MAYOR OF LONDON

AIR QUALITY IN LONDON 2016-2020

London Environment Strategy: Air Quality Impact Evaluation

October 2020

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Greater London Authority
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We are grateful to Dr Gary Fuller, of the Environmental Research Group who kindly provided peer review support and comments on this report.

Since the completion research that underpins this report, the Environmental Research Group from King's College London have transferred to Imperial College London. For details on the group please see: http://www.imperial.ac.uk/school-public-health/environmental-research-group/. As part of this move the London Air Quality Network and the LondonAir website also transferred to Imperial but the website address, www.londonair.org.uk remains unchanged.

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Key Findings

This report assesses the improvements in London's air quality between 2016 and 2020 using data from London's air quality monitoring network and modelling from the Environmental Research Group at King's College London (now Imperial College London). It also evaluates the actions taken by the Mayor of London and Transport for London which have contributed to these changes. Since 2016 there have been dramatic improvements in London's air quality, especially for nitrogen dioxide (NO_2). However, this report also highlights the challenge London still faces, with parts of the city still exceeding legal limits for NO_2 and the majority of the city still exceeding the World Health Organization (WHO) guideline limit for fine particulate matter ($PM_{2.5}$). These pollutants have documented long-term health as well as economic impacts which fall unequally on those least likely to contribute to the problem.

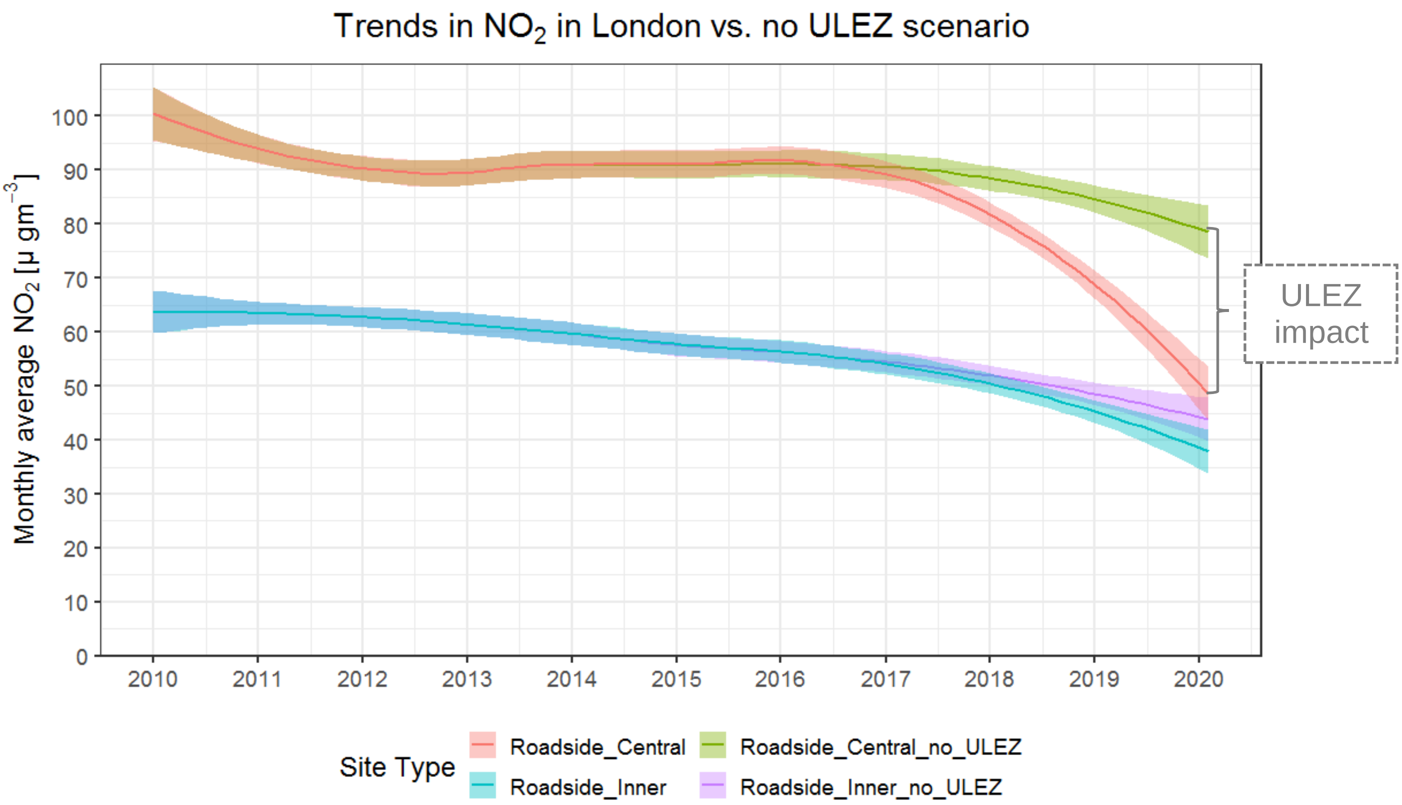
Key findings from modelling by King's College London include:

- The number of Londoners living in areas exceeding the legal limit for NO_2 fell from over 2 million in 2016 to 119,000 in 2019, **a reduction of 94 per cent**.
- The number of state primary and secondary schools in areas exceeding the legal limit for NO_2 fell from 455 in 2016 to 14 in 2019, **a reduction of 97 per cent**.
- In 2016 monitoring sites in London recorded over 4,000 hours above the short-term legal limit for NO_2. In 2019 this reduced to just over 100, **a reduction of 97 per cent**.
- Between 2016 and 2019 the reduction in annual average nitrogen dioxide at roadside sites in central London was **five times the national average reduction**. This shows the most significant improvements in London have been driven by local, as opposed to national, policy.
- In 2016 the whole of London exceeded the World Health Organization (WHO) guideline limit for $PM_{2.5}$. In 2019, for the first time, areas in outer London were within

the limit. However, there is work still to be done. **99 per cent of Londoners still live in areas exceeding the WHO $PM_{2.5}$ limit.**

This report also provides an update on the impact of the central London ULEZ in its first ten months of operation. Key findings include:

- Trend analysis shows that in February 2020 concentrations of NO_2 at roadside sites in the central zone were 39 µgm[3] less than in February 2017[1], **a reduction of 44 per cent**.



- After the first ten months of operation **the average compliance rate with the ULEZ standards was 79 per cent** in a 24 hour period (77 per cent in congestion charging

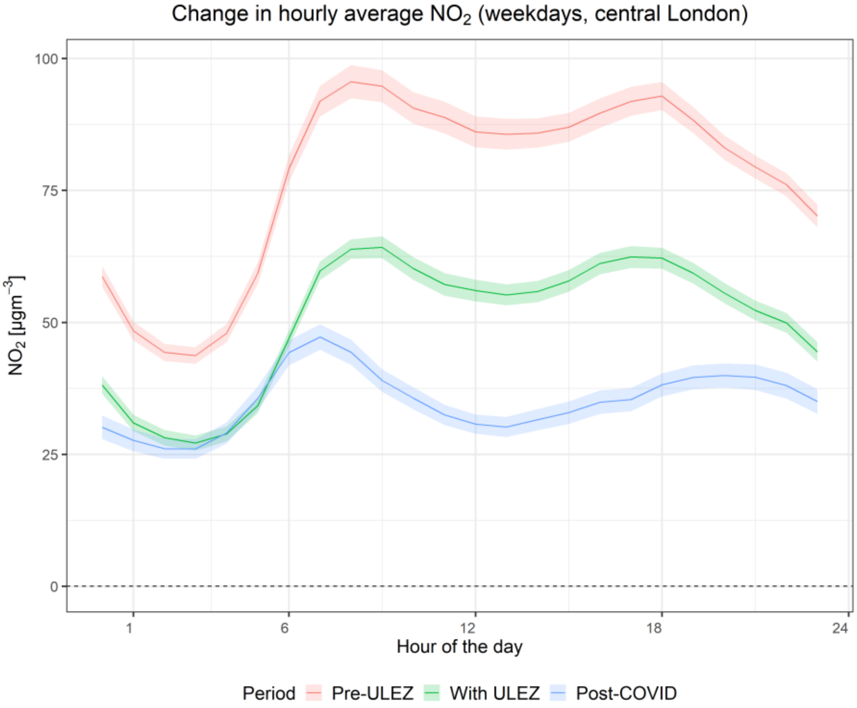
[1] In February 2017 the Mayor confirmed the introduction of the T-charge as a stepping-stone for the ULEZ and this can be seen as the start of the accelerated change in the vehicle fleet as Londoners and businesses prepared for the new schemes and buses on routes in central London began to be upgraded to become ULEZ compliant

hours). This is significantly higher than 39 per cent in February 2017 and 61 per cent in March 2019, the month before the ULEZ was introduced.

- Analysis to determine the directly attributable impact of the ULEZ shows that in the first two months of 2020 NO_2 concentrations at roadside locations in central London were on average 29 µgm^3 lower than they would have been without the scheme, equating to **a reduction of 37 per cent**.
- Preliminary estimates indicate that by the end of 2019 the ULEZ had reduced NO_x emissions from road transport in the central zone by 230 tonnes, **a reduction of 35 per cent**.
- The ULEZ also helping to tackle the climate emergency, preliminary estimates indicate that by the end of 2019 the ULEZ had reduced CO_2 emissions from road transport in the central zone by 12,300 tonnes, **a reduction of 6 per cent**.

In March 2020 strict measures were introduced to tackle the COVID-19 pandemic in London. This had a significant impact on London's air quality. It is important that the change in air pollution concentrations as a result of COVID-19 measures are framed in the context of the substantial improvements in London's air quality in recent years.

- In 2020, before measures to address the COVID outbreak were introduced, **hourly average NO_2 at all sites in central London had already reduced by over one third (35 per cent)** compared to the same period in 2017. During lockdown there was an additional reduction of 26 per cent, this reduction was even higher at roadside sites.



1. Introduction

The World Health Organization (WHO) states air pollution is the biggest environmental risk to health. Air pollution now causes more deaths globally than smoking and is described by the WHO as the “new tobacco”. In London in 2016 two million Londoners, including 400,000 children, lived in areas that exceeded legal limits of air pollution, with thousands of Londoners dying prematurely because of exposure to air pollution every year.

In May 2016 Sadiq Khan was elected Mayor of London and identified air pollution as one of the key challenges facing Londoners and outlined his plans to tackle it in the London Environment Strategy, Mayor’s Transport Strategy and London Plan. This report has been compiled four years later, at the end of the mayoral term, to evaluate the programmes that have been delivered and progress made towards bringing London’s air pollution back to safe levels.

This report first outlines the key policies that have been enacted in the last four years. The next chapter evaluates the improvements measured at the over one hundred air quality monitoring stations across London. The report also includes Londonwide modelling by King's College London, comparing 2016 and 2019. An update is also provided on the impact of the central London Ultra Low Emission Zone and the twelve Low Emission Bus Zones.

The Mayor of London has many of the powers required to tackle road transport emissions. Much of London's road transport pollution, especially NO_x emissions, will be addressed by the plans in the London Environment Strategy and Mayor's Transport Strategy. These policies will also greatly reduce $PM_{2.5}$ emissions from road transport.

However, as a result of this powerful action, the emissions from non-transport sources will increase as a proportion of London's total emissions. The Mayor has much weaker – and often no – powers to tackle these sources. The London Environment Strategy laid out the additional powers required by the Mayor to tackle non-transport sources in order to achieve the WHO recommended guideline limit for $PM_{2.5}$ by 2030.

Nitrogen dioxide (NO_2)

Nitrogen dioxide is a toxic gas that is produced during combustion processes, such as in the engine of a car. NO_2 aggravates respiratory diseases – particularly asthma – and stunts the development of children's lungs. Around half of the NO_2 pollution in London comes from road transport, which is why the highest concentrations of NO_2 in London are recorded at busy roadside locations.

In the European Union (EU), the legal annual mean air quality limit value (the "legal limit") for NO_2 is 40 micrograms per cubic metre of air (μgm^{-3}). This limit has been transposed into UK law. This is the same as the World Health Organization (WHO) guideline[2] limit for NO_2. The EU also set a short-term hourly average limit of 200 μgm^{-3} not to be exceeded more than 18 times per year, which has also been transposed into UK law.

Fine particulate matter ($PM_{2.5}$)

[2] Air quality guidelines – global update 2005, World Health Organization

$PM_{2.5}$, also known as fine particulate matter, refers to particles or liquid droplets in the air that have a diameter less than 2.5 micrometres across (that is one 400th of a millimetre, about 3 per cent of the diameter of a human hair). Some $PM_{2.5}$ is naturally occurring, such as dust and sea salt, and some is man-made, such as particulates from vehicle exhausts. Around a third of the $PM_{2.5}$ emitted in London comes from road transport, with a large proportion also coming from construction, wood burning and commercial cooking. However, around half of $PM_{2.5}$ measured in London's air comes from transboundary sources outside of London.

Based on current evidence $PM_{2.5}$ is thought to be the air pollutant which has the greatest impact on human health. Both short and long-term exposure to $PM_{2.5}$ increases the risk of mortality from lung and heart diseases as well as increasing hospital admissions. Children growing up exposed to $PM_{2.5}$ are more likely to have reduced lung function and develop asthma. The UK Government's Committee on the Medical Effects of Air Pollution (COMEAP) estimate exposure to $PM_{2.5}$ attributes to 29,000 premature deaths in the UK every year[3].

The World Health Organization acknowledges that current evidence suggests no safe level for $PM_{2.5}$. However, the WHO set a guideline limit which reflects the level at which increased mortality from exposure to $PM_{2.5}$ is likely. This recommended guideline limit is an annual mean concentration of 10 μgm^{-3}.

In the EU, the legal annual mean air quality limit value for $PM_{2.5}$ is 25 μgm^{-3}. This limit has been transposed into UK law. The Mayor does not think this limit is strong enough to ensure the protection of human health. That is why in the London Environment Strategy the Mayor set out the ambition that all of London will have concentrations of $PM_{2.5}$ within the World Health Organization guideline limit by 2030.

The UK Government has now published its Environment Bill, which only mandates a target is set before 2022. It does not commit to the legally binding WHO based $PM_{2.5}$ limits that are needed for the protection of human health. Nor does it include the new powers for London and other UK cities need to achieve them.

[3] The Mortality Effects of Long-Term Exposure to Particulate Air Pollution in the United Kingdom, COMEAP, 2010

Particulate matter (PM_{10})

Particulate matter (PM_{10}) refers to a complex mixture of particles or liquid droplets in the air that have a diameter less than 10 micrometres across. Road transport accounts for around a quarter of PM_{10} in London, with a large proportion also coming from construction, wood burning and commercial cooking.

The EU sets legal limits for both long-term and short-term concentrations PM_{10}. The annual average legal limit is 40 μgm^{-3}. This is double the 20 μgm^{-3} limit recommended by the World Health Organization. The EU short-term limit for PM_{10} is a 50 μgm^{-3} average over 24 hours, not to be exceeded more than 35 times a year.

2. Overview of policies and action

The Mayor is committed to cleaning up London's air and is delivering an ambitious action plan to tackle this problem. He has almost doubled Transport for London's (TfL's) spend on air quality and has introduced hard-hitting measures to reduce air pollution and protect public health. These include introducing the world's first Ultra Low Emission Zone in central London, cleaning up London's bus and taxi fleets and taking action to reduce exposure to air pollution at some of the city's most polluted schools, nurseries and hospitals.

This chapter provides an overview of the key policies and action that has been taken in London between 2016 and 2020 to improve air quality. This does not cover the full range of the Mayor's policies and proposals, for this please see the London Environment Strategy, Mayor's Transport Strategy and London Plan strategy documents.

Ultra Low Emission Zone

Toxicity "T" charge

In February 2017 the Mayor announced the first emissions-based charge to be introduced in London, the Toxicity or "T-charge". The charge was introduced in October 2017 in the existing Congestion Charging Zone. Vehicles that did not meet Euro 4 standards, typically those diesel and petrol vehicles registered before 2006, were charged £10 to enter the central zone during Congestion Charging hours (in addition to the Congestion Charge).

Central London Ultra Low Emission Zone

In April 2019 London introduced the world's first Ultra Low Emission Zone (ULEZ) in central London. The ULEZ has the toughest standard of any city in the world, and unlike the T-charge, the ULEZ operates 24 hours a day, 7 days a week (except for Christmas day).

In April 2019 the Congestion Charge Ultra Low Emission Discount was also replaced with the Cleaner Vehicle Discount (CVD). To be eligible for the CVD the vehicle must meet the Euro 6 emission standard, emit no more than 75g/km CO_2 and have a minimum 20-mile zero emission capable range. This will tighten in 2021 to apply only to zero emission vehicles and be removed at the end of 2025.

In October 2020 the Londonwide Low Emission Zone standards for heavy vehicles will be tightened to match the ULEZ standards. In October 2021 the ULEZ will expand up to the

North and South Circular roads. For more information about the central London ULEZ please see the Chapter 5, later in this report.

Scrappage schemes

To help Londoners meet the ULEZ standards the Mayor has launched two vehicle scrappage schemes. The first scheme for vans and minibuses focuses on supporting charities and small businesses with up to 50 employees. The second “car and motorcycle scrappage scheme” is to help low income and disabled Londoners scrap older, more polluting cars and motorcycles in favour of cleaner vehicles and greener forms of transport. More information about the scrappage schemes is available on the Ultra Low Emission Zone pages of TfL website.

Improvements to the TfL bus fleet

London has the largest bus fleet in Europe with over 9,000 buses, of which around 70 per cent are double deck. The Mayor is spending more than £300 million to transform London’s bus fleet by retrofitting thousands of buses and the phasing out of pure diesel double-deck buses since 2018.

All buses in central London now meet or exceed the cleanest Euro 6 standards. TfL is on track to meet its target of all buses Londonwide meeting or exceeding the cleanest standard by October 2020, reducing emissions from the TfL bus fleet by 80 per cent compared to 2016 levels. This will make the whole of London a Low Emission Bus Zone.

Low Emission Bus Zones

Currently TfL all buses in the central zone meet or exceed the cleanest standards. The Low Emission Bus Zones (LEBZ) are 12 areas that were prioritised to receive bus upgrades first. The LEBZ were selected because they were in the worst air pollution hotspots outside central London and buses contributed significantly to road transport emissions. The LEBZ have reduced roadside concentrations by an average of 23 μgm^3, a reduction of 28 per cent since they were introduced. For more information about the Low Emission Bus Zone please see the Chapter 6, later in this report.

Bus Electrification

London faces a unique challenge in electrifying its bus fleet due to the number of double deck buses in the fleet. Double deck buses are less common than single deck, as a result there are less manufacturers and vehicle models available. There are also additional technical challenges when producing double deck electric buses due to their weight.

In 2016 London had 22 electric buses, by February 2020 there were 280. In 2019 the routes 43 and 134 became the UK's first routes to be fully serviced by electric double deck buses. There are now three fully electric, double deck bus routes and London has the largest electric bus fleet in Western Europe.

Improvements to the taxi fleet

Since January 2018 all newly registered taxis have been required to be Zero Emission Capable (ZEC). Taxi drivers were supported in the move to cleaner cabs by TfL's Taxi Delicensing Scheme which launched in 2017. The scheme provided payments of up to £5,000 to retire the oldest taxis from London licensing. In 2019, this scheme was restructured to provide top level payments of £10,000. There are now over 3,500 ZEC taxis and over 70 dedicated taxi rapid charge points.

In late 2019 the first ever fully electric London black cab, the Dynamo, was launched. By February 2020, just a few months later there were already 18 in circulation.

In November 2019 TfL introduced changes to the taxi age limit to speed up the process of the dirtiest vehicles being replaced with zero emission capable cabs. Improvements to the taxi fleet are expected to reduce NO_x emissions from taxis by around 65 per cent in 2025, compared to 2013.

To address congestion related to the increase in the number of Private Hire Vehicles, since April 2019 they have no longer been exempt from the Congestion Charge. The licensing requirements for Private Hire Vehicles also changed in January 2020 so that between 1 January 2020 to 31 December 2022:

- PHVs under 18 months old must be zero emission capable and meet the Euro 6 emissions standard when licensed for the first time.

- PHVs over 18 months old must have a Euro 6 (petrol or diesel) engine when licensed for the first time.

From 1 January 2023:

- All PHVs licensed for the first time must be ZEC and meet the Euro 6 emissions standard.

More information on changes to the rules for Private Hire Vehicles see the "Emissions standards for PHVs" pages on the TfL website.

Preparing for electrification

As London's fleet of electric vehicles (EVs) grows, it is important the right charging infrastructure is installed in the right places. In 2018 the Mayor created a new taskforce to help increase infrastructure for electric vehicles in London. The aim of the EV Infrastructure Taskforce, the first of its kind in the UK, was to make it easier for Londoners to switch to electric vehicles and build towards the Mayor's aims for London to become a zero carbon.

The EV Infrastructure Taskforce brought together representatives from business, energy, infrastructure, Government and the London boroughs. In 2019 the taskforce published a Delivery Plan with recommendations on how, when and where to increase London's electric vehicle infrastructure up until 2025.

Key to the uptake of EVs in London, especially for vehicles like taxis covering large mileage, is the introduction of sufficient charge points, including rapid charge points. The rapid charging network allows faster and more efficient charging of electric vehicles so drivers can charge while on the move, usually in 20-30 minutes. In 2016 there were around 40 rapid charge points in London. There are now over 400, of which TfL have already provided more than 260 and are on track to reach 300 by the end of 2020.

To do this TfL are investing £18 million and working with the boroughs and other organisations to provide the rapid charging points London needs. Rapid charge points have been installed on arterial roads which are owned and maintained by TfL, borough roads, car parks and private land, including Heathrow Airport and several Shell service stations.

The Mayor’s London Local Air Quality Management Framework

The Mayor’s London Local Air Quality Management (LLAQM) framework is the statutory process used by local authorities to review and improve air quality within their areas. The framework also provides resources, co-ordination, and support for boroughs on their air quality work.

The LLAQM framework is managed by the Mayor of London, and is the system to which all London boroughs must adhere to, as outlined by the Secretary of State in the national Local Air Quality Management guidance (which applies to the rest of England).

In October 2019 the LLAQM was revised in order to:

- Ensure boroughs are taking ambitious action, which is properly co-ordinated at the regional level, and which supports Mayoral objectives including those set out in the London Environment Strategy.
- Ensure that London boroughs continue to work towards achievement of World Health Organization guideline limits for pollutants even when legal limits are met.
- Update information in the guidance documents to reflect new research, policies, and priorities.

More information on the LLAQM can be found on the Working with the London boroughs pages of the City Hall website.

Mayor’s Air Quality Fund

The Mayor’s Air Quality Fund (MAQF) is an ongoing fund to support projects by London boroughs to improve air quality. The MAQF is designed to help the boroughs trial local measures to cut pollution and exposure to pollution. They also share learnings and outcomes with each other, including via a series of workshops and events.

The second round of the MAQF ran from April 2016 to April 2019 and included the delivery of five ground-breaking Low Emission Neighbourhoods, which enabled a range of targeted and holistic improvements at pollution hotspots in Greenwich Town Centre, Marylebone, Shoreditch, Ilford, and the Barbican.

Some key highlights from the second round of the MAQF include:

- Reducing 16.5 tonnes of PM and 297 tonnes of NOx emissions through the South London Non-Road Mobile Machinery project.
- A 16 per cent reduction in older more polluting vehicles parking in the Marylebone LEN as a result of the diesel surcharge on metered parking, with no displacement to nearby areas.
- The world's first Ultra Low Emission Streets in the Hackney LEN, contributing to an estimated 16 per cent reduction in NO_x emissions across the LEN.

Further information on the outcomes from the second round of funding can be found in the Mayor's Air Quality Fund Completion Report.

Projects supported in the third round of the MAQF were announced in June 2019 (to be completed by April 2022). This round is supporting four more Low Emission Neighbourhoods and 11 other innovative air quality projects which are tackling emissions from sources such as river vessels, engine idling, and construction.

Improving air quality at schools and nurseries

Through the Mayor's School and Nursery Air Quality Audits Programme, audits were undertaken at 50 primary schools and 20 nurseries in some of the city's most polluted areas. The audits made recommendations to reduce emissions and exposure, including:

- Moving school entrances and play areas away from busy roads.
- 'No engine idling' schemes to reduce emissions from the school run.
- Reducing emissions from boilers, kitchens and other sources.
- Local road changes including better road layouts, restricting the most polluting vehicles around schools and pedestrianisation by school entrances.
- Adding green infrastructure like 'barrier bushes' along busy roads and in playgrounds to help filter fumes.
- Encouraging students to walk and cycle to school along less polluted routes.

Each school was given £10,000 from the Mayor which the school and/or borough match funded. In addition, at least £300,000 was made available through the Mayor's Greener City Fund to deliver greening measures at any school in an area exceeding legal pollution limits.

The audits also provided a generic toolkit that can be used by other schools, with advice from the local borough, as a basis for their own audits. A number of boroughs (to date, Newham, Islington, Southwark, Westminster and Brent) have now agreed to fund air quality audits at all their state primary schools, meaning an additional 200 schools will benefit from the auditing process.

The Mayor also funded £250,000 to pilot the audit concept in nurseries in London's most polluted areas, including £4,500 to be provided to each nursery to implement the recommendations of the audits. The nursery audit programme also included testing air filtration equipment to determine if this could have a positive effect on reducing indoor levels of air pollutants.

The study found that air filtration systems (AFS) can be effective in the right circumstances at reducing $PM_{2.5}$, and to a lesser extent NO_2, in a real-world nursery environment. Given the dynamic nature of classrooms, with opened doors and windows, constantly varying occupancy and pupil movements, the fact that AFS have been able to demonstrate a positive impact upon the nursery indoor air quality was an encouraging outcome of this trial. However, there are currently no UK design standards, minimum performance requirements or testing criteria for air filtration systems. The Mayor has written to the Secretary of State for Environment, and the Secretary of State for Education, calling on the Government to urgently address this in order to help educational establishments and local authorities make a more informed choice about whether to install an AFS. This will ensure they are in a better position to do all they can to reduce exposure to air pollution as safely and effectively as possible.

You can learn more about the audits programme from the Mayor's School Air Quality Audit Programme and Mayor's Nursery Air Quality Audit Programme pages of the City Hall website.

The London Plan

The new London Plan introduces significant new protections for local and regional air quality, including in relation to the most damaging $PM_{2.5}$ particulates. For the first time the largest developments will be required to take an Air Quality Positive approach, meaning that they will have to consider in depth how they will contribute to improving local and regional air quality through intelligent approaches to design, the urban realm and heating and transport infrastructure.

Borough development plans and other area-based policies will no longer be allowed to use improvements in air quality delivered by the Mayor as “headroom” to allow polluting developments to go ahead.

More broadly the new London Plan requires all new developments to take into account local air quality to ensure that they suitable for their use and location, that they are Air Quality Neutral, that they do not have unacceptable impacts during construction and that they take particular care to protect the most vulnerable and most disadvantaged members of society.

The best results for air quality cannot be delivered in isolation. The need to consider air quality has also been written into the top-level Good Growth policies and other key policies around urban design, the public realm, industrial intensification and energy.

Alerts and monitoring

In August 2016, the Mayor announced the introduction of air quality alerts at bus stops, tube stations and road-sides across London to notify Londoners during the worst episodes of air pollution.

In January 2018 the Mayor funded a new partnership with King’s College London to improve how the public, particularly those who are most vulnerable, are informed about incidents of poor air quality in the capital. Timely air pollution information gives disadvantaged people a chance to act to protect themselves, for example by reducing their exposure, or simply by carrying their medication.

For the first time schools, care homes, and GPs' surgeries were directly notified of moderate, high and very high pollution episodes. During and on the day before high and very high air pollution days, air quality alerts are displayed at:

- 2,500 bus countdown signs and river pier signs across London.
- 140 road-side dot matrix message signs on the busiest main roads into London, with instructions to switch engines off when stationary to reduce emissions.
- Electronic update signs in the entrances of all 270 London Underground stations.

Social media channels are also utilised to make people aware of moderate air quality incidents, which currently occur around 40 times a year.

London's air quality is constantly monitored at over 100 different locations. These sites are operated and funded by London boroughs, Transport for London and Heathrow Airport. They make the data publicly available in real time from the two organisations they contract to undertake the monitoring:

- the London Air website of King's College London records real time and historical monitoring data for the majority of the boroughs.
- Ricardo Energy and Environment measures and manages the data for the remainder of the boroughs, more information is on the Air Quality England website.

Analysis of the data from these monitors from the last four years is presented later in this report. The boroughs also collect measurements of NO_2 at over 1,000 locations Londonwide using diffusion tubes. These measurements are reported in the boroughs' Annual Status Reports.

Breathe London

As part of the Mayor's commitment to explore new technologies and to give people the information they need to manage their exposure to pollution London has piloted the Breathe London low cost sensor network. Breathe London is a new £1.5 million air quality monitoring system which measures pollution levels in thousands of hot spots across the city including near schools, hospitals, construction sites and busy roads. Over 100 sensors have been fitted to lampposts and buildings, dedicated Google Street View cars took measurements across the city and personal wearable monitors measured the exposure of 250 children on their route to school.

Breathe London also integrates the data from London's existing monitors. The data collected enables us to better target and monitor the impact of policies (including the central ULEZ) as well as providing information to Londoners to reduce their exposure to air pollution. For example, the Google Car data has shown pollution can vary by as much as 50 per cent depending on which route you select to walk or cycle.

Breathe London has secured philanthropic funding to extend the pilot phase until summer 2020, after which the pilot phase will come to an end and City Hall will take ownership of and fund the network.

Non-Road Mobile Machinery Low Emission Zone

Non-Road Mobile Machinery (NRMM) is a broad category which includes mobile machines, and transportable industrial equipment or vehicles which are fitted with an internal combustion engine and not intended for transporting goods or passengers on roads. NRMM, particularly from the construction sector, is a significant contributor to London's air pollution. In the absence of the proper powers to act on NRMM emissions the NRMM Low Emission Zone uses the Mayor's and London boroughs' planning powers to control emissions from NRMM used on construction sites.

London is the only city in the world to have an NRMM Low Emission Zone. In a similar way to the Ultra Low Emission Zone, the NRMM Low Emission Zone requires that all engines with a power rating between 37 kW and 560 kW meet an emission standard based on the engine emission "stage". The London Environment Strategy included the ambitious target for all NRMM used in construction in London to be emission by 2040.

Green Infrastructure

The Mayor has supported the roll out of green infrastructure to improve local air quality. This has included the publication of a report on Using Green Infrastructure to Protect People from Air Pollution. In addition £300,000 was made available from the Mayor's Greener City Fund to deliver greening measures at any school in an area exceeding legal pollution limits.

Since 2016 City Hall has helped to pay for more than 280,000 new trees to be planted across London. Some of these trees have been planted in parks, some on streets, and others have been given away to Londoners to plant at home and in school playgrounds.

Opposition to the third runway at Heathrow

The Mayor and TfL have actively engaged with and responded to consultations related to UK aviation in general, and Heathrow expansion in particular, to ensure that the views of London and Londoners are represented.

The Mayor put forward the case that the Airports National Policy Statement (ANPS) for Heathrow expansion failed to adequately address a number of fundamental environmental and social problems which would arise from a third runway. These included implications for the UK's obligations in respect of climate change, the significant health impacts of the proposal in terms of air quality and noise, and the adverse impact on surface transport infrastructure which would result from the huge increase in staff, passenger and freight movements. The Mayor joined with the London boroughs of Hammersmith and Fulham, Hillingdon, Richmond and Wandsworth, the Royal Borough of Windsor and Maidenhead and Greenpeace in bringing a legal challenge against the designation of the ANPS by way of judicial review. Transport for London (TfL) was an interested party in the proceedings.

At the first judicial review the Mayor's legal action secured a number of vital concessions, including that meeting air quality obligations was the "reddest of red lines", meaning that the third runway could not proceed without significant protection for air quality in London. In February 2020 the Mayor's position was further vindicated when the designation of the ANPS was ruled unlawful by the court of appeal because ministers did not adequately take into account the Government's climate change commitments.

National and international leadership

In the past four years London has shown national and international leadership in the field of air quality. Including:

- In 2017 London was the first world megacity to join the Breathe Life Campaign, a pledge to meet World Health Organization limits for $PM_{2.5}$ by 2030.
- In 2017 the Mayor became co-chair of the C40 Cities Air Quality Network with Bengaluru, helping cities develop policies to tackle air quality and climate change together.
- London has hosted two national air quality summits, bringing together central Government, Metro Mayors and cities leaders from across the UK.
- In October 2019 London hosted the Mayor of London's International Air Quality Conference, held in partnership with the World Health Organization. During the conference academics and medical professionals offered insights into the research and analysis underpinning ground-breaking action from across the globe.

- London was awarded C40 Cities Bloomberg Clean Air Award 2019 for introducing the central London Ultra Low Emission Zone.

Research, evaluation and guidance

Since 2016 City Hall has published a large amount of research, guidance and tools to inform Londoners about the impact of air pollution in London, and what action they can take to minimise their own impact and exposure, including:

- The London Environment Strategy and Mayor's Transport Strategy.
- The London Atmospheric Emissions Inventory (LAEI 2016).
- A report on air pollution exposure and inequality in London, seeking to identify whether air pollution had a role in health and social inequality and the degree to which it could be quantified.
- An interactive air quality map showing levels of air pollution in London and where interventions are located.
- A health report Modelling the long-term health impacts of changing exposure to NO_2 and $PM_{2.5}$ in London which estimated the long term health benefits delivered by the Mayor's policies and savings to the NHS and social care system.
- A Cleaner Vehicle Checker which informs Londoners if their cars and vans meet the ULEZ standards, as well as the level of NO_x pollution they emit in real-world driving conditions.
- The Electric Vehicle Infrastructure Delivery Plan.
- A generic air quality audits toolkit to be used by schools, with advice from the local borough, as a basis for their own audits.
- A report on the effectiveness of Air Filtration Systems at six nurseries partaking in the Mayor's Nursery Air Quality Audits Programme.
- A monitoring guidance report for Londoners who want to undertake their own air quality monitoring.
- A new NRMM register to log equipment being used in the NRMM Low Emission Zone
- A report on Using Green Infrastructure to Protect People from Air Pollution.
- A report on how London can meet World Health Organization guidelines for $PM_{2.5}$ by 2030.

- Guidance on cleaner fuels and stove options.
- A report on the Breathe London Wearables Study, investigating the exposure of 250 children on their journey to and from school.
- Central London ULEZ - Six Month Report evaluating the impact of the central London Ultra Low Emission Zone (ULEZ) in its first six months of operation, building on the four month and one month reports.
- Low Emission Bus Zones Evaluation Report which evaluated the impact of the 12 LEBZ once they were all operational, building on the half way report.
- Health Impact Assessment of Air Pollution on Asthma in London which provided a modelled estimate of the impact of air pollution in London on asthma admissions.
- A report on Domestic Boiler Emission Testing investigating if boilers performed within the manufacturers' estimates for emissions in the real world.
- An Indoor Air Quality Report reviewing the air quality in London schools, including an extensive literature review and six case studies.
- A study by King's College London investigating Air quality at Lambeth-Brixton Road.

3. Trends in concentrations from air quality monitoring

This chapter presents data from London's air quality monitoring stations from 2016 to 1 March 2020 for nitrogen dioxide (NO_2), fine particulate matter ($PM_{2.5}$) and particulate matter (PM_{10}).

London's air quality is constantly monitored at over 120 different locations. These sites are operated and funded by the London boroughs, Transport for London and Heathrow and City airports. Data from these sites is publicly available in real time from the two organisations they contract to undertake the monitoring:

- King's College London record real time and historical monitoring data for the majority of boroughs and make the data available through the London Air website.
- Ricardo Energy and Environment record real time and historical monitoring data for the remaining boroughs and make the data available from the Air Quality England website.

For some of the analysis in this chapter air quality monitoring stations are grouped by site type, focusing on the two most common types of monitoring site in London; roadside and urban background.

Types of monitoring sites

- **Roadside sites** are within 1 – 5m of a busy road and usually located around adult breathing height. Roadside sites enable us to track and understand changes in air pollution concentrations from traffic. These sites give the best estimate of public exposure on busy roads. Roadside sites are useful for identifying air quality hotspots due to traffic that may have potential health impacts - especially those frequented by large numbers of pedestrians.
- **Urban background sites** are located further away from sources of emissions and are not influenced by one single nearby pollution source. In London, traffic is the main source for background sites to avoid and there are guidelines about how close background sites can be to roads. The benefit of urban background sites is they are usually representative of all the other urban background locations within an area of several square kilometres.

London also has a small number of industrial sites. Pollution levels at industrial sites are influenced predominantly by emissions from nearby industrial sources such as power generation, incinerators and waste treatment plants. Concentrations measured at industrial sites are only representative of the immediate local area.

Air pollution concentrations are highly sensitive to the prevailing meteorology, such as wind speed, wind direction, precipitation and temperature, as well as the long-range transport of pollutants from outside London. Many pollutants have a seasonal cycle too. This seasonal cycle may be caused by seasonally varying emissions, such as heating in wintertime or agricultural emissions during the spring. Seasonal cycles can also be caused by other factors including sunlight that can induce chemical reactions between air pollutants. These seasonal and day-to-day variations can make is difficult to assess short term trends or the impact of interventions such as the ULEZ. One approach to minimise the impact of these variations is to consider a sufficiently long time period. Another is to use statistics to smooth out short-term variability, this reduces the impact of weather and seasonal factors.

Location of monitoring sites

- **Central sites** are located within the central charging zone, this does not include sites on the boundary roads.
- **Inner sites** are located outside the central charging zone, but within (and not including) the North and South circular roads. This is the area that will be covered by the expanded Ultra Low Emission Zone in October 2021.
- **Outer sites** are located outside (and including) the North and South circular roads, but within Greater London.

Note, monitoring data for late 2019 and 2020 is yet to be ratified and may be subject to change. Data from the previous year is usually ratified in the first few months of the next year, it is not likely to change substantially or effect overall trends.

Nitrogen dioxide (NO_2)

The number of monitoring sites in London recording NO_2 has increased from 115 in 2016 to 122 in 2019.

Table 1. Number of hours exceeding the NO_2 hourly limit value

Name	Site Type	Borough	2016	2017	2018	2019	2020*
Wandsworth - Putney High Street	Kerbside	Wandsworth	1,270	76	26	11	0
Lambeth - Brixton Road	Kerbside	Lambeth	538	75	82	0	0
Wandsworth - Putney High Street Façade	Roadside	Wandsworth	401	9	5	0	0
Kensington and Chelsea – Knightsbridge	Roadside	Kensington and Chelsea	262	0	42	15	3
Westminster - Strand (Northbank BID)	Roadside	Westminster	233	26	33	20	0
Westminster - Oxford Street	Kerbside	Westminster	168	1	3	0	0
City of London - Walbrook Wharf	Roadside	City of London	144	126	36	7	0
City of London - Beech Street	Roadside	City of London	143	67	27	5	0
Kensington and Chelsea - Earls Court Road	Roadside	Kensington and Chelsea	121	24	28	2	0
Westminster - Marylebone Road	Kerbside	Westminster	62	38	29	0	0
Kensington and Chelsea – Chelsea	Roadside	Kensington and Chelsea	54	4	0	0	0
Camden - Holborn (Bee Midtown)	Kerbside	Camden	46	10	0	0	0
Ealing - Hanger Lane Gyratory	Roadside	Ealing	45	10	0	2	0
Wandsworth – Putney	Urban Background	Wandsworth	45	7	0	0	0
Camden - Euston Road	Roadside	Camden	39	25	18	6	0
Hounslow – Gunnersbury	Roadside	Hounslow	39	46	0	0	0
Camden - Swiss Cottage	Kerbside	Camden	37	1	2	1	0
Hammersmith and Fulham - Shepherd's Bush	Roadside	Hammersmith and Fulham	33	20	8	3	0
Brent – Ikea	Roadside	Brent	32	32	1	7	0
Brent - Neasden Lane	Industrial	Brent	25	17	0	2	0
Greenwich - Woolwich Flyover	Roadside	Greenwich	24	7	0	0	0
Sutton - Worcester Park	Kerbside	Sutton	24	11	7	9	0
Wandsworth - Lavender Hill	Roadside	Wandsworth	23	0	0	0	0
Ealing - Western Avenue	Roadside	Ealing	22	0	0	0	0
Sutton – Wallington	Kerbside	Sutton	22	1	0	0	0
Hammersmith and Fulham - Hammersmith Town Centre	Roadside	Hammersmith and Fulham	0	0	0	2	3
		All other sites	150	147	17	22	0
		Londonwide total	**4,002**	**780**	**364**	**114**	**6**

*to 1 March 2020

Table 1 shows the number of hourly exceedances for each year from 2016 to 2020 for the 25 sites that breached 18 permitted exceedances of the legal hourly limit of NO_2 in 2016. The bottom row is the Londonwide total for all sites that recorded monitoring data in that year. For 2020 data is shown for the period to 1 March 2020. For a full list of hours exceeding the legal limit in 2016 please see the Air pollution monitoring data in London: 2016 – 2020 report.

In 2016 monitoring sites in London recorded over 4,000 hours above the hourly limit for NO_2. In 2019 this reduced to just over 100, a reduction of 97 per cent. There were 25 monitoring sites in 2016 that breached the 18 permitted hours exceeding the hourly limit for NO_2. In 2019 there was only one, the monitoring site on the Strand in Westminster, which breached in July. From 2004 to 2017 the limit value was been breached within the first week of each year.

There have been huge improvements at sites such as Putney High Street, where thanks to the introduction of the Low Emission Bus Zone the number of hours exceeding the legal threshold for NO_2 fell from over 1,200 in 2016 to just 11 in 2019. In addition, 2019 was the first year since the monitor was installed at Putney High Street in 2009 that it did not breach the 18 permitted exceedances of legal hourly limit.

Similarly, at Brixton Road the introduction of the Low Emission Bus Zone has resulted in a large improvement in local air quality. In 2016 the monitor at Brixton Road recorded over 530 hours above the hourly threshold limit. Technical difficulties meant that for the first four months of the 2019 the monitor was offline, however in the last three quarters of the year the monitor did not record a single hour over the threshold limit.

Sites across central London have seen huge reductions in the number of hourly exceedances, in part due to the central London Ultra Low Emission Zone and improvements to the bus fleet. For example, the monitor on Oxford Street recorded 180 hours over the safe threshold in 2016 and did not record a single hour over the limit in 2019. The number of hourly exceedances at all sites that recorded one hour over the threshold limit between 2016 to 2020 can be found in the Air pollution monitoring data in London: 2016 – 2020 report.

Annual average NO_2

In this section, to ensure the comparison is fair, results are only compared for the 86 sites that have enough data capture in both 2016 and 2019. To be included in this analysis monitoring sites had to collect data for over 75 per cent of the year, which is the requirement made by the European Environment Agency for annual statistics to be included in air quality assessments[4].

[4] Air quality annual statistics calculated by the EEA

Table 2. Annual average NO_2, (legal limit 40 µgm^{-3})

Name	Site type	Borough	2016	2017	2018	2019	Reduction 2016 - 2019
Wandsworth - Putney High Street Facade	Roadside	Wandsworth	98	60	61	49	50%
Wandsworth - Putney High Street	Kerbside	Wandsworth	125	76	68	69	45%
Westminster - Oxford Street	Kerbside	Westminster	87	72	63	53	39%
Camden - Swiss Cottage	Kerbside	Camden	66	53	54	41	37%
Camden - Holborn (Bee Midtown)	Kerbside	Camden	84	74	DC	54	36%
Kensington and Chelsea - Chelsea	Roadside	Kensington and Chelsea	78	63	60	53	32%
Kensington and Chelsea - Earls Court Road	Roadside	Kensington and Chelsea	86	78	79	59	32%
Kensington and Chelsea - Knightsbridge	Roadside	Kensington and Chelsea	80	66	66	55	31%
Lambeth - Bondway Interchange	Industrial	Lambeth	68	65	54	47	31%
Westminster - Marylebone Road	Kerbside	Westminster	89	84	85	63	29%
City of London - Beech Street	Roadside	City of London	85	80	69	60	29%
Sutton - Wallington	Kerbside	Sutton	63	53	47	46	28%
Hammersmith and Fulham - Shepherd's Bush	Roadside	Hammersmith and Fulham	79	77	71	58	27%
Westminster - Strand	Roadside	Westminster	101	92	88	74	26%
Kensington and Chelsea - Cromwell Road	Roadside	Kensington and Chelsea	58	51	48	44	25%
Hounslow - Gunnersbury	Roadside	Hounslow	59	53	45	45	24%
City of London - Walbrook Wharf	Roadside	City of London	92	92	87	71	23%
Hounslow - Brentford	Roadside	Hounslow	57	54	48	44	22%
Camden - Euston Road	Roadside	Camden	88	83	DC	69	21%
Tower Hamlets - Blackwall	Roadside	Tower Hamlets	59	56	51	47	20%
Ealing - Western Avenue	Roadside	Ealing	60	51	DC	48	19%
Greenwich - Woolwich Flyover	Roadside	Greenwich	64	65	57	52	18%
Hackney - Old Street	Roadside	Hackney	57	57	50	46	18%
Hounslow - Chiswick	Urban Background	Hounslow	50	53	47	41	18%
Brent - Ikea	Roadside	Brent	76	72	71	63	17%
Wandsworth - Tooting High Street	Roadside	Wandsworth	59	54	53	49	17%
Ealing - Hanger Lane Gyratory	Roadside	Ealing	75	72	68	64	15%
Hillingdon - Keats Way	Urban Background	Hillingdon	52	53	46	44	14%
Ealing - Horn Lane	Industrial	Ealing	48	45	44	42	13%
Waltham Forest - Crooked Billet	Kerbside	Waltham Forest	62	61	58	54	12%
Hillingdon - Hayes	Roadside	Hillingdon	47	47	43	41	12%
Hillingdon - Heathrow	Airport	Hillingdon	48	48	43	42	11%
Sutton - Worcester Park	Kerbside	Sutton	57	52	52	51	10%
Croydon - Norbury	Kerbside	Croydon	47	48	49	44	6%
		Londonwide	**50**	**46**	**43**	**39**	**21%**

DC denotes insufficient data capture

Table 2 shows the annual average NO_2 from 2016 to 2019 at the 36 monitoring sites which still exceeded the limit value in 2019. For a full list of the 86 sites with comparable data please see the Air pollution monitoring data in London: 2016 – 2020 report.

Between 2016 and 2019 there were large reductions in annual average NO_2 at monitoring sites across London, with an average reduction of 21 per cent across the network. The largest reduction was measured at Putney High Street Façade, with a reduction of 50 per cent. This shows the huge benefit of the first Low Emission Bus Zone which was introduced at Putney High Street in 2017.[5]

Every single one of the 86 monitoring sites that had sufficient data in both 2016 and 2019 recorded a reduction in annual average NO_2. The annual average NO_2 across all sites fell from 50 μgm^{-3} in 2016 to 39 μgm^{-3} in 2019, a reduction of around a quarter. This brings the average across the network below the legal limit for the first time.

However, there is still more work to be done. In 2019, 34 of the 86 comparable sites exceeded the annual legal limit for NO_2. This is a significant reduction when compared to the 56 of the 86 sites that exceeded in 2016, a reduction of 39 per cent, but it highlights the need for schemes such as ULEZ expansion that will further reduce NO_2 emission from road transport. In 2019 a number of roadside sites, including Euston Road and Marylebone Road, exceeded the 40 μgm^{-3} limit for NO_2 by over 50 per cent.

As seen with the short-term peaks in NO_2, one of the largest reductions was measured at Putney High Street, with annual mean NO_2 falling from 125 μgm^{-3} in 2016 to 69 μgm^{-3} in 2019, a reduction of 45 per cent.

Trends in Nitrogen Dioxide (NO_2)

In this analysis monitoring sites are grouped by site type and location. Trends are then calculated using the statistical software package R, the full method is published in the Central London ULEZ - Six Month Report. Grouping sites together reduces the impact of local factors (e.g. road works near a site) to provide a better estimate for all sites with the same characteristics.

[5] Low Emission Bus Zones Evaluation Report, GLA, 2019

Figure 1 shows trends in NO_2 at monitoring sites in London from January 2010 to February 2020. The graph shows the monthly average NO_2 grouped by site type and location, statistically smoothed to reduce the impact of weather. Note, data in Figure 1 for late 2019 and 2020 is yet to be ratified.

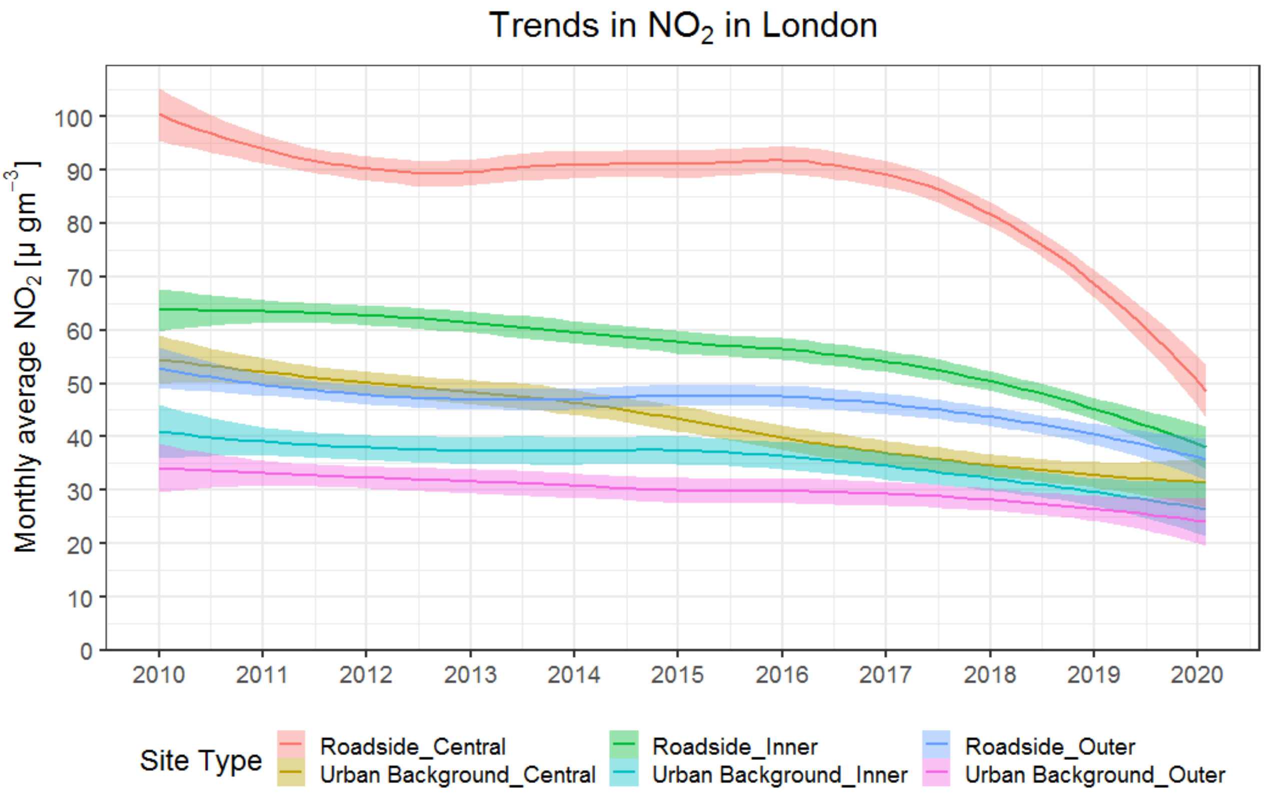


Figure 1: Monthly average NO_2 concentrations in London from 2010 to 2020

There was a slight downward trend in concentrations of NO_2 at monitoring sites across London between 2010 and 2017, most likely reflecting turnover of vehicles in the passenger fleet. However, at central London roadside locations (top red line), an accelerated reduction in NO_2 began in 2017, becoming a steeper downward curve from 2018 to February 2020, far exceeding improvements expected from routine turnover of the vehicle fleet. A similar, though less pronounced, downward trend also occurred in inner London roadside locations (second from top green line). This is in line with when some vehicle owners began to prepare for the ULEZ and buses on routes in central London began to be upgraded to become ULEZ compliant. It is clear the that central London ULEZ, including the upgrading of the bus fleet in central London has contributed to the sharp decrease in NO_2 at roadside sites in the central zone, delivering real world health benefits and bringing NO_2 closer to compliance with the legal limit.

Table 3. Annual average NO_2 by zone and site type

Year	Average NO_2 [μgm^{-3}]					
	Roadside Central	Background Central	Roadside Inner	Background Inner	Roadside Outer	Background Outer
2016	91	38	55	36	47	30
2017	86	36	53	34	45	29
2018	76	34	48	31	42	28
2019	61	32	42	28	39	26
Reduction [μgm^{-3}]	30	6	13	7	8	4
Reduction [per cent]	33%	16%	24%	20%	18%	14%

Table 3 shows annual mean NO_2 grouped by site type and location. The largest reduction, 6 μgm^{-3}, was recorded at roadside sites in central London, a reduction of 33 per cent. The next largest reductions were at roadside sites in inner and outer London. This indicates that reductions in NO_2 were predominantly driven by reduction in traffic emissions, with the largest reduction measured in the area where the central London Ultra Low Emission Zone was introduced. This will be explored in more detail in Chapter 5.

The table below shows the annual average reduction in NO_2 nationally compared to London. National data comes from concentrations of nitrogen dioxide national statistics published by Defra.

Table 4. Reduction in annual average NO_2 from 2016 - 2019

	National average	Central London	Inner London	Outer London
Roadside	6 ugm^3	30 ugm^3	13 ugm^3	8 ugm^3
Background	4 ugm^3	6 ugm^3	7 ugm^3	4 ugm^3

For all site types and areas of London the reduction in annual average NO_2 exceeded the national average reduction, with the largest reduction in central London where the ULEZ was introduced in April 2019. The reduction at roadside sites in central London was five times the national average reduction. This is a strong indication the most significant improvements in London are driven by local (as opposed to national) policy.

Fine particulate matter ($PM_{2.5}$)

Road transport is the largest single source of fine particulate matter in London, accounting for around 30 per cent of emissions[6]. 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. There is also a large proportion of $PM_{2.5}$ emitted within London that the Mayor does not currently have the powers to address, for example wood burning. In addition, a growing proportion of road transport $PM_{2.5}$ emissions are now non-exhaust emissions including road wear, resuspension of road dust and tyre and brake wear.

The number of sites measuring $PM_{2.5}$ increased from 37 in 2016 to 39 in 2019, but many sites struggled with insufficient data capture. There are less $PM_{2.5}$ monitors as historically the focus for boroughs was on pollutants with a larger local component, and that exceeded the legal limits, such as NO_2 and PM_{10}. Due to its smaller size $PM_{2.5}$ is also more difficult to measure, this is why there are more issues with data capture. There were 16 monitoring sites that had sufficient data capture in both 2016 and 2019. These are included in the comparison in

[6] London Atmospheric Emissions Inventory 2016 (LAEI 2016)

Annual average $PM_{2.5}$

Table 5.

Annual average $PM_{2.5}$

Table 5. Annual mean $PM_{2.5}$ (WHO guideline limit 10 µgm^{-3})

Name	Site type	Borough	2016	2017	2018	2019	Reduction 2016 - 2019
Hillingdon - Harmondsworth Os	Urban Background	Hillingdon	6.1	6.8	5.9	5.1	18%
Hillingdon - Heathrow	Airport	Hillingdon	9.4	9.1	9.1	8.6	8%
Greenwich - Westhorne Avenue	Roadside	Greenwich	12.8	11.4	10.9	10.5	18%
Greenwich - A206 Burrage Grove	Roadside	Greenwich	14.6	12.2	12.9	10.8	26%
Greenwich - Eltham	Urban Background	Greenwich	11.7	12.4	10.1	10.8	7%
Havering - Rainham	Roadside	Havering	12.2	11.5	10.9	11.1	9%
Camden - Swiss Cottage	Kerbside	Camden	15.0	15.9	11.3	11.1	26%
City of London - Sir John Cass School	Urban Background	City of London	14.8	DC	12.2	11.4	23%
Sutton - Beddington Lane north	Industrial	Sutton	14.4	DC	11.6	11.7	19%
Richmond - Teddington Bushy Park	Urban Background	Richmond	8.9	10.0	11.4	11.8	-32%*
Camden - Bloomsbury	Urban Background	Camden	12.0	13.5	10.4	12.2	-2%
Greenwich - Plumstead High Street	Roadside	Greenwich	14.0	12.0	12.7	13.4	5%
Camden - Euston Road	Roadside	Camden	16.7	13.6	DC	13.6	18%
Bexley - Slade Green FDMS	Urban Background	Bexley	10.6	10.8	11.9	13.7	-29%*
Westminster - Marylebone Road FDMS	Kerbside	Westminster	15.9	15.4	15.8	14.3	10%
Lewisham - New Cross	Roadside	Lewisham	18.9	15.5	15.0	15.2	20%
		Londonwide average	**13.0**	**12.2**	**11.5**	**11.6**	**9%**

* increase between 2016 and 2019

Between 2016 and 2019 there were reductions in annual average $PM_{2.5}$ at most monitoring sites across London, with an average reduction 9 per cent across the network.

However, of the 16 monitoring sites that had sufficient data in both 2016 and 2019, three of the urban background sites recorded an increase from 2016 to 2019. This highlights the need for more action to reduce levels of $PM_{2.5}$ regionally, nationally and internationally as over half of London's $PM_{2.5}$ pollution comes from outside London.

Of the 27 sites with sufficient data capture in 2019, only 5 met the WHO limit of 10 µgm^{-3}, meaning over 80 per cent of sites recorded levels of $PM_{2.5}$ above the WHO guideline limit – though all sites met the EU limit of 25 µgm^{-3}.

Trends in fine particulate matter ($PM_{2.5}$)

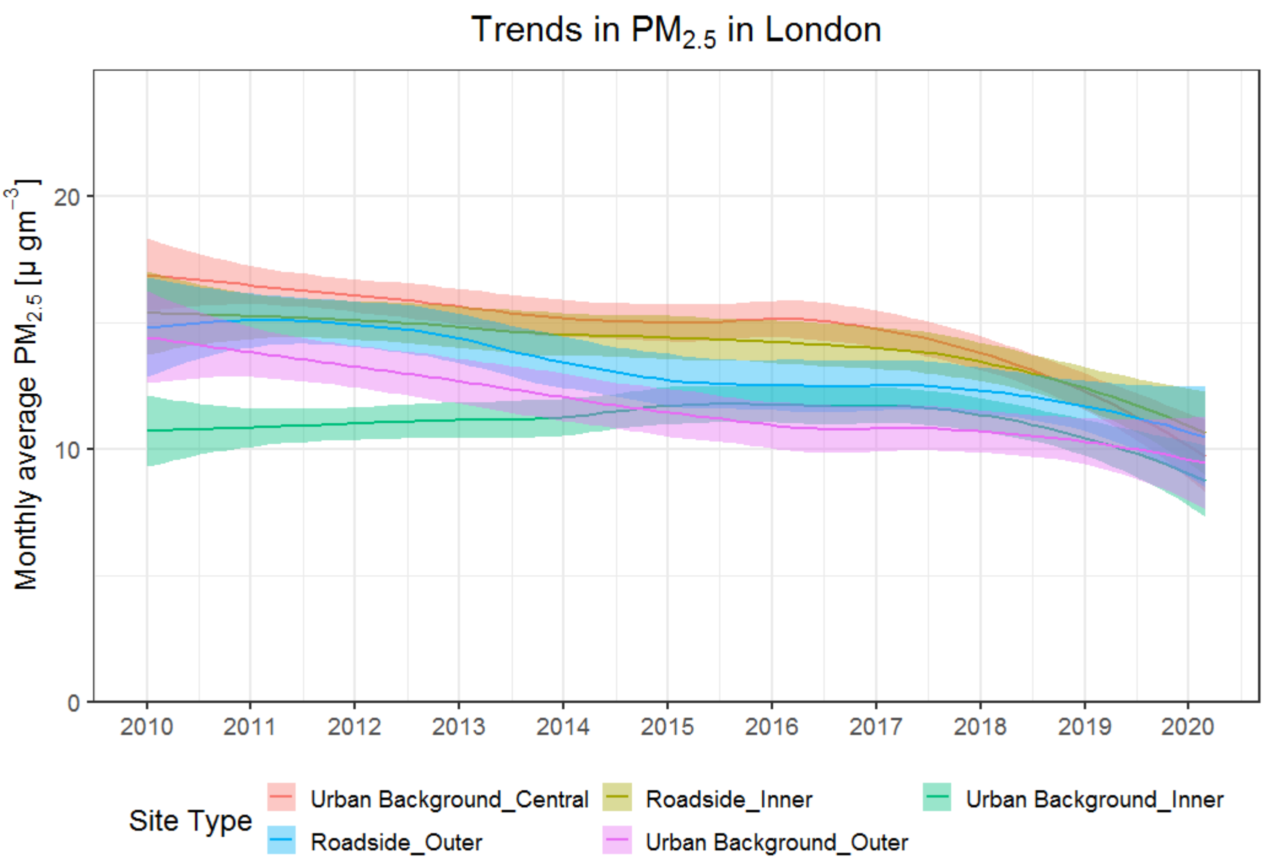


Figure 2: Monthly average $PM_{2.5}$ concentrations in London from 2010 to 2020

As around half of London's fine particulate matter comes from sources outside the city, the reduction in $PM_{2.5}$ emissions reported in Chapter 4 of this report has had a less pronounced impact on concentrations than seen for NO_2, for which London-based sources are dominant. Figure 2 shows there has been a downward trend in $PM_{2.5}$ since 2010 which continued after the introduction of the ULEZ.

In addition, there are far fewer $PM_{2.5}$ monitoring sites than there are for NO_2, and there are no $PM_{2.5}$ roadside monitoring sites in central zone. This is because in the automatic network the focus of these sites is on urban background locations that are representative of a larger area. However, the newly established Breathe London network has greatly increased $PM_{2.5}$ monitoring across London, with over 20 monitors in central London alone. This network provides indicative measurements. Information on accuracy of new lower-cost monitoring methods is being analysed in order understand how the data from lower-cost sensors compares with standard reference grade equipment used in the LAQN and AQE sites.

Table 6. Annual average $PM_{2.5}$ by zone and site type

Year	Average $PM_{2.5}$ [μgm^{-3}]					
	Roadside Central	Background Central	Roadside Inner	Background Inner	Roadside Outer	Background Outer
2016		15	15	12	13	11
2017		15	13	11	12	11
2018		13	13	11	13	11
2019		12	13	10	12	11
Reduction [μgm^{-3}]		3	2	1	1	0
Reduction [per cent]		20%	14%	11%	9%	0%

Table 6 shows the shows the annual mean $PM_{2.5}$ grouped by site type and location. The largest reduction, 3 μgm^{-3}, was recorded at background sites in central London, a reduction of 20 per cent. It is likely these sites are more affected by local changes (e.g. reduction in road traffic emissions) than background sites in outer London. The next largest reduction was at roadside inner sites. As mentioned previously, $PM_{2.5}$ is more complex due to the large transboundary contribution. The fact that there was no change in average concentrations at background sites in outer London indicates the improvements in central London have been driven by local measures, rather than regional or international improvements. This highlights the need for local action but also the need for more action at a regional, national and international level to tackle the sources of $PM_{2.5}$ emissions.

Particulate matter (PM_{10})

The number of monitoring sites recording PM_{10} has risen from 109 in 2016 to 112 in 2019.

Table 7 shows the number of days exceeding the 24 hour PM_{10} limit for between 2016 and 2020 for all sites which exceeded the 35 permitted hours above 50 μgm^{-3} in 2016.

In 2016 there were 995 recorded exceedances of the 24 hour limit value for $PM_{2.5}$. In 2019 this reduced to 802, a reduction of 19 per cent.

In 2016, four monitoring sites breached the 24 hour legal limit for PM_{10}. This reduced to just one in 2019, Lambeth Bondway Interchange which provisional data indicates also exceeded the limit for 2020 on 21 February. Preliminary research indicates this monitoring site may be being impacted by a nearby ventilation shaft from the Tube. The Mayor has instructed TfL to trial new approaches to reduce pollution which is transported from the Tube network to the air above ground via ventilation systems.

Table 7. Number of days exceeding the PM_{10} 24 hr limit

Name	Site type	Borough	2016	2017	2018	2019	2020*
Brent - Ikea	Roadside	Brent	45	41	37	29	6
City of London - Upper Thames Street	Roadside	City of London	45	30	25	14	2
Lambeth - Bondway Interchange	Industrial	Lambeth	43	64	45	74	40
Wandsworth - Battersea	Roadside	Wandsworth	43	16	10	14	2
		All other sites	819	662	336	671	28
		Londonwide	**995**	**773**	**453**	**802**	**78**

*To 1 March 2020

Annual average PM_{10}

Table 8 shows the annual mean PM_{10} concentrations from 2016 to 2019 for the 25 sites that still exceeded the WHO recommended limit of 20 μgm^{-3} in 2019. There were 72 monitoring sites that had sufficient data capture for both 2016 and 2019. For a full list of the 72 sites with comparable data please see the Air pollution monitoring data in London: 2016 – 2020 report.

Between 2016 and 2019 there were reductions in annual average PM_{10} at the majority of monitoring sites across London, with an average reduction of 11 per cent across the network, rising to 14 per cent for roadside sites.

Of the 72 monitoring sites that had sufficient data for comparison, 8 of the sites recorded a small increase from 2016 to 2019. This highlights the need for more local action to reduce particulate matter, particularly from non-transport sources.

Table 8. Annual mean PM_{10} (WHO guideline limit 20 µgm^{-3})

Name	Site type	Borough	2016	2017	2018	2019	Reduction 2016 - 2019
Brent - Ikea	Roadside	Brent	33	33	32	30	10%
Brent - Neasden Lane	Industrial	Brent	27	27	28	26	3%
Camden - Euston Road	Roadside	Camden	24	20	DC	21	12%
City of London - Beech Street	Roadside	City of London	25	23	25	22	14%
City of London - Upper Thames Street	Roadside	City of London	35	32	32	27	22%
Ealing - Hanger Lane Gyratory	Roadside	Ealing	24	26	28	25	-4%
Ealing - Horn Lane	Industrial	Ealing	28	27	25	28	2%
Ealing - Horn Lane TEOM	Industrial	Ealing	26	26	26	25	3%
Ealing - Western Avenue	Roadside	Ealing	30	26	28	26	14%
Greenwich - Woolwich Flyover	Roadside	Greenwich	29	25	25	22	25%
Hackney - Old Street	Roadside	Hackney	24	19	22	22	11%
Hammersmith and Fulham - Shepherd's Bush	Roadside	Hammersmith and Fulham	26	27	26	24	10%
Havering - Romford	Roadside	Havering	21	DC	20	21	2%
Hillingdon - Hayes	Roadside	Hillingdon	28	27	30	28	2%
Hillingdon - Oxford Avenue	Urban Background	Hillingdon	20	19	24	24	-19%
Hounslow - Brentford	Roadside	Hounslow	30	28	25	21	30%
Hounslow - Heston	Roadside	Hounslow	25	22	21	21	16%
Islington - Holloway Road	Roadside	Islington	21	21	20	21	1%
Lambeth - Brixton Road	Kerbside	Lambeth	36	35	DC	25	30%
Southwark - A2 Old Kent Road	Roadside	Southwark	24	22	22	24	0%
Waltham Forest - Crooked Billet	Kerbside	Waltham Forest	29	27	27	26	10%
Wandsworth - Battersea	Roadside	Wandsworth	32	27	25	23	27%
Wandsworth - Putney High Street	Kerbside	Wandsworth	25	25	25	22	14%
Wandsworth - Tooting High Street	Roadside	Wandsworth	24	23	23	23	5%
Westminster - Marylebone Road FDMS	Kerbside	Westminster	26	24	24	22	14%
		Londonwide	**22**	**21**	**21**	**20**	**11%**

*DC = insufficient data capture

Trends in particulate matter (PM_{10})

Figure 3 shows trends in PM_{10} at monitoring sites in London from January 2010 to February 2020. The graph shows the monthly average PM_{10} grouped by site type and location, statistically smoothed to reduce the impact of weather. Note, data in Figure 3 for late 2019 and 2020 is yet to be ratified. For most locations there has been a downward trend in PM_{10} since 2010. This trend accelerated around 2017 for roadside sites in central London. There was an increase in PM_{10} concentrations at urban background sites in central London from around 2013 to 2016 but this trend reversed around 2017.

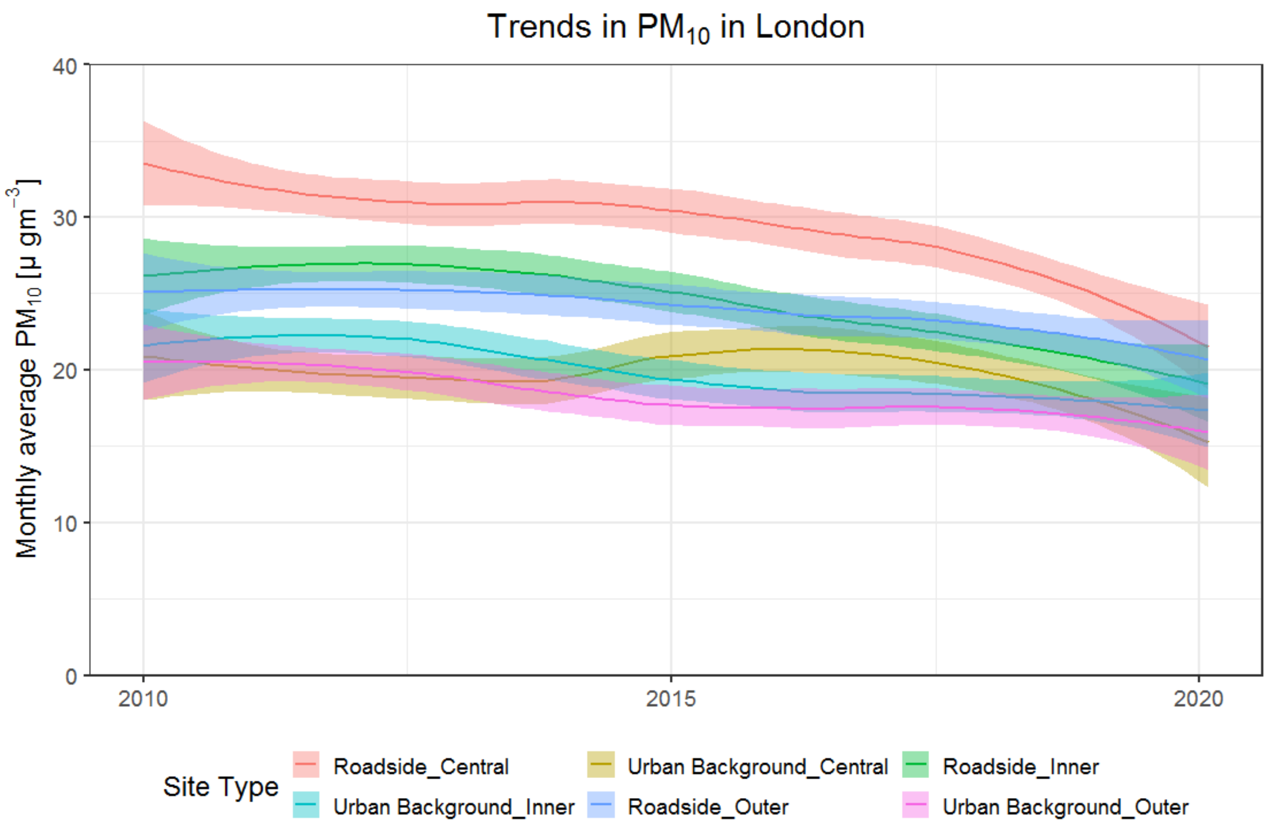


Figure 3: Monthly average PM_{10} concentrations in London from 2010 to 2020

Table 9 shows the annual mean PM_{10} grouped by site type and location. The largest reduction, 5 μgm^{-3}, was recorded at sites in central London, a reduction of around 20 per cent. As with $PM_{2.5}$ these central sites are more affected by local changes (e.g. reduction in road traffic emissions) than background sites in outer London. This is evidenced by the fact the same reduction is recorded at roadside and background sites in central London. The next largest reduction was at roadside sites in inner London. As with $PM_{2.5}$ there has been little reduction at background sites in outer London.

Table 9. Annual average PM_{10} by zone and site type (WHO guideline limit 20 μgm^{-3})

Year	Average PM_{10} [μgm^{-3}]					
	Roadside Central	Background Central	Roadside Inner	Background Inner	Roadside Outer	Background Outer
2016	29	22	24	19	24	18
2017	27	19	22	19	23	17
2018	29	19	22	18	23	18
2019	24	18	20	18	22	17
Reduction [μgm^{-3}]	5	5	3	1	2	1
Reduction [per cent]	17%	21%	14%	4%	8%	5%

Summary of trends from the air quality monitoring network

The data presented in this chapter outlines the progress that has been made between 2016 and 2020 in tackling London's toxic air pollution. The greatest progress has been made in reducing exceedances of the hourly limit for NO_2, with a reduction of 97 per cent. Similarly, good progress has been made in reducing annual average NO_2, with trend analysis indicating a reduction of between 14 – 33 per cent, with the greatest reduction at roadside sites in central London where the central London ULEZ has been introduced. Individual sites have seen reductions of up to 50 per cent at key hotspots such as Putney High Street, where the first Low Emission Bus Zone was introduced in 2017.

Progress in reducing NO_2 has been possible as in London the majority of NO_2 emissions are traffic related. The Mayor and TfL have been able to take bold action, such as introducing the world's first Ultra Low Emission Zone and cleaning up the bus and taxi fleets, that have delivered huge reductions in NO_2 between 2016 and 2020.

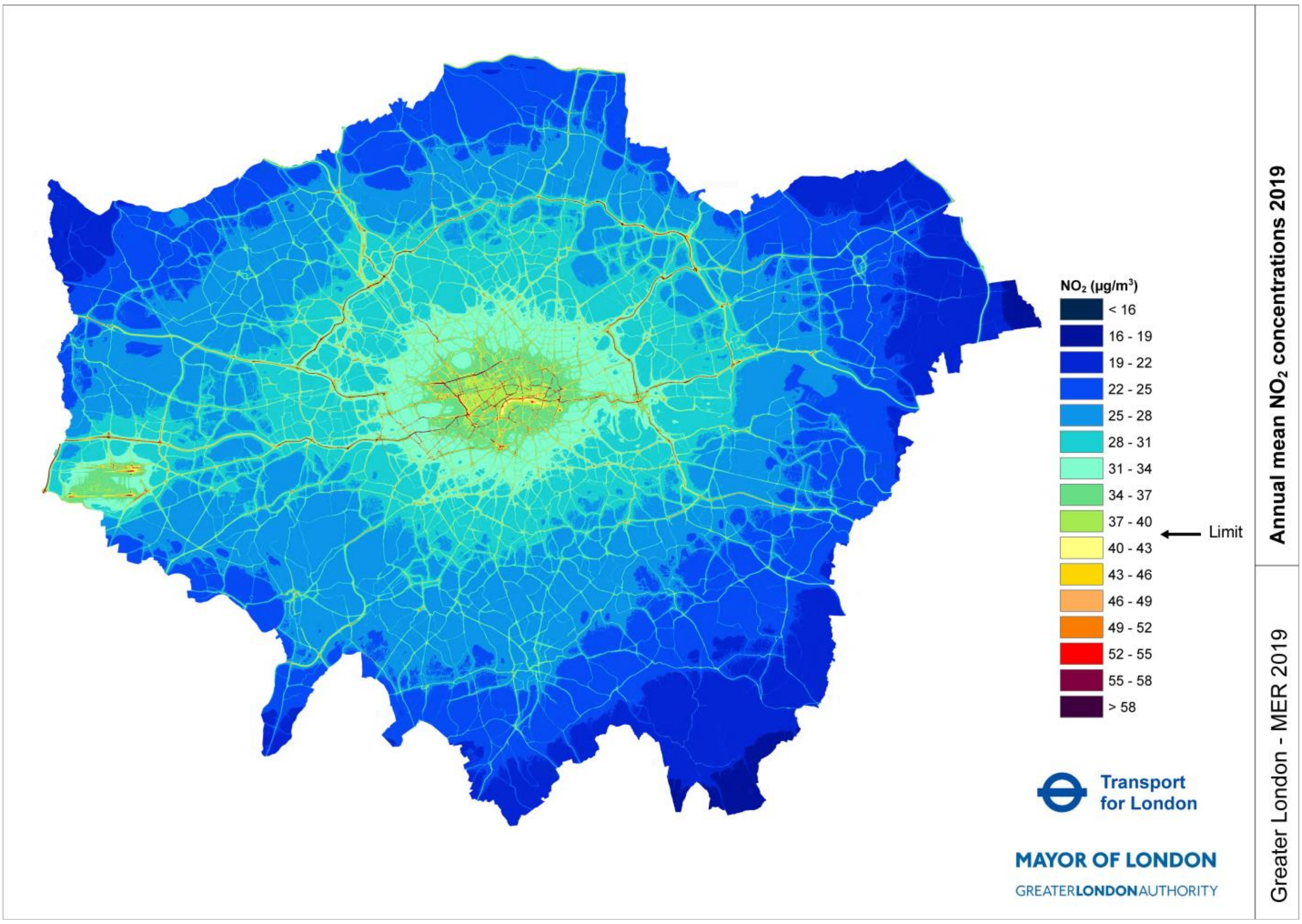
However, in 2019 many roadside sites still exceeded the annual legal limit for NO_2, some by more than 50 percent. This highlights the need for additional action to tackle road transport emissions, including the tightening of emissions standards for the London wide Low

Emission Zone for heavy vehicles and the expansion of the ULEZ to the North and South circular roads.

For particulate matter the picture is more complex. Whilst trend analysis shows there have been reductions in $PM_{2.5}$ of 20 per cent in central London, there was no improvement in concentrations at background sites in inner and outer London. More action is needed regionally, nationally and internationally because of the transboundary nature of $PM_{2.5}$.

If London is to meet the World Health Organization guideline limit for $PM_{2.5}$ by 2030 more local action is also needed. In particular to address non-transport sources such as construction and wood burning, currently sources the Mayor does not have the powers to address. More detail on this is included in the recently published $PM_{2.5}$ in London: Roadmap to meeting WHO guidelines by 2030.

4. Trends from Londonwide modelling



The previous chapter evaluated measured changes in concentrations at London's air quality monitoring stations. Even though London has one of the most extensive monitoring networks in the world, the monitoring network cannot provide Londonwide coverage. For this, dispersion modelling is required.

The modelling presented in this chapter has been undertaken by King's College London and is based on the London Atmospheric Emissions Inventory (LAEI) 2016, alongside a new MER2019 (Mayors Evaluation Report) snapshot model for 2019. It is important to note that the MER2019 is not a full LAEI model, it should be regarded as a "snapshot". Due to the time required to compile the input datasets, some input data for MER2019 has been scaled from previous years because the data for 2019 was not yet available. In addition, some of the monitoring data against which the MER2019 is validated is still provisional. This means the MER2019 results have greater uncertainty than usual LAEI modelling. Please see the Appendix for more detail.

Modelled zones in London

- **Central sites** are located within the central charging zone, this does not include sites on the boundary roads.
- **Inner sites** are located outside the central charging zone, but within (and not including) the North and South circular roads. This is the area that will be covered by the expanded Ultra Low Emission Zone in October 2021.
- **Outer sites** are located outside (and including) the North and South circular roads, but within Greater London.

Nitrogen dioxide (NO_2)

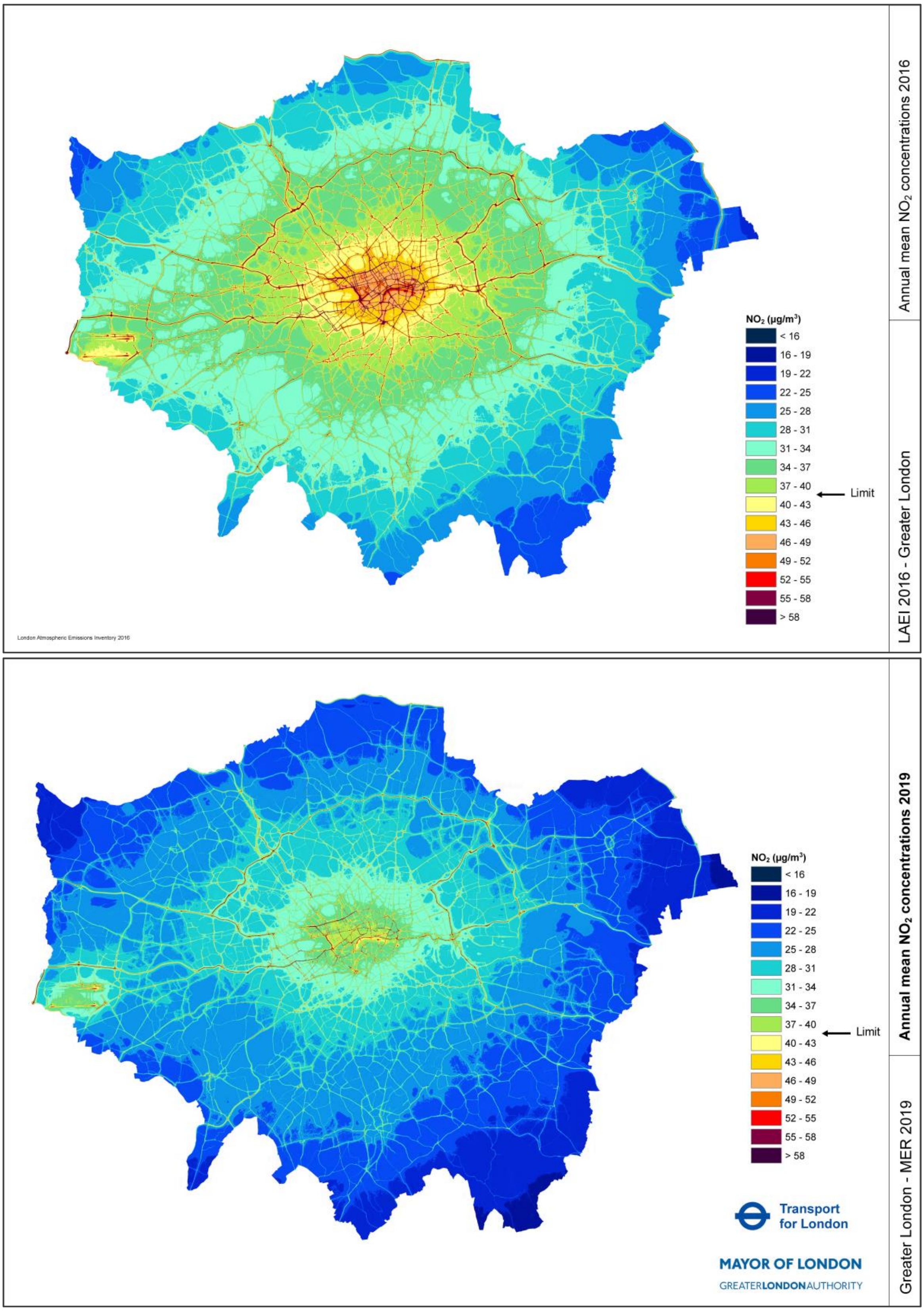


Figure 4: Annual mean NO_2 in London from LAEI 2016 (top) to MER 2019 (bottom)

Changes in NO_2 concentrations

Figure 4 shows the annual mean NO_2 concentrations from the LAEI 2016 in the top map and MER2019 in the bottom map. It is clear there have been significant improvements in concentrations of NO_2 Londonwide between 2016 and 2019, as was also reflected in monitoring trends in Chapter 3. The model estimates that on average, Londonwide NO_2 concentrations have reduced by 7.1 µgm^3, a reduction of 20 per cent.

Table 10. Reduction in average NO_2 between 2016 and 2019

Location in London	Annual average LAEI 2016 [µgm^3]	Annual average MER2019 [µgm^3]	Reduction 2016 – 2019 [µgm^3]	Reduction 2016 – 2019 [%]
Central	49.4	38.2	11.2	23%
Inner	40.4	32.0	8.4	21%
Outer	33.0	26.9	6.1	18%
Londonwide	36.4	29.3	7.1	20%

For comparison, between 2013 and 2016 there were no significant improvements in NO_2 concentrations – some areas were even estimated to increase in concentrations. Between 2013 and 2016 the number of primary schools in areas exceeding the legal limit fell slightly – from 371 to 369 – but the number of secondary schools affected grew from 81 to 86.

Number of people living in areas that exceed legal limits for NO_2

In 2016 over 2 million Londoners, including 400,000 children, lived in areas exceeding the annual mean legal limit for NO_2. In 2019, based on MER2019 snapshot modelling, this is estimated to have fallen to 119,000 people (including 21,000 children), a reduction of 94 per cent. This is much larger than the reduction in annual average NO_2. This is because in 2016 there were a large number of areas with NO_2 concentrations just above the legal limit value. The 20 per cent reduction of concentrations in 2019 means many areas are now just below the limit value.

Table 11. Number of Londoners living in areas exceeding legal limits for NO_2

Location in London	Number of Londoners in areas exceeding in 2016	Number of Londoners in areas exceeding in 2019	Reduction 2016 – 2019	Reduction 2016 – 2019 [%]
Central	195,900	40,100	155,800	80%
Inner	1,745,800	77,300	1,668,500	96%
Outer	142,700	1,600	141,100	99%
Londonwide	2,084,300	119,000	1,965,300	94%

For this analysis concentrations are averaged over census output areas, which typically represent about 350 people. There were around 6,100 output areas above the NO_2 legal limit in 2016. This is estimated to have fallen to less than 350 in 2019. An increase of just 1 μgm^3 from 2019 levels of NO_2 would result in an additional 64,000 living in areas exceeding legal limits. An increase of 2 μgm^3 would result in a return of a further 150,000 people to living in areas exceeding legal limits. This highlights the importance of continued action to tackle NO_2, as relatively small increases could bring areas home to hundreds of thousands of Londoners back over legal limits.

Road kilometres exceeding NO_2 legal limit

As around half of London's NO_2 pollution comes from road transport, busy roads are often pollution hotspots. Roads can also be areas of high exposure as some, such as busy high streets, have high footfall. Roads are also congested meaning drivers are not only contributing to local air pollution, but also being exposed to the highest levels of pollution for extended periods.

Table 12. Percentage of roads exceeding the annual mean legal limit for NO_2

Location in London	% road km exceeding in 2016	% road km exceeding in 2019	Reduction [%]
Central	100%	70%	30%
Inner	89%	24%	73%
Outer	36%	7%	82%
Londonwide	54%	14%	74%

The 2019 modelling shows a significant reduction in the proportion of road kilometres exceeding the legal limit for NO_2. This is similar to the trend observed across the monitoring network, as described the previous chapter. As with the reduction in the number of Londoners living in areas exceeding the limit, the improvements are finely balanced. Analysis of the MER2019 results show that a large proportion of roads are predicted to have concentrations just below the limit value. For example, an increase of just 1 µgm^3 Londonwide would result in an additional 23 per cent of roads exceeding the legal limit. An increase of just 2 µgm^3 would double the proportion of road lengths exceeding the limit. Again, this highlights the importance of continuing to act to reduce emissions in London.

Schools and educational establishments exceeding legal limits for NO_2

Table 13 lists the number of schools and other educational establishments that were in areas exceeding legal limits of NO_2 in 2016 and 2019.

The number of educational establishments located in areas exceeding legal limits for NO_2 has fallen from 793 in 2016 to 34 in 2019, a reduction of 96 per cent.

Table 13. Education establishments in locations exceeding the legal limit for NO_2

Establishment	Number	Number exceeding 2016	Number exceeding 2019	Reduction	Reduction [%]
Nursery	79*	30	0	30	100%
Primary	1,815	369	11	358	97%
Secondary	450	86	3	83	97%
16 plus	50	23	2	21	91%
Community Special School	84	21	0	21	100%
Higher Education Institutions	39	28	6	22	79%
Other Independent School	477	179	11	168	94%
Other Independent Special School	48	16	0	16	100%
Pupil Referral Unit	37	9		9	100%
Other	163	32	1	31	97%
Total	**3,242**	**793**	**34**	**759**	**96%**

*Data on educational establishments locations is taken from Edubase, this does not reflect the true number of nurseries in London as many are privately run and not included in Edubase.

In 2016 there were 369 state primary schools that exceeded the legal limits for NO_2. In 2019 this fell to 11, a reduction of 97 per cent. Of the eleven state primary schools still located in areas exceeding legal limits, five have already taken part in the Mayor's Air Quality Audits Programme.

It is important to note that the Londonwide modelling used for this evaluation cannot take into account local measures such as installing green infrastructure, school streets and no-idling campaigns. It is likely that where these have been implemented, pollution levels within the school grounds will be lower than indicated in this modelling. It is also important to note that where schools are located near busy roads, further action is still advised to reduce children's exposure on their journey to and from school.

Table 14 shows the locations of the educational establishments that were located in areas that exceeded legal limits in 2016 and 2019. In 2019, the remaining establishments located in areas exceeding legal limits were all in central and inner London.

Table 14. Location of educational establishments exceeding the legal limit for NO_2

Location in London	Number	Number exceeding 2016	Number exceeding 2019	Reduction	Reduction [%]
Central	104	104	24	80	77
Inner	1,366	659	10	649	98
Outer	1,772	30	0	30	100
Londonwide	**3,242**	**793**	**34**	**759**	**96**

Changes in NO_x emissions

As described earlier, the emissions reductions from the MER2019 modelling are indicative. Table 15 shows the estimated change in NO_x emissions between 2016 and 2019. The 2016 emissions are those reported in the LAEI 2016. Overall, total NO_x emissions across London reduced significantly, with an estimated reduction of 14 per cent between 2016 and 2019. The most significant reduction was in central and inner London, both estimating a 19 per cent reduction.

Table 15. Annual emissions of NO_x in tonnes

Location in London	Emission 2016 [tonnes]	Emission 2019 [tonnes]	Change [tonnes]	Change [%]
Central	2,440	1,990	-450	-19%
Inner	14,190	11,540	-2,650	-19%
Outer	26,300	23,220	-3,080	-12%
Londonwide	**42,930**	**36,750**	**-6,170**	**-14%**

Table 16 shows the estimated change in road transport NO_x emissions between 2016 and 2019. The improvement is even more significant. NO_x emissions from vehicles have reduced by a quarter across London, and were nearly halved in central London. This is mostly due to the impact of the ULEZ in central London, which has significantly reduced vehicle exhaust emissions. This will be analysed in more detail in the next chapter.

Table 16. Annual road transport emissions of NO_x in tonnes

Location in London	Emission 2016 [tonnes]	Emission 2019 [tonnes]	Change [tonnes]	Change [%]
Central	980	520	-460	-47%
Inner	6,940	4,530	-2,410	-35%
Outer	12,940	10,300	-2,640	-20%
Londonwide	**20,860**	**15,350**	**-5,510**	**-26%**

Fine particulate matter ($PM_{2.5}$)

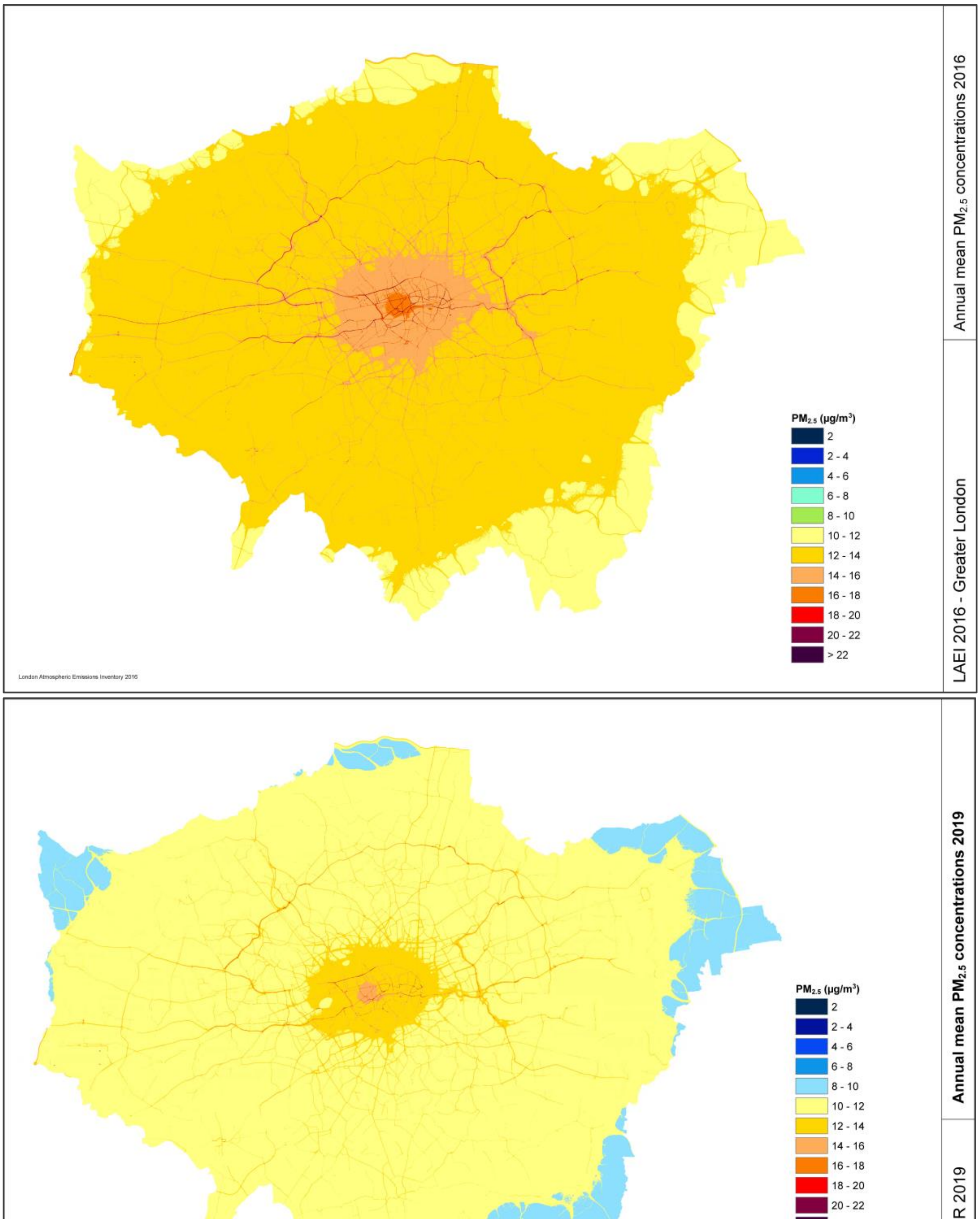


Figure 5: Annual mean $PM_{2.5}$ in London from LAEI 2016 (top) to MER 2019 (bottom)

Changes in $PM_{2.5}$ concentrations

Figure 5 shows the annual mean $PM_{2.5}$ concentrations from the LAEI 2016 in the top map and MER2019 modelling in the bottom map. In 2019, for the first time, parts of London had an annual mean below the WHO guideline limit for $PM_{2.5}$. It is clear there have been improvements in $PM_{2.5}$ between 2016 and 2019, as also reflected in monitoring trends. However, the improvements are on a smaller scale than seen for NO_2. On average, Londonwide $PM_{2.5}$ concentrations have reduced by 2.3 µgm^3, a reduction of 15 per cent.

Table 17. Reduction in annual average $PM_{2.5}$ between 2016 and 2020

Location in London	Annual average 2016 [µgm^3]	Annual average 2019 [µgm^3]	Reduction 2016 – 2019 [µgm^3]	Reduction 2016 – 2019 [%]
Central	15.5	13.2	2.3	15%
Inner	13.9	11.8	2.1	15%
Outer	12.8	10.8	1.9	15%
Londonwide	**13.3**	**11.3**	**2.0**	**15%**

Number of people living in areas that exceed WHO limits for $PM_{2.5}$

For the first time, modelling has estimated some areas of London to be within the World Health Organization Guideline (WHO) limit of 10 µgm^3. In 2019 over 100,000 Londoners lived in areas within the WHO limit. However, a huge challenge still remains with 99 per cent of Londoners still living in areas exceeding the limit.

Table 18. Londoners living in areas above WHO guideline limit for $PM_{2.5}$

Location in London	Number of Londoners in areas exceeding in 2016	% Londoners in areas exceeding in 2016	Number of Londoners in areas exceeding in 2019*	% Londoners in areas exceeding in 2019	Londoners within limit in 2019
Central	195,900	100%	208,900	100%	-
Inner	3,649,500	100%	3,780,100	100%	-
Outer	4,953,600	100%	5,093,700	98%	108,000
Londonwide	**8,799,000**	**100%**	**9,083,000**	**99%**	**108,000**

*Increase is due to population growth

Further analysis of $PM_{2.5}$ concentrations across London shows that 3.4 million people, including over one million children, are now living in areas within 1 μgm^3 of the WHO limit.

Schools and educational establishments exceeding WHO limits for $PM_{2.5}$

Table 19 lists the number of schools and other educational establishments that were located in areas exceeding the WHO limits for $PM_{2.5}$ in 2016 and 2019.

As discussed in the previous section, London still faces a substantial challenge to bring levels of $PM_{2.5}$ within WHO recommended limits. The number of educational establishments located in areas exceeding WHO limits has fallen from 3,242 in 2016 to 3,194 in 2019, a reduction of 2 per cent. In 2019, 98 per cent of state primary and secondary schools were still located in areas exceeding the WHO recommended limit.

Table 19. Education establishments exceeding the WHO limits for $PM_{2.5}$

Establishment	Number	Number exceeding 2016	Number exceeding 2019	Reduction	Reduction [%]
Nursery	79*	79	79	0	na
Primary	1,815	1,815	1,781	34	2%
Secondary	450	450	446	4	1%
16 plus	50	50	48	2	4%
Community Special School	84	84	84	0	na
Higher Education Institutions	39	39	39	0	na
Other Independent School	477	477	476	1	na
Other Independent Special School	48	48	48	0	na
Pupil Referral Unit	37	37	37	0	na
Other	163	163	156	7	4%
Total	**3,242**	**3,242**	**3,194**	**48**	**2%**

*Data on educational establishments locations is taken from Edubase, this does not reflect the true number of nurseries in London. Many are privately run and not included in Edubase

Changes in $PM_{2.5}$ emissions

Table 20 shows the change in estimated total $PM_{2.5}$ emissions between 2016 and 2019. $PM_{2.5}$ emissions have reduced across London, although the reduction (6 per cent for total emissions) is not as significant as seen for NO_x. This underlines London's need for more powers to tackle local sources of $PM_{2.5}$.

Table 20. Annual emissions of $PM_{2.5}$ in tonnes

Location in London	Emission 2016 [tonnes]	Emission 2019 [tonnes]	Change [tonnes]	Change [%]
Central	231	213	-17	-8%
Inner	1,313	1,214	-99	-8%
Outer	2,246	2,117	-130	-6%
Londonwide	**3,790**	**3,544**	**-246**	**-6%**

Table 21 shows the estimated change in road traffic $PM_{2.5}$ emissions between 2016 and 2019. Road transport $PM_{2.5}$ emissions have reduced across London by 9 per cent. Again, this is less than the reductions seen for NO_x. The impact of ULEZ on $PM_{2.5}$ is evident in central London, with an estimated 27 per cent reduction in road traffic emissions.

Table 21. Annual road transport emissions of $PM_{2.5}$ in tonnes

Location in London	Emission 2016 [tonnes]	Emission 2019 [tonnes]	Change [tonnes]	Change [%]
Central	45	32	-12	-27%
Inner	358	312	-46	-13%
Outer	746	701	-46	-6%
Londonwide	**1,149**	**1,045**	**-104**	**-9%**

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Particulate matter (PM_{10})

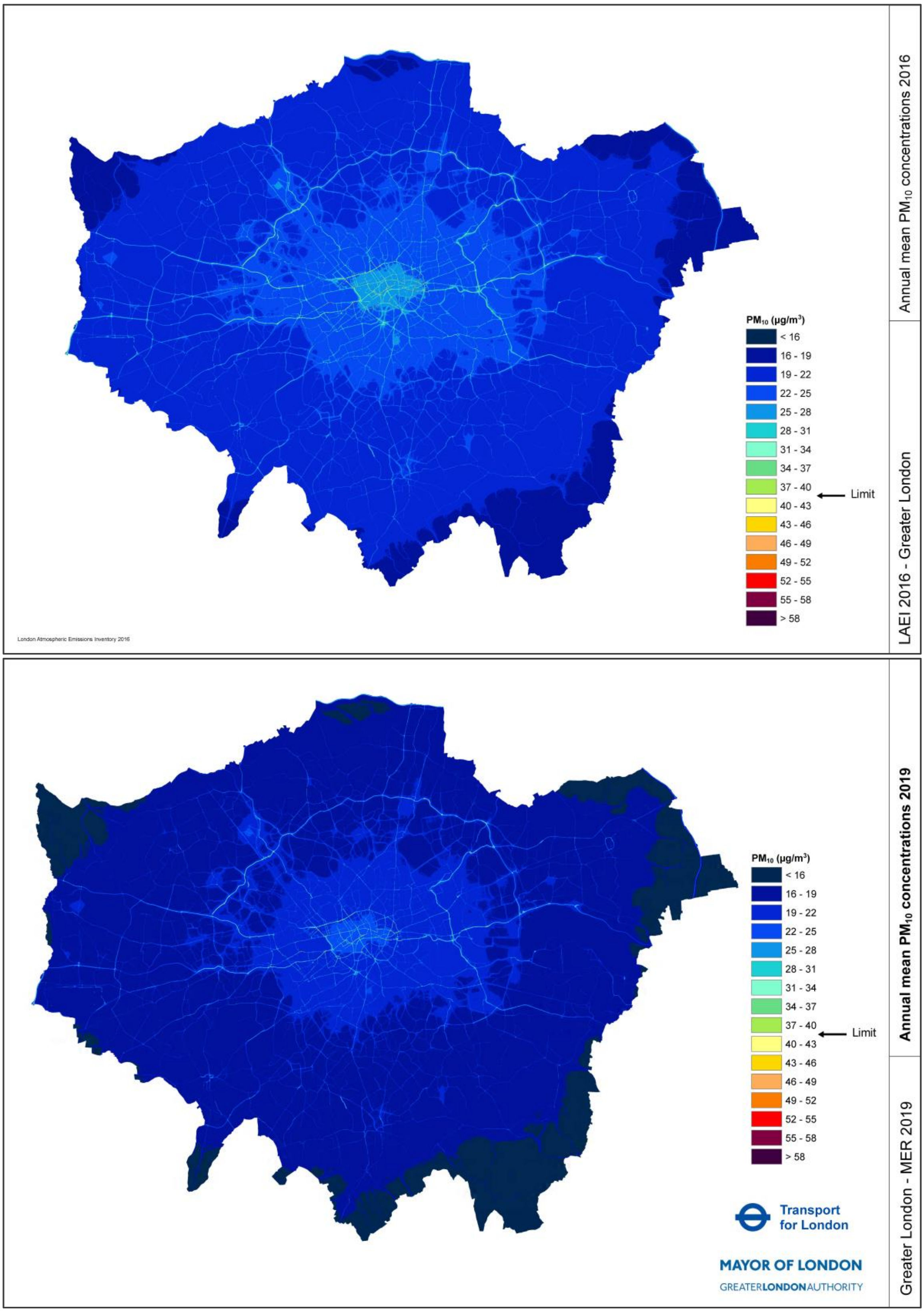


Figure 6: Annual mean PM_{10} in London from LAEI 2016 (top) to MER2019 (bottom)

Changes in PM_{10} concentrations

Figure 6 shows the annual mean PM_{10} concentrations from the LAEI 2016 in the top map and MER2019 modelling in the bottom map. There have been improvements in PM_{10} between 2016 and 2019, as also reflected in monitoring trends. On average, Londonwide PM_{10} concentrations have reduced by 3.2 μgm^3, a reduction of 14 per cent.

Table 22. Reduction in annual average PM_{10} between 2016 and 2020

Location in London	Annual average 2016 [μgm^3]	Annual average 2019 [μgm^3]	Reduction 2016 – 2019 [μgm^3]	Reduction 2016 – 2019 [%]
Central	26.2	22.6	3.5	13%
Inner	23.3	20.1	3.3	14%
Outer	21.0	17.9	3.1	15%
Londonwide	**22.1**	**18.9**	**3.2**	**14%**

Changes in PM_{10} emissions

Table 23 shows the estimated change in total PM_{10} emissions between 2016 and 2019. PM_{10} emissions in 2019 remained broadly constant compared to 2016, with a slight increase in overall emission. This is because estimated PM_{10} emissions from the construction sector increased between 2016 and 2019, counterbalancing the reduction of about 100 tonnes of PM_{10} from road transport (Table 24). It is important to note that estimates from the construction sector are particularly uncertain, as these were derived from the UK National Atmospheric Emissions Inventory (NAEI) 2017 (the inventory for more recent years had not yet been released), and PM from construction sites is difficult to estimate.

Table 23. Annual emissions of PM_{10} in tonnes

Location in London	Emission 2016 [tonnes]	Emission 2019 [tonnes]	Change [tonnes]	Change [%]
Central	390	380	- 10	-1%
Inner	2,770	2,800	30	1%
Outer	4,830	4,940	110	2%
Londonwide	**7,990**	**8,130**	**140**	**2%**

Table 24. Annual road transport emissions of PM_{10} in tonnes

Location in London	Emission 2016 [tonnes]	Emission 2019 [tonnes]	Change [tonnes]	Change [%]
Central	74	60	-14	-19%
Inner	657	608	-49	-7%
Outer	1,382	1,347	-35	-3%
Londonwide	**2,113**	**2,015**	**-98**	**-5%**

Table 24 shows the estimated change in PM_{10} emissions from road transport between 2016 and 2019. PM_{10} road transport emissions follow the same pattern as NO_x and $PM_{2.5}$, showing a significant 19 per cent reduction in central London due to the ULEZ, and much smaller reductions in inner and outer London.

Summary of trends from Londonwide modelling

King's College London produced a Mayor's Evaluation Report "snapshot" model for 2019, based on the methodology of LAEI 2016. The modelling showed reduction in concentrations for all pollutants, with the greatest improvements for NO_2. Key findings include:

- The number of people living in areas exceeding legal limits for NO_2 has fallen from over 2 million in 2016 to 120,000 in 2019, **a reduction of 94 per cent.**
- The number of primary schools in areas exceeding legal limits for NO_2 has fallen from 369 in 2016 to 11 in 2019, **a reduction of 97 per cent.**
- Between 2016 and 2019 Londonwide annual mean NO_2 concentrations **reduced by 20 per cent.**
- Between 2016 and 2019 total NO_x emissions fell by 14 per cent Londonwide, with road transport NO_x emission reducing by 26 per cent, with **a 47 per cent reduction in central London**.
- Smaller reductions were reported for PM concentrations emissions, as the Mayor has less powers to address local sources of PM.
- For the first time in 2019 some areas in London were within the World Health Organization guideline limit for $PM_{2.5}$. However, 99 per cent of Londoners still lived in areas exceeding the limit.
- Reducing Londonwide $PM_{2.5}$ by just 1 μgm^3 would bring an additional 3.4 million Londoners, including over 1 million children, within the WHO limit.

5. Central London Ultra Low Emission Zone

On 8 April 2019 the Mayor of London launched the world's first Ultra Low Emission Zone (ULEZ) in central London. This chapter of the report evaluates the impact of the scheme in its first ten months of operation (to the end of January 2020). Whilst we can determine a number of different impacts within this timeframe, further ongoing analysis will be required to understand the full impacts of the scheme over a longer period of time – particularly in relation to establishing long term changes in air quality.

A number of measures are used to assess the impacts of introducing the ULEZ. Here we evaluate the impact on air pollution concentrations, air pollution emissions, traffic flows and vehicle compliance.

What is the Ultra Low Emission Zone (ULEZ)?

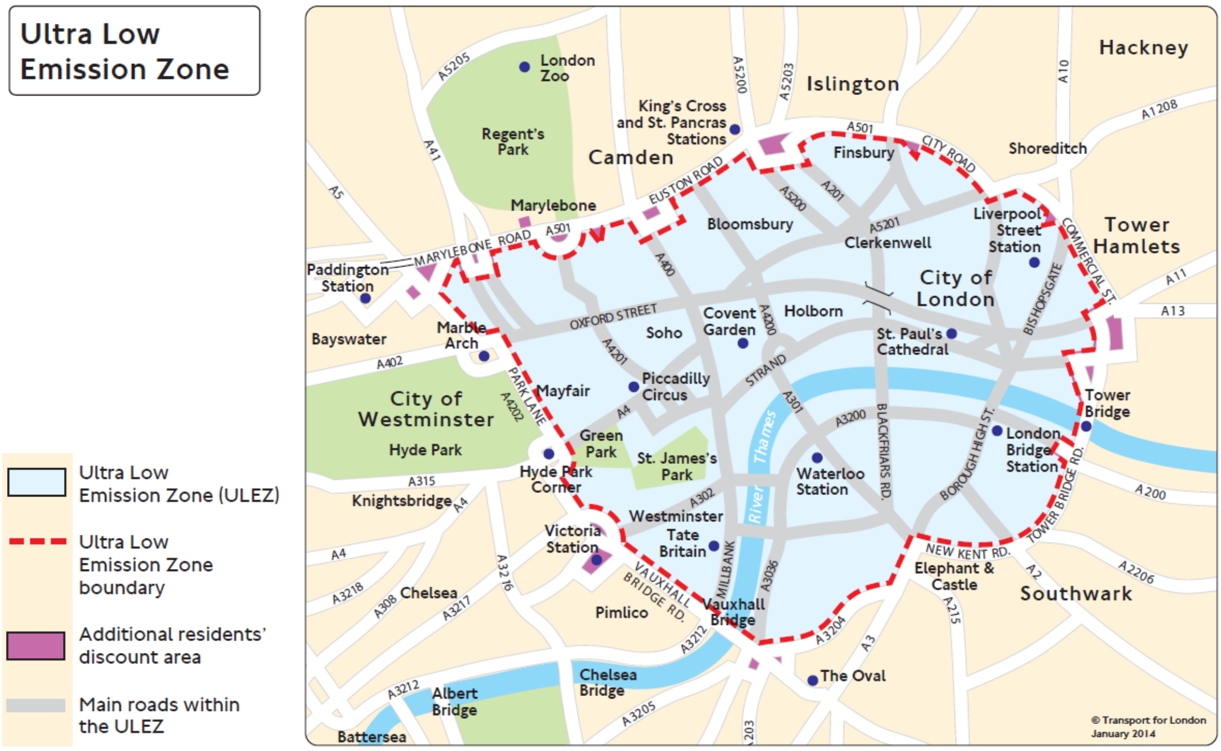


Figure 7. Map of the central London Ultra Low Emission Zone

The Central London ULEZ started on 8 April 2019 and operates in the existing central London Congestion Charge Zone. Figure 7 is a map of the area covered by the central ULEZ. Unlike the Congestion Charge (which operates Monday to Friday between 07:00 and

18:00) the ULEZ operates 24 hours a day, every day of the year except Christmas Day (25 Dec). Vehicles must meet strict emission standards to drive in the ULEZ area:

- Euro 4 for petrol cars and vans (vehicles less than fourteen years old in 2019)
- Euro 6 for diesel cars (vehicles less than five years old in 2019)
- Euro 6 for diesel vans (vehicles less than four years old in 2019)
- Euro 3 for motorcycles and other L-category vehicles
- Euro VI for lorries, buses and coaches

Vehicles that do not meet these standards must pay a charge:

- £12.50 per day for cars, motorcycles and vans
- £100 per day for lorries, buses and coaches

All TfL buses operating in the zone meet the ULEZ standards. The ULEZ replaced the T-Charge in central London and is in addition to the Congestion Charge. Alongside the ULEZ, the Private Hire Vehicle exemption to the Congestion Charge was removed on 8 April 2019 and the Ultra Low Emission Discount was replaced by the new Cleaner Vehicle Discount.

To find out more about the ULEZ or to check if your vehicle is affected please visit:

https://tfl.gov.uk/modes/driving/ultra-low-emission-zone.

This is the fourth report evaluating the impacts of the scheme. The first three reports are available from:

- 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

An updated evaluation will be published once twelve months of data are available.

Assessing the impacts of ULEZ

The purpose of the ULEZ is to improve air quality in and around central London by reducing the number of older more polluting vehicles that enter the central zone. The impact of the ULEZ can be assessed using a number of different metrics including:

- Air quality monitoring[7]
- Modelling of vehicle emissions
- Number of vehicles and compliance rates
- Traffic flow data

Air pollution concentrations are affected by many different factors including the weather and regional contributions from outside London, as well as impacts from other local schemes, therefore analysis of air quality monitoring data will need to continue over time.

Vehicle compliance refers to the number of vehicles that "comply" or meet the ULEZ emission standards. Non-compliant vehicles do not meet the strict ULEZ emissions standards and 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

Limitations of this analysis

To assess the impact of the scheme we have compared the number of vehicles detected in the zone and compliance rates from February 2017 and March 2019 – January 2020. In February 2017 the Mayor confirmed the introduction of the T-charge as a stepping-stone for the ULEZ and this can be seen as the start of the accelerated change in the vehicle fleet as Londoners and businesses prepared for the new schemes and buses on routes in central London began to be upgraded to become ULEZ compliant. In addition, the removal of the exemption from the Congestion Charge for private hire vehicles also commenced on 8 April

[7] At this stage air quality data is from the London Air Quality Network and Air Quality England Network. This is because both provide data going back many years. The newly established Breathe London network will also be used for ULEZ evaluation in a separate report using different techniques.

2019. TfL have also introduced new licensing requirement for private hire vehicles so that as of 1 January 2020:

- PHVs under 18 months old must be zero emission capable and meet the Euro 6 emissions standard when licensed for the first time
- PHVs over 18 months old must have a Euro 6 (petrol or diesel) engine when licensed for the first time

March 2019 is the month before the ULEZ was introduced and January 2020 is the latest available full month of data.

The ULEZ is a 24 hour scheme, however, prior to the start of the scheme in April 2019 data could only be collected during congestion charging (CC) hours – 07:00 to 18:00, Monday to Friday. When assessing the impact of the first ten months of ULEZ compared to historic months, comparison has been made based on CC hours to ensure the comparison is fair. 24 hour data for the months since the scheme has been in operation has also been provided.

As mentioned, the removal of the exemption from the Congestion Charge for private hire vehicles coincided with the launch of the ULEZ. This may also have had an effect on traffic volumes and air quality within the zone, but it is too early at this stage to separate the respective effects.

Disruptions to traffic flow in the central zone in April 2019

As explained in a previous iteration of this report, there were a number of non-typical events in central London in April 2019. These included.

- Road works (leading to signed diversions into the ULEZ)
- The Extinction Rebellion climate protests, leading to further diversions into the central zone and an unknown impact on the number of motorists choosing to drive in central London
- Easter Holidays and Bank Holidays. The timing of the introduction of ULEZ was specifically chosen to target a “quiet” week when there would be fewer vehicles in the zone

As a result, only a limited number of days were used for analysis of the first month of the scheme. Data for April 2019 presented in this report is the average over “typical days” only.

However, using only typical days exclusively in the month of April has little effect on the results.

As the scheme started on 8 April, the first iteration of this report covered the period from 8 April to 5 May 2019 (to provide 4 calendar weeks of “typical days” data). For consistency this report has taken the same approach.

Unique vehicles detected in zone and relation to traffic flow

Vehicle volumes within this report relate to the daily number of confirmed unique vehicles detected in central London. Unique vehicle volumes will be different in scale to changes in traffic volumes entering or within central London for a number of reasons:

- Unique vehicle volumes do not take into account how a vehicle is used. For example, a proportion of traffic is associated with a minority of vehicles that make multiple trips a day within the zone, e.g. delivery vehicles, private hire vehicles and taxis
- Trips made wholly within the zone are currently less likely to be captured by an ANPR camera than trips crossing the boundary (for which all entry and exit points are monitored). There is currently less incentive for internal trips to cease as local residents have a 100% ULEZ discount grace period until 24th October 2021
- Analysis of changes in traffic data based on automatic traffic count sites in London is compared to the same months in 2018. However, traffic exhibits seasonal variation and further analysis will be undertaken once a full year of traffic data is available

If you want to know about estimates for changes in traffic in both central London and pan-London please see the latest Travel in London report, which looks at various sets of data for understanding traffic flow including that from TfL’s automatic traffic counters: https://tfl.gov.uk/corporate/publications-and-reports/travel-in-london-reports

Further analysis is ongoing in order to understand the impacts of ULEZ including trends in changes in compliance, traffic flows, and air quality.

Air pollution concentrations

Around half of London's NO_x emissions are from road transport.[8] The purpose of the ULEZ is to improve air quality in and around central London by reducing the number of older, more polluting vehicles that enter the central zone. This will reduce the amount of NO_x emitted, which in turn will reduce nitrogen dioxide (NO_2) concentrations in the zone. Bringing London closer to compliance with the legal air quality limit values for NO_2 is a key aim of the scheme.

The analysis presented here uses data from London's automatic monitoring network. This data is publicly available from the London Air Quality Network and Air Quality England websites. Full details of the methodology for this chapter can be found in the Central London Ultra Low Emission Zone Six Month Report.

In this analysis monthly average concentrations are used to calculate trends in the period from 2010 to end of February 2020. It should be noted that measurement data from late 2019 and early 2020 have not yet been ratified. As a result, these may be subject to change following equipment tests undertaken as part of the routine audit and servicing of air quality monitoring sites.

Nitrogen dioxide (NO_2)

The ULEZ was introduced part way through 2019, therefore evaluating changes with respect to the ULEZ required analysis on a shorter timescale than a year. To address this we evaluate the change in quarterly (three month) average NO_2 concentrations. It is important to note that Table 25 presents an average across several sites of each type in each zone. Data presented in Table 25 is quarterly as opposed to annual, so is not directly comparable to annual air quality limits.

This analysis evaluates the change in quarterly average NO_2 since February 2017, when changes associated with the ULEZ began. The additional analysis estimated the proportion of reductions in NO_2 that are directly attributable to ULEZ.

Table 25 lists the quarterly average concentrations of NO_2 in London from January 2016 to February 2020 grouped by site type and London zone. The biggest reduction in average

[8] London Atmospheric Emissions Inventory 2016 (LAEI 2016)

concentrations between the beginning of 2017 and February 2020 is at central roadside sites, 39 µgm^{-3}, equating to a 44 per cent reduction. This is over double the reduction at inner roadside sites of 18 µgm^{-3}, and four times the reduction at roadside sites in outer London. The smallest improvement was recorded at urban background sites in outer London, 6 µgm^{-3}.

Table 25. Quarterly average NO_2 from January 2017 to February 2020

Period	Average NO_2 [µgm^{-3}]					
	Roadside Central	Background Central	Roadside Inner	Background Inner	Roadside Outer	Background Outer
Jan – March 17	89	37	54	34	46	29
April – June 17	87	36	53	34	45	29
July – Sept 17	86	36	52	33	45	29
Oct – Dec 17	83	35	51	33	44	28
Jan – March 18	81	35	50	32	44	28
April – June 18	78	34	49	31	43	28
July – Sept 18	75	34	48	31	42	27
Oct – Dec 18	71	33	46	30	41	27
Jan – March 19	67	33	45	29	40	26
April – June 19	63	32	43	29	39	26
July – Sept 19	59	32	42	28	38	25
Oct – Dec 19	54	32	40	27	37	25
Jan – Feb 20*	50	31	38	27	36	24
Reduction ***(Q1 2017 – Q1 2020)*** **[µgm^{-3}]**	39	6	16	7	10	5
Reduction ***(Q1 2017 – Q1 2020)*** **[per cent]**	44%	16%	30%	21%	22%	17%

*Data available to 1 March 2020

Again, this is not comparable to the annual mean limit, as seen in a previous chapter there were still many sites in 2019 in inner and outer London that exceeded the legal air quality limit value for annual mean NO_2 of 40 µgm^{-3}.

As mentioned previously, air pollution is influenced by many complex factors. It is therefore important to perform additional analysis to ensure the trends reported in Table 25 were not a product of weather and seasonal factors and to attribute the proportion of the recent reduction in NO_2 concentrations within the central zone which are attributable to the ULEZ.

Changes in NO_2 attributable to ULEZ

The ULEZ is one of the many policies to reduce air pollution in London. Other policies include the Londonwide Low Emission Zone (for heavy vehicles), investment in new cleaner buses and ZEC licensing requirements for taxis and PHVs (in addition to ULEZ measures), as well as progressively tighter EU-wide exhaust controls for new vehicles. As a result, it is not straight forward to isolate the impact of the ULEZ. For this analysis the trends in outer London (largely away from the influence of the ULEZ in central London) were used as a predictor of the change in central and inner London if the ULEZ was not in place. The change in outer London reflects the “natural churn” of the fleet, as vehicles are replaced by their owners. The changes measured in central London far exceed natural churn. Comparing the measured trends in central and outer London reveals the additional changes within the central zone, which provide an estimate for the impact of the ULEZ.

Detecting the additional change within the ULEZ by comparing trends in the zone to those in outer London has both strengths and weaknesses. Key amongst the strengths are 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 London data that also acts, to some extent, as a control for the weather and seasonal factors that can confound this type of analysis. The key weakness stems from differences in the vehicle fleets in the ULEZ area compared with outer London. Traffic in the ULEZ area has a greater proportion of certain vehicle types, such as taxis, and proportionally fewer private cars than outer London[9]. Interventions on these vehicle types from other Mayoral policies would have a different impact in the ULEZ area than outside, even in the absence of the ULEZ.

Another potential limitation to the analysis presented in this chapter is changes in the number and location of monitoring sites across London over the 10-year period. More detail on this can be found in the Central London Ultra Low Emission Zone Six Month Report.

A technique often used to isolate the proportion of pollution that relates to traffic sources is to subtract the background concentration from the roadside concentration. This is referred

[9] London Atmospheric Emission Inventory (LAEI) 2016, Greater London Authority 2018

to as the "roadside increment"[10]. Changes in the roadside increment, or traffic contribution, in outer London were used as a predictor of the changes in a "no ULEZ" scenario for roadside sites in central and inner London - the rate of change in outer London is an approximation of what would see in central London if there were no ULEZ policy. The analysis in this section follows the exact method for calculating the "no ULEZ" trend that can be found in the Appendix of the Central London Ultra Low Emission Zone – Six Month Report.

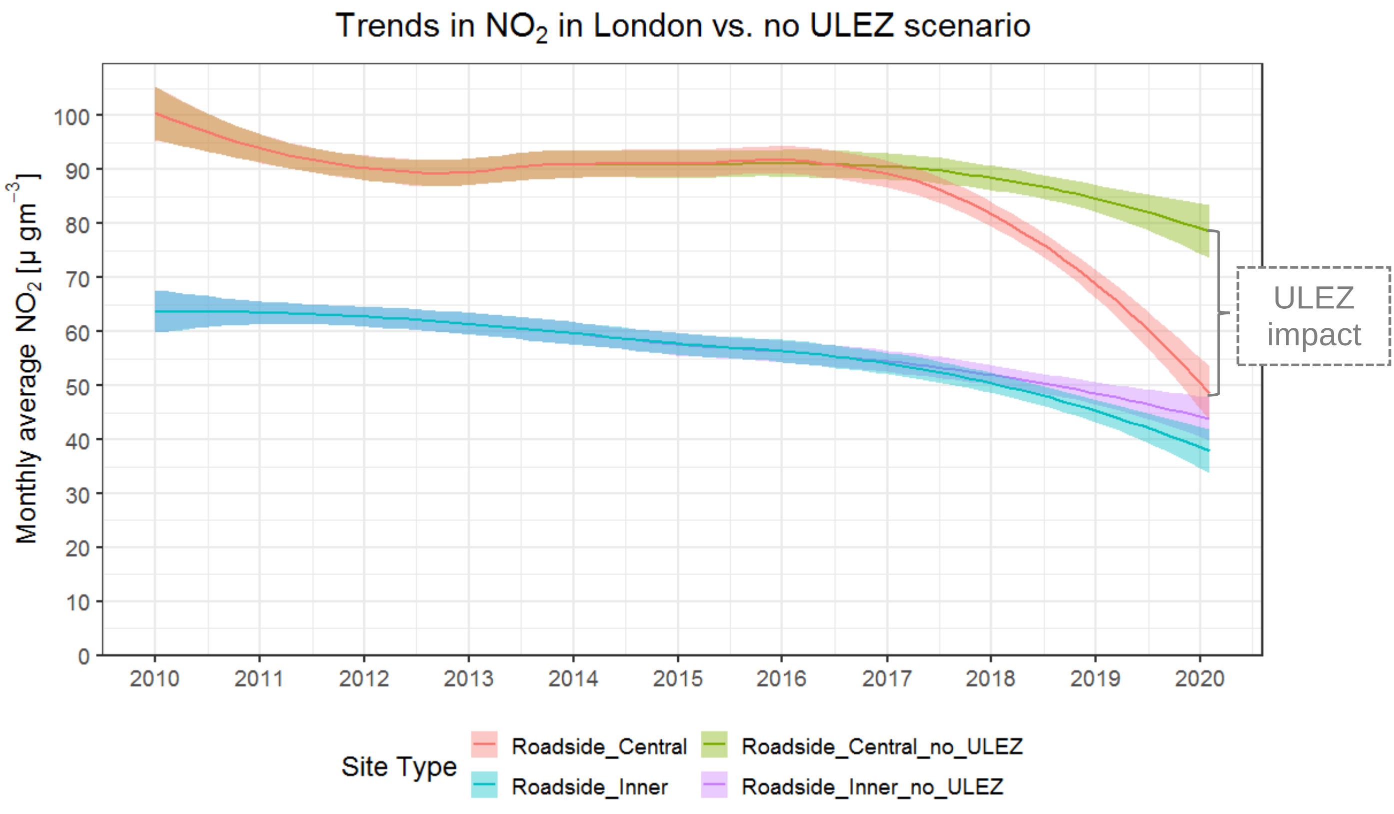


Figure 8: Monthly average NO_2 concentrations in London with and without ULEZ

Figure 8 shows the monthly average NO_2 at roadside sites in central and inner London as well as a "no ULEZ" scenario estimate for each. The "no ULEZ" reflects changes in central and inner London were they to follow the same trend as roadside sites in outer London. The

[10]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

divergence between the measured concentrations and “no ULEZ” scenario is much more pronounced in central London than in inner London. This shows there was a reduction in roadside concentrations in central and inner London that was far greater than the reduction measured at outer London sites.

Table 26 presents the difference between the trend in actual roadside measurements and the scenario where there was no ULEZ over three-month periods since April 2019. This can be understood as the reduction at central and inner London sites that is in addition to the changes measured at outer London roadside sites.

Table 26: Estimated reduction in NO_2 concentrations as a result of ULEZ

Period	Reduction central London roadside compared to “no ULEZ”		Reduction inner London roadside compared to “no ULEZ”	
	[μgm^{-3}]	[per cent]	[μgm^{-3}]	[per cent]
Jan – March 19	17	20%	3	7%
April – June 19	20	24%	4	9%
July – Sept 19	23	29%	5	10%
Oct – Dec 19	26	33%	5	12%
Jan – Feb 20*	29	37%	6	13%

*Data available to 1 March 2020

In January to February 2020, the most recent period for which data is available, the ULEZ is estimated to have reduced mean NO_2 concentrations at roadside sites by 29 μgm^3, a reduction of 37 per cent compared to the scenario where “no ULEZ” is in place.

A smaller reduction of 13 per cent was estimated at roadside sites in inner London. This is expected, since many vehicles driven in the ULEZ also travel in this area. This is the area that will benefit most from the expansion of the Ultra Low Emission Zone to the North and South circular roads in 2021.

Trends in NO_2 on boundary roads

When charging schemes, such as the ULEZ or Congestion Charge, are introduced in part of a city it is always important to measure the impact of the scheme not only in the zone itself, but also in the surrounding area.

There are four established air quality monitoring stations on the central London ULEZ boundary roads. Figure 9 shows that, similar to sites within the central zone, sites on the ULEZ boundary roads measured a continued downward trend in concentrations since 2017.

No sites on the boundary roads have experienced an increase in the trend of monthly average NO_2 since the scheme was introduced in April 2019. (Note, these boundary sites are categorised as inner, as opposed to central, sites).

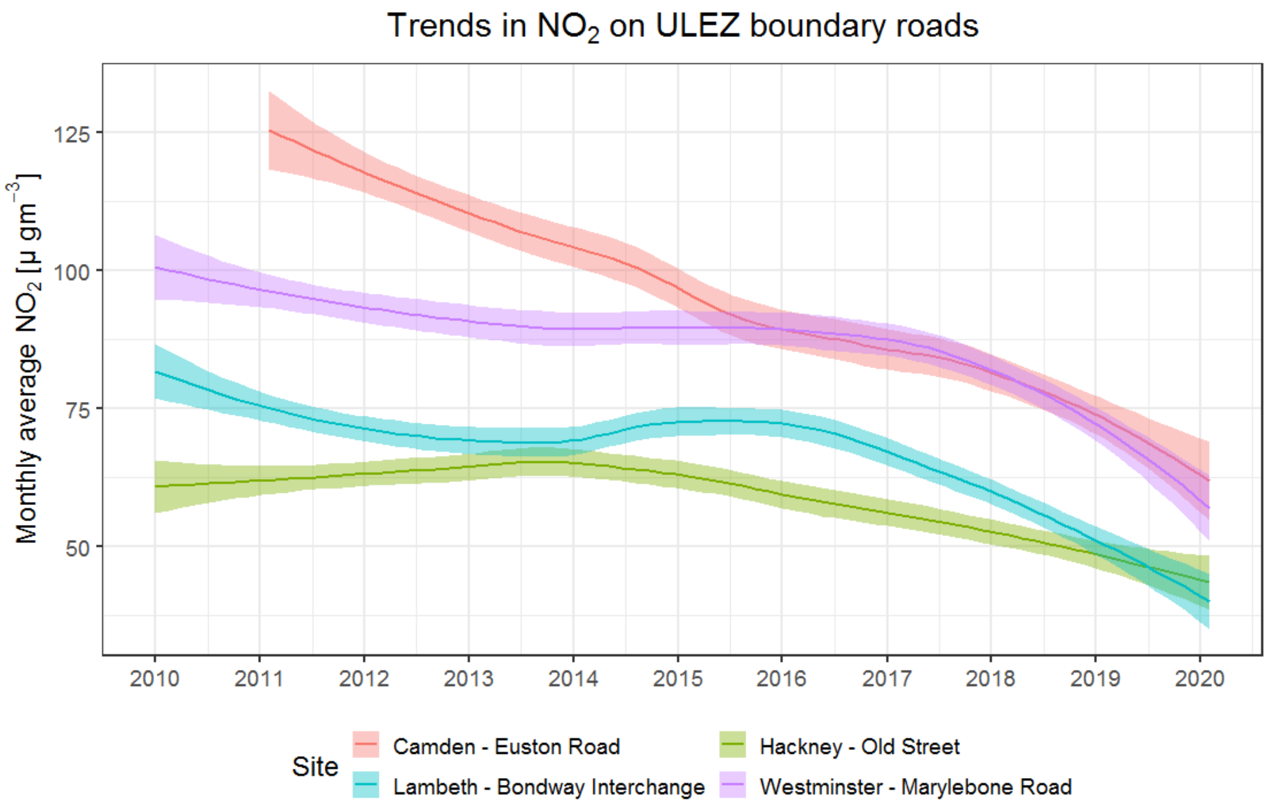


Figure 9: Monthly average NO_2 concentrations at sites on ULEZ boundary roads

This is a strong indication that there has been a positive impact on air pollution on the ULEZ boundary roads. A full picture of the impact on boundary roads will be available later in 2020 (once more data is available and the ULEZ has been in operation a full year).

Fine particulate Matter ($PM_{2.5}$)

As mentioned previously in this report, road transport is the largest single source of particulate matter in 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. There is also a large proportion of $PM_{2.5}$ emitted within London that the Mayor does not currently have the powers to address, for example wood burning. In addition, a growing proportion of road transport $PM_{2.5}$ emissions are now non-exhaust emissions including road wear, resuspension of road dust and tyre and brake wear.

Table 27. Quarterly average $PM_{2.5}$ from January 2017 to February 2020

Period	Average $PM_{2.5}$ [μgm^{-3}]					
	Roadside Central	Background Central	Roadside Inner	Background Inner	Roadside Outer	Background Outer
Jan – March 17		15	14	12	13	11
April – June 17		14	14	12	13	11
July – Sept 17		14	14	12	12	11
Oct – Dec 17		14	14	11	12	11
Jan – March 18		14	13	11	12	11
April – June 18		13	13	11	12	11
July – Sept 18		13	13	11	12	11
Oct – Dec 18		13	13	11	12	11
Jan – March 19		12	12	11	12	11
April – June 19		12	12	10	12	10
July – Sept 19		11	12	10	11	10
Oct – Dec 19		11	12	10	11	10
Jan – Feb 20*		11	11	9	11	10
Reduction *(Q1 2016 – Q1 2020)* [μgm^{-3}]		4	3	3	2	1
Reduction *(Q1 2016 – Q1 2020)* [per cent]		27%	21%	25%	15%	9%

Table 27 shows the quarterly average $PM_{2.5}$ grouped by zone and site type. Since changes associated with the ULEZ began in February 2017 there has been a 27 per cent reduction in quarterly average $PM_{2.5}$ emission in background sites located in central London. It is likely these will have been influenced by the reduction in traffic emissions, as was seen in annual average PM_{10}.

Air pollution emissions

Emissions from road transport have been modelled to estimate how NO_x emissions from vehicles have changed since the ULEZ was introduced. Full details of the methodology can be found in the Central London Ultra Low Emission Zone Six Month Report. Emissions reductions are calculated as the reduction in emissions using current compliance rates compared to a “no ULEZ” scenario for the period October to December 2019. These are estimates based on the first three quarters of operations, a full update after a full year will be included in a report evaluating the first 12 months of the scheme.

Reductions in NO_x emissions

Preliminary estimates indicate that between October to December 2019 NO_x emissions from road transport reduced by 35 per cent (or 230 tonnes of NO_x) compared to a scenario where there was no ULEZ. Modelling done by TfL as part of the ULEZ consultation process estimated that introducing the ULEZ would result in a 45 per cent reduction in NO_x emissions from road transport in the central zone. After the first three quarters of a year in operation the ULEZ is on track to meet its 45 per cent target.

Reductions in $PM_{2.5}$ emissions

Similarly, it has been estimated that between October to December 2019 $PM_{2.5}$ emissions from road transport reduced by 6 tonnes, a reduction of 15 per cent compared to a no ULEZ scenario. As discussed, total $PM_{2.5}$ emissions are more sensitive to changes in vehicle kilometres due to the dominance of non-exhaust particles. This will be addressed by policies in the Mayor’s Transport Strategy that will reduce traffic volumes by encouraging mode shift from car to walking, cycling and using public transport., The Mayor aims for 80 per cent of all trips in London to be made on foot, by cycle or using public transport by 2041.

Reductions in CO_2 emissions

CO_2 emissions in the central zone are estimated to have reduced by 12,300 tonnes, a reduction of 6 per cent, compared to a scenario with no ULEZ in place. This is equivalent to the lifetime carbon savings of over 800 solar PV installations in London. CO_2 emissions are also more sensitive to changes in vehicle kilometres due to the dependence on fuel use.

Summary of emissions reductions

Table 28. Summary of emissions reductions in central zone

Pollutant	Comparison to "no ULEZ" scenario, Oct – December 2019	
	Reduction [tonnes]	Reduction [per cent]
NO_x	230	35%
$PM_{2.5}$	6	15%
CO_2	12,300	6%

Table 28 presents the summary of emissions reductions by pollutant. In future analysis, once more data is available, fleet composition estimates will be revised to take account of a full year of data and consider other changes in vehicle types, such as fuel type, and further assessment of traffic flows. Further emissions calculations will be carried out for a one-year evaluation report including the impact of the central London ULEZ on road transport NO_x, $PM_{2.5}$ and CO_2 emissions in both inner and outer London.

Traffic flows

Transport for London uses automatic traffic count data at representative sites across London to monitor changes in traffic flows. These sites provide total traffic flows (for all vehicles) for each hour of the day. In this analysis the sites have been averaged over each month to allow estimates of changes in traffic flows in central, inner and outer London to be determined.

Traffic flows change across the year reflecting seasonal patterns such as holiday periods. Therefore, the best way to evaluate a change in traffic flow is to compare to the same period in previous years. In Table 29 monthly data for 2019 has been compared to 2018 and the percentage change in average flows calculated.

Table 29: Change in average 24 hour traffic flows in London from 2018 to 2019

	All days of week			Weekdays			Weekends		
Comparison 2019 to 2018	**Central**	**Inner**	**Outer**	**Central**	**Inner**	**Outer**	**Central**	**Inner**	**Outer**
January	0%	-1%	2%	0%	-1%	2%	-1%	-1%	2%
February	0%	-1%	2%	0%	-1%	2%	0%	-2%	2%
March	2%	2%	4%	1%	2%	3%	4%	3%	6%
April	-2%	-2%	2%	-2%	-1%	2%	-3%	-2%	1%
May	-3%	-1%	1%	-2%	-2%	1%	-6%	0%	1%
June	-5%	0%	0%	-5%	0%	0%	-6%	1%	0%
July	-5%	-1%	1%	-5%	-2%	1%	-5%	0%	1%
August	-8%	-4%	1%	-7%	-4%	0%	-9%	-3%	3%
September	-9%	-2%	0%	-9%	-2%	0%	-11%	-1%	0%
October	-9%	0%	-2%	-8%	0%	-2%	-11%	-1%	-2%
November	-7%	0%	-2%	-6%	0%	-2%	-9%	0%	-2%
December	-6%	-1%	0%	-5%	-1%	0%	-8%	-1%	0%
January	-8%	0%	0%	-7%	0%	0%	-10%	0%	1%

The table shows that in early 2019 there was very little change in average traffic flows in central and inner London when compared to 2018, whilst there was around 2 per cent increase in outer London. Traffic in inner and outer London between April and July varied by up to a couple of percent compared to the same months in 2018. However, after March reductions in average traffic flows of around 3 – 9 per cent are reported in central London when compared to the previous year. Similar estimates have been seen across both weekdays and weekends.

This is an indication that the introduction of the ULEZ is contributing to a reduction in traffic flows in central London. Across the year the average change comparing 2019 to 2018 is estimated to be a 4.5 per cent reduction in central London. However, it is too soon to fully attribute these changes solely to ULEZ, as more data is required for analysis over a longer period.

When comparing weekdays, a similar pattern is seen – whereby changes in central London in 2018 are greater than those for inner London. For weekends, the difference appears to be greater still. This is likely to reflect the fact that weekends are now subject to a charge for the first time, unlike congestion charging which only affects weekdays.

Analysis of changes in traffic flows across different times of the day has also been analysed. The results are similar to those seen for 24 hour data. However, the data suggests more substantial differences between 2018 and 2019 in the evening, late evening and night time hours – which are hours where charges have not been applied before.

Traffic flow changes are still preliminary, and data will continue to be collected over the coming months in order to understand if trends are sustained, and how these vary across the different times of day and weekends, and on specific roads across the network.

Number of vehicles and compliance rates

FIRST MONTH – changes in vehicle numbers and compliance (March 2019 – April 2019)

Table 30 compares vehicle numbers and compliance rates for the month immediately before the scheme was introduced (March 2019) and the scheme's first month of operation (April 2019). As explained earlier in this chapter, this excludes non-typical days.

The changes below capture the more immediate effect following the launch of the scheme and do not take into account those who changed their behaviour ahead of time in preparation for the scheme.

Table 30. Average number and proportion of compliant vehicles detected in the zone per 'typical' day during CC hours March 19 – April 19

Month	Number of vehicles driving in the charging zone per day during CC hours			Proportions of vehicles driving in the charging zone during CC hours	
	Unique vehicles detected in zone*	Non-compliant vehicles	Compliant vehicles	Non-compliant vehicles	Compliant vehicles
Mar - 19	91,035	35,578	55,457	39.1%	60.9%
Apr – 19	89,380	26,195	63,185	29.3%	70.7%
Change	-1,655	-9,383	7,728	Decrease of 9.8 percentage points	Increase of 9.8 percentage points
% change	-1.8%	-26.4%	13.9%	-25.0%	16.1%

*not representative of traffic flow

Key impacts of the first month of the scheme compared to the previous month:

- In the first month of operation (excluding non-typical days) the compliance rate with the ULEZ standards in congestion charging hours was around 71 per cent. This is much higher than the 61 per cent in March 2019
- There was a large reduction in the number of older, more polluting, non-compliant vehicles detected in the zone: some 9,383 fewer on an average 'typical' day, a reduction of over a quarter

FIRST TEN MONTHS – changes in vehicle numbers and compliance (March 2019 – January 2020)

Table 31 compares vehicle numbers and compliance rates for the month immediately before the scheme was introduced (March 2019) and the scheme's first ten months of operation. This excludes non-typical days for April 2019. The table below captures the more immediate effect following the launch of the scheme and does not take into account those who changed their behaviour ahead of time in preparation for the scheme, this is captured in the pre-compliance data presented later in this report.

Table 31. Average number and proportion of unique compliant vehicles detected in the zone during CC hours March 19 – January 20

Month	Number of vehicles driving in the charging zone per day during CC hours			Proportions of vehicles driving in the charging zone during CC hours	
	Unique vehicles detected in zone*	Non-compliant vehicles	Compliant vehicles	Non-compliant vehicles	Compliant vehicles
March 19	91,035	35,578	55,457	39.1%	60.9%
April 19	89,380	26,195	63,185	29.3%	70.7%
May 19	88,796	25,610	63,186	28.8%	71.2%
June 19	87,113	24,549	62,564	28.2%	71.8%
July 19	83,899	23,054	60,844	27.5%	72.5%
August 19	80,128	21,133	58,994	26.4%	73.6%
Sept 19	85,854	22,133	63,721	25.8%	74.2%
Oct 19	82,776	21,239	61,537	25.7%	74.3%
Nov 19	84,797	21,222	63,575	25.0%	75.0%
Dec 19	84,032	20,533	63,499	24.4%	75.6%
Jan 20	78,754	18,182	60,572	23.1%	76.9%
Change March 19 – Jan 20	-12,281	-17,396	5,115	Decrease of 16 percentage points	Increase of 16 percentage points
% change	-13%	-49%	9%	-41%	26%

*not representative of traffic flow

Key impacts of the first ten months of the scheme compared to March 2019 (the month before the scheme was implemented):

- In January 2020 the compliance rate with the ULEZ standards was 77 per cent. This is much higher than the 61 per cent in March 2019.
- From March 2019 – January 2020 there was a large reduction in the number of older, more polluting, non-compliant vehicles detected in the zone: some 17,396 fewer on an average day, a reduction of around 49 per cent.
- There was around a 41 per cent decrease in the proportion of vehicles in the central zone that were non-compliant between March 2019 and January 2020.

PRE- COMPLIANCE – changes in vehicle numbers and compliance (February 2017 – March 2019)

Table 32 below shows the change in the number of vehicles detected in the zone and the compliance level between February 2017 and March 2019. This data was released in April 2019 to coincide with the launch of the scheme.[11]

Table 32. Average number and proportion of unique compliant vehicles detected in the zone per day during CC hours February 17 – March 19

Month	Number of vehicles driving in the charging zone per day during CC hours			Proportions of vehicles driving in the charging zone during CC hours	
	Unique vehicles detected in zone*	Non-compliant vehicles	Compliant vehicles	Non-compliant vehicles	Compliant vehicles
Feb 17	102,493	62,310	40,184	60.8%	39.2%
March 19	91,035	35,578	55,457	39.1%	60.9%
Change Feb 17 – March 19	-11,458	-26,732	15,273	Decrease of 21.7 percentage points	Increase of 21.7 percentage points
% change	-11%	-43%	38%	-35.7%	55.4%

*not representative of traffic flow

As Table 32 indicates, the proportion of compliant vehicles detected in the Central London ULEZ zone rose from 39 per cent in February 2017 (when the Mayor confirmed the introduction of the T-charge) to 61 per cent in March 2019. This represents a 55 per cent increase in the proportion of compliant vehicles detected in the zone.

The proportion of vehicles that are compliant is the best way of comparing changes in the vehicle fleet, given the number of unique vehicles detected in the zone also changed over this period.

[11] https://www.london.gov.uk/press-releases/mayoral/ulez-launches-in-central-london

PRE- COMPLIANCE and LATEST MONTH – changes in vehicle numbers and compliance (February 2017 – January 2020)

Table 33 shows the change in vehicle compliance from February 2017 to January 2020. This is presented as an absolute change in the number of vehicles detected, the change in the percentage of vehicles that are compliant, and also the change in the proportion of vehicles that are compliant.

Table 33. Average number and proportion of unique compliant vehicles detected in the zone during CC hours February 17 – January 20

Month	Number of vehicles driving in the charging zone per day during CC hours			Proportions of vehicles driving in the charging zone during CC hours	
	Unique vehicles detected in zone*	Non-compliant vehicles	Compliant vehicles	Non-compliant vehicles	Compliant vehicles
Feb 17	102,493	62,310	40,184	60.8%	39.2%
Jan 20	78,754	18,182	60,572	23.1%	76.9%
Change Feb 17 – Jan 20	-23,739	-44,128	20,388	Decrease of 38 percentage points	Increase of 38 percentage points
% change	-23%	-71%	51%	-62%	96%

*not representative of traffic flow

Key findings for the first ten months of the scheme compared to February 2017, taking pre-compliance into account:

- From February 2017 to January 2020 there was a large reduction in the number of older, more polluting, non-compliant vehicles detected in the zone: some 44,128 fewer on an average day, a reduction of 71 per cent.
- There was a 96 per cent increase in the proportion of vehicles detected in the zone that met the ULEZ standards between February 2017 and January 2020. As mentioned previously, the proportion of vehicles that are compliant is the best way of comparing changes in the vehicle fleet, given the number of unique vehicles detected in the zone also changed over this period.

Comparison between congestion charge hours and 24 hour data

To ensure a fair comparison with historic data the previous analysis compares data for CC hours only. Table 34 below includes vehicle numbers and compliance rates for CC hours and 24 hour average daily vehicles detected in the zone for January 2020. The 24 hour compliance rate in January 2020 was 79 per cent.

Table 34. Comparison of average unique daily vehicles for January 2020 for CC hours and 24 hour data

	Number of vehicles driving in the charging zone per day			Proportions of vehicles driving in the charging zone	
Time	**Unique vehicles detected in zone***	**Non-compliant vehicles**	**Compliant vehicles**	**Non-compliant vehicles**	**Compliant vehicles**
CC hours	78,754	18,182	60,572	23.1%	76.9%
24 hour	106,664	22,255	84,409	20.9%	79.1%

*not representative of traffic flow

As was the case in the preceding months, the majority of unique vehicles detected in the zone (around three quarters) were detected during CC hours. There was a slight increase in compliance rate between CC hours and 24 hour data, this indicates that vehicles entering the zone in the evening and on weekends were less likely to be older more polluting vehicles.

Table 35. Average number and proportion of unique compliant vehicles detected in the zone over a 24 hour period from April 2019 – January 2020

Month	Number of vehicles driving in the charging zone per day			Proportions of vehicles driving in the charging zone	
	Unique vehicles detected in zone*	Non-compliant vehicles	Compliant vehicles	Non-compliant vehicles	Compliant vehicles
April 19	121,664	32,137	89,527	26.4%	73.6%
May 19	117,289	30,146	87,144	25.7%	74.3%
June 19	118,021	29,434	88,588	24.9%	75.1%
July 19	116,082	28,562	87,520	24.6%	75.4%
August 19	108,932	25,802	83,130	23.7%	76.3%
Sept 19	116,601	27,044	89,557	23.2%	76.8%
Oct 19	114,035	26,240	87,795	23.0%	77.0%
Nov 19	116,930	26,366	90,564	22.5%	77.5%
Dec 19	113,597	25,293	88,304	22.3%	77.7%
Jan 20	106,664	22,255	84,409	20.9%	79.1%

*not representative of traffic flow

Table 35 above shows the number of unique vehicles detected in the zone and compliance rate for an average day (24 hours) from April to January 2020. For all months the 24 hour compliance rate was higher than the CC hours compliance rate.

As discussed, data before April 2019 was collected during congestion charging (CC) hours only and we are therefore unable to compare 24 hour data to a time before the ULEZ was introduced

Charge payments and penalty charges

On an average day in January 2020 around 22,255 non-compliant, unique vehicles were detected in the zone. Of these:

- Around 10,628 (48 per cent) paid the charge (2,611 ULEZ web or call centre payments, 5,142 Auto Pay payments and 2,875 ULEZ Fleet charge payments)
- Around 1,894 (9 per cent) were in contravention of the scheme and incurred a penalty charge
- Around 9,733 (44 per cent) were not required to pay the daily ULEZ charge as they are eligible for a 100% discount or exemption

Compliance by vehicle type

Table 36 shows the daily average 24 hour compliance rate in January 2020 broken down by vehicle type.

Table 36. 24hr compliance rate in January 2020 by vehicle type

Vehicle type	Number of vehicles driving in the charging zone per day			Proportions of vehicles driving in the charging zone	
	Unique vehicles detected in zone*	Non-compliant vehicles	Compliant vehicles	Non-compliant vehicles	Compliant vehicles
All Vehicles	106,664	22,255	84,409	20.9%	79.1%
Cars	78,684	13,968	64,716	17.8%	82.2%
Cars (excluding taxis)	*69,724*	*7,609*	*62,115*	*10.9%*	*89.1%*
Taxis only[12]	*8,961*	*6,359*	*2,602*	*71.0%*	*29.0%*
Vans	18,808	6,837	11,971	36.4%	63.6%
HGVs	3,376	327	3,049	9.7%	90.3%
TfL buses	1,621	0	1,621	0%	100%
Non-TfL Bus/Coach	452	105	347	23.2%	76.8%
Other *	2,847	154	2,693	5.4%	94.6%
Unknown	877	865	12	**	**

*Other vehicle category includes motorbikes, mini-buses, TfL buses and non-road going vehicles
**Unknown means vehicle type cannot be determined (e.g. foreign vehicles). These default to non-compliant unless registered.

Table 36 shows the highest compliance rate is for HGVs at 90 per cent, next is car (excluding taxis) with a compliance rate of 89 per cent. The data shows that the compliance rate for cars in general is very high, but when grouped with taxis it falls to 82 per cent.

The Mayor has taken steps to support taxi drivers in the move to cleaner cabs with TfL's Taxi Delicensing Scheme launched in 2017, with payments of up to £5,000 to retire the oldest taxis from London licensing. The scheme was enhanced in 2019 to offer top level payments of £10,000. There are now over 3,370 ZEC taxis. In late 2019 the first ever fully electric London black cab, the Dynamo, was launched and just a few months later there are already 18 in circulation.

[12] Taxis refers to black cabs only and does not include Private Hire Vehicles

To ensure London returns to being on track to reduce emissions from taxis by 65 per cent by 2025, TfL confirmed last year that the age limit for black cabs will be reduced to 12 years for Euro 3, 4 and 5 taxis by 2022. From November 2019, the current 15-year age limit will apply to the anniversary of the date when the vehicle was licensed, with a proposed reduction in the age limit to 14 years from November 2020 and an annual reduction of one year each year until the 12-year age limit is reached. Euro 6 taxis, those converted to liquid petroleum gas (LPG) which reduces NOx emissions from taxis by over 70 per cent, and ZEC taxis will retain the 15-year age limit. TfL retains the ability to grant exemptions to the age limit requirements on a case by case basis.

For more information please see the Taxi and Private Hire pages of the TfL website.

Summary of the impacts of the ULEZ in the first ten months

On 8 April 2019 the Mayor of London launched the world's first Ultra Low Emission Zone (ULEZ). Ten months on, data indicates the scheme is having a significant and immediate impact – although further analysis will be needed to fully assess the long-term impacts.

This report includes data from February 2017 (when the Mayor confirmed the T charge and the change in the vehicle fleet began), March 2019 (the month before the scheme was introduced) and April 2019 – January 2020 (the first ten months of the scheme).

Key findings from the first ten months of operation are:

- Trend analysis shows that concentrations of NO_2 at roadside sites in the central zone in February 2020 are 39 μgm^{-3} less that in February 2017, when changes associated with the ULEZ began. This is a **reduction of 44 per cent**. This is over double the reduction at inner roadside sites, of 18 μgm^{-3}, and four times the reduction at roadside sites in outer London. The smallest improvement was recorded at urban background sites in outer London, 6 μgm^{-3}. This underlines the need for expanding the central London ULEZ to the North and South Circular roads in 2021
- After the first ten months of operation the **average compliance rate with the ULEZ standards was 79 per cent** in a 24 hour period (77 per cent in congestion charging hours). This is significantly higher than 39 per cent in February 2017 and the 61 per cent in March 2019 during congestion charging hours

- Analysis to determine the directly attributable impact of the ULEZ shows that, for the period January to February 2020, NO_2 concentrations at roadside locations in central London were on average 29 μgm^{-3} lower, equating to **a reduction of 37 per cent**, compared to a scenario where there was no ULEZ
- Preliminary estimates indicate that by the end of 2019 NO_x emissions from road transport in the central zone have **reduced by 35 per cent (230 tonnes)** compared to a scenario where there was no ULEZ. This is on track to achieve a 45 per cent reduction in the first year of the scheme.
- Preliminary estimates indicate that by the end of 2019 CO_2 emissions from road transport in the central zone have **reduced by 6 per cent (12,300 tonnes)** compared to a scenario where there was no ULEZ.
- None of the air quality monitoring stations located on ULEZ boundary roads have measured an increase in NO_2 concentrations since the introduction of the ULEZ indicating no issue with the displacement of traffic and related emissions
- Preliminary analysis of traffic flows indicate that the introduction of the central London ULEZ has contributed to a **reduction in traffic flows in central London from May to January 2020 of between 3 – 9 per cent** when compared to 2018, though further analysis is needed to better understand long term complex changes in traffic flows as a result of ULEZ
- From March 2019 to January 2020 there was a large reduction in the number of older, more polluting, non-compliant vehicles detected in the zone: **some 17,400 fewer on an average day, a reduction of 49 per cent** in congestion charging hours. This is higher than the 13,500 reduction reported after 6 months.
- There was a **41 per cent decrease** in the proportion of vehicles in the central zone that were non-compliant from March 2019 to January 2020 in congestion charging hours

To fully understand the impact of the scheme it is necessary to take into account pre-compliance (i.e. people and businesses preparing ahead of time for the start of the new scheme). With this in mind, the changes between February 2017 and January 2020 were as follows:

- There was a large reduction in the number of older, more polluting, non-compliant vehicles detected in the zone: **a reduction of 44,100 vehicles on an average day, equating to a 71 per cent reduction**
- There was a **96 per cent increase** in the proportion of vehicles detected in the central zone that were compliant from February 2017 to January 2020
- The average 24 hour compliance rate for all vehicles was 79 per cent in January 2020. However, there was a large discrepancy between different vehicle types. HGVs have the highest compliance of any vehicle groups with 90 per cent. Taxis had the lowest compliance rate with only 29 per cent.

6. Low Emission Bus Zones

Introduction

In August 2016 the Mayor of London announced London's first Low Emission Bus Zone (LEBZ) programme. A total of twelve Low Emission Bus Zones are now in operation across London. This report reviews the impact of the Low Emission Bus Zone programme on air quality emissions and concentrations and is an update to the Low Emission Bus Zones Evaluation Report published in September 2019.

What is a Low Emission Bus Zone?

Low Emission Bus Zones are bus corridors that are only used by buses with top-of-the-range engines and exhaust systems that meet or exceed the highest Euro VI emissions standards[13]. The zones have been prioritised in the worst air quality hotspots outside central London where buses contribute significantly to road transport emissions. Since April 2019 all TfL buses operating in the central London Ultra Low Emission Zone meet or exceed the Euro VI standard. All the Low Emission Bus Zones meet the following criteria:

- Buses are forecast to still be contributing 40 per cent or more of road transport NOx in 2020
- Pollutant concentrations were above legal limits for NO_2 and are forecast to continue to exceed in 2020; and
- Outside of the central Ultra Low Emission Zone (where all the buses have been cleaned up for the start of the ULEZ in April 2019).

The first zone was introduced along Putney High Street in March 2017 and was followed by a second between Brixton Road and Streatham High Road in December 2017.

All 12 zones were completed much sooner than the planned delivery date of 2020. The emissions reductions from the Low Emission Bus Zones form a central part of the Mayor's far-reaching plans for a drastic clean-up of London's toxic air. By October 2020, all of London's buses will either meet or exceed the Euro VI standard, meaning the whole of London will be a Low Emission Bus Zone.

[13] Due to the length of the zones there are locations where non-compliant buses cross or travel for a short distance along a Low Emission Bus Zone, even though they do not serve a bus stop within the zone.

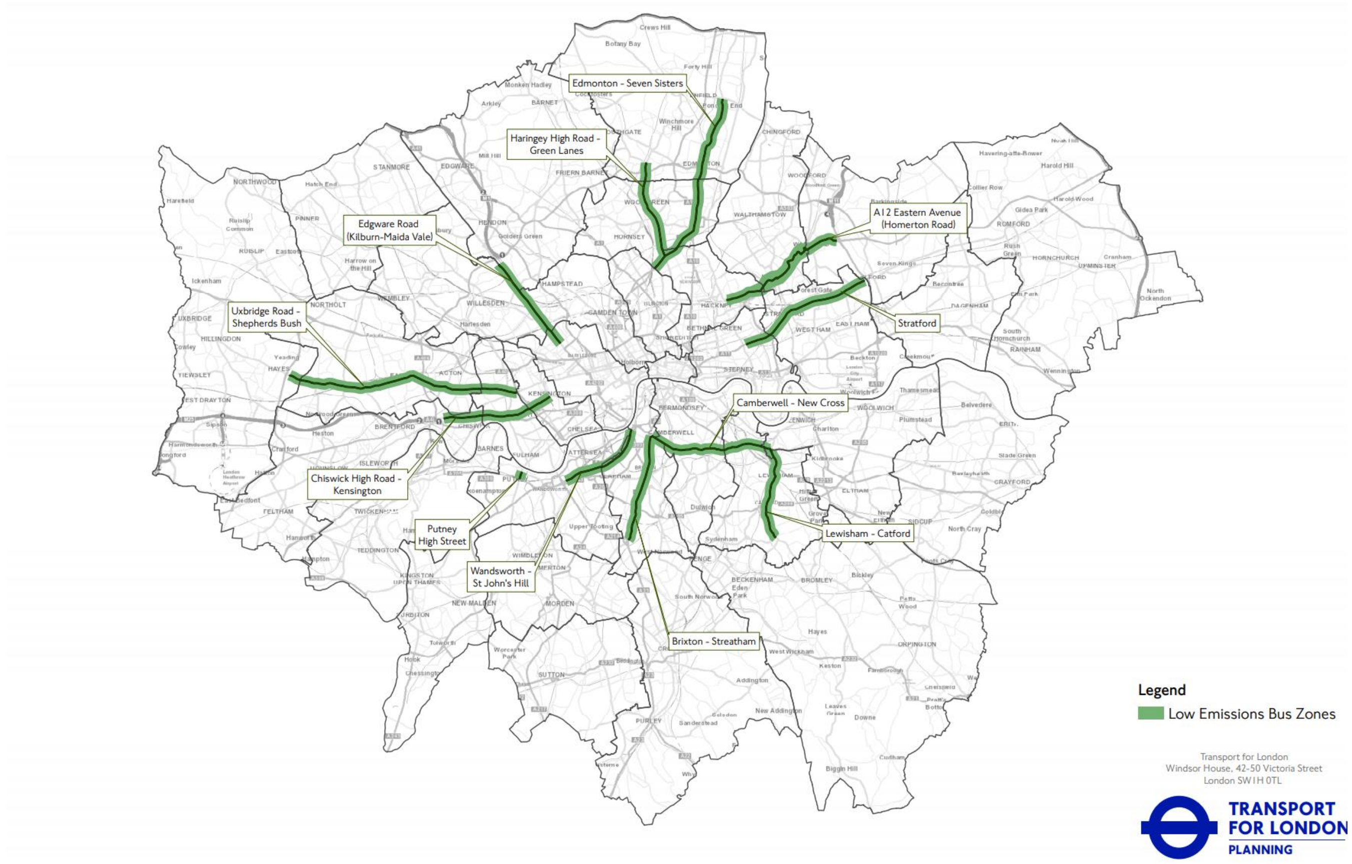


Figure 10: Map of the twelve Low Emission Bus Zones

Low Emission Bus Zone locations and completion dates

Putney High Street from Putney Station to Putney Bridge Road – completed October 2017

Brixton to Streatham from Brixton Road, along Brixton Hill, Streatham Hill and Streatham High Road – completed October 2017

Camberwell to New Cross from Camberwell New Road, along Peckham High Street to New Cross Road – completed July 2018

Wandsworth to St John's Hill from Lavender Hill to Wandsworth Road – completed July 2018

Haringey from High Road to Green Lanes – completed July 2018

A12 Eastern Avenue from Homerton High Street along Homerton Road, Warren Road, Gainsborough Road, Cambridge Park Road to Eastern Avenue – completed September 2018

Edgware Road (Kilburn to Maida Vale) from Cricklewood Broadway via Shoot-Up Hill to Kilburn High Road – completed October 2018

Lewisham to Catford from Bromley Road, along Lewisham High Street to Lewisham Road – completed December 2018

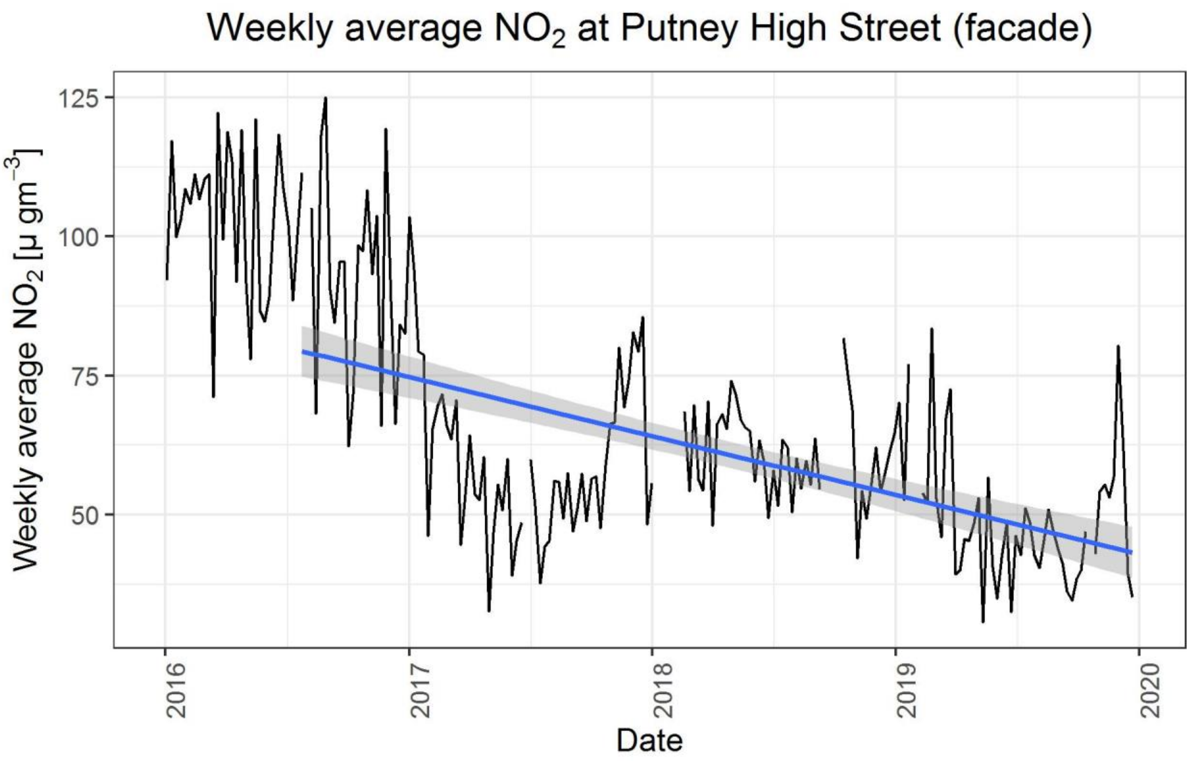
Edmonton to Seven Sisters from Hertford Road High Street via Fore Street to Seven Sisters Road – completed April 2019

Stratford from Mile End Road to Romford Road – completed May 2019

Chiswick High Road to Kensington from Chiswick High Road via Hammersmith Broadway to Kensington High Street – completed June 2019

Uxbridge Road to Shepherds Bush from Uxbridge Road via Ealing Broadway, The Vale to Uxbridge Road – completed August 2019

In addition, since April 2019 all buses entering the **Central London Ultra Low Emission Zone** either meet or exceed the strictest Euro VI standards.



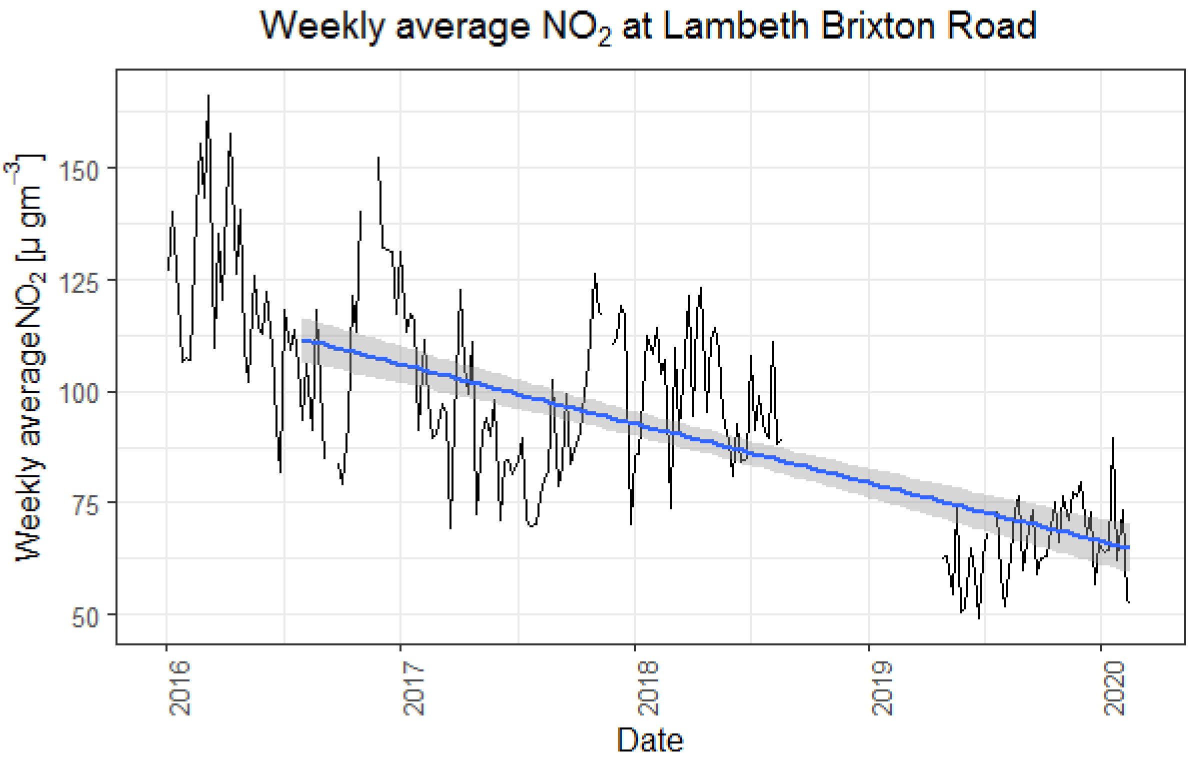
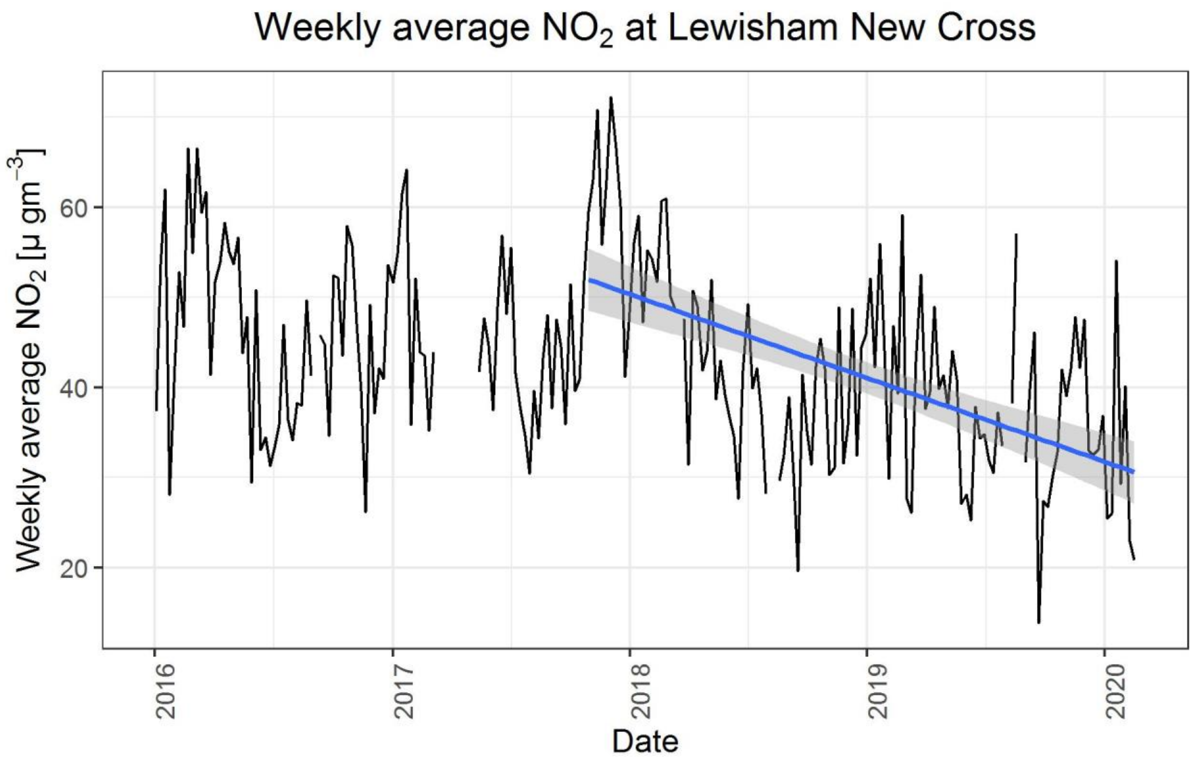


Figure 11 and Figure 12: Weekly average NO_2 at Putney High Street and Brixton Road



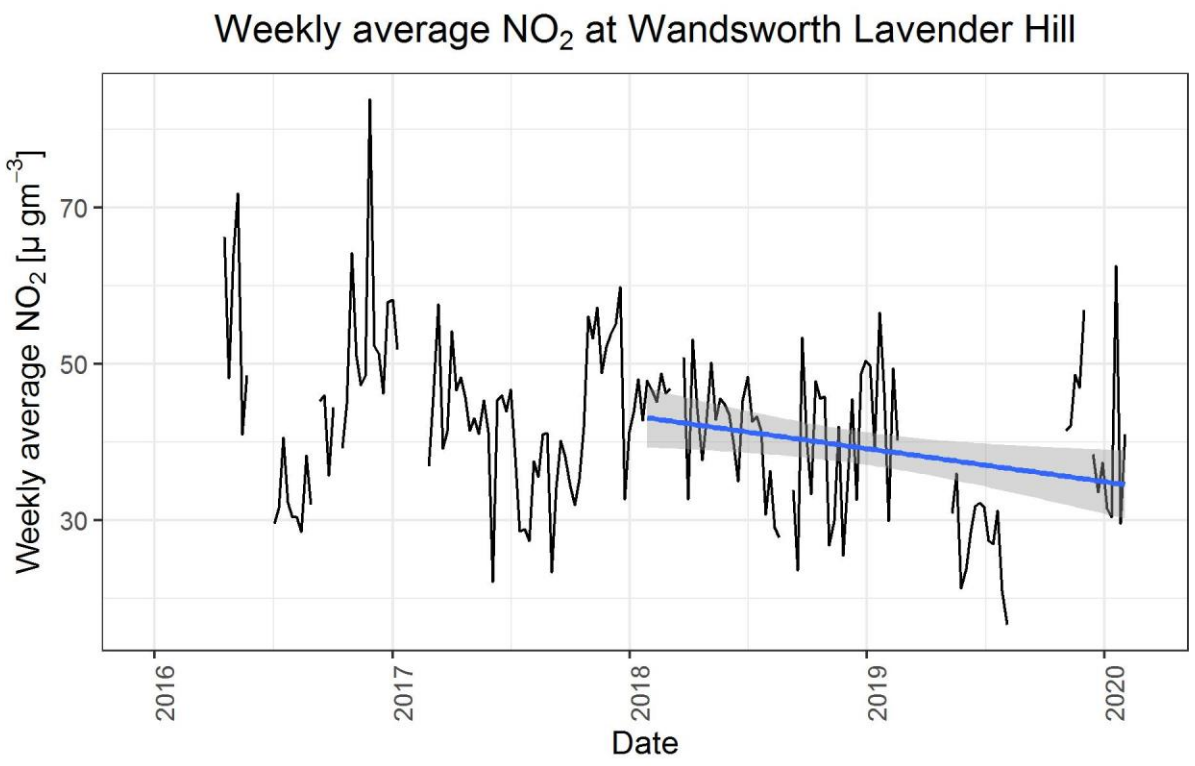
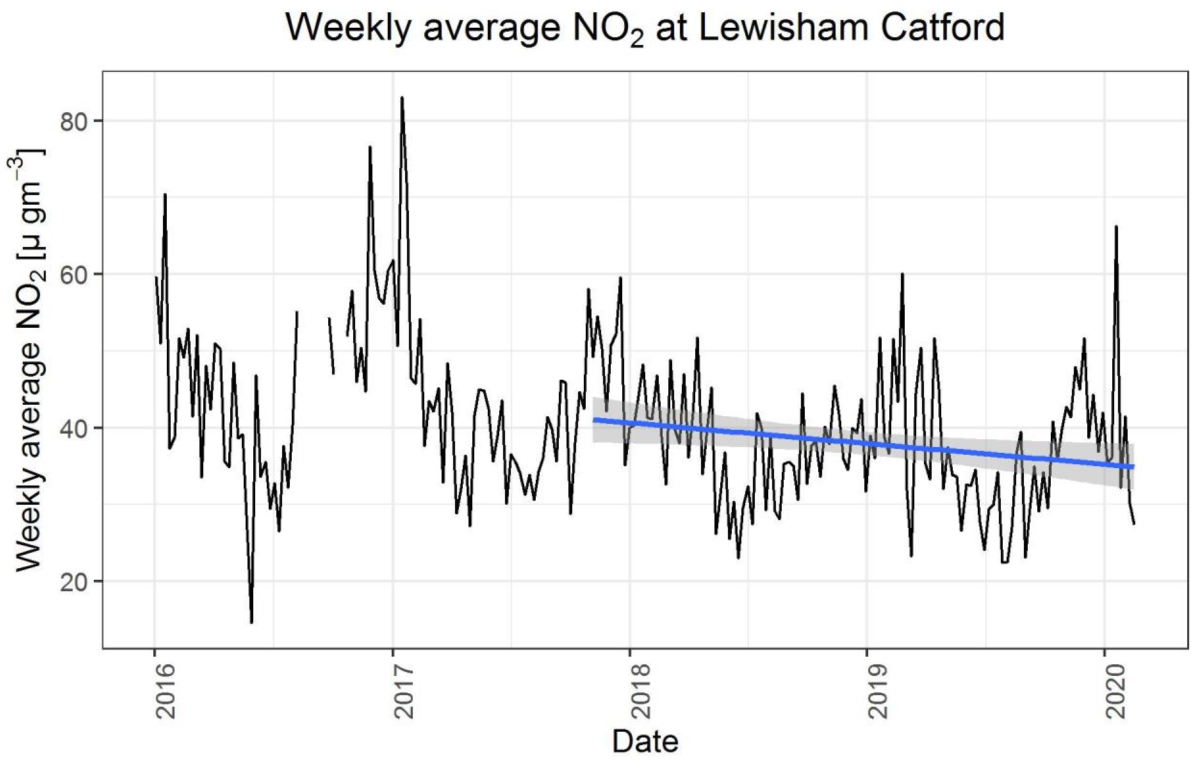


Figure 13 and Figure 14: Weekly average NO_2 at Lewisham New Cross and Wandsworth Lavender Hill



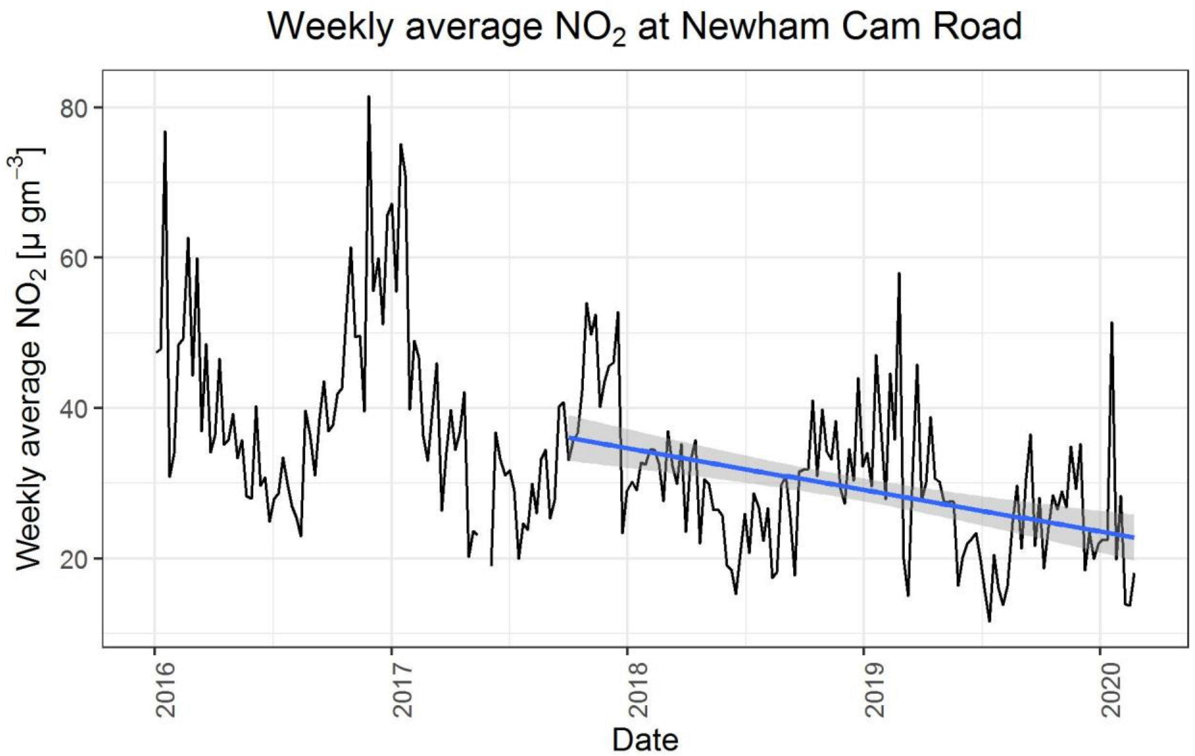
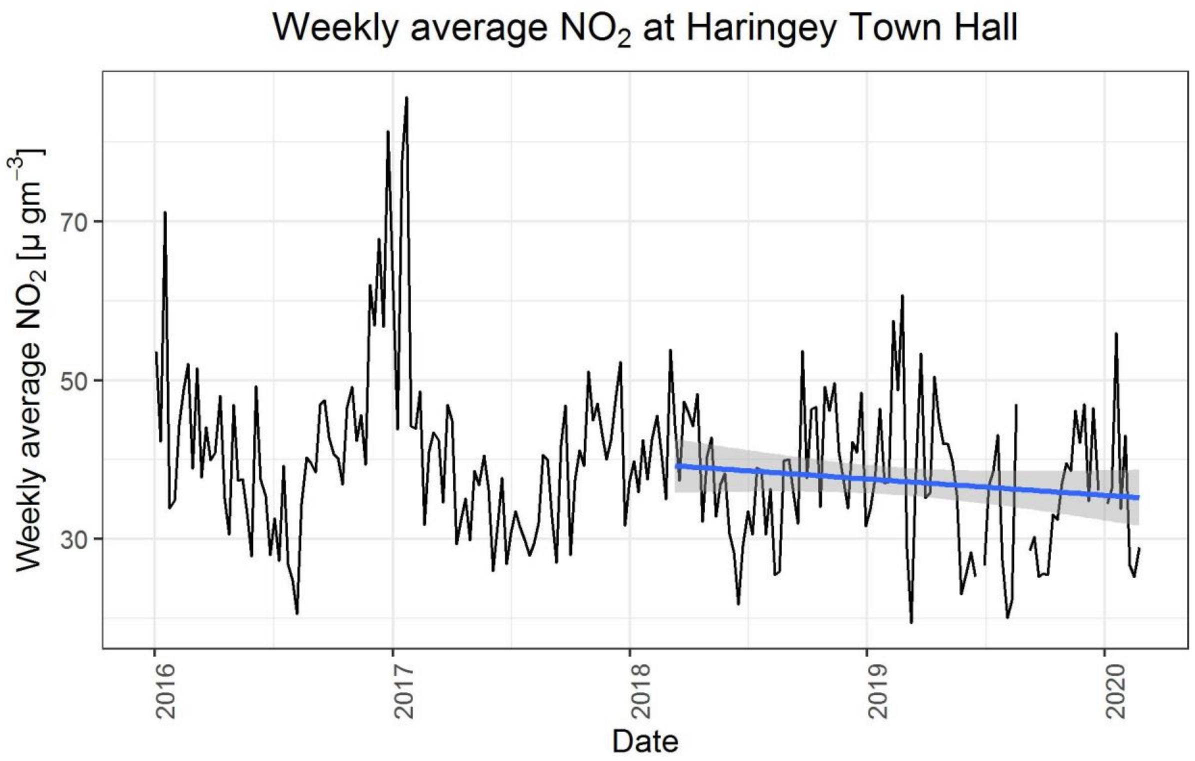


Figure 15 and Figure 16: Weekly average NO_2 at Lewisham Catford and Newham Cam Road



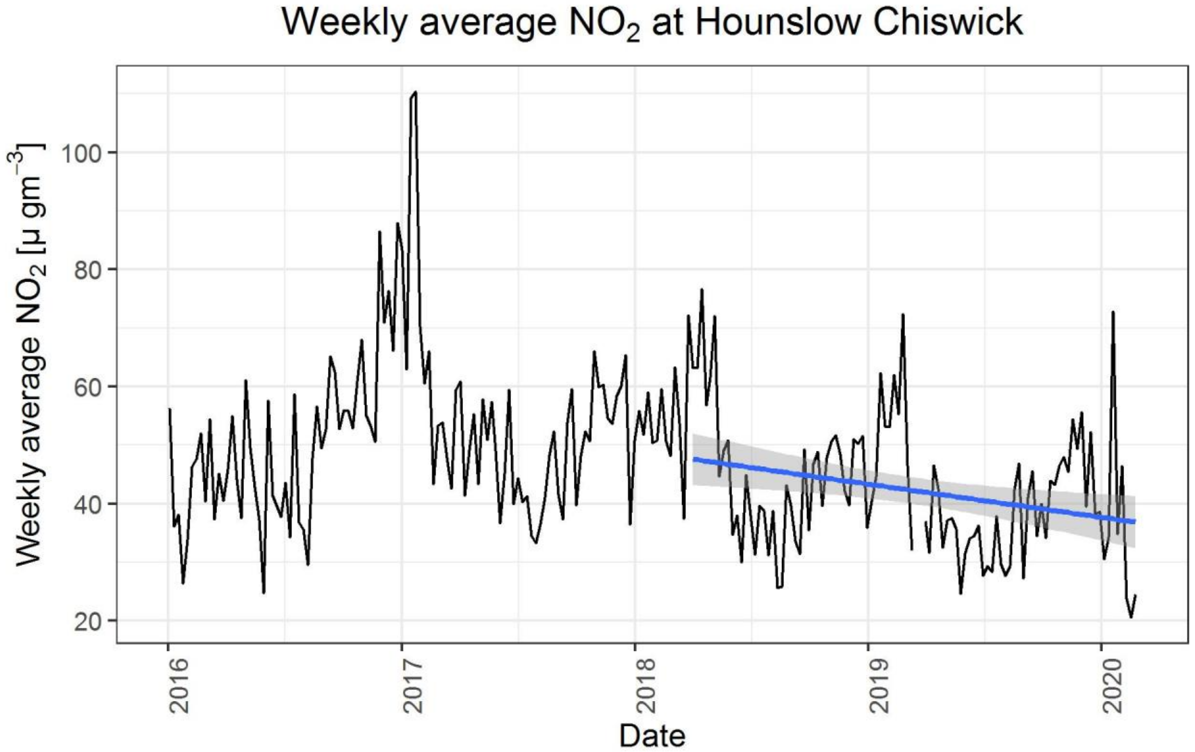


Figure 17 and Figure 18: Weekly average NO_2 at Haringey Town Hall and Hounslow Chiswick

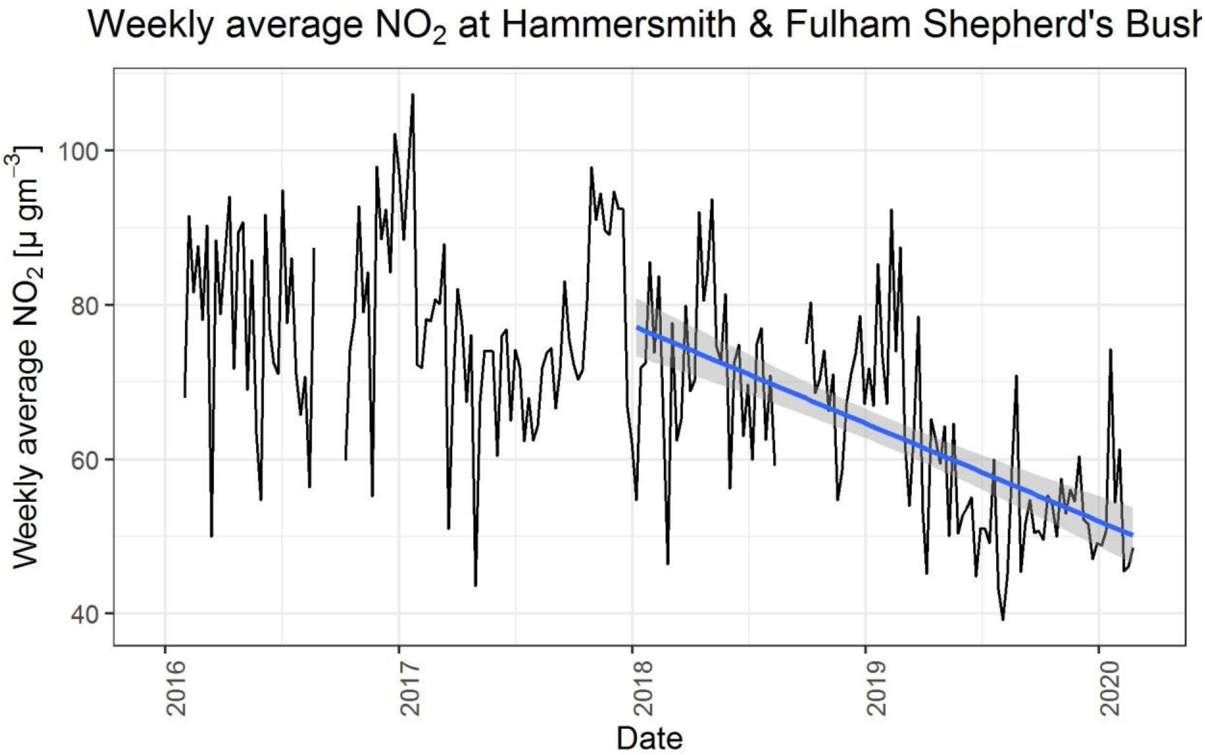


Figure 19: Weekly average NO_2 at Hammersmith & Fulham Shepherd's Bush

Figure 11 to Figure 19 have been generated using the statistical software package R and show the weekly average NO_2 at each monitoring site, excluding weeks with less than 75 per cent data capture. The blue line represents the linear smoothed trend from the date the LEBZ became fully operational. Note there was a phased introduction of upgraded buses in each LEBZ, meaning there will have been some benefits before this point. All sites measured a reduction, with sites where buses made up a larger proportion of emissions (e.g. Putney and Brixton) making up the largest reduction.

Concentration reductions

Every monitoring site located on a LEBZ recorded a reduction in annual average NO_2 between 2016 and 2019. The largest reduction, 56 μgm^{-3}, was recorded at Putney High Street. On average annual mean NO_2 concentrations reduced by 23 μgm^{-3}, a reduction of 28 per cent in just four years.

Table 37. Reduction in annual average NO_2 concentrations

Route	Monitoring site	Annual average in 2016 [μgm³]	Average in 2019 [μgm³]*	Reduction [μgm³]	Reduction [%]
Putney High Street	Putney High Street	125	69	56	45%
Putney High Street	Putney High Street (Façade)	98	49	49	50%
Brixton to Streatham	Lambeth Brixton Road	118	*65*[1]	*53*	*45%*
Camberwell to New Cross	Lewisham New Cross	46	38	8	17%
Wandsworth to St. John's Hill	Wandsworth Lavender Hill	43[2]	*37*[3]	*6*	*14%*
Lewisham to Catford	Lewisham Catford	43[2]	37	6	14%
Edmonton to Seven Sisters	Haringey Town Hall	43	37	6	14%
Stratford	Newham Cam Road	42	27	15	36%
Chiswick High Road to Kensington	Hounslow Chiswick	50	42	8	16%
Uxbridge Road to Shepherds Bush	Hammersmith & Fulham Shepherd's Bush	79	58	21	27%

*2019 data still to be ratified, may be subject to slight amendment
[1]Brixton Road 2019 indicative value as only 67 per cent data capture
[2] Lavender Hill and Lewisham Catford there was not sufficient data capture to report an annual average for 2016. Instead the figure quoted is the annual average for 2017. Both zones were not fully complete until 2018.
[3]Lavender Hill 2019 indicative value as only 57 per cent data capture

Whilst there were improvements at every site, there is still more action required to reduce concentrations at some locations. Four of the sites still exceeded the annual mean limit for NO_2 in 2019, with the measurement for Brixton indicating it also would have exceeded had there been sufficient data capture.

Table 38 shows the number of NO_2 hours with an average concentration exceeding 200 μg m³ reported at air quality monitoring stations located within a LEBZ.

Table 38. Reduction in numbers of hours exceeding NO_2 hourly limit [200 µgm^3]

Route	Monitoring site	Hours in 2016	Hours in 2019*	Reduction	Reduction [%]
Putney High Street	Putney High Street	1,272	11	1,261	99%
Putney High Street	Putney High Street (Façade)	403	0	403	100%
Brixton to Streatham	Lambeth Brixton Road	539	*0*[1]	*539*	*100%*
Camberwell to New Cross	Lewisham New Cross	0	0	0	na
Wandsworth to St. John's Hill	Wandsworth Lavender Hill	23[2]	*0*[3]	*20*	*87%*
Lewisham to Catford	Lewisham Catford	0[2]	0	0	na
Edmonton to Seven Sisters	Haringey Town Hall	6	0	6	100%
Stratford	Newham - Cam Road	0	0	0	na
Chiswick High Road to Kensington	Hounslow - Chiswick	6	0	6	100%
Uxbridge Road to Shepherds Bush	Hammersmith & Fulham Shepherd's Bush	33	3	30	91%

*2019 data still to be ratified

[1] Brixton Road 2019 indicative value as only 67 per cent data capture

[2] Lavender Hill and Lewisham Catford there was not sufficient data capture to report an annual average for 2016. Instead the figure quoted is the annual average for 2017. Both zones were not fully complete until 2018.

[3] Lavender Hill 2019 indicative value as only 57 per cent data capture

All monitoring sites located on a LEBZ met the legal hourly limit for NO_2 in 2019. Every monitoring site that had recorded an hour above the threshold limit in 2016 saw a reduction in 2019. The largest reduction was again at Putney High Street, where the number of exceedances reduced from 1,272 in 2016 to 11 in 2019, a reduction of 99 per cent. On average there was a 97 per cent reduction in the number of hourly exceedances at monitoring sites in LEBZ from 2016 to 2019.

Buses are only one part of the traffic contributing to local pollution concentrations. Therefore, the subsequent reductions in pollution concentrations as a result of the introduction of a LEBZ will vary by location. The reductions reported may also capture the benefits of other air quality policies, such as the introduction of the central London Ultra Low Emission Zone.

There are a number of reasons different monitoring sites may record different levels of reduction since the implementation of the LEBZs. These include;

- All LEBZs are in areas where buses account for at least 40 per cent of NO_x emissions. However, some of the zones such as Putney High Street have a higher percentage of emissions coming from buses than in other LEBZs. We therefore see a greater reduction in concentrations at these zones
- Some zones may also be impacted by other policies making concentrations reductions higher in these zones
- The siting of the monitoring station can have a big impact on the concentrations recorded. Monitoring sites are placed varying distances from the kerb of the road, sites located further from the kerb will be influenced more by non-road transport sources and therefore likely to report lower reductions
- The topography of a road can influence local dispersion patterns as well as local prevailing wind directions which can have a large impact on the concentrations of pollutants recorded at monitoring sites

Emissions reductions

Table 39 shows the reduction in NO_x emissions as a result of introducing the twelve Low Emission Bus Zones. For context, in 2016 the entire London bus fleet emitted 3,083 tonnes of NOx. The LEBZ programme has reduced the London wide bus fleet emissions by 29 per cent. By October 2020 all buses in London will meet the LEBZ standards resulting in a 90 per cent reduction in NO_x emissions from buses Londonwide compared to 2016.

Table 39. Reduction in NO_x emissions as a result of the Low Emission Bus Zone

Route	Emissions in 2016 before LEBZ [tonnes]	Emissions in 2019 after LEBZ [tonnes]	Saving [tonnes]	Reduction [%]
Putney High Street	20	3	17	87%
Brixton to Streatham	82	9	73	89%
Camberwell to New Cross	104	11	93	90%
Wandsworth to St. John's Hill	53	5	48	91%
High Road to Green Lanes	86	7	79	92%
A12 Eastern Avenue	59	5	54	91%
Edgware Road	43	5	39	90%
Lewisham to Catford	118	12	107	90%
Edmonton to Seven Sisters	106	10	96	91%
Stratford	87	8	78	90%
Chiswick High Road to Kensington	78	7	71	91%
Uxbridge Road to Shepherds Bush	138	11	127	92%
Total	**974**	**92**	**881**	**91%**

Summary of impact of Low Emission Bus Zones

- All twelve Low Emission Bus Zones were delivered much sooner than the planned delivery date of 2020. In addition, since April 2019 all buses entering the central London ULEZ have to meet the Low Emission Bus Zone standards
- Modelling shows that Low Emission Bus Zones have reduced **bus NO_x emissions by an average of 90 per cent** across the routes operating in those areas
- Introduction of the twelve Low Emission Bus Zones has reduced NO_x emissions from those buses by 881 tonnes. This equates to a **29 per cent reduction** in Londonwide bus fleet emissions
- Large reductions in annual and hourly concentrations have been recorded at the first two Low Emission Bus Zones in operation, Putney High Street and Brixton Road
- At Putney High Street, annual mean **NO_2 concentrations have reduced by 45 per cent** and exceedances of the hourly mean limit **have reduced by 99 per cent** since 2016

- At Brixton Road annual mean NO_2 concentrations have **reduced by 45 per cent** and exceedances of the hourly mean limit have **reduced by 100 per cent since** 2016, though these figures are indicative due to low data capture at that site in 2019
- Concentration monitoring data is available for seven of the other Low Emission Bus Zones. Although the zones have been in place a shorter time, reductions in annual and hourly average nitrogen dioxide were recorded at every site
- The average reduction in annual average NO_2 at the nine Low Emission Bus Zones where monitoring is available 23 μgm^3, **a reduction of 28 per cent from** 2016 to 2019
- The three other Low Emission Bus Zones do not have monitoring sites located along the route. Our modelling shows these zones have all had reductions in NO_x emissions of over 90 per cent.

7. Impact of COVID-19 lockdown

In March 2020 strict measures were introduced to tackle the COVID-19 pandemic in London. This had a significant impact on London's air quality.

It is important that the change in air pollution concentrations as a result of COVID-19 measures are framed in the context of London's normal seasonal pattern for pollutants and the substantial improvements in London's air quality in recent years, in particular in central London where the Ultra Low Emission Zone had already significantly reduced concentrations of pollutants, as demonstrated in Figure 20.

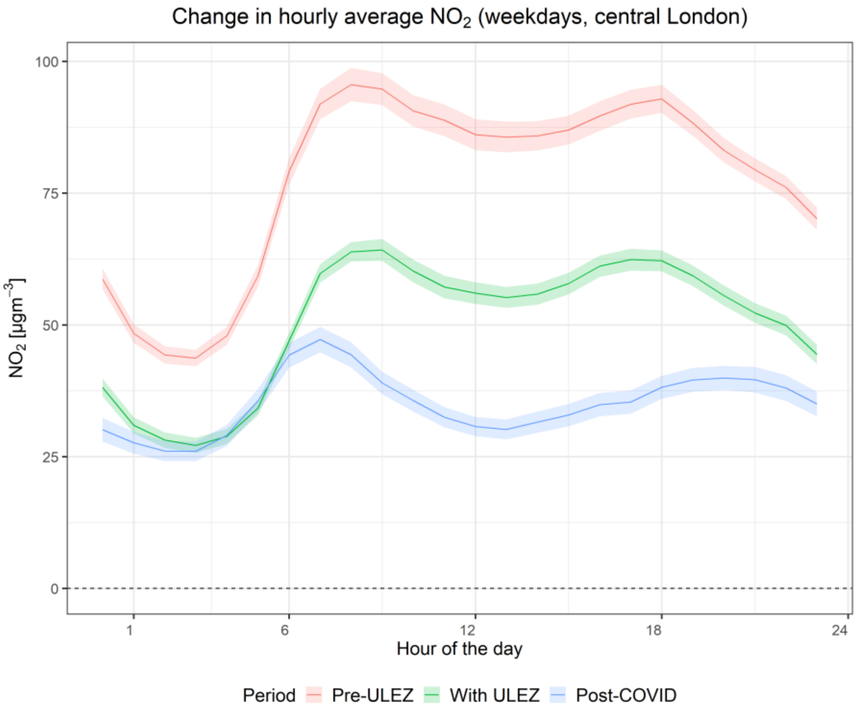


Figure 20. Change in hourly average NO_2 in central London

Figure 20 shows the change in hourly average NO_2 at all sites in central London, from the period January – April 2020. The red line shows the hourly trends in NO_2 in central London from 1 January 2017 – 20 April 2017 (before changes associated with the central ULEZ took full effect). The green line shows the hourly trends in NO_2 in central London from 1 January

– 15 March 2020, with the ULEZ in place but before COVID measures were introduced. The blue line shows the hourly trends in NO_2 in central London from 16 March – 20 April 2020, with COVID-19 measures in place.

In 2020, before measures to address the COVID outbreak were introduced, hourly average NO_2 at all sites in central London had already reduced by over one third (35 per cent) compared to the same period in 2017. During lockdown there was an additional reduction of 26 per cent, this reduction was even higher at roadside sites.

In recent years policies and measures have been introduced in London (including Low Emission Bus Zones, the ULEZ and changes to the taxi fleet) that have resulted in significant improvements in air quality. Other studies looking into the impact of lockdown on London's air quality have compared concentrations during lockdown to the same period for previous years. Whilst this may be appropriate for other locations, it is not appropriate for London due to the significant recent improvements which pre-date the COVID outbreak.

For the other pollutants which are more affected by regional changes, the picture was more complex. There were peaks in ozone, PM_{10} and $PM_{2.5}$ during the period when stricter measures were introduced in London. These peak in particulate matter were usual for the time of year and not thought to be linked to the introduction of COVID-19 measures. During lockdown there were three particulate matter pollution episodes partly caused by domestic wood-burning, garden waste-burning and barbeques in London.

There was also one high pollution episode for ozone and increases in ozone at roadside and kerbside locations. There is a complex relationship between ozone and NOx, in bright sunlight nitrogen dioxide and other pollutants react to form large amounts of ozone, without sunlight, a different reaction takes place where nitrogen dioxide "mops up" ozone, reducing levels. This increase in ozone may be linked to the decrease in NOx emissions from road transport, although further research is needed to confirm this.

For more information please see the Estimation of changes in air pollution during the COVID-19 outbreak report.

8. Looking ahead

Whilst the results presented in this report represent a substantial and immediate improvement in air quality in recent years, significant work remains to bring London's pollution down to levels where it does not have a harmful impact on public health. This chapter outlines the scale of this challenge, then highlights how the Mayor and Transport for London, working with partners including London's boroughs and the Government, plan to complete London's air quality transformation.

The challenge

Between 2016 and 2020 there was huge progress in improving London's air quality, especially for NO_2. However, a significant challenge remains to bring London's air pollution down to the recommended limits. For NO_2, 70 per cent of roads in central London and 24 per cent of roads in inner London – where some of the most deprived Londoners live – still exceed the legal limits for NO_2. For $PM_{2.5}$ the remaining challenge is even greater, with 99 per cent of Londoners still living in areas that exceed the World Health Organization guideline limit.

It is also important to remember that the World Health Organization is currently reviewing their guideline limits for both particulate matter and NO_2. As a result, these thresholds will probably reduce over time. Achieving these enhanced standards will deliver greater health benefits for Londoners and cost savings to the NHS and social care system. The Mayor has committed to continue to be led by the best available health evidence from the World Health Organization and others.

And as London begins its work to recover from the pandemic and evidence emerges of an association between air pollution and COVID-19, it is more important than ever to move forward with policies that will clean up London's air.

A strong economic recovery and a green recovery are not mutually exclusive. As part of the plans for London's recovery, the Mayor is committed to a Green New Deal for Londoners. This has the potential to combat the challenges of the climate emergency, ecological emergency and air pollution, but also boost the economy whilst tackling inequalities.

The Mayor has also called on the Government to take the once-in-a-generation opportunity presented by the upcoming Environment Bill to give London the powers it needs to address sources of pollution in the city as well as bring in new legally binding health-based targets for particulate matter, adopting the WHO target for 2030 as the Mayor has already done for London.

In the meantime, two new areas that the Mayor is pressing ahead on, building on Londoners' desire to build back better are his Streetspace Plan and School Streets.

Mayor's Streetspace for London programme

With social distancing reducing the effective capacity of public transport – a double decker bus for example is currently limited to carrying just 33 people – there is a risk that travel by car becomes more attractive. A car-based recovery would have significant risks not just for air quality, but also road danger, congestion, London's economy and wider public health.

The Mayor's Streetspace programme is seeking to prevent a spike in car use by rapidly repurposing London's streets to enable millions more journeys to be made by on foot or by bike. This frees up capacity on public transport and by car for Londoners who cannot walk or cycle.

The Mayor and Transport for London are working with the London boroughs to create more space for people to walk and cycle, with the programme focussed on three key areas:

- Building a strategic cycling network, using temporary materials and including new routes, to help reduce crowding on the Tube, trains and busy bus routes. Over 70 km of new or upgraded cycle infrastructure has been completed or is under construction
- Widening pavements and reducing motor traffic in town centres so people can safely walk past queues outside shops or stations. Over 20,000m^2 of highway has been reallocated to people walking across TfL's streets.
- Reducing traffic on residential streets, creating low-traffic corridors right across London so more people can walk and cycle as part of their daily routine. 152 low traffic neighbourhood schemes have been awarded funding.

Streetspace schemes are being delivered quickly and cheaply, using temporary or experimental powers. TfL and the boroughs will continue to engage with residents as decisions are made about whether schemes should be made permanent, or be amended or removed. More information and maps of the Streetscape Plan are available on TfL's Streetspace for London webpages.

School Streets

As part of the Mayor's Streetspace for London programme over 400 'School Streets' are being introduced Londonwide ensuring children and their parents can return to school safely. A School Street is where vehicle access is restricted outside a school during drop off and pick up times.

Advice on school travel is that parents/carers, children and young people should be encouraged to walk or cycle where possible, only drive if absolutely essential and avoid public transport. 'School Streets' reduce levels of traffic and pollution around schools and have been recommended wherever possible.

Most School Streets close the carriageway to traffic at set times. Pre COVID-19 this would typically be for 45-60 minutes at the start and end of the school day, though with social distancing and staggered start times this may have to be longer. Signage is used to communicate the closure to road users and ensure the closure is enforceable. The closure is usually enforced using either physical barriers or automatic number plate recognition cameras.

School Streets reduce levels of air pollution during drop off and collection and have already been introduced at a number of schools as part of the Mayor’s school air quality audits programme. School Streets also improve road safety and incentivise walking, cycling and scooting.

Schools streets provide a solution for additional space outside primary and secondary schools. They have been successfully implemented in London on a range of street types, including bus routes (with buses exempt from the closure).

More information about implementing School Streets as part of the Streetspace Plan is available from the London Streetspace Plan supplementary guidance: School Streets.

A series of case studies can be found in Hackney’s School Streets Toolkit for professionals.

New powers to tackle $PM_{2.5}$

More action is needed to tackle $PM_{2.5}$ in London to achieve the World Health Organization guideline limit of 10 µgm^3 by 2030. At present, London and other cities in the UK do not have sufficient devolved powers to tackle key local sources of $PM_{2.5}$.

In 2019 City Hall published $PM_{2.5}$ in London: Roadmap to meeting World Health Organization guidelines by 2030. This demonstrated London could only meet WHO guidelines by 2030 if additional action over and above that included in the London Environment Strategy, facilitated by Government, was taken. This action included:

- UK Government adoption of legally binding targets for $PM_{2.5}$ in line with World Health Organisation limits
- New powers for London to reduce emissions from woodburning
- New powers for London to abate emission from commercial cooking
- New powers for London to reduce emission on the river – a growing proportion of emissions as other sources such as road transport are reduced

Londonwide Low Emission Zone and ULEZ expansion

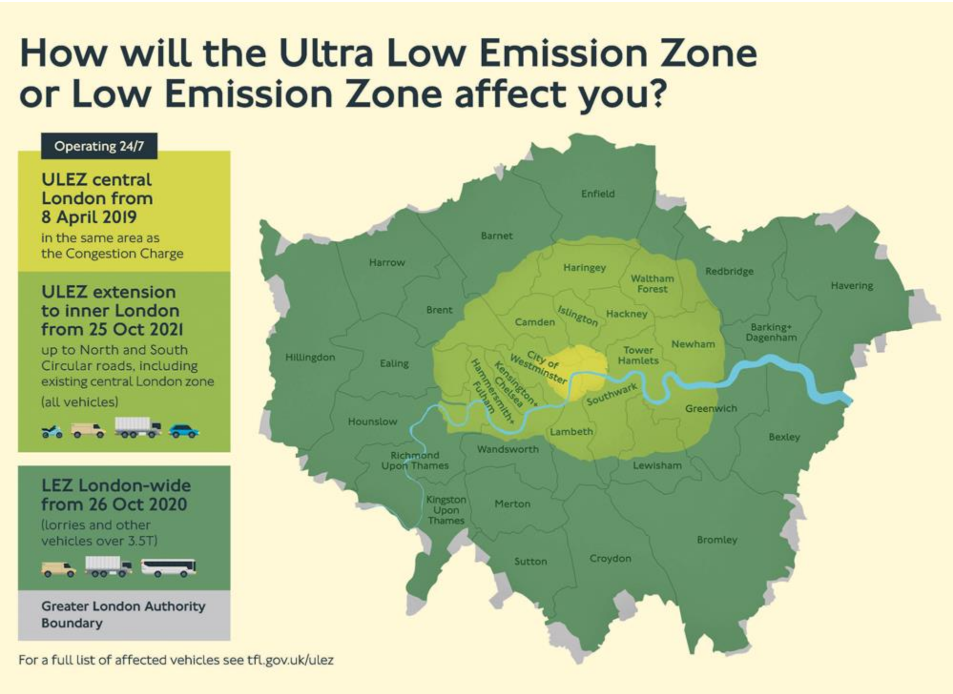


Figure 21. Map of the Londonwide LEZ and expanded ULEZ

New stricter rules for freight vehicles, driving in the London Low Emission Zone (LEZ) were due to come into force from October 2020. Disrupted supply chains during the coronavirus pandemic have made it more difficult for the new standards to be met on time.

The Mayor of London has therefore asked TfL to delay enforcement of the new rules for at least four months to give the industry and fleet operators more time to adopt cleaner, safer vehicles. This means no charges will be payable or enforced for non-compliant vehicles under new LEZ standard until the end of February 2021 at the earliest.

From 1 March 2021 (at the earliest) the emission standards for the Londonwide Low Emission Zone for heavy vehicles will tighten to align with the ULEZ Euro VI diesel standard. If people driving a HGV, lorry, van or other specialist heavy vehicle over 3.5 tonnes gross vehicle weight or a bus/minibus or coach over 5 tonnes gross vehicle weight within the LEZ do not meet:

- Euro VI (NOx and PM) - they will need to pay a daily charge of £100
- Euro IV (PM) - they will need to pay a daily charge of £300

From October 2021 the ULEZ boundary will be extended to create a single larger zone bounded by the North and South Circular Roads. People driving any petrol or diesel vehicle within the expansion will also need to meet the tighter emissions standards or pay a daily charge. This daily charge is in addition to the weekday Congestion Charge in central London. Vehicles using the North and South Circular Roads and not going into the ULEZ will not be charged.

Transport for London bus fleet

The majority of the Transport for London bus fleet now meets or exceeds the cleanest Euro VI standard. By October 2020 the entire fleet will be ULEZ compliant. The Mayor's Transport Strategy outlined key milestones for cleaning up London's bus fleet including:

- From 2020 TfL will only buy electric or hydrogen single deck buses
- From 2025 TfL will only buy electric or hydrogen double deck buses
- By 2030 90 per cent of single deck buses will be electric or hybrid
- By 2030 60 per cent of double deck buses will be hybrid, 40 per cent will be electric or hydrogen

- By 2037 (at the latest) all TfL buses will be electric or hydrogen

The Mayor has already committed to all buses being zero emission by 2037 at the very latest. However, he wants this to be delivered as soon as practicable and has asked TfL to explore options for bringing this forward.

Given the scale of the air quality health crisis and climate emergency we face, the Government must also play its role and provide extra funding to accelerate the transition to zero emission buses, including helping to resolve complicated infrastructure requirements at bus depots. This will also create new jobs and industrial opportunities for our country.

Non-Road Mobile Machinery (NRMM)

The London Environment Strategy set out an ambitious target of all NRMM used in construction in London being zero emission by 2040. The NRMM Low Emission Zone will include progressively tightening standards, with the current proposals as follows:

- Currently: Stage IIIB in the Central Activities Zone (CAZ) plus Canary Wharf area, Stage IIIA everywhere else
- 2020: Stage IV in CAZ plus Opportunity Areas, Stage IIIB everywhere else
- 2025: Stage IV throughout London
- 2030: Stage V throughout London
- 2040: zero emissions throughout London

Long term health benefits

In February 2020 City Hall published a report Modelling the long-term health impacts of changing exposure to NO_2 and $PM_{2.5}$ in London.

The report revealed that by 2050 the impact of the Mayor's air quality policies, including the ULEZ, Low Emission Bus Zones and no longer licensing new diesel taxis, are predicted to result in:

- Almost 300,000 Londoners saved from diseases attributable to air pollution, such as coronary heart disease, lung cancer and dementia. This is a reduction of around one in every four air pollution related diseases
- A cost saving to London's NHS and social care system of around £5 billion

- One million fewer new air pollution related hospital admissions in London.

The report also found that in addition to the policy areas controlled by the Mayor, if no wider action is taken by the Government to reduce air pollution:

- Around 550,000 Londoners would develop diseases attributable to air pollution over the next 30 years
- The cumulative cost to the NHS and social care system in London is estimated to be £10.4 billion.

9. Conclusion

Between 2016 and 2020 the Mayor of London embarked on the most ambitious programme of air quality action in the world. This included introducing the world's first Ultra Low Emission Zone, cleaning up London's bus and taxi fleets and taking action to reduce exposure to air pollution at some of the city's most polluted schools. The evidence from London's air quality monitoring network and modelling from King's College London shows this bold action has delivered significant real-world improvements for London's air quality.

Since the Mayor took office in 2016 the scale of reduction in toxic NO_2 at roadside sites has been five times greater in central London than the national average. The Government's own data shows just how little progress has been made outside London in the same period, demonstrating the significant improvements in London have been driven by local (as opposed to national) policy.

Between 2016 and 2019 the number of Londoners living in areas exceeding legal limits for nitrogen dioxide fell from over 2 million in 2016 to 120,000 in 2019. A reduction of 94 per cent. This will have health benefits for these Londoners for years to come and avoid costs to the NHS and economy.

However, there is much more work still to be done. 70 per cent of roads in central London and 24 per cent in inner London still exceed the legal limits for nitrogen dioxide. Looking forward, further action, including the expansion of the Ultra Low Emission Zone in 2021 will be necessary if London is to meet its target of city-wide compliance with the annual mean legal limit for nitrogen dioxide by 2025.

A recent study by King's College London looking at the overall rate of improvement in NO_2 levels across London before 2016 found that, compared with legal pollution limits, if the trend of inaction seen between 2010 and 2016 continued it would take 192 years to reach legal compliance[14]. However, further modelling undertaken for City Hall by King's College London suggests the Mayor's far-reaching policies would reduce this to just five years, meaning London's air would be within legal pollution limits by 2025. This report shows we are on track to meet this target.

For fine particulate matter the challenge is greater still, with 99 per cent of Londoners living in areas exceeding the World Health Organization guideline limit. The evidence presented in this report underlines the need for new powers allowing London to tackle local sources of $PM_{2.5}$. This will be essential for London to meet the World Health Organization guideline limit by 2030, and deliver further vital health improvements for Londoners.

[14] A tale of two cities: is air pollution improving in Paris and London, Font et al, 2019

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