# APPENDICES

# Appendix A.
# **Understanding Air Quality In the Borough**

**Air quality has improved a lot in the borough over the last 20 years. A good example of this is the fall in annual average NO2 shown in the graph at many locations in the borough Figure A1. The progress achieved, and the resulting health benefits, have been the result of cooperative action. This included contributions by local residents, the Council, London-wide policies like the ULEZ and work at national level. Here in Richmond, thousands of residents and businesses have bought electric and other cleaner vehicles, increased walking and cycling or their use of public transport.**

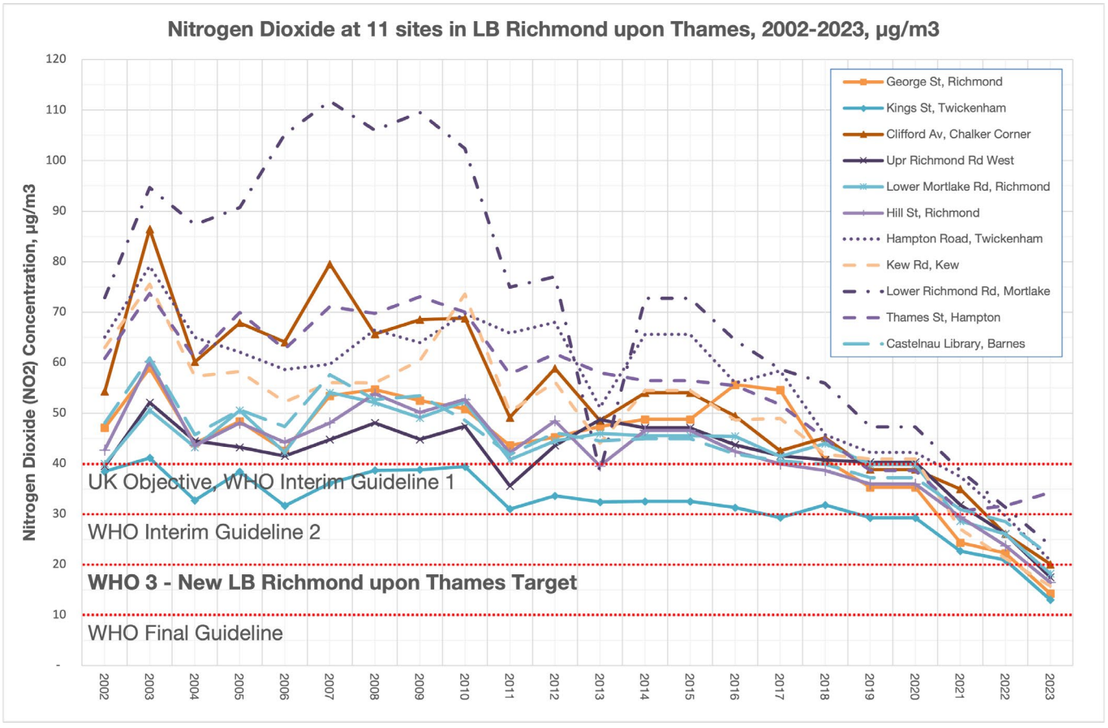


Figure A1. Annual average $NO_2$ measurements at 11 sites in the borough over 2002-2023, in µg/m³. Also shown are the UK, WHO and new borough targets.



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The Council has been highly proactive. Hundreds of EV chargers, cargo delivery schemes, parcel lockers and engine idling work have reduced emissions from our roads. Better footpaths and new bike paths have made it safer to walk and cycle. New school streets and school air quality assessments have made schools safer. And we've taught school children about how to protect themselves from air pollution and reduce it. The Council has made developers avoid creating new traffic, support active travel and minimise emissions from buildings and during construction. And the Councils work implementing an Ultra-Low Emission Zone for Construction across London has been exceptionally successful. It has cut by nearly half the toxic emissions from construction site machinery.

These measures have been very effective. The results is that the borough has some of the cleanest air in London, and we are proud of how our work has improved our air compared to others. But air pollution still remains the 3rd overall cause of preventable mortality in the borough, and contributes to many diseases like ischaemic heart disease, lung cancer, dementia and asthma. To tackle it we must fully understand the risks and causes.

### Methods uses to map air quality risks

Mapping our local air quality risks helps us identify areas with the highest air quality risks. This helps us prioritize where and who to engage with to achieve the biggest benefit. To map these risks we use a network of monitoring stations and systems. These measure $NO_2$, $PM_{2.5}$ and Coarse Particulate Matter ($PM_{10}$) in several different ways at around 120 locations. For these, the main metrics used to map risk are the annual average values of these air pollutants, as well as exceedances of hourly or daily means. We also use analyses of London-wide air quality conducted by the GLA, including the four priority Focus Areas in Richmond town centre, Upper Richmond Road West, Twickenham and Hammersmith Bridge Road. These London Atmospheric Emissions Inventory analyses help us understand local emissions. This is then combined with knowledge of exposure and vulnerability at these locations to determine which locations are most at risk. The results of this analysis are detailed below.

We also use health impact calculations completed for the Richmond area both by the Government (UK Office for Health Improvement and Disparities, 2024) and for the GLA by Imperial College (Dajnak, Evangelopoulos, Kitwiroon, Beevers, & Walton, 2020)

To enhance these capabilities and assist in further prioritisation, these mapping techniques will in future be extended to account for more detailed statistics on air pollution, health vulnerabilities, inequalities and inclusion, age groups, and heat risk, which when coupled with air pollution generates additional acute health challenges. Examples of some of these statistics are discussed on the following pages.

Continued overleaf...

### Where are air pollution risks highest and lowest?

To study the level of risk we use several different standards. First we compare local measurements with the UK Government legally set objectives. While these use evidence from the WHO they would still allow air pollution to be the 3rd major cause of death locally. This is unacceptable. So we also compare local measurements with the guidelines set by the WHO itself. The WHO recommends that targets for the annual average $NO_2$ measurements are made progressively tighter, first to 40µg/m³ (the existing UK target in 2024), second to 30µg/m³, third to 20µg/m³ with a final goal of 10µg/m³. A similar approach is recommended for annual average $PM_{2.5}$ with 10µg/m³ (the GLA's current target) the penultimate target and 5µg/m³ the final target. This have been partly adopted by the GLA and EU and some other UK Councils. By adopting this approach we ensure we are steadily working towards making your air safe to breath.

First we consider annual averages and peak levels of NO2 measurements using our regulatory Diffusion Tube network. Comparing with the UK Government objectives, air quality meet the objectives everywhere except in Richmond town centre and near Upper Richmond Road West. In Richmond town centre two measurement sites exceeded the UK's annual average NO2 objective of 40µg/m³ in 2022 (with 41µg/m³ and 43µg/m³), though this improved in 2023 to just one location exceeding (down to 40µg/m³). In 2022 Upper Richmond Road West exceeded the UK limit with 52µg/m³ and again in 2023 with 48µg/m³. $NO_2$ at these high exposure locations is a cause for concern and focussed action.

Compared with WHO $NO_2$ guidelines, a more mixed picture for $NO_2$ emerges, though still showing solid progress. Two sites away from roads are approaching the WHO final target of 10µg/m³ for annual average $NO_2$: Barnes Wetland Centre and Holly Lodge in Richmond Park. Air quality at both locations is very good, with low health risks. At about 2/3rd of locations, including near 28 schools, measurements are in the WHO Level 3 range of 20-30µg/m³, carrying some health risks. There are somewhat higher risks in the 1/3rd of locations, including 18 schools, in the Level 2 range of 30-40µg/m³. But at Richmond town centre and Upper Richmond Road West measurements exceed WHO guidelines.

Pollution there has significant health impacts, though exactly how much is hard to estimate.

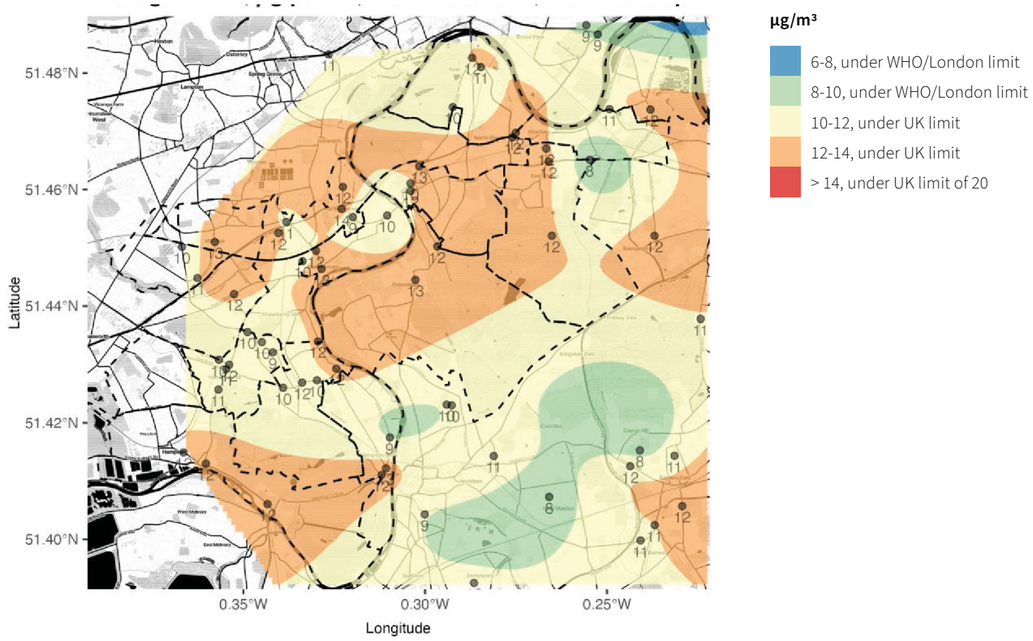
Now consider annual average measurements of $PM_{2.5}$. The Mayor of London, following WHO recommendations, sets an annual average target of 10µg/m³ for Greater London. This is the same as WHO's Interim Target 4. Defra operates a very precise measuring instrument far from a road at the National Physical Laboratory in Teddington. This recorded $PM_{2.5}$ levels at 9µg/m³ in 2022 and 8µg/m³ in 2023, similar to previous years. This achieves the London standard and approaches the WHO Final Target of 5µg/m³. This suggests that at locations well away from roads, $PM_{2.5}$ poses low risks to health. Since 2022, the Council's own Breathe London automatic sensors have measured $PM_{2.5}$ hourly at over 40 locations that have been strategically chosen due to their risks of being high human-exposure areas. These sensors detected annual $PM_{2.5}$ levels exceeding the Mayor's 10µg/m³ target at all but four locations in 2022, but with much better results in 2023 with most locations inside the London/WHO target (see maps below). These sensors detected annual $PM_{2.5}$ levels exceeding the Mayor's 10µg/m³ target at all but four locations in 2022, but with a much better results in 2023 with most locations inside the London/WHO target (see maps below).

Considering $PM_{10}$ measurements, we again use the WHO standards. Measurements were made in two places, one at a background site, away from the roadside, and the other closer to a road. Annual average $PM_{10}$ away from roads was 14µg/m³. This is inside WHO Interim Target 4 of 15µg/m³. Closer to roads the value was 15µg/m³. In both cases these represent a low risk to health. They are both much lower than UK limits. Similar results apply for short term high $PM_{10}$ events.





**Average $PM_{2.5}$, µg per m³, Richmond 2022, Richmond upon Thames**




**Average $PM_{2.5}$, µg per m³, Richmond 2023, Richmond upon Thames**

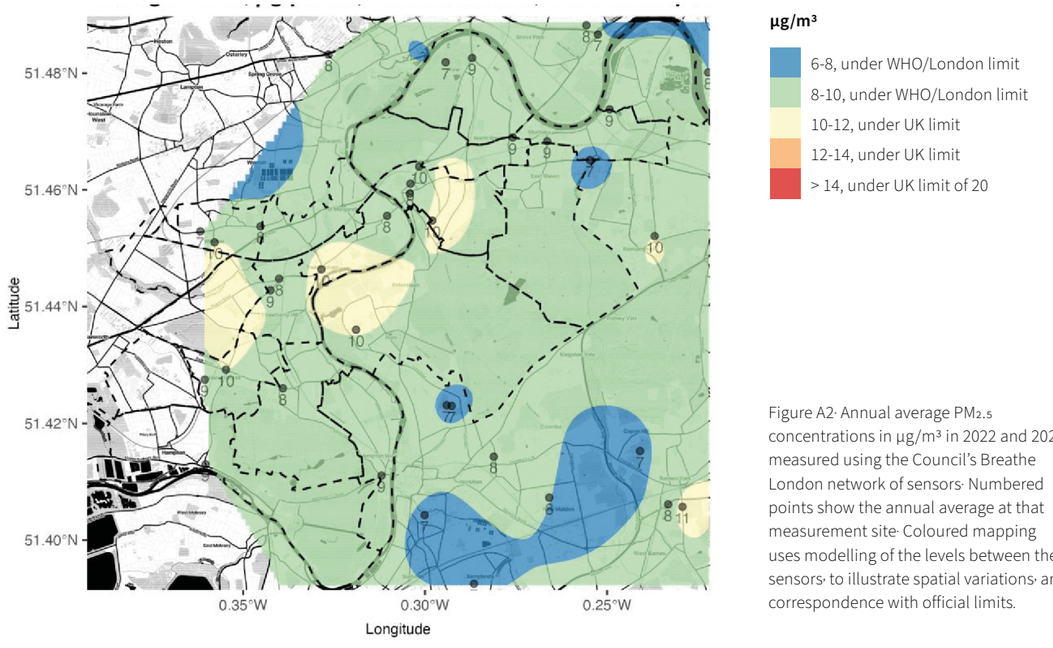



Figure A2· Annual average $PM_{2.5}$ concentrations in µg/m³ in 2022 and 2023 measured using the Council's Breathe London network of sensors· Numbered points show the annual average at that measurement site· Coloured mapping uses modelling of the levels between the sensors· to illustrate spatial variations· and correspondence with official limits.

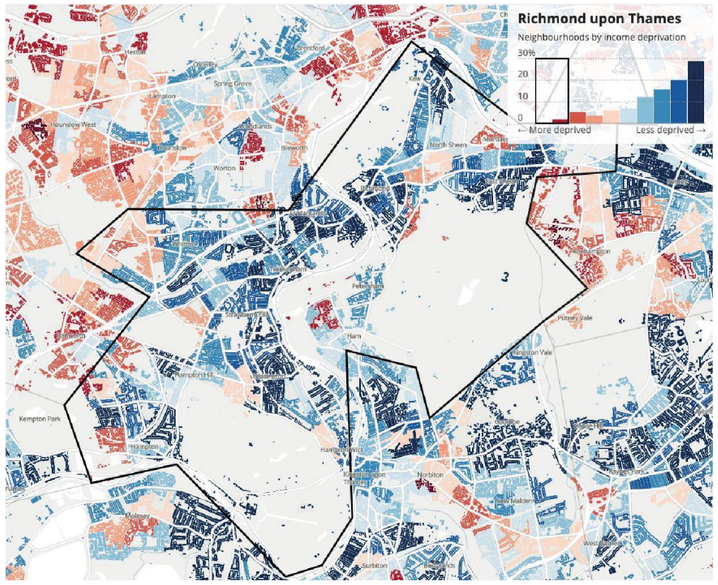



Figure A3. From ONS publication 'Mapping income deprivation at a local authority level: 2019,' based on the English Indices of Multiple Deprivation: 2019, to Lower Super Output Area (LSOA), 2019.

Of the 115 neighbourhoods in Richmond upon Thames, 2 were among the 20 percent **most income-deprived** in England. This is shown in the first two bars in the chart on the top right In red.

### Mapping of inequalities indices and poorer air quality

People in deprived areas have greater vulnerability to air pollution. So areas where both deprivation and air pollution are higher need special attention. Considering air quality alone might miss these areas that deserve action.

For income deprivation, the borough is ranked 282nd out of the 316 English councils. But two neighbourhoods are in the bottom fifth most income-deprived in England (see Figure A3). Several neighbourhoods are below the English average. These include areas in the Mortlake, East Sheen, North Sheen hotspot areas. It also includes areas in Hampton, Hampton Hill and Whitton. There, NO2 levels in 2022 and 2023 were in the range 20-30µg/m³, and $PM_{2.5}$ levels in 2022 exceeded our target of 10µg/m³.

### People who are naturally more vulnerable to air pollution

Some people are naturally more vulnerable to air pollution, so air pollution affects them more. This includes young children, older people and people with medical conditions like asthma or cardiovascular disease.

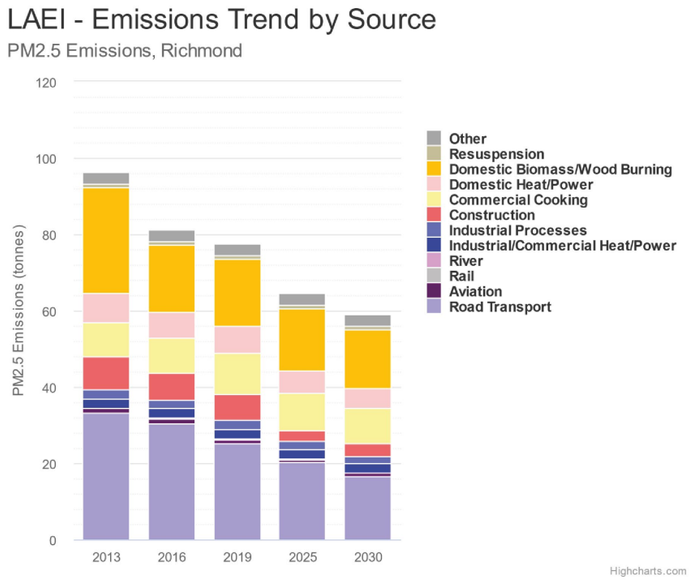
### Local emissions and their implications for actionable policy

Local emissions come from a very wide range of sources and having a good understanding of these allows us to prioritise areas for action. Results of the most recent London Atmospheric Emissions Inventory (Greater London Authority & Transport For London, 2022) are shown in the figures below.

This indicates that $PM_{2.5}$ emissions are expected to be dominated by road transport, domestic wood burning and commercial cooking at least until 2030. Emissions of $PM_{10}$ are thought to be dominated by road transport (both emissions and resuspension), with the other major large source being construction. Emissions of Nitrogen Oxides ($NO_x$) are expected to no longer be dominated by road transport by 2030. By then aviation related $NO_x$ will be the dominant source, commercial heating the second main source.







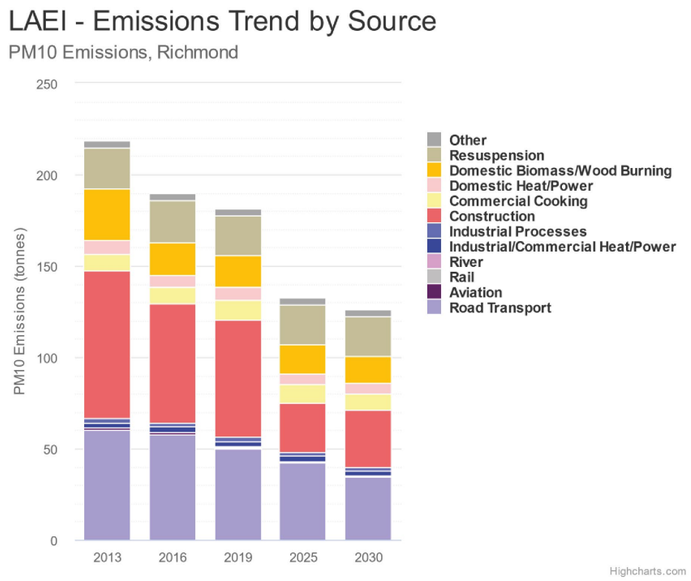
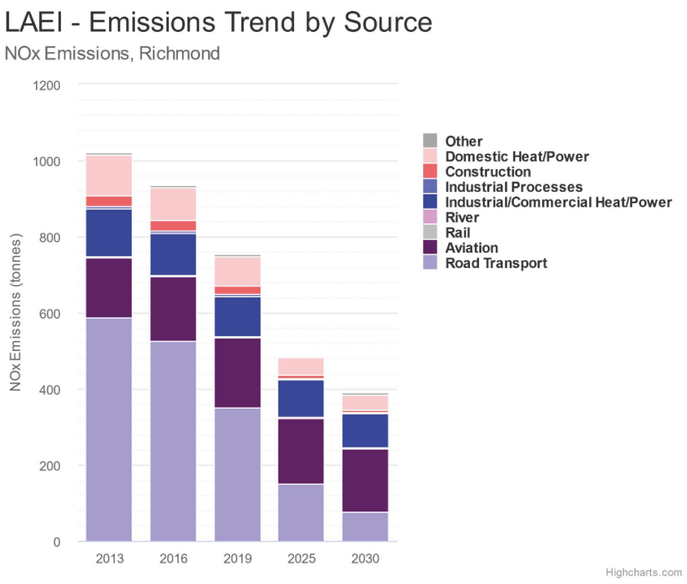



Figure A4. Estimated emissions of $PM_{2.5}$, $PM_{10}$, and $NO_x$ (in tonnes) in Richmond in 2013, '1 , '19, '2 and '30, from the 2022 revision to the 2019 London Atmospheric Emissions Inventory, a model of emissions across London at high spatial resolution.




## What this analysis tells us

**Taken together this analysis indicates that:**

- **Road transport, construction and commercial heating must be the foci of immediate local action.**
- **Air quality outside schools is higher than the WHO recommends. Action is needed to protect vulnerable populations and reduce $NO_2$.**
- **Richmond Town Centre should be a priority due to high $NO_2$ levels and pedestrian footfall.**
- **Upper Richmond Rd West and Chalker's Corner area require additional actions to reduce $NO_2$ levels to below UK and WHO recommended limits.**
- **Twickenham, Teddington, East Sheen, and Whitton have air quality compliant with UK objectives. But considering WHO guidelines, inequalities and pedestrian footfall, $PM_{2.5}$ and $NO_2$ levels at these places should be reduced.**
- **Vulnerable individuals other than school children should be supported in collaboration with the NHS.**
- **There continues to be a significant need to develop new policy at London and national level on wood burning.**
- **Commercial cooking is a key area for future action once solutions are identified.**



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# Appendix B.
# Richmond's New Air Quality Objectives: Why They Matter

**Table B1: WHO recommended air quality guideline levels and interim targets**

| Pollutant | Averaging time | Interim target | | | | Level, µg/m³ |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | |
| **$PM_{2.5}$** | Annual | 35 | 25 | 15 | 10 | 5 |
| **$NO_2$** | Annual | *40* | 30 | 20 | | 10 |

Table B1. WHO guidelines for $NO_2$ and $PM_{2.5}$, showing approximate current situation in yellow and Richmond targets for 2024-2029 in green.

**The Council has set new goals for air quality in the borough that are challenging but achievable. They are based on the WHO Guidelines for Air Quality published in 2021 (World Health Organization, 2021). The guidelines are based on the latest scientific evidence which increasingly points to air quality as a major source of ill-health and improving air pollution being a key route to improving public health. To explain our choices, we summarise the scientific evidence below.**

### The science behind the WHO guidelines

The WHO 2021 guidelines for air quality are the first major update since 2005. It significantly reduced many of the recommended air pollution levels, considering substantial new evidence. Since the 2005 review, thousands of research studies had taken place in most regions of the world. This expanded the research base beyond Europe and North America as it was in 2005. This new research linked air pollution with many new health conditions. The strongest links were found to cardiovascular disease and cancer, but also asthma, diabetes, reproductive outcomes, and neurocognitive issues. The research included efforts to pinpoint the most toxic sources and components of PM. A major focus was particles made by combustion and particles made by chemical reactions between air pollutants.

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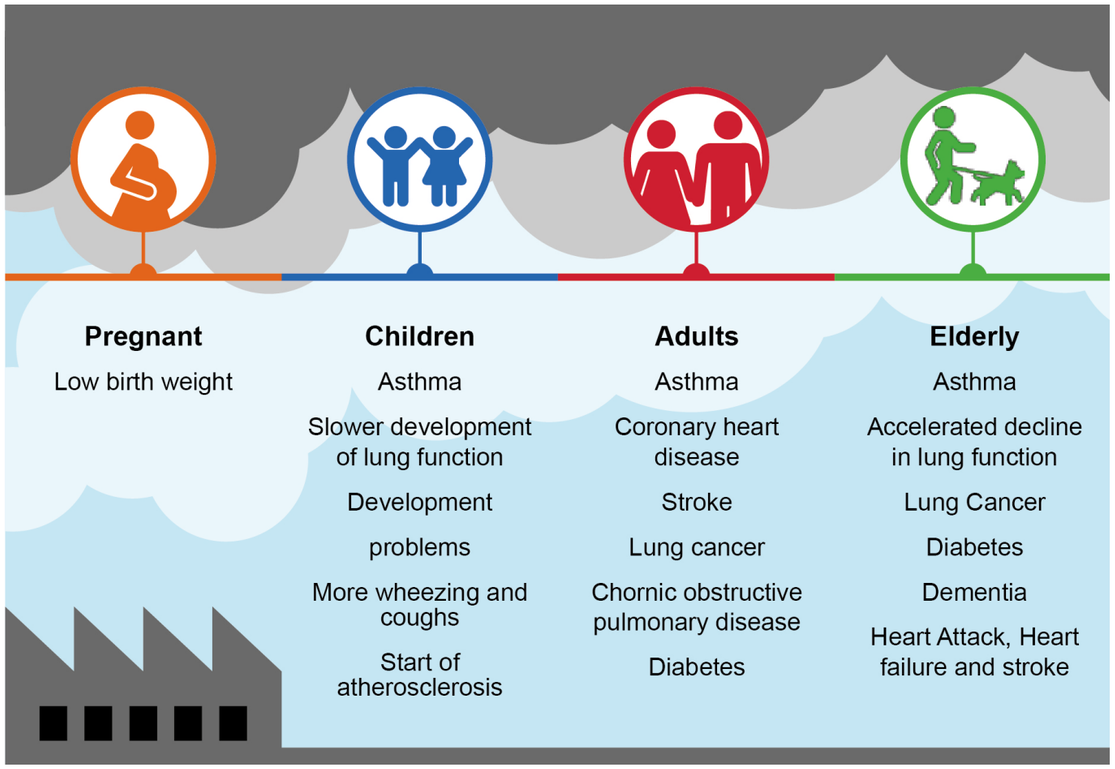


Figure A4. Impacts of air pollution on human health at different stages of life. From Chief Medical Officer's Annual Report 2022, Dept of Health, 2022.

Some links were harder to identify, especially short-term and long-term effects of various pollutants. Large-scale studies delivered by collaborations of many research centres around the world resolved these questions. Advancements have also been made in exposure assessment methods, statistical analysis techniques, and linking causes to outcomes. These made possible more accurate estimates of how many people in the world get sick or die from air pollution, particularly $PM_{2.5}$ exposure.

Here are the key findings. Highly reliable evidence was found that long term exposure to $PM_{2.5}$ causes deaths from cardiovascular disease, all lung diseases, and overall death rates excluding accidents. The harms are thought to be caused by the fine particles getting into the lung tissue and blood. In the blood it travels throughout the body, including into unborn babies. Everywhere that they lodge they cause inflammation which then causes other diseases.

Coarse particles ($PM_{10}$) were found to cause deaths from heart disease, lung cancer and other respiratory illnesses, as well as all overall death rates excluding accidents. The harms are thought to be come from $PM_{10}$ particles sticking in the upper airways and lungs. The metal and other chemical components then cause inflammation. For $NO_2$ quantifiable links were made to deaths from Cardio Obstructive Pulmonary Disease (COPD), respiratory disease and acute lower respiratory infections, as well as all non-accidental cause mortality. Research in London has also found links between childhood exposure to $NO_2$ and reduced lung capacity, affecting children over the whole subsequent course of their lives.





Considering all this **the new guidelines are in almost every case substantially lower than the previous concentrations**. The annual average limit for $PM_{2.5}$ has been cut by half. As The Lancet medical journal put it, **"this means that $PM_{2.5}$ is incredibly hazardous."** Similarly, the guidelines for $NO_2$ have been reduced from 40µg/m³ to 10µg/m³. The goal of the WHO guidelines are that governments work "towards reducing exposures every year, as much as you can, and if you can manage that there will be important health benefits to the population" (World Health Organization, 2021).

### Research on whether air pollution can be fixed

In addition to research into the health effect of air pollutants, over the 2005-21 period, extensive work was done to see how to fix the problem. This included work on the links to climate change and to see whether fixing air pollution could also solve other problems. Work was also done to understand whether physical activity improves our health. This research improved both our ability to:

- Improve air quality;
- Improve air quality and climate change together;
- Improve both together using sustainable transport and energy efficiency schemes.

Another major innovation was caused by the VW Emissions Scandal. This led to improvements to diesel vehicle emissions controls. Widespread adoption of these technologies means that new diesel cars today are only 2-3 more polluting than petrol cars. There have also been enormous improvements in electric vehicle technology and cost. By 2012 the technologies had advanced such that electric buses could be introduced on certain, carefully planned routes. Today London alone has over 3000 electric buses in operation. Extraordinary improvements have been made in electric car technologies and economics. This allows the gradual transformation of car fleets to zero tailpipe emissions. And new technologies for home and commercial heating and insulation have been driven by needs to address climate change. Over time we expect these to eliminate PM and $NO_2$ emissions from space heating.

## Our long term vision is to deliver these guidelines

This evidence suggests that that UK Government's current annual target for $NO_2$ of 40µg/m³ is inadequate to protect people's health. Repeated Governments have chosen to maintain it despite many other nations adopting tighter standards, including in the EU.

To improve your health, the evidence tells us to be more ambitious. By 2029 our goal is to reduce the annual average concentration of $NO_2$ gas below 20µg/m³ at all measurement sites in the borough. This is the WHO Interim Target 3 for ambient $NO_2$ (see Table B1). This is the same as the approach adopted by our EU neighbours and it is a strong complement to the GLAs annual average $PM_{2.5}$ target for London of 10µg/m³. We anticipate that once Richmond's 20µg/m³ target has been achieved we would adopt the final WHO target for $NO_2$.

Developments and infrastructure proposals, plans and policies will be measured against these objectives, unless the UK objectives become tighter than these.

# References


- **Dajnak, D., Evangelopoulos, D., Kitwiroon, N., Beevers, S., & Walton, H. (2020).** ***London Health Burden of Current Air Pollution and Future Health Benefits of Mayoral Air Quality Policies.*** **London: Imperial Projects, Imperial College London.**
- **Greater London Authority & Transport For London. (2022). London Atmospheric Emissions Inventory 2019. London.**
- **Health & Wellbeing Partners, LB Richmond upon Thames. (2019).** ***Joint Strategic Needs Assessment.*** **London: London Borough of Richmond upon Thames.**
- **UK Office for Health Improvement and Disparities. (2024, September 18).** ***Public Health Outcomes Framework, Public health profiles.*** **Retrieved from https://fingertips.phe.org.uk/**
- **World Health Organization. (2021).** ***WHO global air quality guidelines. Particulate matter ($PM_{2.5}$ and $PM_{10}$), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide.*** **Geneva: World Health Organization.**




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# Appendix C.
# Implementation, Monitoring, Statutory Duties

## List of time bounded actions and KPIs using London Local Air Quality Management thematic approach

**Prioritisation scheme**

1. Lead policy and programme priorities for Regulatory Services (AQ);
2. Operational delivery by Regulatory Services (AQ) of funded core duties, projects and programmes;
3. Delivered by others with secured funding, with AQ support as required;
4. Operational delivery by Regulatory Services (AQ) of projects and programmes that depend on securing funding;
5. Completed actions, included to note.