ULEZ Worked — But Not When Anyone Expected

Bootstrap CUSUM applied to a decade of Marylebone Road NO_2 data (Defra AURN, N=134 monthly observations, 99.7% confidence) finds four structural stages — three things neither side of the ULEZ debate predicted.

Data: Defra AURN · Marylebone Road MY1 · Monthly mean NO2 · April 2015–May 2026 · By Syd Stewart, StepChangeAnalysis.com · May 2026

Four findings

Finding 1 — The anticipatory effect

The ULEZ signal appeared 18 months before launch. Bootstrap CUSUM dates the first structural change to October 2018 — a 24.7% drop at 99.9% confidence — driven by drivers and fleet operators upgrading vehicles in advance of the April 2019 launch. Evaluating ULEZ by comparing before and after April 2019 misses the effect entirely.

Finding 2 — COVID was the biggest change

The largest single structural improvement in a decade of Marylebone Road data was COVID: -34.6% at 100% confidence from February 2020. The benefit was real. The cost — hundreds of thousands of deaths and economic damage on a wartime scale — was not in the data.

Finding 3 — The London-wide expansion worked

The August 2023 London-wide expansion produced a detectable structural change point in March 2024 — seven months later, within the expected policy lag. At 100% confidence, NO2 fell from 43.00 to 31.78 µg/m³ — the first time Marylebone Road's stage mean has been below the 40 µg/m³ legal limit.

Finding 4 — Legal limit met; health standard not

31.78 µg/m³ is below the UK legal limit of 40 µg/m³ — a milestone for a site in breach of legal standards for decades. But the WHO revised its guideline to 10 µg/m³ in 2021. The Stage 4 mean is still more than three times the health standard.

The four structural stages

Stage	Period	Mean NO■	Change	Conf.	Driver
1	Apr 2015–Oct 2018	87.21 µg/m³	Baseline	—	Pre-policy. >2× legal limit.
2	Oct 2018–Feb 2020	65.71 µg/m³	–24.7%	99.9%	Anticipatory ULEZ compliance — 18 months before launch.
3	Feb 2020–Mar 2024	43.00 µg/m³	–34.6%	100%	COVID structural break. Largest single change in dataset.
4	Mar 2024–present	31.78 µg/m³	–26.1%	100%	London-wide ULEZ expansion (Aug 2023). First stage below legal limit.

★ THE ANTICIPATORY COMPLIANCE FINDING

The Stage 2 change point — October 2018, -24.7%, 99.9% confidence — predates the April 2019 ULEZ launch by 18 months. Rational drivers and fleet operators upgraded vehicles in advance of an announced future policy. This is the policy lag in reverse. Any evaluation that sets its baseline at April 2019 misses the entire ULEZ effect.

Implication for other cities: begin air quality monitoring at the point of policy announcement, not at the launch date. The pre-launch period contains a genuine and substantial policy signal.

★ THE POLICY LAG FINDING

The London-wide expansion launched August 2023. The CUSUM change point is March 2024 — a 7-month lag. This is within the expected 6–12 month window for fleet turnover and compliance to work through normal driving patterns. Bootstrap CUSUM provides an objective test: set a 12-month minimum observation period after any ULEZ expansion, then let the CUSUM state when — and if — a structural change occurred.

Legal limit versus health standard

Standard	Level	Marylebone Stage 1	Marylebone Stage 4
UK legal limit (2000)	40 µg/m³	87.21 — 2.2× limit	31.78 — below limit ✓
WHO guideline (2021)	10 µg/m³	87.21 — 8.7× guideline	31.78 — 3.2× guideline

The UK legal limit of 40 µg/m³ derives from the EU Air Quality Directive (1999/30/EC) and has not been updated since. The WHO revised its annual mean NO■ guideline from 40 µg/m³ to 10 µg/m³ in 2021, reflecting accumulated evidence that health effects occur at much lower concentrations. Meeting the legal standard is a genuine achievement. It is not the same as meeting the health standard.

Method and data

Bootstrap CUSUM asks: did this process structurally change, when, and with what confidence? It works by calculating a cumulative sum of deviations from the mean, then using thousands of random resamples (bootstrap loops) to test whether any apparent change point is statistically significant. No counterfactual model. No assumptions about what would have happened. Just the measured data and a statistical verdict.

Data: Defra AURN, Marylebone Road (MY1), daily mean NO■ aggregated to monthly means, blank monitoring days removed. April 2015–May 2026, N=134. Settings: 99.7% confidence, Turn Length 5, Loops 1000.

References

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• GLA London-wide ULEZ One Year Report, March 2025. london.gov.uk

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• Taylor (2000), Page (1954), Hinkley (1971), Efron & Tibshirani (1993) — Bootstrap CUSUM method.

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stepchangeanalysis.com/ulez-london-air-quality.html

Scan the QR code or visit the URL to reproduce this analysis with the free Bootstrap CUSUM tool. The data CSV is available for download directly from the article.