Imperial College London Projects

Environmental Research Group

Breathe London network report July – September 2021

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Environmental Research Group, Imperial College London

clarity

Bloomberg Philanthropies

MAYOR OF LONDON

The Environmental Research Group

Founded in the early 1990s, the Environmental Research Group (ERG) is internationally renowned for its work on air quality. The ERG's approach to tackling air pollution is extensive, covering air quality measurement and modelling, testing and deploying portable sensors and policy development. The ERG established and continues to operate the London Air Quality Network, Europe's most advanced air quality monitoring network, with over 100 stations providing a comprehensive picture of air pollution across London. The ERG works closely with government at all levels to shape policy around air pollution. Over the last 15 years all major air pollution strategies in London, including the congestion charging scheme, have been devised and tested using emissions and air pollution models developed by ERG. It was the first UK organisation to make air quality information publicly available online, leading the way for the development of air quality apps used by thousands every day. The Environmental Research Group is led by Professor Frank Kelly, Humphrey Battcock Chair of Environment and Health. It is part of the School of Public Health at Imperial College London.

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Summary of key performance indicators

This quarterly report details work undertaken by the Environmental Research Group to deliver the Breathe London network contract awarded by the GLA in December 2020.

Work is described in relation to seven key performance indicators (KPIs), as specified in the contract and summarised in Table 1. The report is not intended to be an exhaustive description of the network and its outputs, which will be captured on the network website (www.breathelondon.org) and in associated reports.

This report delivers the seventh KPI: "Network evaluation report to be produced every three months including performance of sensors (e.g., number online, number of QA/QC issues) and number of visits to the website"

Table 1: Summary of key performance indicators.

KPI	Target	Status
Install, maintain and insure air quality sensors at 100+ sites	100+	GLA-funded: 106 Other: 33
Demonstrate sensors continue to meet the uncertainty requirements of the EU Air Quality Directive for indicative (Class 1) methods for particulate matter ($PM_{2.5}$) and nitrogen dioxide (NO_2)	NO_2: 25% uncertainty $PM_{2.5}$: 50% uncertainty	NO_2: 62% uncertainty $PM_{2.5}$: 15% uncertainty (network means)
Ensure a minimum 90% of sensors are in operation at any given time	100% of hours	99.6% of hours
Increase the number of sensors in the network by an additional 5% per year by allowing the website to integrate data from sensors owned by Londoners, businesses and organisations	5% expansion by January 2022	25% expansion by June 2021
Website must be live continuously and display data in real time from the sensors	End of March 2021	Launched 15th March 2021
Data must also be available via an Application Programming Interface (API)	Not specified	API complete. Launching end 2021

1. Introduction

Breathe London is a new partnership between the Mayor of London, Imperial College London (facilitated via Imperial Projects) and Bloomberg Philanthropies. The Mayor initially provided funding for 130 air quality sensor nodes at hospitals, schools and other priority locations. This was subsequently increased to 135 to include Business Low Emission Neighbourhoods. Data are displayed on the network website – www.breathelondon.org.

Community groups, charities, businesses, individuals, academics, and boroughs will also be able to "buy in" to the Breathe London network to source air pollution data for local projects or schemes.

This report summarises progress on building the network during July to September 2021.

2. Deployment of nodes

KPI: Install, maintain and insure air quality sensors at 100+ sites

106 GLA sponsored nodes were deployed by the end of September 2021, plus 33 additional nodes sponsored by the South London Partnership (Table 2). These nodes comprise of a mix of locations, including schools, hospitals, reference site co-locations, Local Authority designated community placements and other areas of interest.

Delays in deployments of Local Authority Designated nodes caused by the COVID-19 pandemic and associated lock downs have largely been overcome and it is expected that the outstanding GLA sponsored nodes will be installed by the end of 2021.

Table 2: Number of GLA sponsored (black) and other sponsored (red) nodes deployed and in operation in each London Borough as of the end of September 2021

Borough	Reference sites	Hospitals	Schools	Special projects[1]	Areas of Interest	Local Authority designated	South London Partnership	Total
Barking and Dagenham						1		1
Barnet			2		1	1		4
Bexley	1					2		3
Brent	1				1	2		4
Bromley					1			1
Camden			2			1		3
City of London		2			1	1		4
Croydon				1		1		2
Ealing			1		1			2
Enfield								0
Greenwich	5	1	2			6		14
Hackney			1					1

[1] Business Low Emission Neighbourhood and Greener Together

Hammersmith and Fulham			1	1		1		3
Haringey		1	1			1		3
Harrow								0
Havering	1		1		1			3
Hillingdon						1		1
Hounslow			1		1	1		3
Islington			2			1		3
Kensington and Chelsea	1		3		2	1		7
Kingston		1					11	12
Lambeth			2					2
Lewisham	3	1	1			1		6
Merton						1		1
Newham				1		1		2
Redbridge	1	1	1	1				4
Richmond			1			1	15	17
Southwark	1		3			2		6
Sutton	1	1					7	9
Tower Hamlets	1		5	1				7
Waltham Forest		1		1	1	1		4
Wandsworth		1	1	1		1		4
Westminster	3		1		1			5
Totals	19	10	32	7	10	28	33	139

3. Quality assurance and quality control

KPI: Demonstrate sensors continue to meet the uncertainty requirements of the EU Air Quality Directive for indicative (Class 1) methods for particulate matter ($PM_{2.5}$) and nitrogen dioxide (NO_2)

The current calibration and scaling process applied to Breathe London nodes is described in the first quarterly report (available at https://www.breathelondon.org/network-reports). These methods continue to be improved and developed and will be published in a peer reviewed scientific journal in due course.

The impact of the corrections applied to the nodes will be assessed using the methodology recommended in EU guidance. The uncertainty is calculated at the hourly limit value (200 µg m^{-3}) for NO_2 and the indicative threshold is 25%, the uncertainty for $PM_{2.5}$ is calculated at the suggested daily limit value of 35 µg m^{-3} and the indicative threshold is 50%.

Prior to deployment each node is co-located at the Honor Oak Park London Supersite for 10-14 days. Following a two day stabilisation period, these data are used to calculate a linear

correction algorithm generated from the node and the reference instrument, which is applied to all subsequent data at the node's destination location.

Network mean uncertainty at the EU Limit Value across the quarter is shown in Table 3. These percentages are based on all nodes passing through the co-location calibration process during the reporting period. Uncertainty can only be calculated when there is a sensor co-located with a reference instrument - you need to know what a sensor should be reading to evaluate the uncertainty in what it is actually reading. Thus, we report uncertainty for sensors only when they are undergoing their 10-14 day calibration. After deployment, we use well established methods similar to those used to manage the UK reference monitoring networks to identify sensors that are not performing as they should.

There was one calibration exercise for 20 new nodes during the reporting period, in late August. All nodes were well within the target uncertainty for $PM_{2.5}$, however, meteorological conditions during the period meant that the linear correction algorithm applied to the NO_2 sensors performed unusually poorly, which explains why the NO_2 uncertainty is over the target 25%, at 62%, with 14 out of 20 nodes failing to meet the target uncertainty. This result is disappointing, but not unexpected and merits further explanation.

As was established during the Breathe London pilot (https://www.breathelondon.org/pilot), static linear correction methods work well for electrochemical NO_2 sensors during some meteorological conditions and not during others. Therefore, if you use such a method the resulting uncertainty will vary according to the period that you use for co-location with a reference method. Up until the August calibration, meteorological conditions were not exceptional, and the majority of nodes met the uncertainty target. However, during August ozone concentrations were elevated, causing cross-gas interference in the sensor detectors leading to an over-read in comparison with the reference. The sensors have an ozone scrubbing coating to counter this effect, but it is not entirely effective during elevated ozone conditions. Reference grade NO_2 analysers do not have this sensitivity to ozone, so are unaffected during elevated ozone conditions.

We operate two further QA/QC stages to address this shortcoming in electrochemical NO_2 sensors. First, we compare individual node performance against two nodes permanently sited at the Honor Oak Park Supersite, i.e., test sensor precision instead of accuracy. This method is not subject to the same meteorological effects, so allows us to identify faulty nodes even during elevated ozone conditions. These precision tests are useful to us to check sensor precision and performance, but are not applicable to the KPI, which tests accuracy.

Second, we have developed a more advanced NO_2 sensor correction method using dynamic multiple linear regression (MLR), with a new factor calculated and applied each day. As the correction factors are calculated dynamically, they can respond to changing meteorological and ozone conditions, resulting in much reduced uncertainty. To develop this method we needed a long time series of sensor data incorporating a wide range of meteorological conditions, thus it could not be applied from the network launch. However, it is now fully developed and being tested for launch during the next reporting period. When launched, the new correction method will be applied to all historical and ongoing NO_2 data.

Users of the data should note that they will need to update any historical data archives that they hold to reflect this change. This is the principal reason why we have not launched the

network API and data download features on the website – to minimise the distribution of historical data that requires updating. Both features will be launched during the next reporting period following the application of the new correction method.

Table 3: Uncertainty targets for indicative methods and corresponding uncertainties at the EU Limit Values during the reporting period (July to September 2021)

Pollutant	Target uncertainty (%)	Mean measured uncertainty (%)	Proportion of nodes not achieving target
NO_2	25	62	82% (14/20 nodes)
$PM_{2.5}$	50	15	0

4. Data capture

KPI: Ensure a minimum 90% of sensors are in operation at any given time

The data collection system created to interface between the nodes and Breathe London website is described in the first quarterly report (available at https://www.breathelondon.org/network-reports).

Data capture across the quarter is shown in Table 4. These percentages are based on a count of all valid hourly mean concentrations recorded by nodes deployed at permanent sites (i.e., not undergoing calibration at reference sites) throughout the period July to September 2021.

Table 4: Data capture for all deployed nodes over the reporting period (July to September 2021)

Pollutant	Network mean data capture (%)	Hours with 90% of nodes in operation (%)
NO_2	99.2	99.6
$PM_{2.5}$	99.2	99.6

5. Network expansion

KPI: Increase the number of sensors in the network by an additional 5% per year by allowing the website to integrate data from sensors owned by Londoners, businesses and organisations

Expansion of the network was restricted while the first 130 GLA sponsored nodes were deployed. However, the GLA agreed to an exceptional expansion of nodes funded by the South London Partnership (SLP) – a sub-regional collaboration of five London boroughs: Croydon, Kingston upon Thames, Merton, Richmond upon Thames and Sutton – to deliver the InnovaTe Project, which will link co-located air quality and traffic count data gathered outside of schools. An additional 20 SLP nodes were installed during this reporting period, representing a total network expansion of 25%.

Additional funding provided by Bloomberg Philanthropies to provide free nodes to disadvantaged communities was described in the first quarterly report (available at https://www.breathelondon.org/network-reports). The Breathe London Community Programme is due to launch in October 2021.

6. Website development

KPI: Website must be live continuously and display data in real time from the sensors

The website launched on 15th March with a live map showing the location and current daily air quality index of each deployed node alongside a selectable layer of LondonAir reference sites, with plans to include Air Quality England data in future. Further details were provided in the first quarterly report. There were no major developments to the website during this reporting period.

There have been c. 13,000 visits to the breathelondon.org website since its launch (Figure 1). Visits have been stable at just below 2,000 per month since April.

7. Application Programming Interface

KPI: Data must also be available via an Application Programming Interface (API)

An Application Programming Interface (API) for Breathe London data has been developed, but its launch was put on hold until the second stage correction algorithm described in Section 3 has been applied.

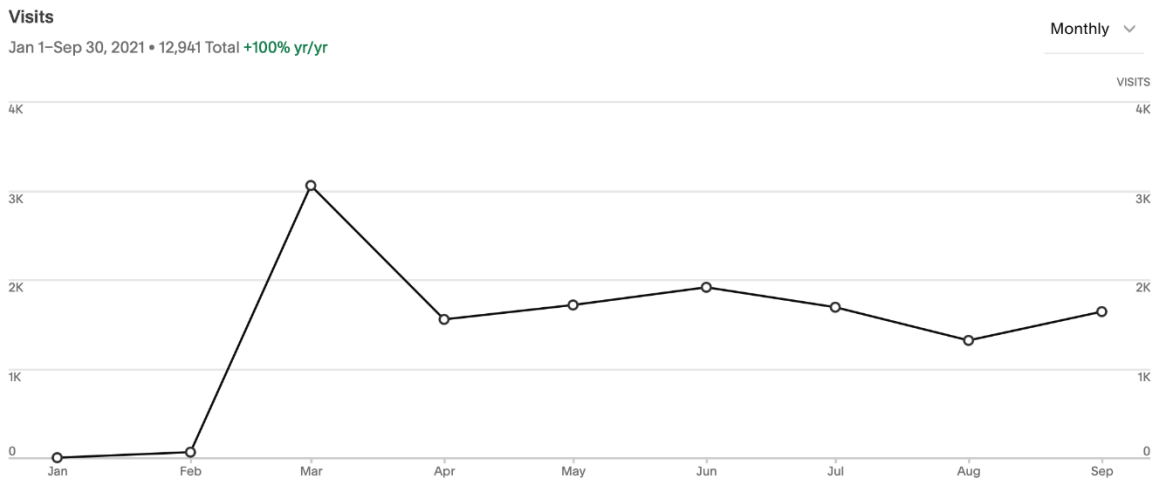

Figure 1: Monthly time series of visits to the breathelondon.org website year to September 2021.

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