior to launch) §	128,000	35,000	93,000	29.0%	71.0%
Nov-21	127,000	27,000	100,000	21.4%	78.6%
Dec-21	105,000	21,000	84,000	20.0%	80.0%
Jan-22	107,000	20,000	88,000	18.3%	81.7%
Feb-22	120,000	22,000	98,000	18.3%	81.7%
Mar-22	125,000	23,000	102,000	18.2%	81.8%
Apr-22	113,000	20,000	93,000	17.9%	82.1%
May-22	119,000	21,000	98,000	17.4%	82.6%
Jun-22	117,000	20,000	97,000	16.9%	83.1%
Jul-22	115,000	19,000	96,000	16.2%	83.8%
Aug-22	112,000	18,000	94,000	15.9%	84.1%
Sep-22	120,000	18,000	101,000	15.4%	84.6%
Oct-22	119,000	18,000	101,000	15.0%	85.0%
Change Oct 21 – Oct 22	- 9,000	- 17,000	8,000	-14.0 ppt^	14.0 ppt^
% Change	- 7.0%	- 48.6%	8.6%		

† Figures for vehicles subject to the ULEZ only, excluding vehicles subject to other schemes. Due to changes in scheme coverage over time these figures are not comparable with the central London ULEZ reports.

** "Unique vehicles" means that each vehicle is only counted one time each day even if it makes multiple journeys within the zone.*

§ *Based on indicative data gathered from 12 to the 20 October*

^ *Percentage points (ppt)*

Table 7: Changes in the daily average number and proportion of ULEZ compliant motorcycles (L) detected in the zone†

Date	Number of vehicles driving in the charging zone			Proportions of vehicles driving in the charging zone	
	Unique vehicles detected in zone*	Non-compliant vehicles	Compliant vehicles	Non-compliant vehicles	Compliant vehicles
Oct – 21 (prior to launch) §	27,700	1,200	26,600	4.3%	95.7%
Nov-21	28,500	1,000	27,500	3.4%	96.6%
Dec-21	23,100	800	22,300	3.4%	96.6%
Jan-22	23,600	800	22,900	3.3%	96.7%
Feb-22	25,900	900	25,100	3.3%	96.7%
Mar-22	28,900	1,000	28,000	3.3%	96.7%
Apr-22	28,800	900	27,800	3.3%	96.7%
May-22	30,500	1,000	29,500	3.3%	96.7%
Jun -22	31,400	1,000	30,400	3.2%	96.8%
Jul-22	30,800	1,000	29,800	3.1%	96.9%
Aug-22	29,000	800	28,200	2.9%	97.1%
Sep-22	30,400	800	29,600	2.8%	97.2%
Oct-22	29,900	800	29,100	2.7%	97.3%
Change Oct 21 – Oct 22	2,200	- 400	2,500	-1.6ppt^	1.6ppt^
% Change	7.9%	- 33.3%	9.4%		

† Figures for vehicles subject to the ULEZ only, excluding vehicles subject to other schemes. Due to changes in scheme coverage over time these figures are not comparable with the central London ULEZ reports.

** "Unique vehicles" means that each vehicle is only counted one time each day even if it makes multiple journeys within the zone.*

§ *Based on indicative data gathered from 12 to the 20 October*

^ *Percentage points (ppt)*

Compliance rates have continued to increase for all vehicle types with the highest rates being seen for motorbikes at 97 percent in October, as seen in Table 7.

Diesel cars have been separated out in Table 5 as diesel cars produce higher NOx emissions than petrol cars and hence have tighter emissions standards under the ULEZ, with diesel vehicles having to meet Euro 6 and for petrol vehicles, Euro 4. There has been a significant reduction in the proportion of non-compliant diesel cars

entering the zone, down by 63 per cent over the year since the expansion. Given the historic challenges with diesel vehicles, this is a key metric of success for the policy in removing harmful emissions from the city. As seen in Table 4, the total number of cars in the zone each day has reduced by 4.9 per cent over the year, indicating that the diesel cars that are no longer entering the zone have not all simply been swapped for petrol cars instead, mitigating the potential impacts on CO_2 emissions.

The compliance rate for vans is slightly lower than that for cars however there are significantly fewer vans traveling in the zone each day due to the ULEZ. At 85 per cent in October, the compliance rate is still high and crucially it has risen at a much quicker pace than the average for all vehicles, with van compliance increasing by 14 percentage points over the year compared to an increase of 7.5 percentage points for all vehicles.

LEZ compliance

Compliance for the London-wide low emission zone (LEZ) is reported separately than for the ULEZ as the policy applies to different vehicles and covers a different area. More detailed information on the progression of emission standards under the LEZ is available in the previous London Low Emission Zone Six Month Report[13].

Table 8 gives the average monthly compliance rates for large and heavy vehicles traveling in the LEZ. This is based on the numbers of unique vehicles detected in the zone each day. The emissions standards for the LEZ were tightened to match the ULEZ standards on 1st March 2021. In Table 8, data up to February 2021 is prior to the change in emissions standards, but all data shown is the compliance with the new standards in order to show changes over time.

Table 8 shows that LEZ compliance rates have now reached around 97 per cent. This is extremely high for the scheme and highlights the success of the policy in reducing numbers of older more polluting heavy vehicles on London's roads.

[13] London Low Emission Zone Six Month Report

Table 8: London-wide Low Emission Zone compliance rate

Month	LEZ Compliance Rate (new emissions standards)
Feb – 2017 baseline[§]	48%
May-19[*]	71.0%
Sep-19[*]	73.7%
Jan-20[*]	78.5%
May-20[†]	83.2%
Jun-20[†]	83.4%
Jul-20[†]	83.8%
Aug-20[†]	85.0%
Sep-20[†]	85.0%
Oct-20[†]	85.8%
Nov-20[†]	87.9%
Dec-20[†]	88.7%
Jan-21[†]	89.9%
Feb-21[†]	90.4%
March-21	93.5%
Apr-21	94.3%
May-21	94.5%
Jun-21	94.9%
Jul-21	95.3%
Aug-21	95.5%
Sep-21	95.4%
Oct-21	95.7%
Nov-21	95.8%
Dec-21	95.9%
Jan-22	96.1%
Feb-22	96.2%
Mar-22	96.1%
Apr-22	96.2%
May-22	96.2%
Jun-22	96.3%
Jul-22	96.7%
Aug-22	97.0%

Month	LEZ Compliance Rate (new emissions standards)
Sep-22	97.0%
Oct-22	97.1%
Overall change in compliance February 17 to present	**Increase of 49.1 percentage points**
Change in compliance since the standards were tightened.	**Increase of 6.7 percentage points**

Table notes:
§ February 2017 based on data from the London Atmospheric Emissions Inventory
** Analysis based on sampled days within these months, using historical data*
† Compliance rates estimated using information from ANPR camera data and associated vehicle information such as age and type of vehicle

Compliance rates across London

Figures 5 to 7 show the ULEZ compliance rates (as percentages and based upon the numbers of unique vehicles detected in the zone each day, as with the tables above) for different vehicle categories, split by zone. For this analysis central refers to the central congestion charge zone, ULEZ zone refers to the current inner London ULEZ area up to the boundary along the North and South Circulars.
All three graphs show a sharp increase in the compliance rate for the ULEZ zone (orange line) from September to October 2021, when the ULEZ was expanded. This provides evidence that the expansion has had a significant impact within the zone causing a step change in the compliance rates of the vehicles driving within. Compliance rates on the boundary road also jumped around the time of the ULEZ expansion.

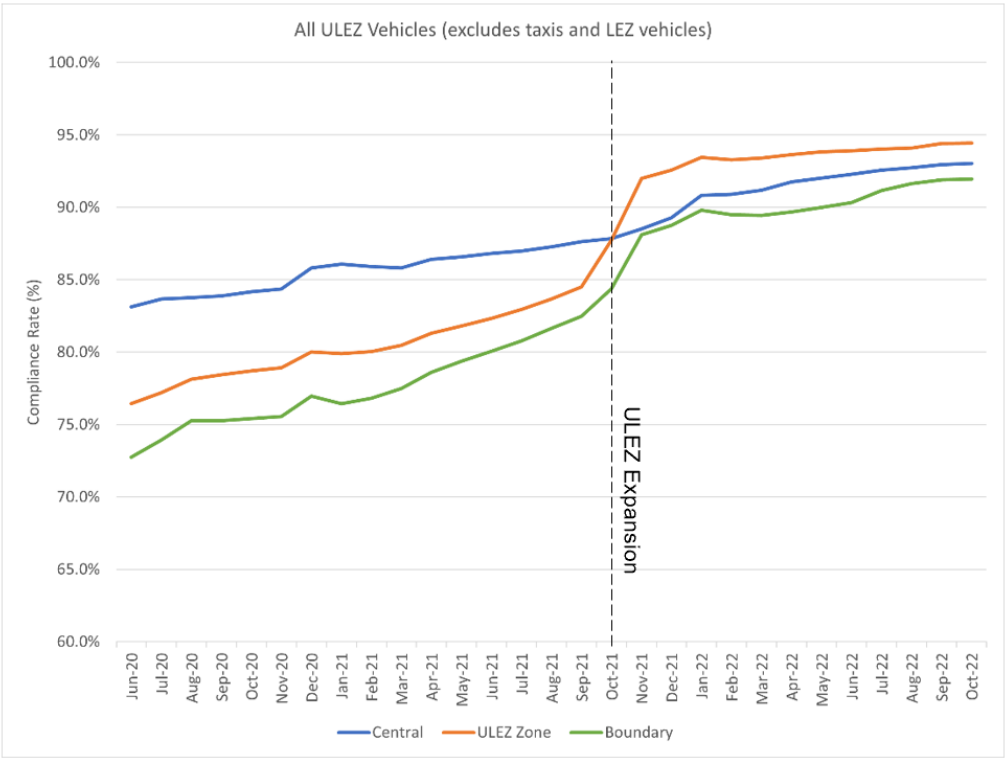

Figure 5: Monthly average ULEZ compliance rates split by zone, for all ULEZ vehicles

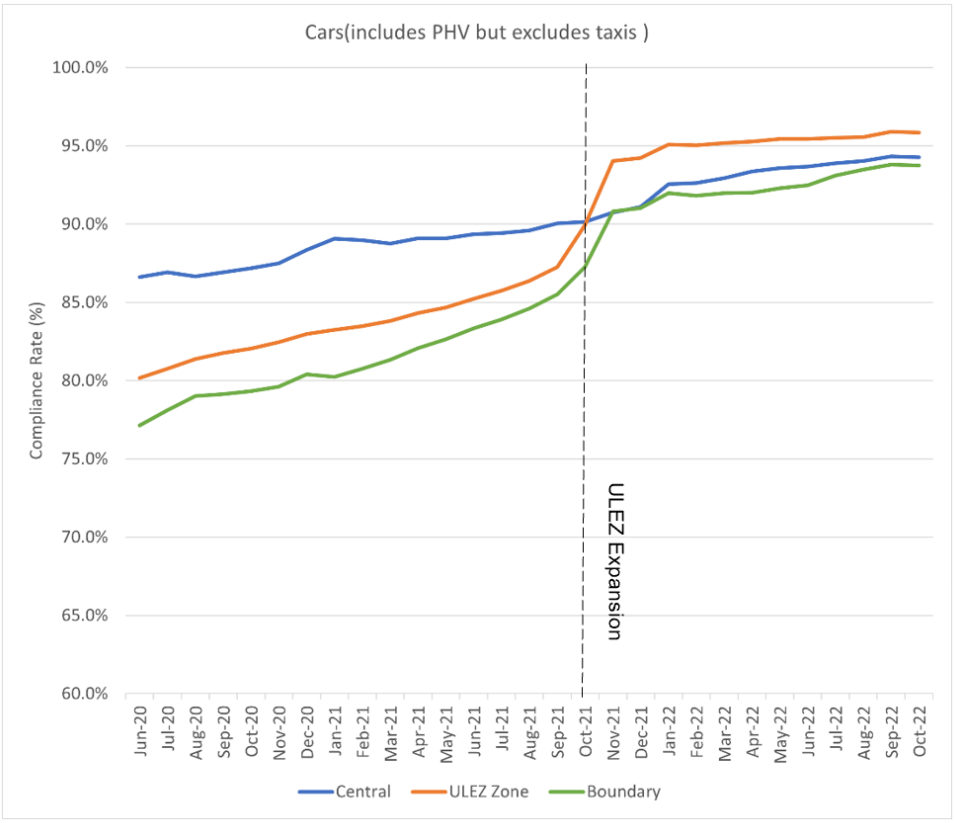

Figure 6: Monthly average ULEZ compliance rates split by zone, for cars.

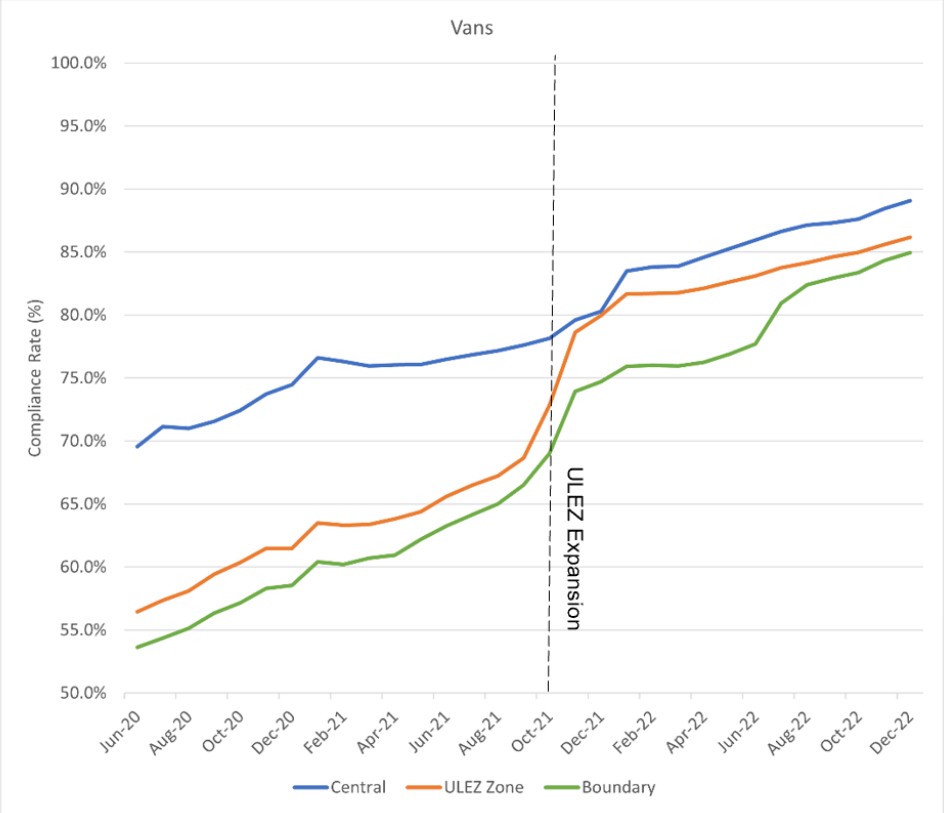

Figure 7: Monthly average ULEZ compliance rates split by zone, for vans.

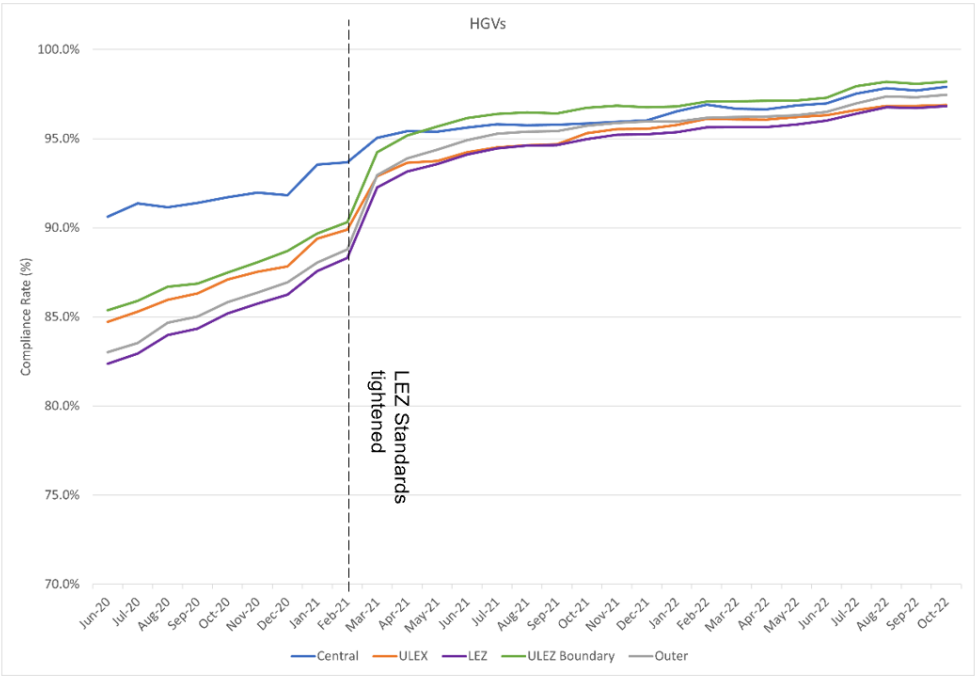

Figure 8: Monthly average LEZ compliance rates split by zone, for HGVs.

Figure 8 shows the monthly average LEZ compliance rates for HGVs, split by zone. There is a substantial increase in compliance rates for all zones between February and March 2021, when the emissions standards were tightened. London-wide this was an increase from 88 to 92 per cent of HGVs meeting the LEZ emissions standards from February to March 2021 indicating that fewer non-compliant vehicles were driven in the zone following the tightening of the standards. This clearly demonstrates the impact of the scheme in reducing the numbers of older, more polluting HGVs from the roads. The increase in compliance rate has slowed since the scheme was implemented in March 2021 and has reached 97 per cent in recent months.

Fleet compositions

The fleet composition is the mix of vehicles, split by vehicle type and fuel type, that travel in London and is a key input for estimating the emissions from vehicles and the changes in emissions due to the ULEZ and associated policies.

As London's vehicle fleet becomes cleaner as a result of the Mayor's policies, emissions from vehicles operating in London are expected to reduce. Both the ULEZ and LEZ influence the fleet composition because they incentivise the uptake of cleaner vehicles above and beyond the natural turnover of vehicles that would be expected.

Fleet composition (including fuel types) are based on a proportion of the total vehicle kilometres driven rather than vehicle numbers, as some vehicles travel much further than others (e.g. delivery drivers, private hire vehicles). For the purposes of this report, we refer to the fleet composition representing the proportion of kilometres estimated by vehicle type and fuel type (and power train).

The data used in this section has been based on data analysis of observations using TfL's camera network. Monthly information on changes to the fleet composition have been compiled for this report including information from February 2019, just prior to the launch of the ULEZ in central London in April 2019. The monthly fleet composition information can be used to estimate the changes in emissions from vehicles over time as the proportions of mileage, especially by compliant vehicles, increases, and changes in fuel types are taken into account. Monthly fluctuations are visible in the dataset because they are representing different levels of activity including during Covid lockdowns, holiday periods, as well as reflecting immediate scheme impacts during and after implementation. Fleet composition changes would also include the impacts of the Mayor's scrappage schemes[14] that have been particularly successful in encouraging modal shift away from vehicles, with a third of recipients not replacing their vehicles. It should also be recognised that changes in the fleet compositions will also in part reflect consumer awareness of issues such as the Dieselgate scandal and the acceptance of electric vehicles which work alongside schemes such as ULEZ encouraging cleaner vehicles.

[14] ULEZ scrappage schemes evaluation report November 2022

Figures 9 to 11 show the change in fleet composition over time. The graphs show the change in percentage of vehicles with each engine type, split by London zone. The different engine types include diesel and petrol internal combustion engines (ICE); petrol hybrid electric vehicle (HEV); petrol plug in (PHEV); and fully electric.

As with the air pollution concentrations section, the central zone is the extent of the original central London ULEZ; the inner zone is the doughnut surrounding (but not including) the central zone and extending out to the North and South Circular, the boundary of the inner London ULEZ and the outer London zone is outside of the ULEZ.

There are separate graphs for each vehicle type. Figure 9 summarises the fleet composition for cars, Figure 10 for private hire vehicles (PHV) and Figure 11 for vans (LGV).

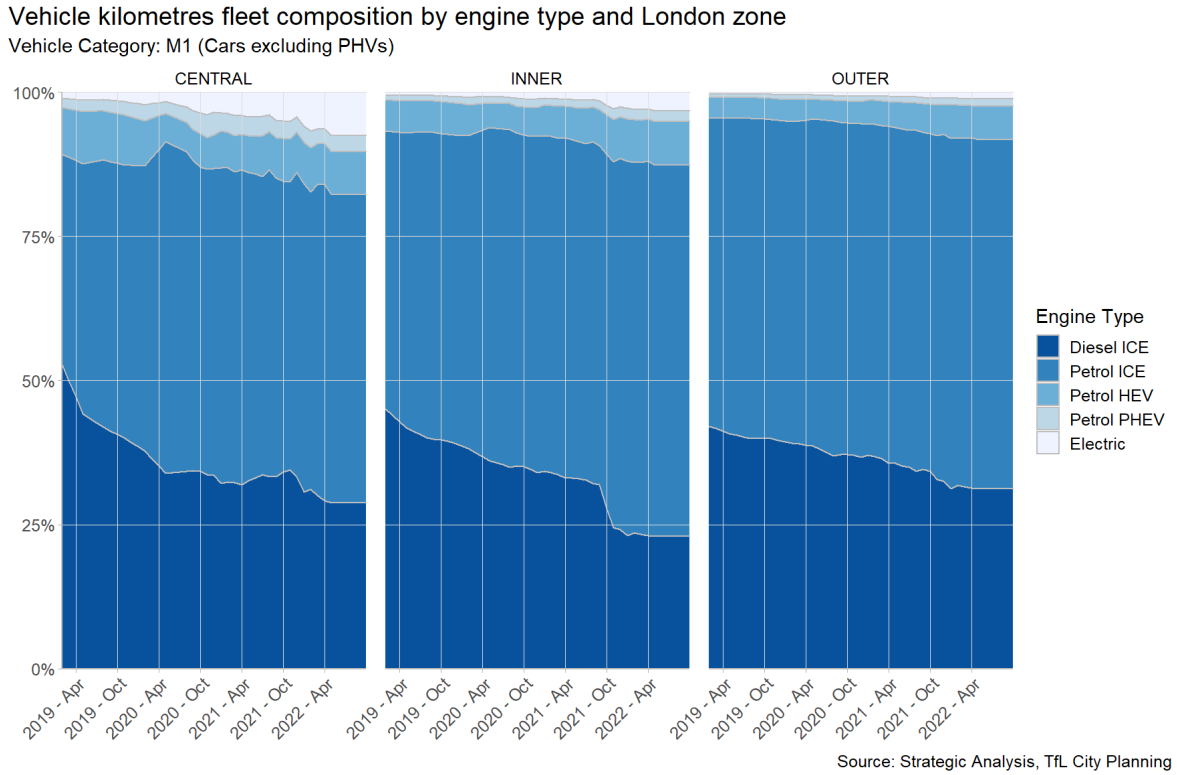

Figure 9: Fleet composition for cars, split by engine type and London zone.

Figure 9 shows the percentage split of engine types for cars in London. The graph shows that the proportion of diesel car kilometres has reduced from 2019 to 2022 for all London zones. In inner London there is a sharp reduction in the proportion of diesel car kilometres, from 32 per cent to 25 per cent between September and November 2021 when the ULEZ was expanded up to inner London, showing the impact of the expansion in reducing diesel cars in inner London. This reduction in the proportion of diesel car kilometres is also accompanied by smaller increases in the proportion of petrol and electric vehicles. It can also be seen that changes in the fleet compositions for outer London also have occurred with reducing proportions of

diesel kilometres since 2019, including a reduction of approximately 3 per cent around the introduction of the expanded ULEZ, though fuel prices may also have had an impact on overall trends.

Central London has the largest proportion of electric car kilometres and this has steadily increased since 2019 to about 8 per cent in mid-2022, in the inner zone the percentage of electric car kilometres has increased to about 4 per cent.

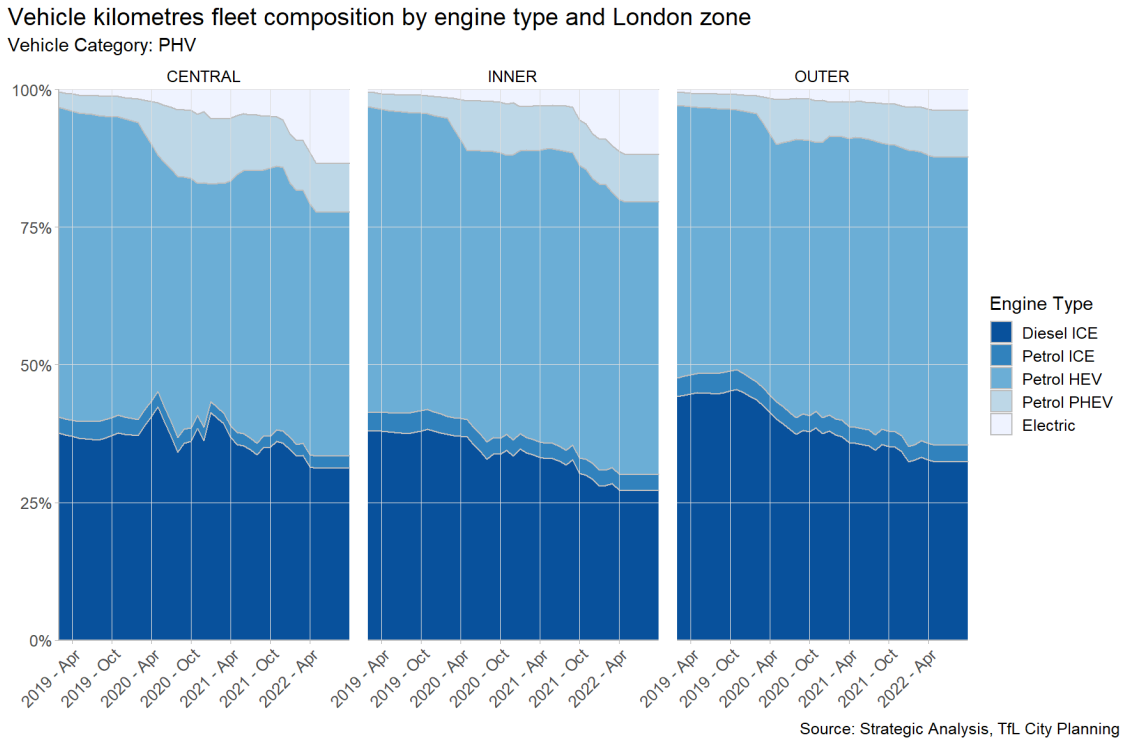

Figure 10: Fleet composition for private hire vehicles (PHVs), split by engine type and London zone.

Figure 10 shows percentage split of engine types for private hire vehicles (PHV) in London. The fleet composition for private hire vehicles shows that the largest proportion of PHVs are petrol HEVs. The graph also shows that PHVs have a higher proportion of electric and hybrid vehicles in their fleet composition than in the fleet composition for cars, seen in Figure 10. PHVs experienced an increase in the proportion of electric vehicles from October 2021 when the ULEZ was expanded, in both central and inner London.

The fleet compositions of PHV are also highly influenced by the additional licensing requirements set by TfL especially for newly registered PHVs in order to reduce the impact of emissions from these vehicles. Whilst the vast majority of PHVs meet the ULEZ standards due to these licensing conditions a small reduction in the proportion of diesel vehicles and an increase in electric vehicle kilometres can be seen in October 2021 when the ULEZ expansion was implemented.

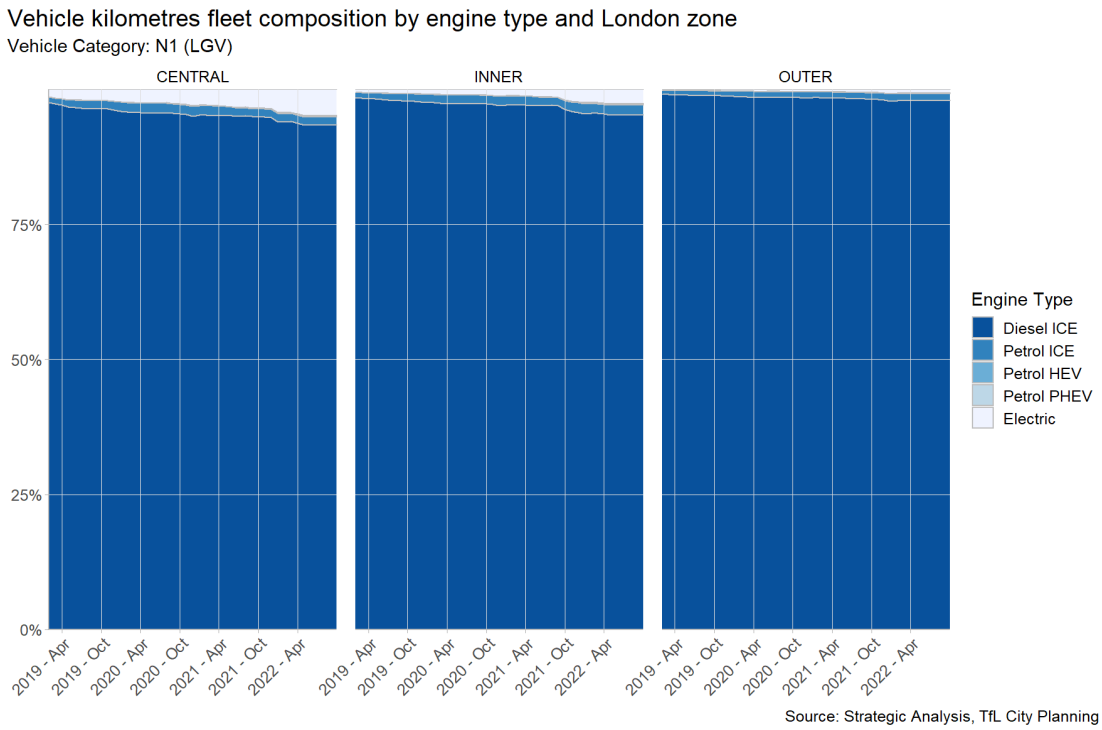

Figure 11: Fleet composition for vans (LGVs), split by engine type and London zone.

Figure 11 shows that the vast proportion of vans in all zones in London have diesel internal combustion engines. There has been little change to this in inner and outer London, though there has been a small increase in the proportion of electric vans driving from 2019 to an estimated 3 per cent in central London and 2 per cent in inner London in 2022.

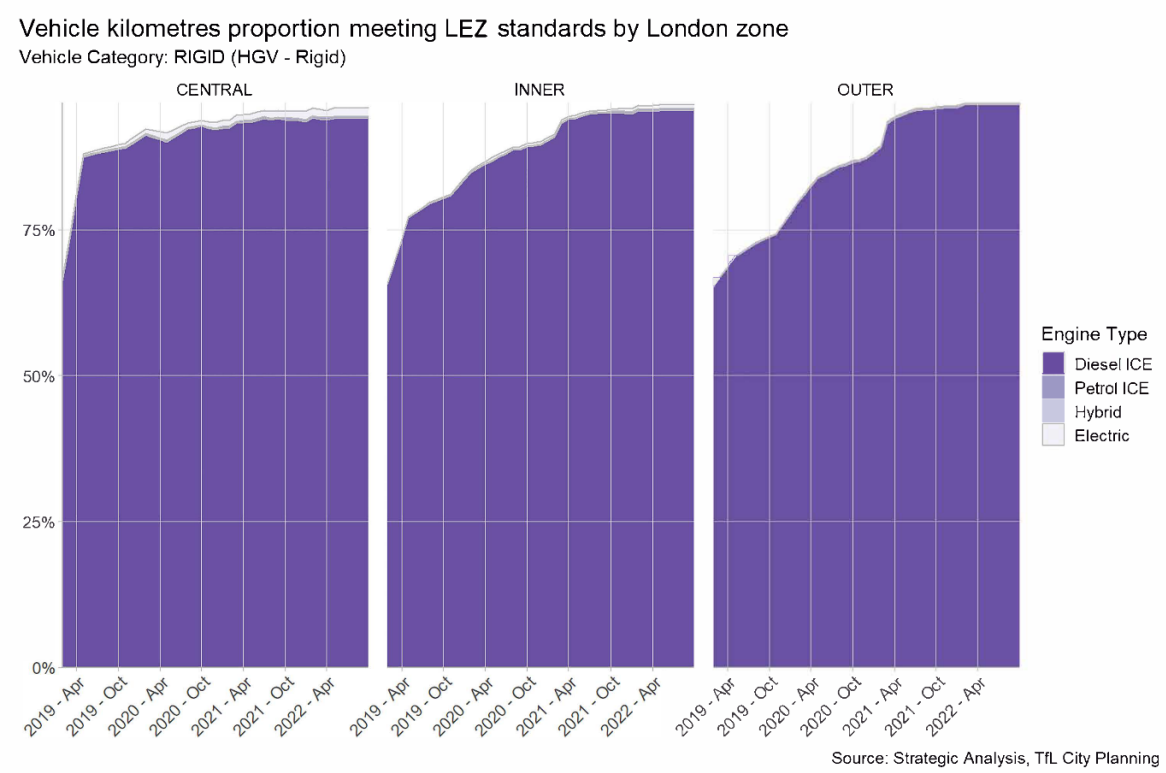

Figure 12: Proportion of HGVs meeting the LEZ standards, split by engine type and London zone.

Fleet compositions for heavy goods vehicles which are subject to the tightened Low Emission Zone requirements have also been determined as these are also required to estimate emissions. As heavy vehicles are predominantly diesel, the Figure 12 shows how the proportion of vehicle kilometres meeting the LEZ standards has changed over time. It can be seen that there was a large increase in the proportion of kilometres before April 2019 in central London, when the first ULEZ was implemented, alongside increases in both inner and outer London especially in March 2021 when the LEZ was tightened. The fleet compositions show very small proportions of electric and hybrid vehicles kilometres as fewer models are available for heavy vehicles compared to cars and vans.

The Mayor's scrappage scheme aims to influence fleet compositions by encouraging the removal of older more polluting vehicles from the fleet. The scrappage schemes removed over 15,000 non-ULEZ compliant vehicles from London's roads with one third not purchasing a replacement vehicle[15].

[15] ULEZ scrappage schemes evaluation report November 2022

Traffic Impacts

This section of the report provides the changes in traffic flows across London following the expansion of the ULEZ up to the North and South Circular roads.

The ULEZ aims to tackle the triple threats of air pollution, the climate emergency and congestion. By introducing minimum emission standards for vehicles the ULEZ is likely to deter a small proportion of trips or lead to a change in how people travel. Traffic flows are also an important input for estimating the impacts of the ULEZ on pollution emissions, which are provided in the next section of the report.

Many factors influence traffic patterns in London. Traffic normally follows a usual pattern of seasonal variation with lower levels in holiday periods. However, in recent years there have been a number of additional factors which have had significant impacts on traffic levels. The lockdowns and changes to working patterns due to the Covid-19 pandemic led to greatly reduced traffic flows in 2020 and also in 2021, particularly in central London. TfL's Travel in London Report[16] provides further detailed analysis on the impacts of the pandemic on transport. The fuel shortages and following price crisis may have and continue to influence traffic, however the recent Travel in London Report has yet to find evidence of this. Therefore, it has not been possible to identify fully the sole and direct impact of the ULEZ on traffic flows.

Data Sources

The data described in this section is based on automatic traffic count (ATC) data from Department for Transport (DfT), Highways England and TfL's ATC Network. As with the fleet composition, the data is presented as vehicle kilometres rather than numbers of unique vehicles detected, as used in the previous section on numbers of vehicles and compliance rates. Using vehicle kilometres as an indicator of traffic levels gives a better indication of the traffic flows than using the number of unique vehicles detected, as certain vehicles will be on the roads for longer and may travel through the zone multiple times a day. The DfT data for 2022 is yet to be released so figures for 2022 are solely based upon TfL's ATC network.

The following periods apply:

- 2019 baseline – pre-COVID baseline using 2019 traffic data
- Pre-ULEZ expansion baseline – 13 September to 24 October 2021 (excluding 25 September – 3 October 2021 due to the petrol shortages)

- Post ULEZ expansion – based on actual data collected from date of the ULEZ launch (25 October 2021) to October 2022

The year 2019 was chosen for the baseline year as the most recent 'typical' year of traffic flows due to 2020 traffic flows being heavily impacted by the Covid-19 pandemic causing significant changes to usual travel patterns.

[16] Travel in London Report 15 (tfl.gov.uk)

The pre-ULEZ expansion baseline uses traffic data collected during September and October 2021, which are considered to be 'neutral' months in terms of traffic patterns, away from school holidays and inclement weather conditions.

Results

Table 9 shows the comparison of the post-ULEZ expansion traffic flows with the pre-ULEZ expansion traffic flows and the 2019 baseline traffic flows split by inside the ULEZ, outside the ULEZ and on the boundary roads. The table shows monthly and quarterly average comparisons of vehicle kilometres in the baseline and post – ULEZ expansion.

The data show that following the ULEZ expansion, there have been reductions in traffic levels both inside the zone and outside the zone and also on the boundary roads, compared to the pre-ULEZ expansion period. The reductions are even greater when comparing against the 2019 baseline data, however that is more likely to be influenced by the pandemic.

The reductions in traffic vary throughout the year following the expansion and the impacts of seasonal variation are evident in the monthly data.

Reductions in traffic flows were greatest in November to January compared to the pre-ULEZ baseline, at 4.9 per cent within the zone, 5.8 per cent outside the zone and 3.3 per cent on the boundary roads. This includes the impacts of Christmas and New Year when traffic levels are usually lower and also the work from home order that was introduced by the government in the second week of December 2021 and continued into the new year. This will also have contributed to the reductions seen when comparing the post-ULEZ expansion data to the 2019 baseline for the same period.

In May to July 2022, traffic levels were very similar to that during the pre-ULEZ expansion baseline, both within the zone and outside of it and 0.6 percent lower on the boundary roads. This is potentially due to the return to work following the pandemic and also seasonal variation in comparing a period of data in summer to September and October which the pre-ULEZ expansion baseline was derived from.

During August to October 2022, traffic flows reduced inside the zone by 3.7 per cent and by 2.1 per cent outside the zone, both compared to the pre-ULEZ expansion baseline. This is a more representative comparison as it is comparing a similar time period as the pre ULEZ expansion baseline, which was taken from September to October 2021, and is in line with our initial modelled estimates of a one to three per cent fall in traffic within the zone.

However, it is not yet possible to isolate the impact of the ULEZ due to impacts from the continued rise in fuel prices through 2022 and the longer-term pandemic effects on travel including return to work from mid-March 2022. We will continue to monitor traffic impacts over the year.

Table 9: Percentage change in vehicle kilometres post-ULEZ expansion vs 2019 and post-ULEZ expansion vs pre-ULEZ expansion baseline, averaged by month and quarter.

		Inside expanded ULEZ		Outside expanded ULEZ		Boundary	
	Month/ Year	Post-ULEZ expansion vs 2019 baseline	Post-ULEZ expansion vs pre-expansion baseline	Post-ULEZ expansion vs 2019 baseline	Post-ULEZ expansion vs pre-expansion baseline	Post-ULEZ expansion vs 2019 baseline	Post-ULEZ expansion vs pre-expansion baseline
Monthly Averages	Oct-2021	-7.6%	-1.3%	-4.1%	-1.5%	-2.8%	-1.2%
	Nov-2021	-7.2%	-0.7%	-4.3%	-1.6%	-2.5%	-2.0%
	Dec-2021	-9.3%	-5.9%	-8.2%	-8.3%	-5.6%	-6.6%
	Jan-2022	-9.7%	-8.0%	-6.3%	-7.6%	-4.6%	-6.9%
	Feb-2022	-6.7%	-2.8%	-4.0%	-3.0%	-3.1%	-3.1%
	Mar-2022	-10.2%	-1.3%	-6.3%	-1.6%	-4.8%	-1.5%
	Apr-2022	-10.4%	-3.5%	-6.6%	-2.9%	-6.4%	-2.4%
	May-2022	-8.8%	-0.5%	-5.2%	-0.5%	-3.4%	0.3%
	Jun-2022	-8.5%	0.8%	-6.0%	0.3%	-4.9%	0.4%
	Jul-2022	-8.6%	-0.4%	-5.6%	-0.1%	-5.9%	0.1%
	Aug-2022	-8.8%	-4.4%	-5.5%	-3.2%	-8.2%	-4.8%
	Sep-2022	-10.9%	-3.5%	-6.4%	-2.3%	-7.6%	-4.0%
	Oct-2022	-9.3%	-3.2%	-3.5%	-0.7%	-5.3%	-3.4%
Quarterly averages	Sep to Oct-2021	-7.4%	-0.3%	-4.0%	-0.6%	-3.0%	-0.4%
	Nov-2021 to Jan-2022	-8.7%	-4.9%	-6.2%	-5.8%	-2.2%	-3.3%
	Feb to Apr-2022	-9.2%	-2.5%	-5.6%	-2.5%	-6.4%	-3.8%
	May to Jul-2022	-8.7%	0.0%	-5.6%	-0.1%	-5.5%	-0.6%
	Aug to Oct-2022	-9.7%	-3.7%	-5.1%	-2.1%	-5.8%	-2.9%

Figure 13 is taken from the recently published Travel in London Report 15[17]. The graph shows the effects of the pandemic restrictions in early 2020, with traffic levels dropping across all areas of London, although the decline was much sharper in central London. During 2021, traffic levels increased gradually before plateauing across all areas at a lower level than before the pandemic, about seven per cent below the 2019 traffic levels in the latest period. Traffic flows in both inner and outer London in autumn 2022 are around six to seven per cent below pre-pandemic levels, while flows in central London are around 15 per cent lower than in 2019, indicating that the UEZ has helped mitigate the post-pandemic increases in traffic.

[17] TfL Travel in London Report 15

As Figure 13 presents a moving average and indexed data it differs to that shown in Figure 14 which presents total monthly vehicle kilometres.

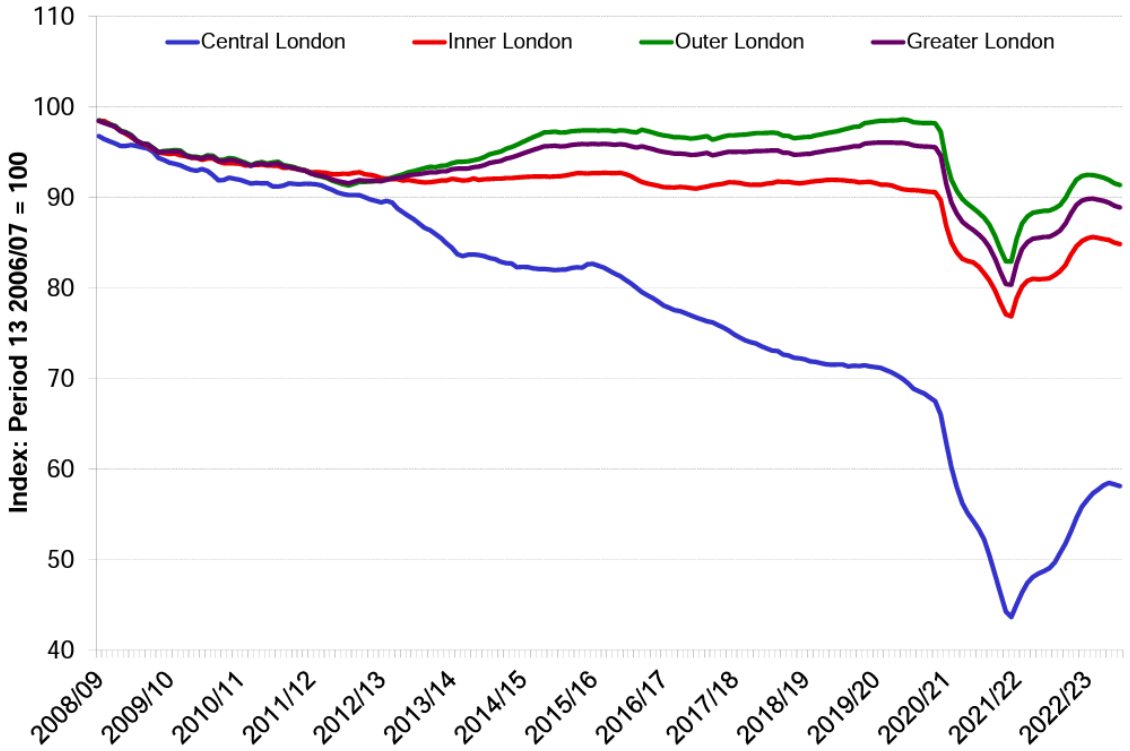

Figure 13: Traffic flows by London zone, all vehicles, 13 period moving average, 208/209- 2022/23.
Source: Travel in London Report 15.

Emissions

This report presents the first analysis of the impact of the expanded ULEZ and tightened LEZ standards on air pollution emissions. The changes in emissions over time are estimated based upon the changing fleet composition data and estimates of vehicle kilometres of traffic across the London zones.

Reducing emissions of pollution is essential to reducing levels of harmful pollution in the air and ultimately improving the health for all Londoners.

As the ULEZ and LEZ are based upon road vehicle engine emissions standards and disincentivise the use of older vehicles with higher pollution emissions being used in the zones, it is expected that the vehicle emissions would reduce as compliance increases and the fleet becomes cleaner.

Data Sources and Methodology

Annual vehicle kilometre estimates in each zone, as represented in the London Atmospheric Emissions Inventory 2019[18], have been indexed on a monthly basis between January 2019 and October 2022 using data from approximately 300 ATC sites across London, as well as Department for Transport (DfT) manual traffic counts and TfL camera data. As DfT data is not available for 2022 (this is not due to be released until September 2023), only TfL ATC and camera data has been used to index vehicle kilometres in 2022. Figure 14 shows the monthly vehicle kilometres estimated for each zone used in order to estimate emissions. Large reductions in April 2020 and December 2020 represent Covid-19 lockdowns but monthly variability can be seen across the dataset for example reductions in August due to summer holidays, and the Christmas period in December and January. Traffic levels have now largely returned to pre-pandemic in outer London but in central and inner London they remain below what they were in 2019, as seen in Figure 14.

[18] London Atmospheric Emissions Inventory (LAEI) 2019

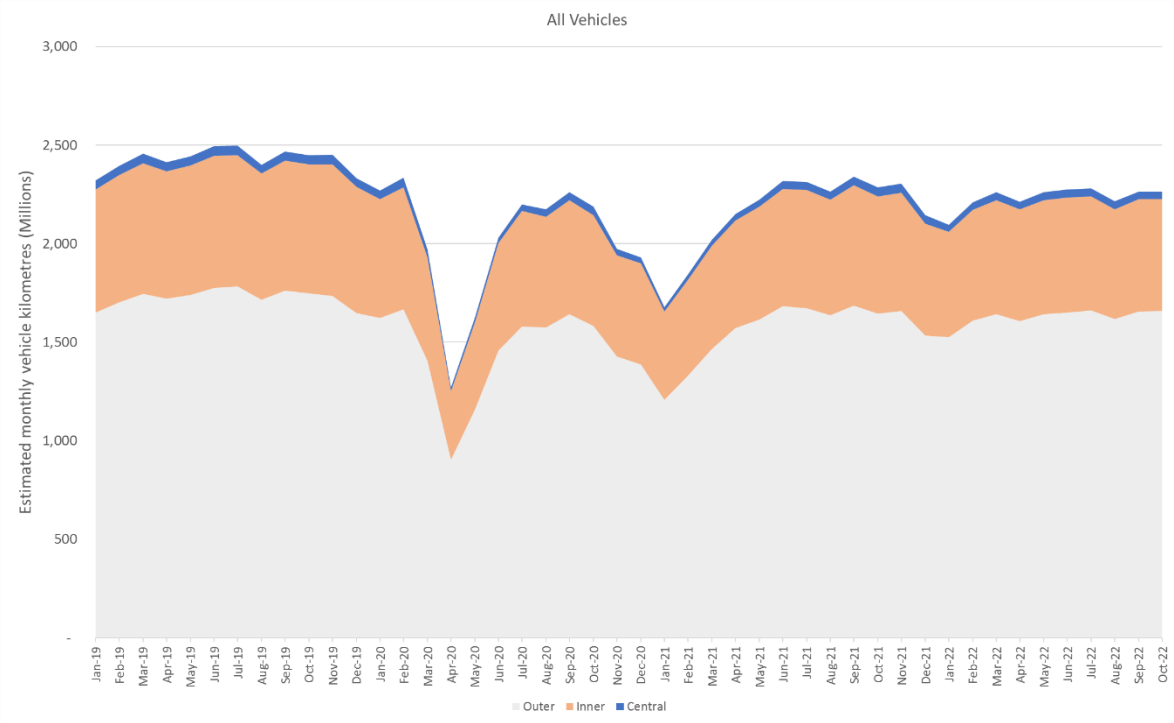

Figure 14: Estimated Monthly vehicle kilometres, split by London zone

Monthly emission rates (in grams per kilometre) for vehicles have been derived using the fleet compositions and speed related emission factors (COPERT) for the pollutants NOx, $PM_{2.5}$ and CO_2. Zonal emission factors for each vehicle type have been calculated for each London zone (central, inner and outer) using the speeds on the major road network, data provided by the LAEI, weighted by vehicle kilometres. As such the average zonal speeds are lowest in central London, and highest in outer London reflecting speed distributions.

The quantity of pollutants emitted can be estimated by multiplying the vehicle kilometres for each vehicle type by the emission rate. The resulting emissions therefore fluctuate each month as both vehicle kilometres and fleet compositions change.

This section presents the changes in nitrogen oxides (NOx), $PM_{2.5}$ and CO_2 emissions over time as well as an estimation of what the emissions would have been should the ULEZ not have been implemented.

Two sets of emissions estimated have been undertaken. A set with the ULEZ expansion in order to represent what we have monitored since early 2019 and reflecting the changes in fleet compositions we have observed over time. A second set of emissions have been estimated using fleet compositions aimed to represent only natural churn in the vehicle fleet, a 'no ULEZ scenario' - I.e. what the emissions would have been without the ULEZ in place. The same levels of vehicle kilometres have been used to calculate emissions except in central London were the estimated vehicle kilometre impacts reported in the 1 year report have been taken into account (estimated to be a 6 per cent reduction on average). Traffic impacts of expanding ULEZ have not been accounted for because these are more uncertain especially

post-pandemic and therefore we are using the best available data in excluding these from the emissions assessment. The difference between the two sets of emissions estimates represents the impact of the ULEZ policies. However, it must be clearly stated that whilst ULEZ itself is the most significant policy affecting cars, vans, and heavy vehicles and TfL buses (through the LEZ), additional taxi age limits and licensing requirement changes were also implemented, and the impacts of these are also included because together all of these interventions reduce emissions.

NOx Emissions

Table 10 shows the estimated NOx emissions with and without ULEZ (including the LEZ and taxis) in 2019, 2020, 2021 and 2022 for the ULEZ area. It has been estimated that the ULEZ policies have reduced emissions in the zone by 20 per cent, 26 per cent, 28 per cent and 34 per cent respectively in each year – equating to 1,260 tonnes of NOx saved in 2019, nearly 1,200 tonnes saved in 2020, 1,160 tonnes saved in 2021, and 1,308 tonnes in 2022 (including an estimate for November and December 2022 traffic). Cumulatively across the 4 years, over 4,900 tonnes of NOx have been saved – equating to a 26 per cent reduction.

Table 10: Estimated NOx emissions for the ULEZ area, by vehicle type and year

		NOx Emissions [Tonnes Per year]					
Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
NO ULEZ	2019	6,249	1,977	1,357	477	1,706	731
NO ULEZ	2020	4,539	1,452	1,126	332	1,151	478
NO ULEZ	2021	4,191	1,401	1,115	364	1,085	226
NO ULEZ	2022	3,865	1,315	1,132	340	864	213
WITH ULEZ	2019	4,989	1,769	1,347	469	1,152	254
WITH ULEZ	2020	3,339	1,190	1,085	264	663	136
WITH ULEZ	2021	3,031	1,085	1,055	273	560	57
WITH ULEZ	2022	2,556	835	940	252	473	56
CHANGE	2019	-1,259	-208	-11	-9	-554	-477
CHANGE	2020	-1,200	-262	-41	-68	-487	-342
CHANGE	2021	-1,160	-315	-60	-91	-525	-169
CHANGE	2022	-1,308	-480	-192	-88	-391	-157
% CHANGE	2019	-20%	-11%	-1%	-2%	-32%	-65%
% CHANGE	2020	-26%	-18%	-4%	-20%	-42%	-72%
% CHANGE	2021	-28%	-23%	-5%	-25%	-48%	-75%
% CHANGE	2022	-34%	-37%	-17%	-26%	-45%	-74%
2019-2022 Cumulative							
NO ULEZ	2019 - 2022	18,843	6,145	4,731	1,514	4,806	1,648

	NOx Emissions [Tonnes Per year]						
Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
WITH ULEZ	2019 - 2022	13,915	4,879	4,428	1,258	2,848	502
CHANGE	2019 - 2022	-4,928	-1,266	-303	-255	-1,958	-1,146
% CHANGE	2019 - 2022	-26%	-21%	-6%	-17%	-41%	-70%

Table 10 shows that NOx emissions have reduced for all vehicle types with emissions from TfL busses the biggest proportion at 70%. The largest total emissions savings are from HGVs with a saving of 1,146 tonnes over the four-year period since 2019. The GLA average emissions (see appendix 1 for emissions split by London zones and GLA average) shows that NOx emissions from vans have reduced in the GLA area only 2 per cent since 2019, compared to 17 per cent within the ULEZ. This highlights the need to expand the ULEZ further as this will reduce the emissions from the most polluting vans in outer London. Appendix 1 also shows emissions in each year by zone (central, inner and outer) and averaged for London as a whole.

$PM_{2.5}$ Emissions (including non-exhaust emissions)

Table 11 below shows the estimated $PM_{2.5}$ emissions with and without ULEZ (including the LEZ and taxis) in 2019, 2020, 2021 and 2022 (to end October) for the ULEZ. It has been estimated that the ULEZ policies have reduced emissions in the zone by 11 per cent, 10 per cent, 10 per cent and 13 per cent in each year respectively, equating to 24 tonnes of $PM_{2.5}$ saved in 2019, nearly 18 tonnes saved in 2020, 18 tonnes saved in 2021, and 19 tonnes in 2022 (includes Nov and December estimate). Cumulatively across the 4 years, over 80 tonnes of $PM_{2.5}$ have been saved, equating to a 10 per cent reduction. Reductions are lower when averaged for London as a whole, where a reduction of 6 per cent in 2022 is estimated, with a 5 per cent reduction in outer London (See appendix 1).

Table 11: Estimated $PM_{2.5}$ emissions for the ULEZ area, by vehicle type and year

		$PM_{2.5}$ Emissions (including non-exhaust) [Tonnes per year]					
Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
NO ULEZ	2019	237	121	40	15	41	19
NO ULEZ	2020	183	91	33	11	33	15
NO ULEZ	2021	179	93	33	11	35	8
NO ULEZ	2022	172	90	32	9	32	8
WITH ULEZ	2019	213	108	39	11	38	16
WITH ULEZ	2020	164	82	32	7	31	13
WITH ULEZ	2021	161	83	32	7	33	7
WITH ULEZ	2022	153	78	31	6	31	7
CHANGE	2019	-24	-13	-2	-4	-2	-3
CHANGE	2020	-18	- 9	-1	-4	-2	-2
CHANGE	2021	-18	-10	-1	-4	-2	-1
CHANGE	2022	-19	-12	-1	-3	-1	-1
% CHANGE	2019	-10%	-11%	-4%	-26%	-6%	-15%
% CHANGE	2020	-10%	-10%	-3%	-35%	-6%	-15%
% CHANGE	2021	-10%	-10%	-2%	-39%	-7%	-13%
% CHANGE	2022	-11%	-13%	-4%	-34%	-5%	-12%
2019-2022 Cumulative							
NO ULEZ	2019 - 2022	771	395	138	46	141	51
WITH ULEZ	2019 - 2022	691	351	134	31	133	44
CHANGE	2019 - 2022	-80	-44	-5	-15	-8	-7
% CHANGE	2019 - 2022	-10%	-11%	-3%	-32%	-6%	-14%

$PM_{2.5}$ Emissions (exhaust emissions only)

Table 12 below shows the emissions with and without ULEZ (including the LEZ and taxis) in 2019, 2020, 2021 and 2022 (to end of October 2022) for the ULEZ. It has been estimated that the ULEZ policies have reduced exhaust $PM_{2.5}$ emissions in the zone by 30 per cent, 34 per cent, 38 per cent and 48 per cent in each year respectively, equating to 22 tonnes of exhaust $PM_{2.5}$ saved in 2019, 17 tonnes saved in 2020, 16 tonnes saved in 2021, and 17 tonnes in 2022 (including estimate for November and December). Cumulatively across the 4 years, 72 tonnes of exhaust $PM_{2.5}$ have been saved, equating to a 36 per cent reduction.

Reductions are significantly lower when averaged for London as a whole where a reduction of 36 per cent is estimated for 2022, with a 24 per cent reduction in outer London (see appendix 1 for emissions split by zone and for the GLA area).

Most of the $PM_{2.5}$ emissions reductions are within the exhaust fraction (around 90 per cent) because this is mostly tackled through the tighter ULEZ emissions standards, whilst non-exhaust is more directly related changes in vehicle kilometres and to some small reductions in brake wear related to hybrid and electric vehicles with regenerative braking.

Table 12: Estimated $PM_{2.5}$ emissions (exhaust only) for the ULEZ area, by vehicle type and year

		$PM_{2.5}$ Emissions (exhaust only) [Tonnes per year]					
Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
NO ULEZ	2019	75	37	12	9	11	5
NO ULEZ	2020	50	25	8	6	7	4
NO ULEZ	2021	43	22	7	5	7	2
NO ULEZ	2022	35	19	5	4	6	2
WITH ULEZ	2019	53	26	11	5	8	2
WITH ULEZ	2020	33	17	7	2	5	1
WITH ULEZ	2021	27	14	6	2	5	1
WITH ULEZ	2022	18	8	4	1	4	1
CHANGE	2019	-22	-11	-2	-4	-2	-3
CHANGE	2020	-17	-8	- 1	-3	-2	-2
CHANGE	2021	-16	-8	-1	-4	-2	-1
CHANGE	2022	-17	-10	-1	-3	-2	-1
% CHANGE	2019	-30%	-30%	-13%	-43%	-22%	-56%
% CHANGE	2020	-34%	-33%	-14%	-57%	-29%	-62%
% CHANGE	2021	-38%	-37%	-12%	-69%	-33%	-64%
% CHANGE	2022	-48%	-55%	-24%	-68%	-28%	-63%
2019-2022 Cumulative							
NO ULEZ	2019 - 2022	202	102	33	24	31	12
WITH ULEZ	2019 - 2022	130	65	28	10	22	5
CHANGE	2019 - 2022	-72	-38	-5	-14	-8	-7
% CHANGE	2019 - 2022	-36%	-37%	-15%	-57%	-27%	-60%

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CO_2 Emissions

Table 13 below shows the CO_2 emissions from vehicles with and without ULEZ (including the LEZ and taxis) in 2019, 2020, 2021 and 2022 (to end of October 2022) for the ULEZ area. It has been estimated that the ULEZ policies have reduced CO_2 emissions in the zone by 3 per cent, 4 per cent, 4 per cent and 5 per cent each year respectively, equating to around 74,650 tonnes of CO_2 emissions saved in 2019, 67,290 tonnes saved in 2020, 69,300 tonnes saved in 2021 and 81,680 saved in 2022 Cumulatively across the 4 years, around 293,000 tonnes of CO_2 have been saved thanks to the ULEZ – equating to a 4 per cent reduction.

London-wide reductions of CO_2 are mostly related to HGVs and TfL buses; however, taxis are also an important contributor which is a result of the taxi age limits and Zero Emission Capable taxi licensing policies which mean no new diesel taxi can be licensed by TfL.

Table 13: Estimated CO_2 emissions for the ULEZ area, by vehicle type and year

		CO_2 Emissions [Tonnes per year]					
Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
NO ULEZ	2019	2,248,339	1,027,151	326,825	116,319	548,754	229,290
NO ULEZ	2020	1,799,848	796,729	289,167	85,946	446,101	181,905
NO ULEZ	2021	1,815,697	829,611	301,190	95,916	487,897	101,083
NO ULEZ	2022	1,797,490	827,463	314,878	88,956	460,254	105,939
WITH ULEZ	2019	2,173,688	993,639	330,410	121,028	518,047	210,564
WITH ULEZ	2020	1,732,558	780,427	292,450	76,488	415,152	168,041
WITH ULEZ	2021	1,746,401	815,053	303,413	82,169	456,880	88,886
WITH ULEZ	2022	1,715,806	810,786	313,819	76,605	425,161	89,435
CHANGE	2019	- 74,651	- 33,512	3,585	4,708	-30,707	-18,726
CHANGE	2020	-67,290	-16,302	3,283	-9,458	-30,950	-13,863
CHANGE	2021	-69,296	-14,558	2,223	-13,747	-31,017	-12,197
CHANGE	2022	-81,684	-16,677	-1,060	-12,351	-35,093	-16,504
% CHANGE	2019	-3%	-3%	1%	4%	-6%	-8%
% CHANGE	2020	-4%	-2%	1%	-11%	-7%	-8%
% CHANGE	2021	-4%	-2%	1%	-14%	-6%	-12%
% CHANGE	2022	-5%	-2%	0%	-14%	-8%	-16%
2019-2022 Cumulative							
NO ULEZ	2019 - 2022	7,661,374	3,480,953	1,232,060	387,137	1,943,007	618,218
WITH ULEZ	2019 - 2022	7,368,453	3,399,905	1,240,091	356,290	1,815,240	556,927
CHANGE	2019 - 2022	-292,921	-81,048	8,032	-30,848	-127,767	-61,291
% CHANGE	2019 - 2022	-3.8%	-2.3%	0.7%	-8.0%	-6.6%	-9.9%

Air pollution concentrations

Improving health by reducing air pollution concentrations is a key aim of expanding the ULEZ. The policy does this by disincentivising the use of older, more polluting vehicles within the zone which in turn reduces the emissions of pollutants in the area. This leads to a reduction in pollution concentration within the zone. As most vehicles do not drive solely within the zone this positive impact will also be seen outside the zone.

In September 2021 the World Health Organization (WHO) updated its recommended guidelines for ambient air pollution[19], with much lower concentrations. These are based on the evidence of the health impacts of air pollution, which shows that there is no known safe level. While much progress has been made in reducing air pollution concentrations across London, all of London currently exceeds the new WHO guidelines.

Air pollution concentrations are highly variable and are influenced by a number of factors including meteorology, emissions sources and the urban built form, and follow well understood patterns of diurnal and seasonal variation. It is preferable therefore to have at least one year's data when assessing the impacts of interventions on air quality. This is the first analysis of a full year of air quality monitoring data following the expansion of the ULEZ.

Context and limitations

The ULEZ is one of many policies to reduce air pollution from road transport and other sources in London. Other local policies include the London-wide LEZ (for heavy vehicles); investment in cleaner buses and taxis; the Low Emission Zone for non-road mobile machinery and planning policies; and supporting local traffic reduction and air quality projects, alongside wider policies such as the progressively tighter European exhaust controls for new vehicles. As a result, it is not straightforward to isolate the impact of the ULEZ and its expansion.

For this analysis the trends in outer London (largely away from the influence of the earlier central ULEZ and recently expanded zone) were used as a predictor of the change in central and inner London that would have happened without the ULEZ in place (that is with other Mayoral policies in place and the normal replacement cycle for vehicles). Comparing the measured trends in central and inner London with those in outer London reveals the additional changes within the central and inner zones, which provides an estimate for the impact of the ULEZ. We are grateful to Dr Gary Fuller of Imperial College London who kindly provided peer review support and comments on this methodology.

Detecting the impact of the ULEZ within the ULEZ area by comparing trends in the zone to those in outer London has both strengths and weaknesses. Key amongst the strengths is the ease of analysis, allowing data to be analysed as it is produced, and the large number of measurement sites involved. Another strength is the use of outer

[19] What are the WHO Air quality guidelines?

London data that also acts, to some extent, as a control for the weather and seasonal factors that can confound this type of analysis. However, a weakness stems from differences in the vehicle fleets in the ULEZ area compared with outer London. Traffic in central and inner London has a greater proportion of certain vehicle types, such as taxis and PHVs, and proportionally fewer private cars than outer London[20]. Interventions from other Mayoral policies targeting these vehicle types would have a different impact in the ULEZ area than outside it, even in the absence of the ULEZ.

Changes to transport patterns due to the Covid-19 pandemic may also have affected the attribution of change due to the ULEZ scheme. However, the use of outer London air pollution measurements in the analysis will control for any pandemic changes that affected all of London
equally as the rate of change in outer London is used as the basis of the 'No ULEZ' scenario in inner and central London.

Another potential limitation of the analysis in this chapter is the change in the number and location of monitoring sites across London over the 12-year period from 1 January 2010 to 31 October 2022. We work closely with the boroughs to maintain a high-quality monitoring network with a historical legacy of long-term sites across a wide area More detail on this can be found in Appendix 2.

Data sources

London has one of the densest air pollution monitoring networks in the world which enables us to effectively monitor the impacts of air quality policies across London.

The analysis carried out in this section is using data from London's reference grade analyser networks[21], the London Air Quality Network and Air Quality England which, together provide continuous monitoring data for over 150 locations. All data used is publicly available from the London Air Quality Network and the Air Quality England's websites. The full methodology is outlined in Appendix 2.

The analysis uses monthly average NO_2 and $PM_{2.5}$ concentration data and splits the monitoring sites by type – roadside and urban background – and by ULEZ zone, i.e. central, inner and outer. Roadside sites are those within one to five metres of the kerb of a busy road and urban background sites are those distanced away from sources and are therefore broadly representative of city-wide background conditions. These are the two most common monitoring site types in London.

The central zone is the congestion charging zone and the extent of the original central London ULEZ. The inner zone is the doughnut surrounding (but not including) the central zone and extending out to the North and South Circular, the boundary of the extended ULEZ.

It should be noted that measurement data from 2022 have not yet been ratified. As a result, these may be subject to change following equipment tests undertaken as part

[20] London Atmospheric Emission Inventory (LAEI) 2019, Greater London Authority 2022
[21] London's reference grade air quality monitoring stations are monitors that meet the MCERTS standards. The monitoring stations are managed by the London boroughs.

of the routine, independent, audit and servicing of air quality monitoring sites, though any changes to zonal averages are likely to be small, as with previous years.[22]

Trends in nitrogen dioxide (NO_2)

This section provides an update to the analysis that was reported in the ULEZ Expansion Six month report. As with the six-month inner London ULEZ expansion report, the methodology is based on that used in the central London ULEZ reports but was revised to ensure that the central London concentration trend captures both Covid-19 pandemic and post-pandemic changes in concentrations.

As described in the full methodology in the Appendix 2, statistical smoothing has been used to better detect the long-term trends in concentrations by removing the impacts of weather and patterns of seasonal variation. However, smoothing to the same degree as that used in the central London ULEZ reports means that the trend analysis becomes less responsive to short-term variations from other factors including pandemic and post-pandemic traffic changes, The method was therefore revised to reduce the degree of smoothing and allow the trend data to be more responsive to change and to reduce the risk of misattributing impacts of the Covid-19 pandemic to the ULEZ for example the recent increase in NO_2 concentrations in central London which were smoothed out when using the same methodology used in the 6 month report..

[22] Monitoring data for a specific year is usually finalised by April the following year and usually only shows small variations from the initial readings.

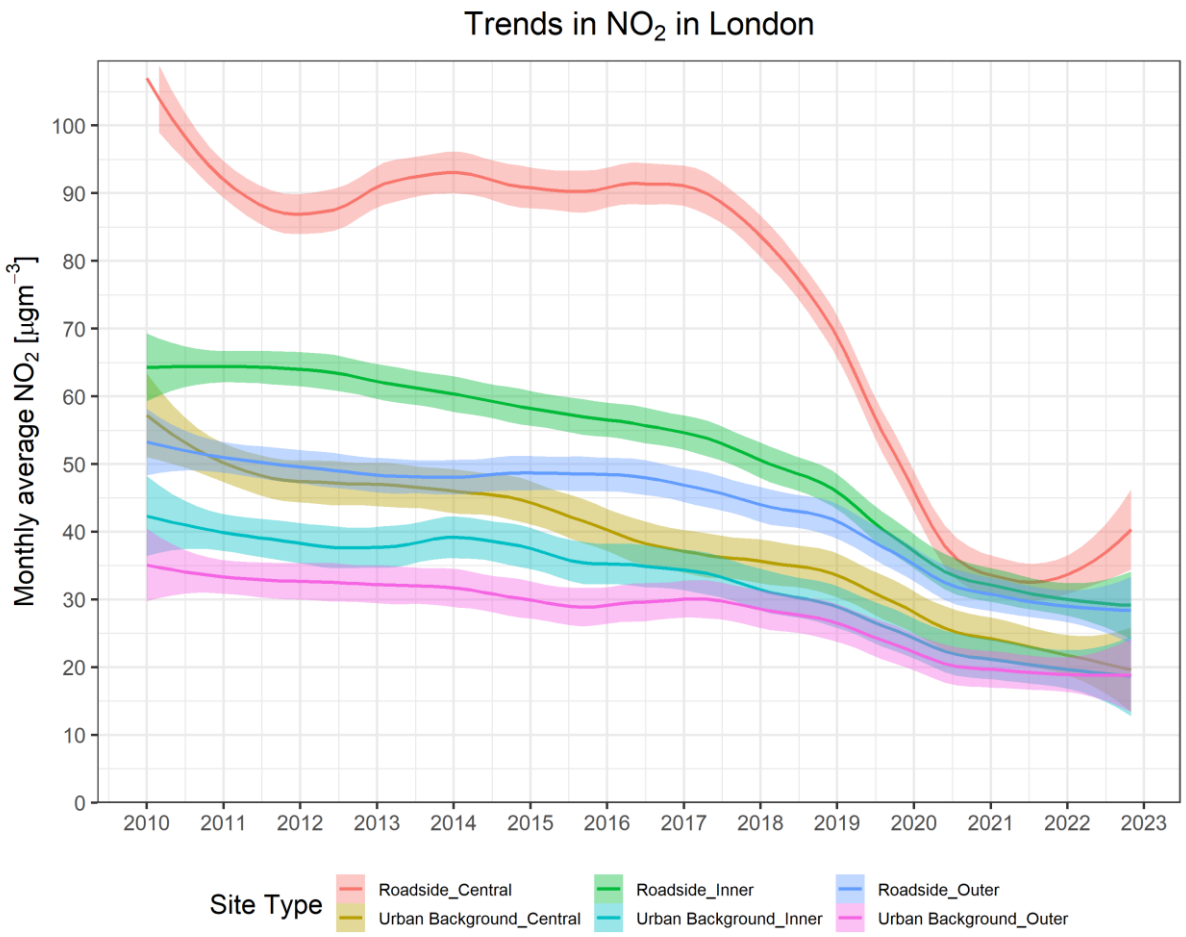

Figure 15: Trends in monthly NO_2 concentrations in London from 2010 to 2022

Figure 15 shows the trend in monthly average NO_2 concentrations split by site type and location from January 2010 to October 2022. The graph shows there was a rapid reduction in NO_2 at roadside sites in central London from 2018, with average concentrations reducing from 83 μgm^{-3} at the start of that year to 33 μgm^{-3} at their lowest in 2021. From 2021 onwards central London roadside monitoring sites show a different trend to all other site types with NO_2 levels increasing again. Central London experienced the largest reduction in traffic volumes due to the Covid-19 pandemic, which will have contributed to reductions in NO_2 levels, NO_2 levels have increased slightly as traffic levels returned towards pre pandemic levels, as seen in Figure 13 which shows that the recent increase in traffic has been far larger in central London than it has been in inner and outer. Central roadside NO_2 levels, however, remain below those pre-pandemic indicating the impact of the ULEZ, with average NO_2 concentrations in October 2022 at 40 μgm^{-3} compared to 44 μgm^{-3} in the period January to March 2020, as shown in Table 14 below.

All other site types have shown a continued, albeit slower, reduction in NO_2 concentrations. The range between the different site types has narrowed over time, since 2021 roadside sites in inner London are almost at the same level as those in outer London at 29 μgm^{-3} and 28 μgm^{-3} respectively. Average concentrations at inner and outer London background monitoring sites have converged at the same level in 2022 at 19 μgm^{-3}.

Table 14 provides the quarterly average NO_2 concentrations at each site type and location with the reduction from 2017, when the ULEZ expansion plan was first announced. Substantial reductions have been seen across all site types and locations with the largest being 56 per cent at roadside sites in central London. Roadside sites in inner London reduced by 47 per cent and in outer London 37 per cent. Background monitoring sites away from the main road network also had significant reductions of 47 per cent in central and 46 per cent in inner London, compared to 2017. Unlike central and inner London sites, outer London background sites have remained constant since 2021.

Table 14: Quarterly average NO_2 at roadside monitoring sites by zone based on the trends analysis in Figure 15

Period	Average NO_2 [μgm^{-3}]					
	Central Roadside	Central Background	Inner Roadside	Inner Background	Outer Roadside	Outer Background
Jan - March 17	91	37	54	34	47	30
April - June 17	90	36	54	34	46	30
July - Sept 17	88	36	53	33	45	30
Oct - Dec 17	86	36	51	32	45	29
Jan - March 18	83	36	50	31	44	28
April - June 18	80	35	49	31	43	28
July - Sept 18	76	35	48	30	43	28
Oct - Dec 18	72	34	47	29	42	27
Jan - March 19	67	33	45	29	41	26
April - June 19	61	32	43	27	39	25
July - Sept 19	55	30	40	26	38	24
Oct - Dec19	50	29	38	25	36	23
Jan - March 20 *	44	28	36	24	35	22
April - June 20	39	26	35	23	33	21
July - Sept 20	36	25	33	22	32	20
Oct - Dec 20	34	25	33	21	31	20
Jan - March 21	33	24	32	21	31	20
April - June 21	33	23	31	21	30	19
July - Sept 21	33	23	31	20	30	19
Oct - Dec 21	33	22	30	20	29	19
Jan - March 22	34	22	30	20	29	19
April – June 22	36	21	30	19	29	19
Jul - Sep 22	38	20	29	19	29	19
Oct-22	40	20	29	19	28	19
Reduction Q1 2017 to October 2022 [µgm-3]	51	17	25	16	18	11
Reduction Q1 2017 to October 2022 per cent	56%	47%	46%	45%	39%	37%

**Pandemic starts*

ULEZ impact analysis

NO_2 concentrations are impacted by numerous factors, as described previously. Therefore, in reviewing the impacts of ULEZ it is important to assess whether the impacts seen are due to policies and not just the impacts of weather, natural fleet turnover and the Covid-19 pandemic. Additional analysis has been carried out to isolate and estimate the impact of the ULEZ and associated policies, on top of the trend analysis shown in the previous section.

Methodology

To estimate the 'no ULEZ' scenarios, air pollutant concentrations at central and inner roadside sites were assumed to reduce at the same rate as concentrations measured at outer roadside sites, where the ULEZ is not in place.

A technique often used to isolate the proportion of pollution related to traffic sources is to subtract the background concentration from the roadside concentration. This is referred to as the "roadside increment"[23]. Changes in the roadside increment, or traffic contribution, in outer London have been used to represent the changes that would have occurred in a "no ULEZ" scenario for roadside sites in central and inner London and at boundary sites[24] (see later section). However, policies including the LEZ and other transport schemes have also been implemented in outer London meaning pollution changes here are not solely due to natural turnover over the fleet.

As time progresses and NO_2 concentrations continue to decline due to Mayoral policies, local authority initiatives and the natural churn of the vehicle fleet, it is becoming increasingly complex to disentangle the impacts of each separate policy on air pollution concentrations in the different areas of London. In addition to the ULEZ and LEZ, many of the Mayor's other policies, such as the growth of the zero-emission bus and taxi fleets, will have had positive impacts on concentrations, particularly in central and inner London. Therefore, the analysis below should be taken as showing the impacts of not just the central London ULEZ and its expansion, but of all the Mayor's policies to reduce emissions from transport. In practice this method may underestimate the ULEZ impact as many vehicles in outer London will have been upgraded by owners who drive frequently into the zone.

The same methodology was used in the previous six-month ULEZ expansion report[25] and also in the reports assessing the impacts of the original central London ULEZ. The full detailed methodology can be found in Appendix 2 of this report.

[23] Font, A. & Fuller, G. (2016) Did policies to abate atmospheric emissions from traffic have a positive effect in London? Environmental Pollution, Volume 218, November 2016, Pages 463-474

[24] The boundary monitoring sites are those sited on the roadside of the North and South Circular roads

[25] Expanded Ultra Low Emission Zone Six Month Report

Results

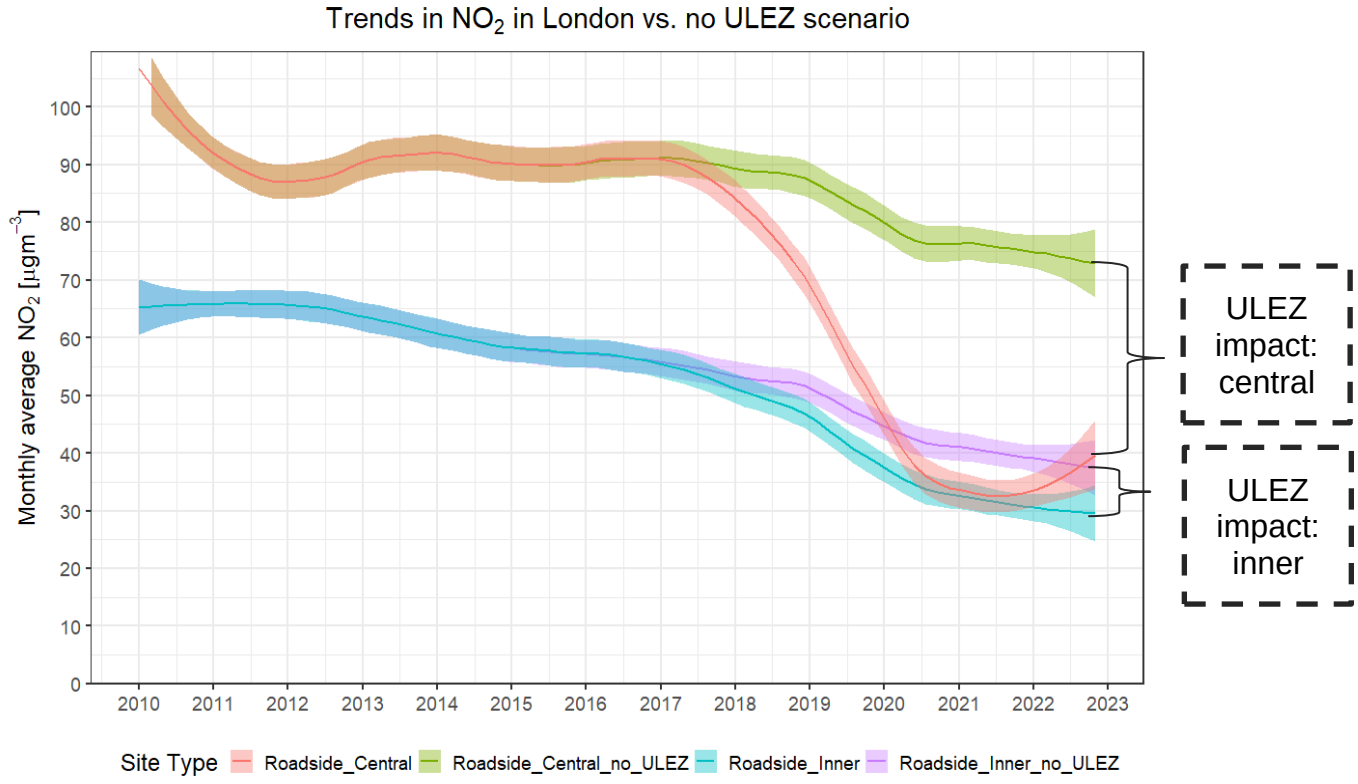

Figure 16: Trends in monthly average NO_2 concentrations with and without ULEZ policies

Figure 16 shows the trends in monthly average roadside NO_2 concentrations in central and inner London (red and blue lines, respectively), along with the estimated trend in concentrations had the ULEZ and associated policies not been implemented, shown by the green and purple lines, based on a no-ULEZ scenario assuming the central and inner sites had reduced at the same rate as outer London roadside sites.

The green line represents the estimated concentrations in central London had the ULEZ not been in place. An additional reduction is seen in 2020 from the impact of the Covid-19 pandemic, however even as traffic returned to pre-pandemic levels the broader ULEZ impact has been sustained.

Table 15 quantifies the reduction in NO_2 concentrations due to the ULEZ and associated policies as the difference between the central and inner roadside concentrations and the central and inner 'no ULEZ' scenarios respectively, shown in Figure 16.

Table 15: Estimated reduction in NO_2 concentrations due to ULEZ policies

Period	Reduction in central London roadside compared with no ULEZ		Reduction in inner London roadside compared with no ULEZ	
	[μgm^{-3}]	[per cent]	[μgm^{-3}]	[per cent]
Jan - March 19	19	22%	5	10%
April - June 19	24	28%	6	12%
July - Sept 19	28	34%	6	14%
Oct - Dec19	31	39%	7	15%
Jan - March 20	35	44%	7	17%
April - June 20	38	49%	8	18%
July - Sept 20	40	53%	8	19%
Oct - Dec 20	42	55%	8	20%
Jan - March 21	43	56%	8	21%
April - June 21	43	57%	9	21%
July - Sept 21	43	57%	9	22%
Oct - Dec 21	42	56%	9	22%
Jan - March 22	41	55%	9	22%
April – June 22	39	52%	8	22%
Jul - Sep 22	36	49%	8	22%
Oct-22	34	46%	8	21%

Table 15 shows that there have been substantial reductions in NO_2 concentrations in central London compared to a scenario where the ULEZ was not implemented. The ULEZ, LEZ and other associated policies have together had a transformational impact in central London, which, crucially, has been maintained over time. In July to September 2022, the most recent quarter of data available, NO_2 in central London had reduced by 36 μgm^{-3} compared with a scenario without the ULEZ, a reduction of almost half at 49 per cent. Inner London too has seen significant improvements compared with the no ULEZ scenario, with a reduction of 21 per cent compared with a scenario without the ULEZ, in October 2022. This is above what was originally forecast for the scheme.

As reducing harmful NO_2 levels is one of the main aims of the ULEZ, this is a significant indicator of the success of the policy. As the expansion covers 18 times the size of the original central London ULEZ, 3.7 million more Londoners living in inner London have now benefitted from cleaner air as a result of the policy, as well as 1,362 more schools.

As seen in Figure 15, central London roadside concentrations have risen slightly since the end of the pandemic as traffic returns to central London. As the concentrations have risen the ULEZ impact has therefore reduced as seen by the gap in the red and green lines in Figure 16 which represents the ULEZ impact. However crucially, as seen in Table 14, the NO_2 levels have not returned to those experienced pre-pandemic, indicating that even as traffic levels have risen, the escalated cleaning of the fleet caused by the ULEZ and its expansion, have had

sustained and positive impacts on pollution meaning concentrations still continue to be far below what they would have been otherwise.

Further details on changes in traffic and fleet composition can be found in the other sections of this report.

The trends analysis utilises the locally estimated scatterplot smoothing (LOESS) function to smooth data and reduce impacts of seasonality. As more data is added to the time series the LOESS function incorporates the extra data and recalculates the trend meaning that the slope and curve of the trend line is altered for the previous time periods too. This means the estimate impacts for the time period assessed in the six-month report differ slightly in this analysis.

Trends in nitrogen dioxide on ULEZ boundary roads

Monitoring trends on boundary roads is important for assessing the impacts of a road charging scheme to ensure that more polluting traffic has not been displaced to the boundary of the zone.

There are six established long term reference monitoring sites that measure NO_2 on the boundary of the expanded ULEZ. These are Brent Ikea, Ealing Hangar Lane Gyratory, Enfield Bowes Primary School, Enfield Derby Road, Greenwich Westhorne Avenue and Hounslow Gunnersbury.

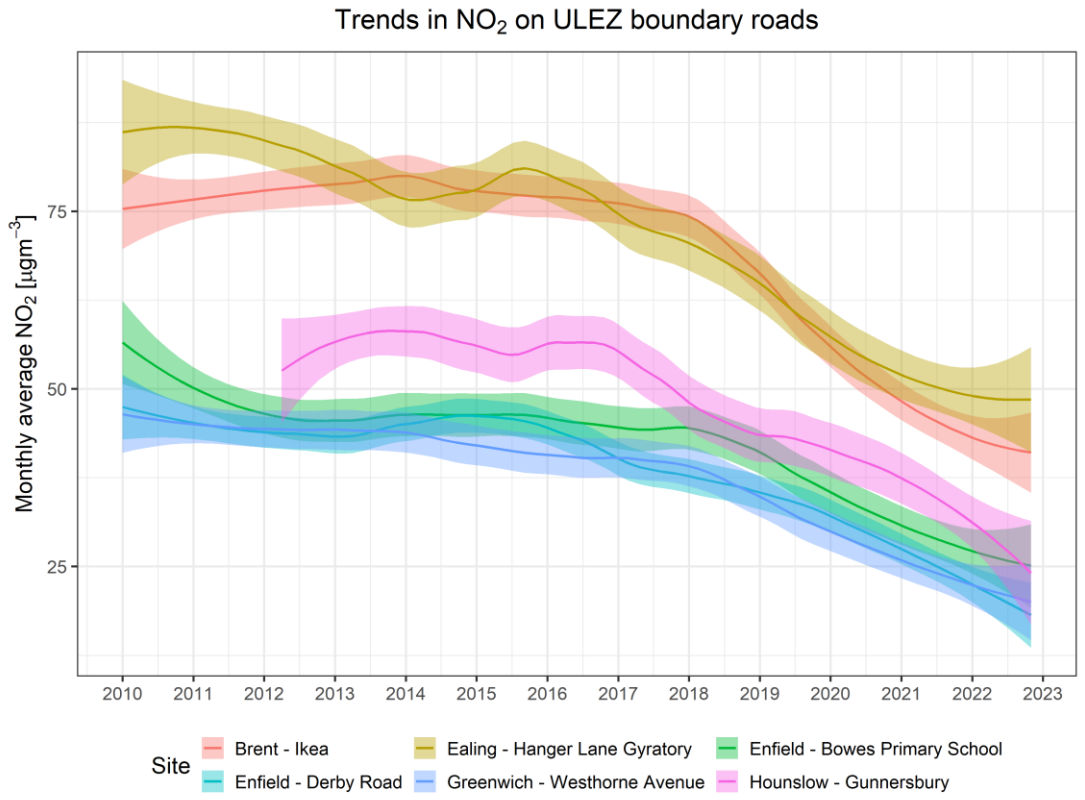

Figure 17: Monthly average NO_2 concentrations on ULEZ boundary roads

Figure 17 shows the trends in monthly average NO_2 concentrations at these six sites, analysed as per the NO_2 trends section. All six sites show a decreasing trend in NO_2 concentrations at ULEZ boundary roads since 2010, with a sharp decline from 2018 onwards. In 2022 the rate of reduction in NO_2 slowed slightly at Hangar Lane, Ikea, Bowes Primary and Westhorne Avenue.

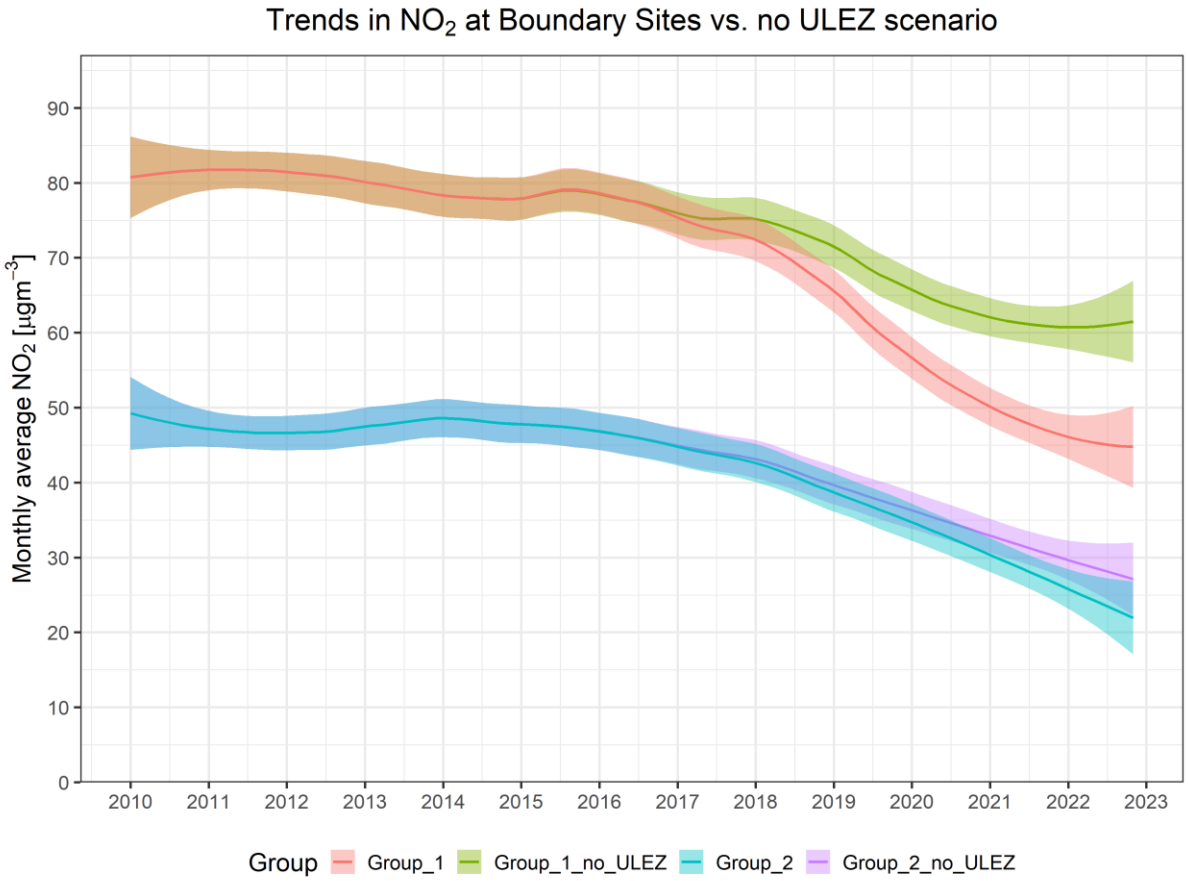

Figure 18: Trends in monthly average NO_2 concentrations at ULEZ boundary roads, with and without ULEZ. Group 1 is Brent Ikea and Hanger Lane. Group 2 includes the other 4 boundary sites.

Additional analysis has been carried out on the boundary sites to estimate the impact of the ULEZ and associated policies. This has followed the same methodology as the previous section on ULEZ impacts. For this analysis the boundary sites were grouped with group 1 consisting of Brent Ikea and Ealing Hangar Lane due to the higher NO_2 concentrations that prevail on this section of the North circular. The remaining sites with lower concentrations were combined in group 2. Figure 18 shows the average monthly NO_2 concentrations for each group and the estimated trend they would have followed without the ULEZ.

Table 16 presents the estimated quarterly average reductions in NO_2 concentrations due to the ULEZ and associated policies. The data shows that the impact has increased over time with both groups of sites having significant concentration reductions compared to the scenario without the ULEZ. Group one sites saw the largest impact with a 27 per cent reduction in NO_2 compared to the scenario without the ULEZ in October 2022. Group two sites saw a slightly smaller impact of 19 per cent reduction compared to if there were no ULEZ. In contrast with the ULEZ area,

the impact on the boundary roads has continued to increase compared with the no ULEZ scenario. This may be due to the boundary roads having a higher proportion of HGVs traveling on them, which now have very high compliance rates with the LEZ.

Table 16: Estimated reduction in NO_2 concentrations at boundary sites, as a result of ULEZ policies

Period	Reduction in Group 1 boundary sites compared to no ULEZ		Reduction in Group 2 boundary sites compared to no ULEZ	
	[μgm^{-3}]	[per cent]	[μgm^{-3}]	[per cent]
Jan - March 19	6	9%	1	3%
April - June 19	7	10%	1	3%
July - Sept 19	8	12%	1	3%
Oct - Dec19	9	13%	1	4%
Jan - March 20	9	14%	2	5%
April - June 20	10	16%	2	5%
July - Sept 20	11	17%	2	6%
Oct - Dec 20	11	18%	2	7%
Jan - March 21	12	20%	3	8%
April - June 21	13	21%	3	9%
July - Sept 21	14	22%	3	11%
Oct - Dec 21	14	23%	4	12%
Jan - March 22	15	24%	4	14%
April – June 22	15	25%	4	15%
Jul - Sep 22	16	26%	5	17%
Oct-22	17	27%	5	19%

Fine particulate matter ($PM_{2.5}$)

Road transport is the largest single source of fine particulate matter from within London, accounting for around 30 per cent of emissions. However, unlike NO_2, over half of London's concentrations of $PM_{2.5}$ come from regional, and often transboundary (non-UK) sources outside of London. $PM_{2.5}$ concentrations from these sources are also heavily influenced by meteorological conditions, causing more variation between different years.

There is also a large proportion of $PM_{2.5}$ emitted within London that the Mayor does not currently have the powers to control, for example from wood burning, which accounts for 17 per cent of $PM_{2.5}$ emissions and would not be affected by the ULEZ. Additionally, a growing proportion of road transport $PM_{2.5}$ emissions are now non-exhaust emissions including road wear and tyre and brake wear, as well as resuspension of road dust, which would not be affected by the tightening of tailpipe emission standards for traffic in the ULEZ area.

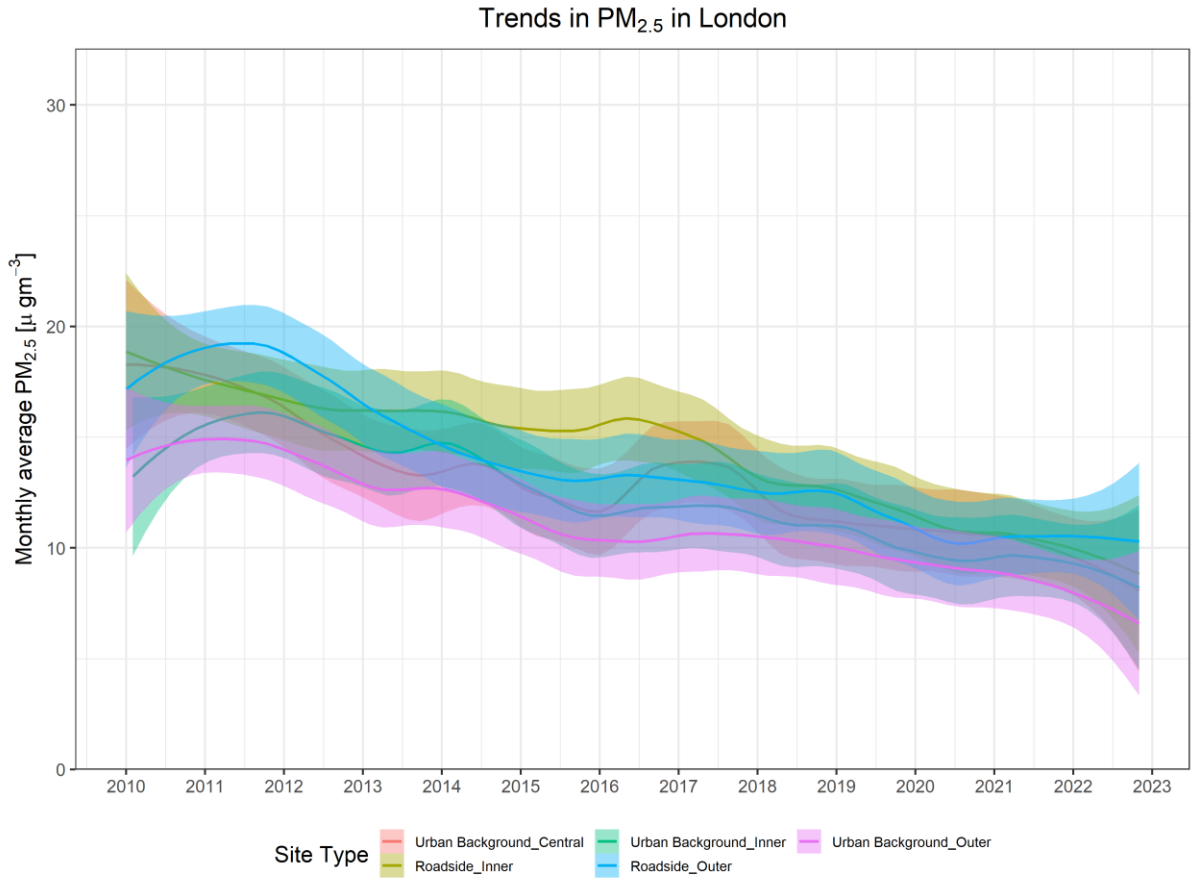

Figure 19: Monthly average $PM_{2.5}$ concentrations across London 2010 to October 2022

Figure 19 shows the monthly average $PM_{2.5}$ concentrations, averaged by site type and location. Central roadside is not included as there are no central London roadside sites with long term monitoring data[26]. The graph shows that there has been an overall decline in $PM_{2.5}$ concentrations across all site types with some variation year on year. $PM_{2.5}$ concentrations have a much smaller range between site types and locations and differences are more difficult to interpret from the graph.

Table 17 sets out the quarterly average $PM_{2.5}$ concentrations by site type and location. The largest percentage reduction was seen at central background and inner roadside locations which both reduced by 41 per cent since 2017. The table shows that roadside sites in outer London have reduced the least at 21 per cent, much less than central and inner London and concentrations are now higher than inner London roadside sites. Average concentrations across all site types and locations have met the WHO interim guidelines of 10 μgm^{-3} since mid-2022.

[26] There are only two central roadside sites monitoring $PM_{2.5}$, Westminster Waterloo Place and Westminster Elizabeth Bridge, both of which only commenced monitoring in 2020 and therefore have not been included in the long term trends analysis.

Table 17: Quarterly average $PM_{2.5}$ at roadside monitoring sites by zone based on the trends analysis in Figure 19

Period	Average $PM_{2.5}$ Concentration [μgm^{-3}]				
	Central Background	Inner Roadside	Inner Background	Outer Roadside	Outer Background
Jan - March 17	14	15	12	13	11
April - June 17	14	15	12	13	11
July - Sept 17	14	14	12	13	11
Oct - Dec 17	13	14	12	13	11
Jan - March 18	12	13	11	12	10
April - June 18	12	13	11	12	10
July - Sept 18	11	13	11	13	10
Oct - Dec 18	11	13	11	13	10
Jan - March 19	11	13	11	12	10
April - June 19	11	12	11	12	10
July - Sept 19	11	12	10	12	10
Oct - Dec19	11	12	10	11	9
Jan - March 20 *	11	11	10	11	9
April - June 20	11	11	10	10	9
July - Sept 20	11	11	9	10	9
Oct - Dec 20	11	11	9	10	9
Jan - March 21	11	11	10	10	9
April - June 21	10	11	10	11	9
July - Sept 21	10	10	10	11	8
Oct - Dec 21	10	10	9	11	8
Jan - March 22	9	10	9	11	8
April – June 22	9	10	9	10	7
Jul - Sep 22	9	9	9	10	7
Oct-22	8	9	8	10	7
Reduction Q1 2017 to October 2022 [µgm-3]	6	6	4	3	4
Reduction Q1 2017 to October 2022 per cent	41%	41%	30%	21%	37%

Conclusion

The report provides updated monitoring data on the different metrics used for monitoring the success of the ULEZ and its expansion.

Compliance rates have substantially increased since the expansion of the ULEZ to inner London and have now reached 94.4 per cent, which is one of the main indicators of the success of the scheme. The number of older, more polluting vehicles seen travelling in the zone has reduced by almost 60 per cent in the year following the expansion to inner London. The Low Emission Zone has continued to ensure only the cleanest heavy vehicles are driven through London with compliance rates reaching 97 per cent.

The report provides evidence that there has been a step change in compliance rates and fleet composition when the zone was expanded to inner London, and that the impacts have been sustained thereafter.

Air quality emissions have been assessed and estimates show that cumulatively since 2019 the ULEZ and its expansion has led to NOx emissions from road traffic reducing by 13,500 tonnes; and $PM_{2.5}$ emissions have reduced by 180 tonnes across London, compared to estimates of what they would have been without the ULEZ. This is a reduction of 23 per cent and 7 per cent respectively. The ULEZ has also helped reduce vehicular CO_2 emissions, with a reduction of 800,000 tonnes of CO_2 emissions across London Since 2019, a saving of 3 per cent.

The air quality concentrations analysis shows the ULEZ has had considerable impact in reducing nitrogen dioxide levels, with central London NO_2 concentrations reducing by 46 per cent and inner London by 21 per cent compared to a scenario without the ULEZ. The air on the boundary roads is also cleaner with an estimated reduction of 19 - 27 per cent reduction in NO_2 compared to a scenario without the ULEZ. Analysis shows that NO_2 levels have not returned to those experienced pre-pandemic, indicating that even as traffic levels have risen, the escalated cleaning of the fleet caused by the ULEZ and its expansion, have had sustained and positive impacts on pollution meaning concentrations still continue to be far below what they would have been otherwise.

Together these impacts show that the ULEZ has been highly successful in its aims of tackle the triple threats of air pollution, the climate emergency and congestion.

The future London-wide ULEZ expansion will bring the benefits of the ULEZ to a further 5 million Londoners ensuring the health benefits of cleaner air are brought to outer London, where over half of the air pollution attributable deaths occur.

Appendix 1

Air quality emissions split by London Zone

Emissions for the latter half of 2022 are still provisional until DfT traffic data becomes available.

Table 18: NOx emissions by London zone [tonnes per year]

Central London NOx [tonnes per year]							
Emissions Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
NO ULEZ	2019	620	110	104	138	193	75
NO ULEZ	2020	408	71	76	94	118	48
NO ULEZ	2021	402	70	76	103	118	35
NO ULEZ	2022	363	67	77	98	96	24
WITH ULEZ	2019	452	86	96	135	117	19
WITH ULEZ	2020	272	50	70	74	64	14
WITH ULEZ	2021	296	49	69	77	88	13
WITH ULEZ	2022	279	44	66	75	81	13
CHANGE	2019	-168	-24	-8	-4	-77	-56
CHANGE	2020	-135	-21	-6	-20	-54	-34
CHANGE	2021	-106	-21	-7	-26	-30	-22
CHANGE	2022	-84	-23	-11	- 24	-15	-11
% CHANGE	2019	-27%	-22%	-7%	-3%	-40%	-75%
% CHANGE	2020	-33%	-30%	-8%	-21%	-46%	-71%
% CHANGE	2021	-26%	-31%	-9%	-25%	-26%	-63%
% CHANGE	2022	-23%	-34%	-14%	-24%	-16%	-44%
Inner London NOx [tonnes per year]							
Emissions Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
NO ULEZ	2019	5,628	1,866	1,254	339	1,513	656
NO ULEZ	2020	4,132	1,381	1,050	238	1,033	430
NO ULEZ	2021	3,789	1,331	1,039	261	968	191
NO ULEZ	2022	3,501	1,248	1,055	242	768	189
WITH ULEZ	2019	4,537	1,683	1,251	334	1,035	235
WITH ULEZ	2020	3,067	1,139	1,015	190	600	122
WITH ULEZ	2021	2,735	1,037	986	196	473	44
WITH ULEZ	2022	2,277	791	874	178	392	42
CHANGE	2019	-1,091	-184	-3	-5	-478	-421
CHANGE	2020	-1,065	-241	-35	-48	-433	-308
CHANGE	2021	-1,054	-294	-53	-65	-495	-147
CHANGE	2022	-1,224	-457	-181	-65	-376	-146

% CHANGE	2019	-19%	-10%	0%	-1%	-32%	-64%
% CHANGE	2020	-26%	-17%	-3%	-20%	-42%	-72%
% CHANGE	2021	-28%	-22%	-5%	-25%	-51%	-77%
% CHANGE	2022	-35%	-37%	-17%	-27%	-49%	-77%
Outer London NOx [tonnes per year]							
Emissions Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
NO ULEZ	2019	12,222	5,062	2,853	192	2,981	1,134
NO ULEZ	2020	9,663	3,865	2,507	138	2,222	931
NO ULEZ	2021	9,427	3,779	2,523	155	2,042	927
NO ULEZ	2022	8,941	3,612	2,576	158	1,729	866
WITH ULEZ	2019	10,368	4,648	2,853	187	2,169	511
WITH ULEZ	2020	7,612	3,441	2,513	111	1,341	206
WITH ULEZ	2021	7,030	3,336	2,520	122	934	118
WITH ULEZ	2022	6,616	3,056	2,509	125	810	116
CHANGE	2019	-1,854	- 415	0	-5	-812	-623
CHANGE	2020	-2,050	-424	5	-27	-880	-725
CHANGE	2021	-2,396	-443	-3	-33	-1,108	-809
CHANGE	2022	- 2,325	-556	-67	-33	-920	-750
% CHANGE	2019	-15%	-8%	0%	-3%	-27%	-55%
% CHANGE	2020	-21%	-11%	0%	-19%	-40%	-78%
% CHANGE	2021	-25%	-12%	0%	-22%	-54%	-87%
% CHANGE	2022	-26%	-15%	-3%	-21%	-53%	-87%
GLA Area NOx [tonnes per year]							
Emissions Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
NO ULEZ	2019	18,471	7,039	4,210	669	4,687	1,865
NO ULEZ	2020	14,202	5,317	3,633	470	3,373	1,409
NO ULEZ	2021	13,617	5,180	3,638	519	3,127	1,153
NO ULEZ	2022	12,805	4,927	3,708	498	2,593	1,078
WITH ULEZ	2019	15,357	6,416	4,199	656	3,321	765
WITH ULEZ	2020	10,951	4,631	3,598	376	2,005	342
WITH ULEZ	2021	10,061	4,421	3,576	395	1,495	175
WITH ULEZ	2022	9,173	3,891	3,450	377	1,283	172
CHANGE	2019	-3,114	-623	-11	-14	-1,366	-1,100
CHANGE	2020	-3,251	-687	-35	-95	-1,368	-1,067
CHANGE	2021	-3,556	-759	-63	-124	-1,633	- 978
CHANGE	2022	-3,633	-1,036	-258	-121	-1,311	-907
% CHANGE	2019	-17%	-9%	0%	-2%	-29%	-59%
% CHANGE	2020	-23%	-13%	-1%	-20%	-41%	-76%
% CHANGE	2021	-26%	-15%	-2%	-24%	-52%	-85%
% CHANGE	2022	-28%	-21%	-7%	-24%	-51%	-84%
NO ULEZ	2019 - 2022	59,096	22,464	15,190	2,157	13,780	5,505

WITH ULEZ	2019 - 2022	45,542	19,359	14,823	1,803	8,103	1,454
CHANGE	2019 - 2022	-13,554	-3,105	-367	-353	-5,678	-4,051
% CHANGE	2019 - 2022	-23%	-14%	-2%	-16%	-41%	-74%

Table 19: $PM_{2.5}$ emissions by London zone (includes non-exhaust) [tonnes per year]

Central London $PM_{2.5}$ [tonnes per year]							
Emissions Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
NO ULEZ	2019	19	6	3	5	3	2
NO ULEZ	2020	13	4	2	3	2	2
NO ULEZ	2021	13	4	2	3	3	2
NO ULEZ	2022	13	4	2	3	2	2
WITH ULEZ	2019	15	5	2	3	3	2
WITH ULEZ	2020	11	3	2	2	2	1
WITH ULEZ	2021	11	3	2	2	2	1
WITH ULEZ	2022	11	3	2	2	2	2
CHANGE	2019	-4	-1	-1	-1	-0	-0
CHANGE	2020	-3	-1	-0	-1	-0	-0
CHANGE	2021	-2	-1	-0	-1	-0	-0
CHANGE	2022	- 2	-1	-0	- 1	0	-0
% CHANGE	2019	-21%	-22%	-20%	-28%	-15%	-15%
% CHANGE	2020	-20%	-20%	-14%	-37%	-11%	-12%
% CHANGE	2021	-18%	-18%	-12%	-41%	-4%	-8%
% CHANGE	2022	-14%	-16%	-8%	-36%	4%	-3%
Inner London $PM_{2.5}$ [tonnes per year]							
Emissions Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
NO ULEZ	2019	218	115	37	11	37	17
NO ULEZ	2020	169	87	31	8	30	13
NO ULEZ	2021	166	88	30	8	33	6
NO ULEZ	2022	160	86	30	6	30	7
WITH ULEZ	2019	198	103	36	8	35	15
WITH ULEZ	2020	154	79	30	5	29	11
WITH ULEZ	2021	150	79	30	5	30	6
WITH ULEZ	2022	142	75	29	4	28	6
CHANGE	2019	-20	-12	-1	-3	-2	-3
CHANGE	2020	-16	-9	-1	-3	-2	-2
CHANGE	2021	-16	-9	-1	-3	-2	-1

CHANGE	2022	-17	-11	-1	-2	-2	- 1
% CHANGE	2019	-9%	-10%	-3%	-25%	-5%	-15%
% CHANGE	2020	-9%	-10%	-2%	-34%	-6%	-15%
% CHANGE	2021	-9%	-10%	-2%	-38%	-7%	-15%
% CHANGE	2022	-11%	-13%	-4%	-33%	-5%	-14%
Outer London $PM_{2.5}$ [tonnes per year]							
Emissions Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
NO ULEZ	2019	542	333	84	6	96	23
NO ULEZ	2020	440	257	74	4	85	20
NO ULEZ	2021	454	264	74	5	91	21
NO ULEZ	2022	454	263	74	4	92	21
WITH ULEZ	2019	507	305	85	5	93	19
WITH ULEZ	2020	417	241	76	3	82	15
WITH ULEZ	2021	433	251	77	3	87	15
WITH ULEZ	2022	433	249	77	3	88	16
CHANGE	2019	-35	-28	1	-2	-3	-4
CHANGE	2020	-24	-16	2	-1	-3	-5
CHANGE	2021	-22	-13	3	-2	-4	-5
CHANGE	2022	-21	-15	3	-1	-3	-5
% CHANGE	2019	-6%	-8%	1%	-24%	-3%	-17%
% CHANGE	2020	-5%	-6%	2%	-31%	-4%	-24%
% CHANGE	2021	-5%	-5%	4%	-35%	-5%	-26%
% CHANGE	2022	-5%	-6%	4%	-30%	-4%	-24%
GLA Area $PM_{2.5}$ [tonnes per year]							
Emissions Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
NO ULEZ	2019	778	454	124	22	136	43
NO ULEZ	2020	623	348	107	15	118	35
NO ULEZ	2021	633	356	106	15	126	29
NO ULEZ	2022	627	354	107	13	124	29
WITH ULEZ	2019	720	413	123	16	131	36
WITH ULEZ	2020	581	323	108	10	113	28
WITH ULEZ	2021	594	333	108	10	120	22
WITH ULEZ	2022	586	327	108	9	119	23
CHANGE	2019	-59	- 41	-0	-5	-5	-7
CHANGE	2020	-42	-25	0	-5	-5	-7
CHANGE	2021	-40	-23	2	-6	-7	-7
CHANGE	2022	-40	-27	2	-4	-5	-6
% CHANGE	2019	-8%	-9%	0%	-25%	-4%	-16%
% CHANGE	2020	-7%	-7%	0%	-34%	-5%	-20%
% CHANGE	2021	-6%	-6%	2%	-37%	-5%	-22%
% CHANGE	2022	-6%	-8%	2%	-33%	-4%	-21%

NO ULEZ	2019 - 2022	2,661	1,512	444	65	504	136
WITH ULEZ	2019 - 2022	2,480	1,396	448	44	483	109
CHANGE	2019 - 2022	-181	- 116	4	-21	-22	-26
% CHANGE	2019 - 2022	-7%	-8%	1%	-32%	-4%	-19%

Table 20: $PM_{2.5}$ emissions (exhaust only) by London zone [tonnes per year]

Central London $PM_{2.5}$ (exhaust only) [tonnes per year]							
Emissions Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
NO ULEZ	2019	8	2	1	3	1	1
NO ULEZ	2020	5	1	1	2	1	0
NO ULEZ	2021	4	1	1	2	1	0
NO ULEZ	2022	3	1	0	1	1	0
WITH ULEZ	2019	4	1	1	2	1	0
WITH ULEZ	2020	2	1	0	1	0	0
WITH ULEZ	2021	2	1	0	0	1	0
WITH ULEZ	2022	2	1	0	0	1	0
CHANGE	2019	-3	-1	-1	-1	-0	-0
CHANGE	2020	-2	-1	-0	-1	-0	-0
CHANGE	2021	-2	-1	- 0	-1	-0	-0
CHANGE	2022	-1	- 0	- 0	-1	-0	-0
% CHANGE	2019	-44%	-43%	-49%	-44%	-33%	-63%
% CHANGE	2020	-51%	-50%	-50%	-58%	-36%	-57%
% CHANGE	2021	-50%	-46%	-48%	-70%	-13%	-47%
% CHANGE	2022	-44%	-44%	-39%	-68%	0%	-24%
Inner London $PM_{2.5}$ (exhaust only) [tonnes per year]							
Emissions Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
NO ULEZ	2019	67	35	11	6	10	5
NO ULEZ	2020	45	23	8	4	7	3
NO ULEZ	2021	38	21	6	4	6	1
NO ULEZ	2022	32	18	5	3	5	1
WITH ULEZ	2019	48	25	10	4	8	2
WITH ULEZ	2020	30	16	7	2	5	1
WITH ULEZ	2021	24	13	6	1	4	0
WITH ULEZ	2022	17	8	4	1	4	0
CHANGE	2019	-19	-10	-1	-3	-2	-3

CHANGE	2020	-14	-7	-1	-2	-2	-2
CHANGE	2021	-14	-8	-1	-3	-2	- 1
CHANGE	2022	-15	-10	-1	-2	-2	-1
% CHANGE	2019	-28%	-29%	-10%	-43%	-21%	-55%
% CHANGE	2020	-32%	-32%	-11%	-57%	-28%	-63%
% CHANGE	2021	-36%	-37%	-9%	-69%	-36%	-67%
% CHANGE	2022	-48%	-56%	-23%	-68%	-31%	-68%
Outer London $PM_{2.5}$ (exhaust only) [tonnes per year]							
Emissions Scenario	**Year**	**All Vehicles Outer**	**Cars and motorcycles Outer**	**Vans Outer**	**Taxis Outer**	**HGVs Outer**	**TfL Buses Outer**
NO ULEZ	2019	152	96	24	3	20	8
NO ULEZ	2020	105	64	18	2	14	7
NO ULEZ	2021	94	57	14	2	14	7
NO ULEZ	2022	80	49	12	2	12	6
WITH ULEZ	2019	118	70	25	2	17	4
WITH ULEZ	2020	82	49	19	1	11	2
WITH ULEZ	2021	73	45	17	1	9	1
WITH ULEZ	2022	61	36	14	1	9	1
CHANGE	2019	-33	- 26	1	-2	-3	-4
CHANGE	2020	-23	- 15	1	-1	-3	-5
CHANGE	2021	- 21	-12	2	-1	-4	-5
CHANGE	2022	-19	-12	3	-1	-3	-5
% CHANGE	2019	-22%	-27%	4%	-43%	-17%	-47%
% CHANGE	2020	-22%	-23%	7%	-56%	-23%	-72%
% CHANGE	2021	-22%	-21%	17%	-68%	-31%	-82%
% CHANGE	2022	-24%	-25%	23%	-68%	-27%	-81%
GLA Area $PM_{2.5}$ (exhaust only) [tonnes per year]							
Emissions Scenario	**Year**	**All Vehicles Outer**	**Cars and motorcycles Outer**	**Vans Outer**	**Taxis Outer**	**HGVs Outer**	**TfL Buses Outer**
NO ULEZ	2019	226	133	36	12	31	13
NO ULEZ	2020	155	89	26	8	21	10
NO ULEZ	2021	137	79	21	7	21	8
NO ULEZ	2022	115	67	17	6	18	8
WITH ULEZ	2019	171	96	36	7	25	7
WITH ULEZ	2020	115	66	26	4	16	3
WITH ULEZ	2021	100	59	23	2	14	2
WITH ULEZ	2022	79	45	18	2	13	2
CHANGE	2019	- 56	-37	-1	-5	- 6	-7
CHANGE	2020	- 40	-23	0	-5	-5	-7
CHANGE	2021	-37	-20	2	-5	-7	-7
CHANGE	2022	- 36	-23	1	- 4	-5	-6
% CHANGE	2019	-25%	-28%	-2%	-43%	-19%	-51%

% CHANGE	2020	-26%	-26%	0%	-57%	-25%	-69%
% CHANGE	2021	-27%	-25%	8%	-69%	-32%	-78%
% CHANGE	2022	-31%	-34%	8%	-68%	-27%	-77%
NO ULEZ	2019 - 2022	633	368	101	34	90	40
WITH ULEZ	2019 - 2022	465	266	103	15	68	13
CHANGE	2019 - 2022	- 168	-103	2	-19	-22	-26
% CHANGE	2019 - 2022	-27%	-28%	2%	-57%	-25%	-66%

Table 21: CO_2 emissions by London zone [tonnes per year]

Central London CO_2 [tonnes per year]							
Emissions Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
NO ULEZ	2019	152	96	24	3	20	8
NO ULEZ	2020	105	64	18	2	14	7
NO ULEZ	2021	94	57	14	2	14	7
NO ULEZ	2022	80	49	12	2	12	6
WITH ULEZ	2019	118	70	25	2	17	4
WITH ULEZ	2020	82	49	19	1	11	2
WITH ULEZ	2021	73	45	17	1	9	1
WITH ULEZ	2022	61	36	14	1	9	1
CHANGE	2019	-33	-26	1	-2	-3	-4
CHANGE	2020	-23	-15	1	-1	-3	-5
CHANGE	2021	-21	-12	2	-1	- 4	-5
CHANGE	2022	-19	- 12	3	-1	- 3	-5
% CHANGE	2019	-22%	-27%	4%	-43%	-17%	-47%
% CHANGE	2020	-22%	-23%	7%	-56%	-23%	-72%
% CHANGE	2021	-22%	-21%	17%	-68%	-31%	-82%
% CHANGE	2022	-24%	-25%	23%	-68%	-27%	-81%
Inner London CO_2 [tonnes per year]							
Emissions Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
NO ULEZ	2019	2,041,270	963,585	298,705	79,030	500,567	199,383
NO ULEZ	2020	1,648,476	752,777	266,997	59,266	411,145	158,291
NO ULEZ	2021	1,653,773	783,609	278,106	66,199	447,434	78,425

NO ULEZ	2022	1,634,911	780,842	290,616	60,796	420,262	82,394
WITH ULEZ	2019	1,985,977	939,450	303,278	83,465	474,076	185,708
WITH ULEZ	2020	1,595,292	741,473	270,106	53,430	382,009	148,274
WITH ULEZ	2021	1,599,713	774,477	280,156	57,333	417,743	70,004
WITH ULEZ	2022	1,568,141	770,047	289,520	52,601	386,353	69,620
CHANGE	2019	-55,294	-24,135	4,572	4,435	-26,491	-13,676
CHANGE	2020	-53,184	-11,304	3,109	-5,836	-29,136	-10,017
CHANGE	2021	-54,060	-9,132	2,050	-8,866	-29,691	-8,420
CHANGE	2022	-66,770	-10,795	-1,096	-8,195	-33,908	-12,775
% CHANGE	2019	-3%	-3%	2%	6%	-5%	-7%
% CHANGE	2020	-3%	-2%	1%	-10%	-7%	-6%
% CHANGE	2021	-3%	-1%	1%	-13%	-7%	-11%
% CHANGE	2022	-4%	-1%	0%	-13%	-8%	-16%
Outer London CO_2 [tonnes per year]							
Emissions Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**
NO ULEZ	2019	4,756,509	2,540,961	633,296	43,877	1,296,164	242,211
NO ULEZ	2020	4,024,993	2,019,056	601,892	32,948	1,159,519	211,578
NO ULEZ	2021	4,254,273	2,118,769	632,395	37,494	1,237,082	228,533
NO ULEZ	2022	4,337,207	2,160,739	664,815	37,280	1,237,756	236,616
WITH ULEZ	2019	4,633,248	2,535,859	639,417	42,969	1,187,548	227,456
WITH ULEZ	2020	3,899,500	2,035,823	606,850	28,102	1,032,039	196,686
WITH ULEZ	2021	4,114,862	2,157,603	637,109	31,299	1,081,592	207,259
WITH ULEZ	2022	4,218,268	2,216,938	668,210	31,933	1,091,258	209,929
CHANGE	2019	-123,261	-5,102	6,121	-908	-108,616	-14,756
CHANGE	2020	-125,493	16,767	4,958	-4,846	-127,480	- 14,892
CHANGE	2021	-139,411	38,833	4,715	-6,195	-155,491	-21,273
CHANGE	2022	-118,939	56,198	3,395	-5,347	-146,498	-26,687
% CHANGE	2019	-3%	0%	1%	-2%	-8%	-6%
% CHANGE	2020	-3%	1%	1%	-15%	-11%	-7%
% CHANGE	2021	-3%	2%	1%	-17%	-13%	-9%
% CHANGE	2022	-3%	3%	1%	-14%	-12%	-11%
GLA Area CO_2 [tonnes per year]							
Emissions Scenario	**Year**	**All Vehicles**	**Cars and motorcycles**	**Vans**	**Taxis**	**HGVs**	**TfL Buses**

NO ULEZ	2019	7,004,848	3,568,112	960,120	160,196	1,844,918	471,502
NO ULEZ	2020	5,824,841	2,815,785	891,059	118,894	1,605,620	393,482
NO ULEZ	2021	6,069,970	2,948,380	933,584	133,410	1,724,979	329,616
NO ULEZ	2022	6,134,697	2,988,202	979,694	126,236	1,698,010	342,555
WITH ULEZ	2019	6,806,936	3,529,497	969,827	163,997	1,705,595	438,020
WITH ULEZ	2020	5,632,058	2,816,250	899,300	104,590	1,447,191	364,727
WITH ULEZ	2021	5,861,264	2,972,656	940,522	113,468	1,538,471	296,145
WITH ULEZ	2022	5,934,074	3,027,724	982,029	108,538	1,516,420	299,365
CHANGE	2019	-197,912	-38,614	9,706	3,800	-139,323	-33,482
CHANGE	2020	-192,783	465	8,241	-14,304	-158,430	-28,755
CHANGE	2021	-208,707	24,275	6,938	-19,942	-186,508	-33,470
CHANGE	2022	-200,623	39,521	2,335	-17,698	-181,590	-43,191
% CHANGE	2019	-3%	-1%	1%	2%	-8%	-7%
% CHANGE	2020	-3%	0%	1%	-12%	-10%	-7%
% CHANGE	2021	-3%	1%	1%	-15%	-11%	-10%
% CHANGE	2022	-3%	1%	0%	-14%	-11%	-13%
NO ULEZ	2019 - 2022	25,034,356	12,320,479	3,764,458	538,737	6,873,528	1,537,155
WITH ULEZ	2019 - 2022	24,234,331	12,346,127	3,791,678	490,592	6,207,677	1,398,257
CHANGE	2019 - 2022	-800,025	25,648	27,220	-48,144	-665,851	-138,898
% CHANGE	2019 - 2022	-3.2%	0.2%	0.7%	-8.9%	-9.7%	-9.0%

Appendix 2

We are grateful to Dr Gary Fuller of Imperial College London who kindly provided peer review support and comments on this methodology.

Air quality concentrations

All air quality data analysis was performed using the open source statistical software R.[27] Air pollutant concentration monitoring data across London is publicly available from the London Air Quality Network and Air Quality England websites. Only data from reference analysers has been used in this analysis. In order to present the full context for any changes in air pollutant concentrations, the period from 1 January 2010 to 31 October 2022 has been analysed.

Air quality monitoring stations are funded and maintained by the London boroughs, Defra, Transport for London and Business Improvement Districts. Over the period 2010 to 2022 many monitoring stations have opened, moved or closed. Figure 20 shows how the number of sites in each zone and each type has changed over this period.

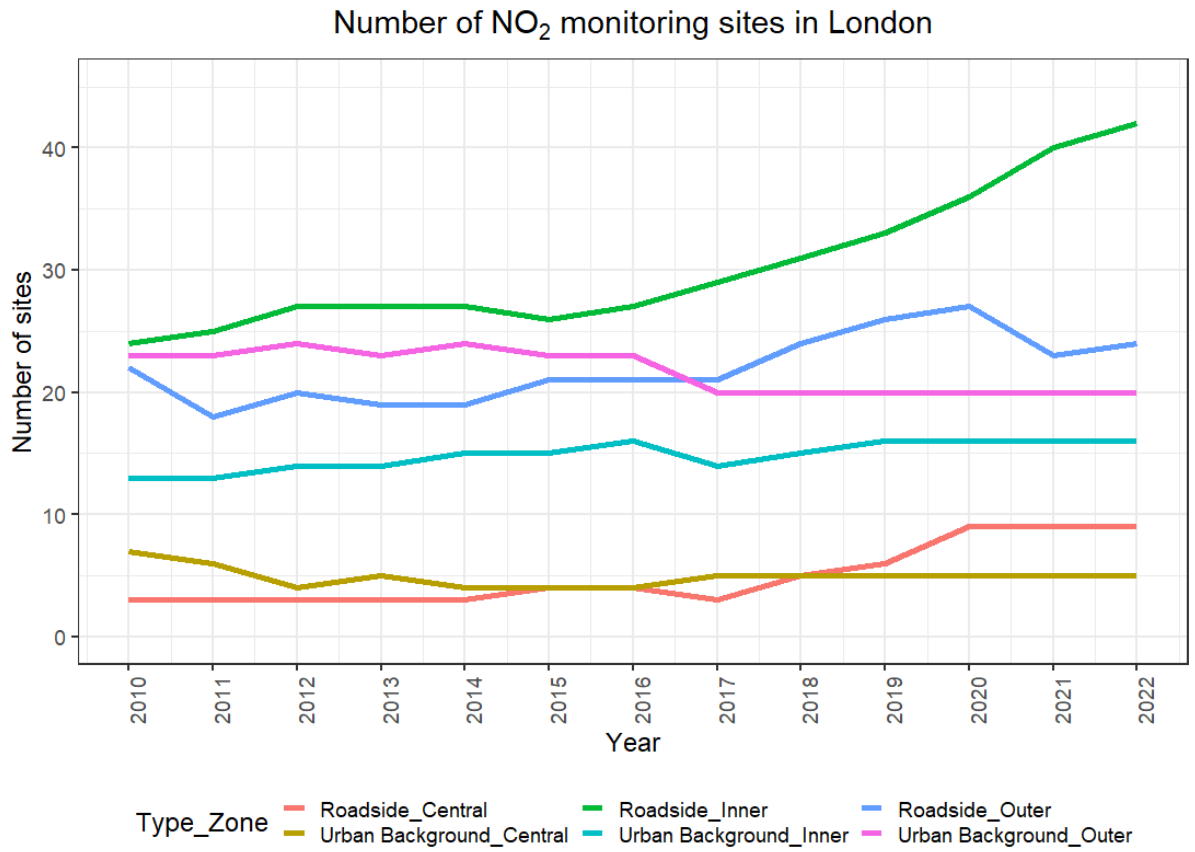

Figure 20: Number of NO_2 monitoring sites in London per year

Monthly average concentration trends for NO_2 and $PM_{2.5}$

[27] https://www.r-project.org/

The trends analysis includes all historic monitoring sites in London categorised as "Roadside" or "Urban Background". For this analysis "Suburban" and "Urban Centre" sites have been treated as "Urban Background". "Industrial", "Airport" and "Kerbside" sites have not been included as they are fewer in number and not typical of population exposure. The table below includes a list of all 159 sites that measured NO_2 concentrations in London between 2010 and the end of 2022 and were included in the NO_2 trend analysis presented in this report. Sites were only included if they have one year or more of data.

Table 22: Sites included in NO_2 trend analysis

Site Code	Name	Site Type	Data Owner	Site Manager	Location	Years of data
BG1	Barking and Dagenham - Rush Green	Urban Background	Barking and Dagenham	Imperial College London	Outer	13
BG2	Barking and Dagenham - Scrattons Farm	Urban Background	Barking and Dagenham	Imperial College London	Outer	13
BL0	Camden - Bloomsbury	Urban Background	Camden	Imperial College London	Central	13
BN2	Barnet - Chalgrove School	Urban Background	Barnet	Ricardo-AEA	Outer	13
BQ7	Bexley - Belvedere West	Urban Background	Bexley	Imperial College London	Outer	13
BT1	Brent - Kingsbury	Urban Background	Brent	Imperial College London	Outer	1
BT4	Brent - Ikea	Roadside	Brent	Imperial College London	Outer	13
BT6	Brent - John Keble Primary School	Roadside	Brent	Imperial College London	Inner	13
BT7	Brent - St Marys Primary School	Urban Background	Brent	Imperial College London	Inner	1
BT8	Brent - ARK Franklin Primary Academy	Roadside	Brent	Imperial College London	Inner	6
BX1	Bexley - Slade Green	Urban Background	Bexley	Imperial College London	Outer	13
BX2	Bexley - Belvedere	Urban Background	Bexley	Imperial College London	Outer	13
BX7	Bexley - Thames Road North	Roadside	Bexley	Imperial College London	Outer	1
BX8	Bexley - Thames Road South	Roadside	Bexley	Imperial College London	Outer	1
BY7	Bromley - Harwood Avenue	Roadside	Bromley	Imperial College London	Outer	5

Site Code	Name	Site Type	Data Owner	Site Manager	Location	Years of data
CD009	Camden - Euston Road	Roadside	Camden	Ricardo-AEA	Inner	12
CD010	Camden - High Street	Roadside	Camden	Ricardo-AEA	Inner	2
CD3	Camden - Shaftesbury Avenue	Roadside	Camden	Imperial College London	Central	7
CD4	Camden - St Martins College (NOX 1)	Urban Background	Camden	Imperial College London	Central	1
CD5	Camden - St Martins College (NOX 2)	Urban Background	Camden	Imperial College London	Central	2
CE1	Westminster - Regent St (Crown Estate)	Roadside	Westminster	Imperial College London	Central	3
CE2	Westminster - Waterloo Pl (Crown Estate)	Roadside	Westminster	Imperial College London	Central	3
CR2	Croydon - Purley Way	Roadside	Croydon	Imperial College London	Outer	1
CR4	Croydon - George Street	Roadside	Croydon	Imperial College London	Outer	6
CR7	Croydon - Purley Way A23	Roadside	Croydon	Imperial College London	Outer	11
CR9	Croydon - Park Lane	Roadside	Croydon	Imperial College London	Outer	6
CT1	City of London - Senator House	Urban Background	City of London	Imperial College London	Central	4
CT3	City of London - Sir John Cass School	Urban Background	City of London	Imperial College London	Central	13
CT4	City of London - Beech Street	Roadside	City of London	Imperial College London	Central	11
CT6	City of London - Walbrook Wharf	Roadside	City of London	Imperial College London	Central	13
CW3	Tower Hamlets - Jubilee Park	Urban Background	Tower Hamlets	Imperial College London	Inner	1
CY1	Croydon - Crystal Palace Parade	Roadside	Croydon	Imperial College London	Outer	1
EA010	Ealing - Green Quarter	Urban Background	Ealing	Ricardo-AEA	Outer	2
EA1	Ealing - Ealing Town Hall	Urban Background	Ealing	Imperial College London	Outer	3
EA2	Ealing - Acton Town Hall	Roadside	Ealing	Imperial College London	Inner	3
EA6	Ealing - Hanger Lane Gyratory	Roadside	Ealing	Imperial College London	Outer	13
EA7	Ealing - Southall	Urban Background	Ealing	Imperial College London	Outer	7

Site Code	Name	Site Type	Data Owner	Site Manager	Location	Years of data
EI1	Ealing - Western Avenue	Roadside	Ealing	Imperial College London	Inner	13
EI2	Ealing - Southall Railway	Roadside	Ealing	Imperial College London	Outer	4
EI3	Ealing - Acton Vale	Urban Background	Ealing	Imperial College London	Inner	6
EN1	Enfield - Bush Hill Park	Urban Background	Enfield	Imperial College London	Outer	12
EN4	Enfield - Derby Road	Roadside	Enfield	Imperial College London	Outer	13
EN5	Enfield - Bowes Primary School	Roadside	Enfield	Imperial College London	Inner	13
EN7	Enfield - Prince of Wales School	Urban Background	Enfield	Imperial College London	Outer	11
GB6	Greenwich - Falconwood	Roadside	Greenwich	Imperial College London	Outer	13
GN0	Greenwich - A206 Burrage Grove	Roadside	Greenwich	Imperial College London	Outer	13
GN3	Greenwich - Plumstead High Street	Roadside	Greenwich	Imperial College London	Outer	13
GN4	Greenwich - Fiveways Sidcup Rd A20	Roadside	Greenwich	Imperial College London	Outer	12
GN5	Greenwich - Trafalgar Road (Hoskins St)	Roadside	Greenwich	Imperial College London	Inner	6
GN6	Greenwich - John Harrison Way	Roadside	Greenwich	Imperial College London	Inner	5
GR4	Greenwich - Eltham	Urban Background	Greenwich	Imperial College London	Outer	13
GR5	Greenwich - Trafalgar Road	Roadside	Greenwich	Imperial College London	Inner	6
GR7	Greenwich - Blackheath	Roadside	Greenwich	Imperial College London	Inner	13
GR8	Greenwich - Woolwich Flyover	Roadside	Greenwich	Imperial College London	Inner	13
GR9	Greenwich - Westhorne Avenue	Roadside	Greenwich	Imperial College London	Inner	13
GV1	Westminster - Ebury Street (Grosvenor)	Roadside	Westminster	Imperial College London	Inner	5
GV2	Westminster - Duke Street (Grosvenor)	Roadside	Westminster	Imperial College London	Central	4

Site Code	Name	Site Type	Data Owner	Site Manager	Location	Years of data
HF4	Hammersmith and Fulham - Shepherd's Bush	Roadside	Hammersmith and Fulham	Ricardo-AEA	Inner	12
HF5	Hammersmith and Fulham - Hammersmith Town Centre	Roadside	Hammersmith and Fulham	Ricardo-AEA	Inner	4
HG1	Haringey - Haringey Town Hall	Roadside	Haringey	Imperial College London	Inner	13
HG2	Haringey - Priory Park	Urban Background	Haringey	Imperial College London	Inner	3
HG4	Haringey - Priory Park South	Urban Background	Haringey	Imperial College London	Inner	11
HI0	Hillingdon - Keats Way	Urban Background	Hillingdon	Imperial College London	Outer	13
HI1	Hillingdon - South Ruislip	Roadside	Hillingdon	Ricardo-AEA	Outer	13
HI2	Hillingdon - Hillingdon Hospital	Roadside	Hillingdon	Imperial College London	Outer	2
HI3	Hillingdon - Oxford Avenue	Urban Background	Hillingdon	Ricardo-AEA	Outer	13
HIL1	Hillingdon - Harmondsworth	Urban Background	Hillingdon	Ricardo-AEA	Outer	13
HIL5	Hillingdon - Hayes	Roadside	Hillingdon	Ricardo-AEA	Outer	13
HK4	Hackney - Clapton	Urban Background	Hackney	Imperial College London	Inner	2
HK6	Hackney - Old Street	Roadside	Hackney	Imperial College London	Inner	13
HK9	Hackney - Queensbridge Road	Roadside	Hackney	Imperial College London	Inner	1
HN1	Hackney - Hommerton Library	Roadside	Hackney	Imperial College London	Inner	1
HN0	Hackney - Amhurst Road	Roadside	Hackney	Imperial College London	Inner	1
HP1	Lewisham - Honor Oak Park	Urban Background	Lewisham	Imperial College London	Inner	5
HR1	Harrow - Stanmore	Urban Background	Harrow	Imperial College London	Outer	13
HR2	Harrow - Pinner Road	Roadside	Harrow	Imperial College London	Outer	13
HS010	Hounslow - Boston Manor Park	Roadside	Hounslow	Ricardo-AEA	Outer	3
HS2	Hounslow - Cranford	Urban Background	Hounslow	Ricardo-AEA	Outer	11

Site Code	Name	Site Type	Data Owner	Site Manager	Location	Years of data
HS4	Hounslow - Chiswick	Urban Background	Hounslow	Ricardo-AEA	Inner	12
HS5	Hounslow - Brentford	Roadside	Hounslow	Ricardo-AEA	Outer	13
HS6	Hounslow - Heston	Roadside	Hounslow	Ricardo-AEA	Outer	13
HS7	Hounslow - Hatton Cross	Urban Background	Hounslow	Ricardo-AEA	Outer	13
HS8	Hounslow - Gunnersbury	Roadside	Hounslow	Ricardo-AEA	Outer	11
HS9	Hounslow - Feltham	Urban Background	Hounslow	Ricardo-AEA	Outer	13
HV1	Havering - Rainham	Roadside	Havering	Imperial College London	Outer	13
HV3	Havering - Romford	Roadside	Havering	Imperial College London	Outer	13
IS2	Islington - Holloway Road	Roadside	Islington	Imperial College London	Inner	13
IS6	Islington - Arsenal	Urban Background	Islington	Imperial College London	Inner	13
KC1	Kensington and Chelsea - North Ken	Urban Background	Kensington and Chelsea	Imperial College London	Inner	13
KC2	Kensington and Chelsea - Cromwell Road	Roadside	Kensington and Chelsea	Ricardo-AEA	Inner	13
KC3	Kensington and Chelsea - Knightsbridge	Roadside	Kensington and Chelsea	Ricardo-AEA	Inner	13
KC4	Kensington and Chelsea - Chelsea	Roadside	Kensington and Chelsea	Ricardo-AEA	Inner	13
KC5	Kensington and Chelsea - Earls Court Road	Roadside	Kensington and Chelsea	Ricardo-AEA	Inner	13
KG1	Kensington and Chelsea - Green Screen RS	Roadside	Kensington and Chelsea	Imperial College London	Inner	2
KG2	Kensington and Chelsea - Green Screen BG	Urban Background	Kensington and Chelsea	Imperial College London	Inner	2
KT3	Kingston - Sopwith Way	Roadside	Kingston	Imperial College London	Outer	2
KT4	Kingston - Tolworth Broadway	Roadside	Kingston	Imperial College London	Outer	8
KT5	Kingston - Cromwell Road	Roadside	Kingston	Imperial College London	Outer	5
KT6	Kingston - Kingston Vale	Roadside	Kingston	Imperial College London	Outer	5

Site Code	Name	Site Type	Data Owner	Site Manager	Location	Years of data
LB1	Lambeth - Christchurch Road	Roadside	Lambeth	Imperial College London	Inner	1
LB3	Lambeth - Loughborough Junct	Urban Background	Lambeth	Imperial College London	Inner	1
LB6	Lambeth - Streatham Green	Urban Background	Lambeth	Imperial College London	Outer	13
LH0	Hillingdon - Harlington	Urban Background	Hillingdon	Imperial College London	Outer	13
LHRBR	Hillingdon - Heathrow Bath Road	Roadside	Hillingdon	Ricardo-AEA	Outer	4
LW1	Lewisham - Catford	Urban Background	Lewisham	Imperial College London	Inner	12
LW2	Lewisham - New Cross	Roadside	Lewisham	Imperial College London	Inner	13
LW4	Lewisham - Loampit Vale	Roadside	Lewisham	Imperial College London	Inner	11
LW5	Lewisham - Deptford	Urban Background	Lewisham	Imperial College London	Inner	4
LW6	Lewisham - Laurence House Catford	Roadside	Lewisham	Imperial College London	Inner	2
ME1	Merton - Morden Civic Centre	Roadside	Merton	Imperial College London	Outer	4
ME9	Merton - Morden Civic Centre 2	Roadside	Merton	Imperial College London	Outer	5
NB1	Westminster - Strand (Northbank BID)	Roadside	Westminster	Imperial College London	Central	8
NM2	Newham - Cam Road	Roadside	Newham	Imperial College London	Inner	13
NM3	Newham - Wren Close	Urban Background	Newham	Imperial College London	Inner	13
RB1	Redbridge - Perth Terrace	Urban Background	Redbridge	Imperial College London	Outer	5
RB4	Redbridge - Gardner Close	Roadside	Redbridge	Imperial College London	Inner	13
RB5	Redbridge - South Woodford	Roadside	Redbridge	Imperial College London	Outer	3
RB7	Redbridge - Ley Street	Urban Background	Redbridge	Imperial College London	Outer	9
RHG	Richmond - Chertsey Road	Roadside	Richmond	Imperial College London	Outer	5
RI1	Richmond - Castelnau	Roadside	Richmond	Imperial College London	Inner	13

Site Code	Name	Site Type	Data Owner	Site Manager	Location	Years of data
RI2	Richmond - Barnes Wetlands	Urban Background	Richmond	Imperial College London	Inner	13
SIPS	Hillingdon - Sipson	Urban Background	Hillingdon	Ricardo-AEA	Outer	13
SK5	Southwark - A2 Old Kent Road	Roadside	Southwark	Imperial College London	Inner	13
SK6	Southwark - Elephant and Castle	Urban Background	Southwark	Imperial College London	Central	10
SK7	Southwark - Heygate	Urban Background	Southwark	Imperial College London	Inner	2
SK8	Southwark - Tower Bridge Road	Roadside	Southwark	Imperial College London	Inner	4
SKA	Southwark - Lower Road	Roadside	Southwark	Imperial College London	Inner	3
SKB	Southwark - Vicarage Grove	Roadside	Southwark	Imperial College London	Inner	2
SKC	Southwark - South Circular Road	Roadside	Southwark	Imperial College London	Inner	2
ST3	Sutton - Carshalton	Urban Background	Sutton	Imperial College London	Outer	7
ST9	Sutton - Beddington Village	Roadside	Sutton	Imperial College London	Outer	3
TD0	Richmond - National Physical Laboratory	Urban Background	Richmond	Imperial College London	Outer	7
TH001	Tower Hamlets - Millwall Park	Urban Background	Tower Hamlets	Ricardo-AEA	Inner	7
TH002	Tower Hamlets - Victoria Park	Urban Background	Tower Hamlets	Ricardo-AEA	Inner	7
TH1	Tower Hamlets - Poplar	Urban Background	Tower Hamlets	Imperial College London	Inner	4
TH2	Tower Hamlets - Mile End Road	Roadside	Tower Hamlets	Imperial College London	Inner	13
TH4	Tower Hamlets - Blackwall	Roadside	Tower Hamlets	Imperial College London	Inner	13
TH5	Tower Hamlets - Victoria Park	Urban Background	Tower Hamlets	Imperial College London	Inner	5
TH6	Tower Hamlets - Millwall Park	Urban Background	Tower Hamlets	Imperial College London	Inner	2
TL4	Greenwich - Tunnel Avenue TFL	Roadside	Greenwich	Imperial College London	Inner	3
TL5	Newham - Hoola Tower TFL	Roadside	Newham	Imperial College London	Inner	2

Site Code	Name	Site Type	Data Owner	Site Manager	Location	Years of data
TL6	Newham - Britannia Gate TFL	Roadside	Newham	Imperial College London	Inner	3
WA2	Wandsworth - Wandsworth Town Hall	Urban Background	Wandsworth	Imperial College London	Inner	13
WA8	Wandsworth - Putney High Street Facade	Roadside	Wandsworth	Imperial College London	Inner	13
WA9	Wandsworth - Putney	Urban Background	Wandsworth	Imperial College London	Inner	12
WAA	Wandsworth - Battersea	Roadside	Wandsworth	Imperial College London	Inner	11
WAB	Wandsworth - Tooting High Street	Roadside	Wandsworth	Imperial College London	Outer	8
WAC	Wandsworth - Lavender Hill (Clapham Jct)	Roadside	Wandsworth	Imperial College London	Inner	7
WL1	Waltham Forest - Dawlish Road	Urban Background	Waltham Forest	Ricardo-AEA	Inner	13
WL5	Waltham Forest - Leyton	Urban Background	Waltham Forest	Ricardo-AEA	Inner	13
WM0	Westminster - Horseferry Road	Urban Background	Westminster	Imperial College London	Central	13
WM4	Westminster - Charing Cross Library	Roadside	Westminster	Imperial College London	Central	2
WM5	Westminster - Covent Garden	Urban Background	Westminster	Imperial College London	Central	8
WM8	Westminster - Victoria	Urban Background	Westminster	Imperial College London	Inner	3
WM9	Westminster - Victoria (Victoria BID)	Roadside	Westminster	Imperial College London	Inner	2
WMA	Westminster - Buckingham Palace Road	Roadside	Westminster	Imperial College London	Inner	3
WMB	Westminster - Oxford Street East	Roadside	Westminster	Imperial College London	Central	5
WMC	Westminster - Cavendish Square	Roadside	Westminster	Imperial College London	Central	5
WMD	Westminster - Elizabeth Bridge	Roadside	Westminster	Imperial College London	Central	3

In order to assess long term trends, monthly average concentrations grouped by site type and London zone (central / inner / outer) were calculated for NO_2 and $PM_{2.5}$.

This is an update to the trend analysis carried out by King's College London for the London Environment Strategy[28] and that used in the previous ULEZ impact reports.

Sites with less than 75% data capture in a given month were excluded for that month and missing monthly data was interpolated. This data capture threshold is consistent with that used for EU reporting when calculating daily mean concentrations. This was calculated using Openair — an R package for air quality data analysis. Trends were then created using the LOESS smoothing function which "de-seasonalized" the data.[29] As with the ULEZ expansion 6 month report, the span argument for the LOESS function was set to 0.375 to avoid over smoothing the recent impacts of the pandemic in central London, which occurred when using the span setting of 0.75, as used in previous central London ULEZ analysis reports. This has resulted in the historical data on the trends analysis charts looking different to the analysis presented in previous central London ULEZ reports.

For the boundary roads analysis, a higher span of 0.5 has been used as it was only the need to reflect the pandemic changes in central London that required us to use a lower span for the impacts within the zone. The pandemic impacts seen in central are not as apparent on the boundary roads.

Reductions in NO_2 concentrations, from early February 2017 (when changes associated with the ULEZ began) to March 2022 (the most recent period for which data is available), have then be calculated by three-month averages (referred to as quarters) and are presented in Table 14.

NO_2 roadside increment (R_{inc})

To analyse the changes in pollution concentrations from local road traffic emissions (i.e. changes attributable to the ULEZ and other policies), trends in NO_2 roadside increments were assessed. The roadside increment isolates the changes in concentration at the roadside from changes in background concentrations, using the equation below:

$$R_{inc} = roadside\ concentration - urban\ background\ concentration$$

This removes the impact of changes over time due to processes at the regional scale (such as meteorological conditions, boundary layer dynamics, policies outside the city, etc.) as described in more detail by Lenschow et al[30] and Font and Fuller[31] in a London context.

For this analysis a R_{inc} was derived from hourly data. A single hourly roadside increment was calculated per site by averaging concentrations across all outer London urban background sites. This approach was adopted for three reasons (following similar methodology to Font and Fuller 2016):

[28] London Environment Strategy (pg 46), Greater London Authority, 2018
[29] Cleveland et al, STL: a seasonal-trend decomposition procedure based on loess, 1990
[30] Lenschow et al, Some ideas about the sources of PM10, 2001
[31] Font and Fuller, Did policies to abate atmospheric emissions from traffic have a positive effect in London? 2016

- The use of a single background hourly value allows R_{inc} to be directly compared between different roadside locations

- Averaging across outer urban background sites creates a complete time series for the period being assessed (2010 – 2022) without interpolation

- Averaging across outer urban background sites ensures R_{inc} follows general trends across a number of sites, although bias can be induced from changes to site availability

In addition, the outer London R_{inc} has been used as a predictor for "business as usual" or in other words the change in R_{inc} that would have happened irrespective of the Ultra Low Emission Zone, its expansion and other policies.

There are a number of outer urban background air quality monitoring sites in the near vicinity of Heathrow airport. These sites have been excluded from the background sites used to calculate the road increments due to the reduction in activity around the airport caused by the pandemic which is yet to return. The effect of these changes due to the airport activity were not seen over most of outer London. Inclusion of these sites in the outer London background would have induced a bias in the estimate of the impacts of ULEZ and its expansion.

Table 23: Heathrow sites excluded from this analysis

Site Code	Name	Site Type	Data Owner	Site Manager	ULEZ Location
HI0	Hillingdon - Keats Way	Urban Background	Hillingdon	Imperial College London	Outer
HI3	Hillingdon - Oxford Avenue	Urban Background	Hillingdon	Ricardo-AEA	Outer
HIL1	Hillingdon - Harmondsworth	Urban Background	Hillingdon	Ricardo-AEA	Outer
HS2	Hounslow - Cranford	Urban Background	Hounslow	Ricardo-AEA	Outer
HS7	Hounslow - Hatton Cross	Urban Background	Hounslow	Ricardo-AEA	Outer
LH0	Hillingdon - Harlington	Urban Background	Hillingdon	Imperial College London	Outer
SIPS	Hillingdon - Sipson	Urban Background	Hillingdon	Ricardo-AEA	Outer

In order not to skew the impact analysis of the trends around the time of the ULEZ expansion in 2021, any sites that were opened in 2021 or later were excluded from this analysis. For the same reason any sites that closed in 2021 were also excluded from the impact analysis.

The sites that either opened in or after 2021 or closed in 2021 and hence excluded from the analysis are listed below.

Table 24: Further sites excluded due to opening/closing in 2021

Site Code	Name	Site Type	Data Owner	Site Manager	ULEZ Location	Reason for exclusion
CD010	Camden - High Street	Roadside	Camden	Ricardo-AEA	Inner	Closed 24.05.2021
EA010	Ealing - Green Quarter	Urban Background	Ealing	Ricardo-AEA	Outer	Opened 03.11.2021
LW1	Lewisham - Catford	Urban Background	Lewisham	Imperial College London	Inner	Closed 03.11.2021
LW6	Lewisham - Laurence House Catford	Roadside	Lewisham	Imperial College London	Inner	Opened 17.11.2021
SKC	Southwark - South Circular Road	Roadside	Southwark	Imperial College London	Inner	Opened 24.07.2021
TL5	Newham - Hoola Tower TFL	Roadside	Newham	Imperial College London	Inner	Opened 08.03.2021

The average concentration across the outer London urban background sites was subtracted from the average central roadside, inner roadside and outer roadside concentrations. This was done on an hourly basis. Monthly averages were calculated excluding sites with less than 75 per cent data capture, values were then linearly interpolating for missing months. This was then aggregated by zone (Central / Inner / Outer London).

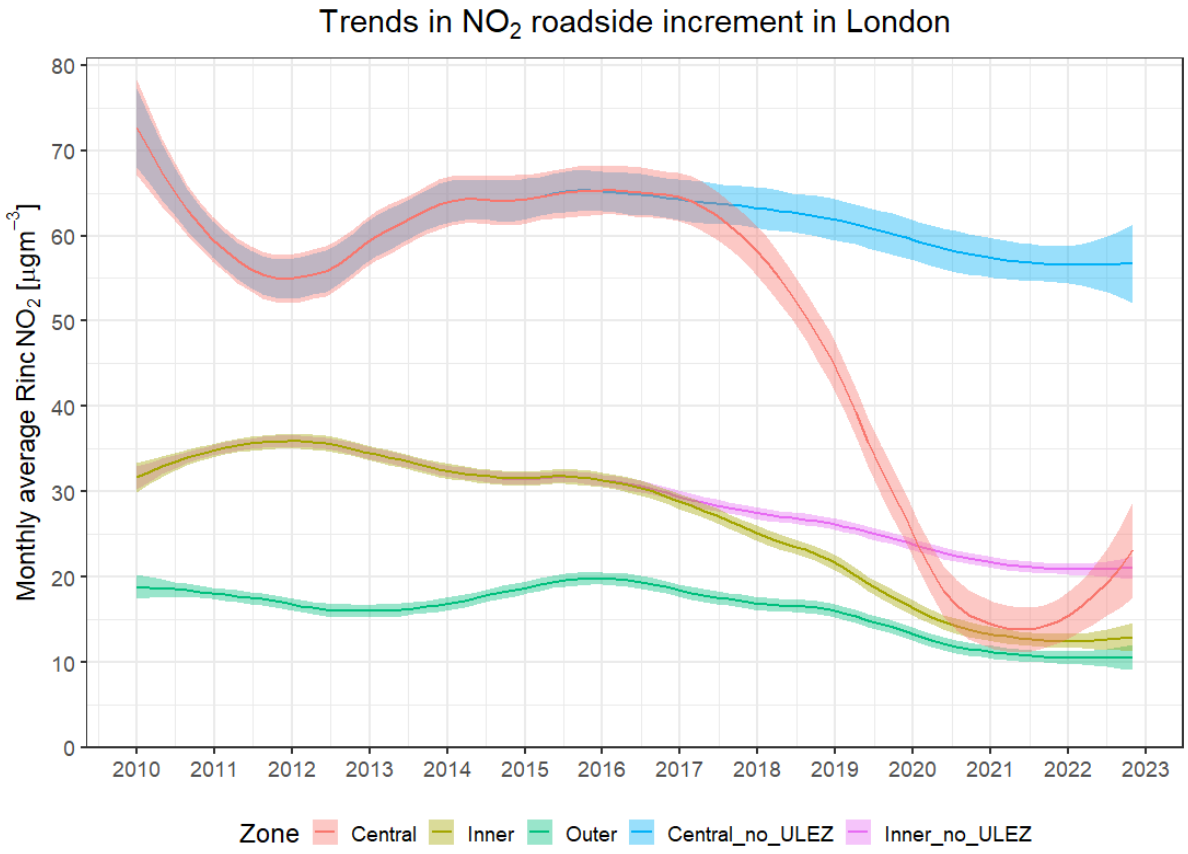

Figure 21: Trends in monthly average NO_2 roadside increment

Figure 21 shows the LOESS trends of monthly average NO_2 roadside increment in central, inner and outer London as well as the central and inner "no ULEZ" scenario roadside increments. As with the previous trend analysis, the LOESS smoothing function "de-seasonalized" the data.[32]

Changes associated with the ULEZ were expected to begin in central London at the beginning of 2017. However, there is also some reduction in the NO_2 roadside increment concentrations in outer London. Independent of schemes such as the ULEZ, a certain proportion of older vehicles are replaced each month. As newer vehicles produce less NO_x emissions, fleet turnover will slowly clean up the vehicle fleet. This means that, in general, if traffic volumes were to remain constant, the roadside increment concentration R_{inc} would be expected to gradually decrease as newer vehicles enter the fleet.

The reductions in outer London R_{inc} reflect turnover of the fleet as well as changes at a regional level. This can be seen as the reduction that would have occurred London-wide, regardless of the introduction of the ULEZ, its expansion and other policies. The implementation of the LEZ for heavy vehicles would also have affected vehicle turnover in outer London therefore the estimate of the trend in roadside increment may be slightly underestimated because it is not possible to remove the effect of the LEZ on monitoring data in outer London.

[32] Cleveland et al, STL: a seasonal-trend decomposition procedure based on loess, 1990

The blue and purple “no ULEZ” curves in Figure 21 are a prediction of central and inner London roadside increments if there was no ULEZ (assuming reductions in roadside increment at central and inner London roadside sites would follow the trend measured at outer London sites). The difference between the red curve and blue curve in Figure 21 represents the reduction in traffic contribution to NO_2 above that is expected from “no ULEZ” scenario. This is an estimate for the impact in central London of the preparation for, the introduction of and the expansion of the ULEZ and other policies including upgrading the bus fleet and the increase in zero emissions taxis.

The no ULEZ scenario was calculated by subtracting the reduction in R_{inc} in outer London compared to January 2017 from the R_{inc} in central/ inner London in January 2017.

$$R_{inc}^{cenral\ no\ ulez}{}_{i} = R_{inc}^{central}{}_{Jan17} - \left(R_{inc}^{outer}{}_{Jan17} - R_{inc}^{outer}{}_{i} \right)$$

It is therefore important to remove the actual road increment concentrations to isolate the NO_2 reduction in central and inner London that can be attributed to the ULEZ. This has been done using the equation below:

$$ULEZ\ impact = R_{inc}^{no\ ULEZ} - R_{inc}^{central}$$

Impact of ULEZ on monthly average NO_2

The equation above produces an estimate of the impact (in µg m^{-3}) of the ULEZ, its expansion and other policies at central and inner London roadside locations. This has been used to estimate “no ULEZ” monthly average NO_2 concentrations, as in Figure 16 in the report. This was done by adding the estimated ULEZ impact concentration (in µg m^{-3}) to the actual monthly average measurements. The LOESS function was again applied to smooth the graph in to remove impacts of seasonality. The reduction presented in Table 15 is the LOESS of the ULEZ impact as per the equation above in µg m^{-3} and converted into a percentage.

Appendix 3

Tables 25 and 26 present the annual average Nitrogen dioxide and $PM_{2.5}$ concentrations for all monitoring stations in London which collected data between 2016-2022.
DC indicates that the data collection at the site for that year was less than 75 per cent and therefore has not been included as would not be representative of an annual average, in line with statutory reporting requirements.

*2022 data has not yet been ratified therefore the final annual average may change at a later date.

Table 25: Annual average NO_2 concentrations at monitoring stations across London, 2016-2022.

DC indicates low data capture as per above

Site Code	Borough	Name	Site Type	Location	Annual Average NO_2 concentration [μgm^{-3}]						
					2016	2017	2018	2019	2020	2021	2022*
BG1	Barking and Dagenham	Barking and Dagenham - Rush Green	Suburban	Outer	21	24	DC	DC	17	17	16
BG2	Barking and Dagenham	Barking and Dagenham - Scrattons Farm	Suburban	Outer	32	28	26	24	20	20	20
BN1	Barnet	Barnet - Tally Ho	Kerbside	Outer	44	DC	42	38	32	32	29
BN2	Barnet	Barnet - Chalgrove School	Urban Background	Outer	28	DC	27	25	19	18	17
BQ7	Bexley	Bexley - Belvedere West	Urban Background	Outer	24	21	21	21	17	17	16
BX1	Bexley	Bexley - Slade Green	Suburban	Outer	25	24	23	22	19	19	18
BX2	Bexley	Bexley - Belvedere	Suburban	Outer	29	28	28	23	18	16	18
BT4	Brent	Brent - Ikea	Roadside	Outer	76	72	71	63	49	46	43
BT5	Brent	Brent - Neasden Lane	Industrial	Inner	DC	45	39	38	28	30	27
BT6	Brent	Brent - John Keble Primary School	Roadside	Inner	DC	44	39	37	29	29	27

Site Code	Borough	Name	Site Type	Location	Annual Average NO_2 concentration [μgm^{-3}]						
					2016	2017	2018	2019	2020	2021	2022*
BT8	Brent	Brent - ARK Franklin Primary Academy	Roadside	Inner		DC	46	41	29	31	27
BY7	Bromley	Bromley - Harwood Avenue	Roadside	Outer				DC	21	22	20
BL0	Camden	Camden - Bloomsbury	Urban Background	Central	42	38	36	31	28	27	21
CD009	Camden	Camden - Euston Road	Roadside	Inner	88	83	DC	70	43	48	44
CD010	Camden	Camden - High Street	Roadside	Inner						DC	29
CD1	Camden	Camden - Swiss Cottage	Kerbside	Inner	66	53	54	43	33	DC	
CD3	Camden	Camden - Shaftesbury Avenue	Roadside	Central	DC						
IM1	Camden	Camden - Holborn (Bee Midtown)	Kerbside	Central	84	74	DC	55	DC	36	DC
CT2	City of London	City of London - Farringdon Street	Kerbside	Central	DC	DC	DC	DC	DC	DC	DC
CT3	City of London	City of London - Sir John Cass School	Urban Background	Central	42	38	32	33	22	23	22
CT4	City of London	City of London - Beech Street	Roadside	Central	85	80	69	62	29	31	36
CT6	City of London	City of London - Walbrook Wharf	Roadside	Central	92	92	87	74	45	46	52
CR5	Croydon	Croydon - Norbury	Kerbside	Outer	47	48	49	44	35	39	36
CR7	Croydon	Croydon - Purley Way A23	Roadside	Outer	31	31	31	29	24	26	DC
CR9	Croydon	Croydon - Park Lane	Roadside	Outer	DC	45	41	44	DC		
EA010	Ealing	Ealing - Green Quarter	Suburban	Outer						DC	17
EA6	Ealing	Ealing - Hanger Lane Gyratory	Roadside	Outer	75	72	68	64	51	49	51
EA8	Ealing	Ealing - Horn Lane	Industrial	Inner	48	45	44	42	33	32	28

Site Code	Borough	Name	Site Type	Location	Annual Average NO_2 concentration [μgm^{-3}]						
					2016	2017	2018	2019	2020	2021	2022*
EI1	Ealing	Ealing - Western Avenue	Roadside	Inner	60	51	DC	48	35	36	34
EI3	Ealing	Ealing - Acton Vale	Urban Background	Inner		DC	29	26	DC	DC	DC
EN1	Enfield	Enfield - Bush Hill Park	Suburban	Outer	28	27	25	22	18	18	18
EN4	Enfield	Enfield - Derby Road	Roadside	Outer	43	38	35	37	28	24	22
EN5	Enfield	Enfield - Bowes Primary School	Roadside	Inner	47	45	44	41	29	30	27
EN7	Enfield	Enfield - Prince of Wales School	Urban Background	Outer	25	23	23	23	18	18	17
GB6	Greenwich	Greenwich - Falconwood	Roadside	Outer	45	40	38	36	27	27	22
GN0	Greenwich	Greenwich - A206 Burrage Grove	Roadside	Outer	39	35	35	33	26	27	26
GN2	Greenwich	Greenwich - Millennium Village	Industrial	Inner	30						
GN3	Greenwich	Greenwich - Plumstead High Street	Roadside	Outer	36	34	33	34	30	25	25
GN4	Greenwich	Greenwich - Fiveways Sidcup Rd A20	Roadside	Outer	46	41	40	37	26	31	26
GN5	Greenwich	Greenwich - Trafalgar Road (Hoskins St)	Roadside	Inner		DC	42	41	34	33	31
GN6	Greenwich	Greenwich - John Harrison Way	Roadside	Inner			DC	33	26	25	23
GR4	Greenwich	Greenwich - Eltham	Suburban	Outer	21	19	16	17	13	15	DC
GR7	Greenwich	Greenwich - Blackheath	Roadside	Inner	46	38	35	38	29	29	30
GR8	Greenwich	Greenwich - Woolwich Flyover	Roadside	Inner	64	65	57	52	43	40	40

Site Code	Borough	Name	Site Type	Location	Annual Average NO_2 concentration [μgm^{-3}]						
					2016	2017	2018	2019	2020	2021	2022*
GR9	Greenwich	Greenwich - Westhorne Avenue	Roadside	Inner	42	39	38	34	25	26	DC
TL4	Greenwich	Greenwich - Tunnel Avenue TFL	Roadside	Inner					DC	34	34
HK6	Hackney	Hackney - Old Street	Roadside	Inner	57	57	50	47	37	33	30
HK9	Hackney	Hackney - Queensbridge Road	Roadside	Inner							DC
HN1	Hackney	Hackney - Hommerton Library	Roadside	Inner							DC
HN0	Hackney	Hackney - Amhurst Road	Roadside	Inner							DC
HF4	Hammersmith and Fulham	Hammersmith and Fulham - Shepherd's Bush	Roadside	Inner	79	77	71	60	43	41	35
HF5	Hammersmith and Fulham	Hammersmith and Fulham - Hammersmith Town Centre	Roadside	Inner				53	37	44	46
HG1	Haringey	Haringey - Haringey Town Hall	Roadside	Inner	40	37	36	34	33	32	30
HG4	Haringey	Haringey - Priory Park South	Urban Background	Inner	26	24	22	22	16	18	17
HR1	Harrow	Harrow - Stanmore	Urban Background	Outer	26	DC	DC	20	15	16	18
HR2	Harrow	Harrow - Pinner Road	Roadside	Outer	44	41	39	36	DC	DC	DC
HV1	Havering	Havering - Rainham	Roadside	Outer	34	34	30	29	23	23	23
HV3	Havering	Havering - Romford	Roadside	Outer	44	40	38	38	29	28	31
HI0	Hillingdon	Hillingdon - Keats Way	Suburban	Outer	52	53	46	45	28	25	27
HI1	Hillingdon	Hillingdon - South Ruislip	Roadside	Outer	44	46	36	34	25	27	28
HI3	Hillingdon	Hillingdon - Oxford Avenue	Urban Centre	Outer	39	35	35	33	22	25	28

Site Code	Borough	Name	Site Type	Location	Annual Average NO_2 concentration [μgm^{-3}]						
					2016	2017	2018	2019	2020	2021	2022*
HIL1	Hillingdon	Hillingdon - Harmondsworth	Urban Background	Outer	27	27	25	24	18	16	18
HIL5	Hillingdon	Hillingdon - Hayes	Roadside	Outer	47	47	43	41	31	34	33
LH0	Hillingdon	Hillingdon - Harlington	Urban Background	Outer	34	31	30	31	20	20	
LHR2	Hillingdon	Hillingdon - Heathrow	Airport	Outer	48	48	43	42	25	25	30
LHRBR	Hillingdon	Hillingdon - Heathrow Bath Road	Roadside	Outer				DC	DC	DC	37
SIPS	Hillingdon	Hillingdon - Sipson	Urban Background	Outer	36	34	30	30	19	19	24
T55	Hillingdon	Hillingdon - Heathrow Green Gates	Airport	Outer	34	32	30	31	19	20	26
HS010	Hounslow	Hounslow - Boston Manor Park	Roadside	Outer			DC	26	DC		
HS2	Hounslow	Hounslow - Cranford	Suburban	Outer	31	30	DC	27	DC		
HS4	Hounslow	Hounslow - Chiswick	Urban Background	Inner	50	53	47	42	32	33	31
HS5	Hounslow	Hounslow - Brentford	Roadside	Outer	57	54	48	44	33	36	32
HS6	Hounslow	Hounslow - Heston	Roadside	Outer	DC	44	40	37	31	29	27
HS7	Hounslow	Hounslow - Hatton Cross	Urban Background	Outer	32	33	28	28	17	18	20
HS8	Hounslow	Hounslow - Gunnersbury	Roadside	Outer	59	53	45	45	38	36	28
HS9	Hounslow	Hounslow - Feltham	Urban Background	Outer	38	34	27	29	25	28	25
IS2	Islington	Islington - Holloway Road	Roadside	Inner	60	49	47	40	31	29	27
IS6	Islington	Islington - Arsenal	Urban Background	Inner	33	31	27	25	20	20	20
KC1	Kensington and Chelsea	Kensington and Chelsea - North Ken	Urban Background	Inner	35	33	29	27	21	20	15

Site Code	Borough	Name	Site Type	Location	Annual Average NO_2 concentration [μgm^{-3}]						
					2016	2017	2018	2019	2020	2021	2022*
KC2	Kensington and Chelsea	Kensington and Chelsea - Cromwell Road	Roadside	Inner	58	51	48	44	30	30	30
KC3	Kensington and Chelsea	Kensington and Chelsea - Knightsbridge	Roadside	Inner	80	66	66	56	32	34	36
KC4	Kensington and Chelsea	Kensington and Chelsea - Chelsea	Roadside	Inner	78	63	60	55	40	39	34
KC5	Kensington and Chelsea	Kensington and Chelsea - Earls Court Road	Roadside	Inner	86	78	79	57	37	44	41
KT3	Kingston	Kingston - Sopwith Way	Roadside	Outer	DC						
KT4	Kingston	Kingston - Tolworth Broadway	Roadside	Outer	DC	49	44	41	DC	31	30
KT5	Kingston	Kingston - Cromwell Road	Roadside	Outer			DC	57	45	50	41
KT6	Kingston	Kingston - Kingston Vale	Roadside	Outer			36	33	25	26	24
LB4	Lambeth	Lambeth - Brixton Road	Kerbside	Inner	118	95	DC	75	60	62	63
LB5	Lambeth	Lambeth - Bondway Interchange	Industrial	Inner	68	65	54	47	36	36	29
LB6	Lambeth	Lambeth - Streatham Green	Urban Background	Outer	DC	30	34	32	26	DC	23
HP1	Lewisham	Lewisham - Honor Oak Park	Urban Background	Inner			DC	23	16	16	16
LW1	Lewisham	Lewisham - Catford	Urban Background	Inner	45	43	37	33	28	25	
LW2	Lewisham	Lewisham - New Cross	Roadside	Inner	46	48	42	38	29	DC	27

Site Code	Borough	Name	Site Type	Location	Annual Average NO_2 concentration [μgm^{-3}]						
					2016	2017	2018	2019	2020	2021	2022*
LW4	Lewisham	Lewisham - Loampit Vale	Roadside	Inner	DC	54	46	43	36	35	38
LW5	Lewisham	Lewisham - Deptford	Urban Background	Inner				DC	19	20	19
LW6	Lewisham	Lewisham - Laurence House Catford	Roadside	Inner						DC	25
ME7	Merton	Merton - Willow Lane Industrial Estate	Industrial	Outer	DC						
ME9	Merton	Merton - Morden Civic Centre 2	Roadside	Outer		DC	47	51	DC		DC
NEW2	Newham	Newham - Cam Road	Roadside	Inner	42	38	29	29	24	DC	
NEW3	Newham	Newham - Wren Close	Urban Background	Inner	33	30	28	28	20	DC	
NM2	Newham	Newham - Cam Road	Roadside	Inner	42	38	29	29	24	23	23
NM3	Newham	Newham - Wren Close	Urban Background	Inner	33	30	28	28	20	21	21
TL5	Newham	Newham - Hoola Tower TFL	Roadside	Inner						22	23
TL6	Newham	Newham - Britannia Gate TFL	Roadside	Inner					DC	26	24
RB4	Redbridge	Redbridge - Gardner Close	Roadside	Inner	42	39	37	37	27	26	25
RB7	Redbridge	Redbridge - Ley Street	Urban Background	Outer	33	30	30	30	21	24	DC
RHG	Richmond	Richmond - Chertsey Road	Roadside	Outer	DC	37	34	35	DC		
RI1	Richmond	Richmond - Castelnau	Roadside	Inner	36	31	31	27	20	21	21
RI2	Richmond	Richmond - Barnes Wetlands	Suburban	Inner	25	21	20	21	15	14	DC
TD0	Richmond	Richmond - National Physical Laboratory	Urban Background	Outer	DC						

Site Code	Borough	Name	Site Type	Location	Annual Average NO_2 concentration [μgm^{-3}]						
					2016	2017	2018	2019	2020	2021	2022*
ZV1	Sevenoaks	Sevenoaks - Greatness Park	Urban Background	Outside	17	DC	15	14	12	12	11
SK5	Southwark	Southwark - A2 Old Kent Road	Roadside	Inner	53	42	41	38	DC	29	26
SK6	Southwark	Southwark - Elephant and Castle	Urban Background	Central	39	34	32	30	21	23	21
SK8	Southwark	Southwark - Tower Bridge Road	Roadside	Inner				DC	30	DC	29
SKA	Southwark	Southwark - Lower Road	Roadside	Inner					DC	28	DC
SKB	Southwark	Southwark - Vicarage Grove	Roadside	Inner						40	32
SKC	Southwark	Southwark - South Circular Road	Roadside	Inner						DC	26
ST3	Sutton	Sutton - Carshalton	Urban Background	Outer	DC						
ST4	Sutton	Sutton - Wallington	Kerbside	Outer	63	53	47	46	41	43	45
ST5	Sutton	Sutton - Beddington Lane north	Industrial	Outer	36	32	29	29	23	22	23
ST6	Sutton	Sutton - Worcester Park	Kerbside	Outer	57	52	52	51	39	43	36
ST8	Sutton	Sutton - Beddington Lane	Industrial	Outer	30	25	25	25	DC	DC	22
ST9	Sutton	Sutton - Beddington Village	Roadside	Outer					DC	24	21
CW3	Tower Hamlets	Tower Hamlets - Jubilee Park	Urban Background	Inner							19
TH001	Tower Hamlets	Tower Hamlets - Millwall Park	Urban Background	Inner	DC	27	23	24	17	17	20
TH002	Tower Hamlets	Tower Hamlets - Victoria Park	Urban Background	Inner	DC	34	26	24	17	16	17

Site Code	Borough	Name	Site Type	Location	Annual Average NO_2 concentration [μgm^{-3}]						
					2016	2017	2018	2019	2020	2021	2022*
TH2	Tower Hamlets	Tower Hamlets - Mile End Road	Roadside	Inner	52	48	47	35	25	22	22
TH4	Tower Hamlets	Tower Hamlets - Blackwall	Roadside	Inner	59	56	51	47	39	37	DC
TH5	Tower Hamlets	Tower Hamlets - Victoria Park	Urban Background	Inner	DC						
TH6	Tower Hamlets	Tower Hamlets - Millwall Park	Urban Background	Inner	25						
WL1	Waltham Forest	Waltham Forest - Dawlish Road	Urban Background	Inner	30	28	23	24	19	18	18
WL4	Waltham Forest	Waltham Forest - Crooked Billet	Kerbside	Outer	62	61	58	58	42	43	39
WL5	Waltham Forest	Waltham Forest - Leyton	Urban Background	Inner	35	33	30	32	25	23	21
WA2	Wandsworth	Wandsworth - Wandsworth Town Hall	Urban Background	Inner	43	40	38	41	30	29	28
WA7	Wandsworth	Wandsworth - Putney High Street	Kerbside	Inner	125	76	67	69	58	62	DC
WA8	Wandsworth	Wandsworth - Putney High Street Facade	Roadside	Inner	98	60	62	66	53	57	DC
WA9	Wandsworth	Wandsworth - Putney	Urban Background	Inner	45	31	35	35	26	27	DC
WAA	Wandsworth	Wandsworth - Battersea	Roadside	Inner	40	33	DC	31	27	28	25
WAB	Wandsworth	Wandsworth - Tooting High Street	Roadside	Outer	59	54	53	50	DC	DC	35
WAC	Wandsworth	Wandsworth - Lavender Hill (Clapham Jct)	Roadside	Inner	DC	43	42	DC	31	35	DC
CE1	Westminster	Westminster - Regent St (Crown Estate)	Roadside	Central					DC	36	39

Site Code	Borough	Name	Site Type	Location	Annual Average NO_2 concentration [μgm^{-3}]						
					2016	2017	2018	2019	2020	2021	2022*
CE2	Westminster	Westminster - Waterloo Pl (Crown Estate)	Roadside	Central					DC	36	38
GV1	Westminster	Westminster - Ebury Street (Grosvenor)	Roadside	Inner			DC	35	23	DC	25
GV2	Westminster	Westminster - Duke Street (Grosvenor)	Roadside	Central				DC	28	30	31
MY1	Westminster	Westminster - Marylebone Road	Kerbside	Inner	89	84	85	63	44	43	42
NB1	Westminster	Westminster - Strand (Northbank BID)	Roadside	Central	101	92	88	76	44	43	DC
WM0	Westminster	Westminster - Horseferry Road	Urban Background	Central	DC	36	31	34	26	24	22
WM4	Westminster	Westminster - Charing Cross Library	Roadside	Central							
WM5	Westminster	Westminster - Covent Garden	Urban Background	Central		DC	39	39	24	24	23
WM6	Westminster	Westminster - Oxford Street	Kerbside	Central	87	72	63	55	34	34	35
WM8	Westminster	Westminster - Victoria	Urban Background	Inner	DC						
WM9	Westminster	Westminster - Victoria (Victoria BID)	Roadside	Inner	DC	DC					
WMA	Westminster	Westminster - Buckingham Palace Road	Roadside	Inner			52	51	DC		
WMB	Westminster	Westminster - Oxford Street East	Roadside	Central			DC	51	35	37	40
WMC	Westminster	Westminster - Cavendish Square	Roadside	Central			DC	50	32	32	31

Site Code	Borough	Name	Site Type	Location	Annual Average NO_2 concentration [μgm^{-3}]						
					2016	2017	2018	2019	2020	2021	2022*
WMD	Westminster	Westminster - Elizabeth Bridge	Roadside	Central					DC	30	33

Table 26: Annual average $PM_{2.5}$ concentrations at monitoring stations across London, 2016-2022

Site Code	Borough	Name	Site Type	$PM_{2.5}$ concentration [μgm^{-3}]							
				Location	2016	2017	2018	2019	2020	2021	2022
BQ7	Bexley	Bexley - Belvedere West	Urban Background	Outer	DC	DC	DC	DC	DC	DC	DC
BX1	Bexley	Bexley - Slade Green	Suburban	Outer	11	11	DC	DC	DC	DC	
BX2	Bexley	Bexley - Belvedere	Suburban	Outer	DC	DC	DC	DC	DC	DC	DC
BX9	Bexley	Bexley - Slade Green FDMS	Suburban	Outer	11	11	12	12	9	9	
BT4	Brent	Brent - Ikea	Roadside	Outer	DC	DC	DC	DC	DC	13	13
BY7	Bromley	Bromley - Harwood Avenue	Roadside	Outer				DC	DC	10	11
BL0	Camden	Camden - Bloomsbury	Urban Background	Central	12	13	10	11	9	DC	10
CD009	Camden	Camden - Euston Road	Roadside	Inner	17	14	DC	14	11	11	11
CD1	Camden	Camden - Swiss Cottage	Kerbside	Inner	15	16	11	11	10	DC	

Site Code	Borough	Name	Site Type	$PM_{2.5}$ concentration [μgm^{-3}]							
				Location	2016	2017	2018	2019	2020	2021	2022
KX004	Camden	Camden - Coopers Lane	Industrial	Inner	DC	DC	DC	DC	DC	DC	10
CT2	City of London	City of London - Farringdon Street	Kerbside	Central	DC	16	16	14	DC	DC	12
CT3	City of London	City of London - Sir John Cass School	Urban Background	Central	15	DC	12	12	12	11	12
CR8	Croydon	Croydon - Norbury Manor	Urban Background	Outer	DC	12	11	10	9	9	DC
EA010	Ealing	Ealing - Green Quarter	Suburban	Outer						DC	9
EI7	Ealing	Ealing - Southall FDMS	Urban Background	Outer	DC						
GB0	Greenwich	Greenwich - Falconwood FDMS	Roadside	Outer	DC	13	13	12	11	13	DC
GN0	Greenwich	Greenwich - A206 Burrage Grove	Roadside	Outer	15	12	13	DC	12	11	11
GN2	Greenwich	Greenwich - Millennium Village	Industrial	Inner	12						
GN3	Greenwich	Greenwich - Plumstead High Street	Roadside	Outer	14	12	13	13	10	DC	DC
GN6	Greenwich	Greenwich - John Harrison Way	Roadside	Inner			DC	11	9	11	DC
GR4	Greenwich	Greenwich - Eltham	Suburban	Outer	12	12	10	11	10	8	DC

Site Code	Borough	Name	Site Type	$PM_{2.5}$ concentration [μgm^{-3}]							
				Location	2016	2017	2018	2019	2020	2021	2022
GR8	Greenwich	Greenwich - Woolwich Flyover	Roadside	Inner	DC	DC	DC	DC	DC	DC	13
GR9	Greenwich	Greenwich - Westhorne Avenue	Roadside	Inner	13	11	11	10	8	7	DC
HK6	Hackney	Hackney - Old Street	Roadside	Inner	DC	DC	DC	DC	DC	DC	DC
HF4	Hammersmith and Fulham	Hammersmith and Fulham - Shepherd's Bush	Roadside	Inner	DC	DC	DC	DC	DC	DC	13
HF5	Hammersmith and Fulham	Hammersmith and Fulham - Hammersmith Town Centre	Roadside	Inner				DC	14	11	10
HG1	Haringey	Haringey - Haringey Town Hall	Roadside	Inner	DC	DC	DC	DC	DC	DC	
HR1	Harrow	Harrow - Stanmore	Urban Background	Outer	11	DC	DC	DC	DC	DC	
HV1	Havering	Havering - Rainham	Roadside	Outer	12	12	11	11	9	DC	10
HI0	Hillingdon	Hillingdon - Keats Way	Suburban	Outer	DC	DC	DC	DC	DC	DC	DC
HIL4	Hillingdon	Hillingdon - Harmondsworth Os	Urban Background	Outer	6	7	6	5	DC	6	7
LH0	Hillingdon	Hillingdon - Harlington	Urban Background	Outer	10	9	9	10	8	8	

Site Code	Borough	Name	Site Type	$PM_{2.5}$ concentration [μgm^{-3}]							
				Location	2016	2017	2018	2019	2020	2021	2022
LHR2	Hillingdon	Hillingdon - Heathrow	Airport	Outer	9	9	9	9	7	7	8
LHRBR	Hillingdon	Hillingdon - Heathrow Bath Road	Roadside	Outer				DC	DC	DC	9
T55	Hillingdon	Hillingdon - Heathrow Green Gates	Airport	Outer	9	8	9	8	7	7	8
HS4	Hounslow	Hounslow - Chiswick	Urban Background	Inner	DC	DC	15	13	10	10	12
HS5	Hounslow	Hounslow - Brentford	Roadside	Outer	DC	DC	13	13	11	10	10
KC1	Kensington and Chelsea	Kensington and Chelsea - North Ken	Urban Background	Inner	12	12	9	10	8	9	9
KC2	Kensington and Chelsea	Kensington and Chelsea - Cromwell Road	Roadside	Inner	17	DC	DC	DC	DC	DC	10
KF1	Kensington and Chelsea	Kensington and Chelsea - North Ken FIDAS	Urban Background	Inner		DC	9	10	8	9	DC
KT4	Kingston	Kingston - Tolworth Broadway	Roadside	Outer	DC	DC	DC	DC	DC	DC	DC
LB4	Lambeth	Lambeth - Brixton Road	Kerbside	Inner	DC	DC	DC	DC	DC	DC	11
HP1	Lewisham	Lewisham - Honor Oak Park	Urban Background	Inner			DC	10	9	9	8

Site Code	Borough	Name	Site Type	$PM_{2.5}$ concentration [μgm^{-3}]							
				Location	2016	2017	2018	2019	2020	2021	2022
LW2	Lewisham	Lewisham - New Cross	Roadside	Inner	19	15	15	15	13	DC	DC
LW5	Lewisham	Lewisham - Deptford	Urban Background	Inner				DC	DC	DC	10
NM2	Newham	Newham - Cam Road	Roadside	Inner	DC	DC	DC	DC	DC	DC	10
NM3	Newham	Newham - Wren Close	Urban Background	Inner	DC	DC	DC	DC	DC	DC	11
TL6	Newham	Newham - Britannia Gate TFL	Roadside	Inner					DC	DC	12
RB7	Redbridge	Redbridge - Ley Street	Urban Background	Outer	DC	DC	DC	DC	11	10	7
TD0	Richmond	Richmond - National Physical Laboratory	Urban Background	Outer	DC						
TD5	Richmond	Richmond - Teddington Bushy Park	Suburban	Outer	9	10	11	12	8	8	9
SK6	Southwark	Southwark - Elephant and Castle	Urban Background	Central	DC	DC	DC	DC	DC	9	10
SK8	Southwark	Southwark - Tower Bridge Road	Roadside	Inner				DC	DC	10	10
SKA	Southwark	Southwark - Lower Road	Roadside	Inner					DC	9	10
SKB	Southwark	Southwark - Vicarage Grove	Roadside	Inner						10	10

Site Code	Borough	Name	Site Type	$PM_{2.5}$ concentration [μgm^{-3}]							
				Location	2016	2017	2018	2019	2020	2021	2022
SKC	Southwark	Southwark - South Circular Road	Roadside	Inner						DC	8
ST5	Sutton	Sutton - Beddington Lane north	Industrial	Outer	14	DC	12	12	9	10	11
TH002	Tower Hamlets	Tower Hamlets - Victoria Park	Urban Background	Inner	DC	DC	DC	10	12	9	9
TH2P	Tower Hamlets	Tower Hamlets - Roadside	Roadside	Inner				DC	12	11	9
TH4	Tower Hamlets	Tower Hamlets - Blackwall	Roadside	Inner	DC	13	13	DC	9	DC	DC
WL1	Waltham Forest	Waltham Forest - Dawlish Road	Urban Background	Inner	DC	DC	DC	12	10	9	10
CE2	Westminster	Westminster - Waterloo Pl (Crown Estate)	Roadside	Central					DC	9	10
MY7	Westminster	Westminster - Marylebone Road FDMS	Kerbside	Inner	16	15	16	14	9	11	
WM0	Westminster	Westminster - Horseferry Road	Urban Background	Central	DC	DC	DC	DC	11	10	8
WMD	Westminster	Westminster - Elizabeth Bridge	Roadside	Central					DC	10	10