QAQC Report for the Automatic Urban and Rural Network, January-March 2016

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Executive summary

Ricardo Energy & Environment carries out the quality assurance and quality control (QA/QC) activities for the Automatic Urban and Rural Monitoring Network (AURN) on behalf of the Environment Agency, the UK Department for Environment, Food and Rural Affairs (Defra), the Scottish Government, Welsh Government and Department of Agriculture, Environment and Rural Affairs (DAERA) in Northern Ireland.

This quarterly report summarises the QAQC activities carried out over the period 1st January 2016 to 31st March 2016. It presents the key data capture and data quality statistics, and highlights any issues that have been identified relating to the monitoring stations and their apparatus. The number of AURN monitoring stations in operation over this period was 158.

During this quarter, the winter 2016 intercalibration exercise was carried out, involving comprehensive performance tests on every analyser in the network. This allows the accuracy of the measured results to be determined, and a measurement uncertainty for each analyser to be determined, as required by the Data Quality Objectives of the European Union's Air Quality Directive (2008/50/EC).

The data from each analyser in the network have been ratified by the QA/QC Unit using documented and validated methods. This process takes into account input from Local Site Operator (LSO) calibrations, the QA/QC audits and records from Equipment Support Unit (ESU) activity. Principal reasons for data loss are given here for stations which fail to make the 85% data capture target for the quarter.

The routine QA/QC procedures have included checking of particulate analyser baselines for some time now. The CEN standard method for ambient particulate matter EN16450 states that action must be taken when baseline response is higher than 3 µg m^{-3} but does not state what the action should be. Up to now the only agreed action was to delete the data. However, as part of ongoing improvement activities a protocol has been agreed to enable baselines to be corrected where baseline responses exceed 3 µg m^{-3}. Accordingly, baseline correction – where it is deemed appropriate – has been incorporated into the data ratification protocols as of 2016.

Data ratification for the quarter was completed by the deadline of 30th June 2016. The mean data capture for ratified hourly average data was 89.3% (averaged over all pollutants O_3, NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$), for the three-month reporting period January to March 2016.

Mean data captures for individual pollutants were as follows: CO 86.7%, NO_2 91.4%, O_3 94.3%, SO_2 88.8%, PM_{10} 80.8%, and $PM_{2.5}$ 84.2%. The data capture target of the Air Quality Directive is 90% excluding periods of planned maintenance e.g. calibrations, audits and servicing). An allowance of 5% is made for this, hence a target of 85%. The mean data captures for all pollutants except PM_{10} and $PM_{2.5}$ met this target in Quarter 1 (Q1) of 2016.

The uncertainty of measurement for each analyser has been determined to ensure compliance with the Data Quality Objective. Thirteen analysers out of the total of 368 tested were found to be outside the required uncertainty.

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1 Introduction

1.1 Background

The UK Automatic Urban and Rural Network (AURN) has been established to provide information on air quality concentrations throughout the UK for a range of pollutants. The primary function of the AURN is to provide data in compliance with the Air Quality Directive 2008/50/EC[1]. In addition, the data and information from the AURN are required by scientists, policy makers and planners to enable them to make informed decisions on managing and improving air quality for the benefit of health and the natural environment.

A number of organisations are involved in the day-to-day running of the network. Currently, the role of Central Management and Co-ordination Unit (CMCU) for the AURN is contracted to Bureau Veritas, whilst the Environmental Research Group (ERG) of King's College London (KCL) has been appointed as Management Unit (MU) for the AURN monitoring stations that are also part of the London Air Quality Network (LAQN). Ricardo Energy & Environment undertakes the role of Quality Assurance and Control Unit (QA/QC Unit) for stations within the AURN. The responsibility for operating individual monitoring stations is assigned to local organisations with relevant experience in the field under the direct management (and contract to) CMCU. Calibration gases for the network are supplied by Air Liquide Ltd and are provided with an ISO17025 certificate of calibration by Ricardo Energy & Environment. The monitoring equipment is serviced and maintained by a number of Equipment Support Units, under contract to the CMCU or the station owner in the case of Local Authority-owned affiliated stations.

Dissemination of the data from the AURN via UK-AIR (the UK online Air Information Resource, http://uk-air.defra.gov.uk /) and other media such social media and freephone services is undertaken by the Data Dissemination Unit (DDU). A summary report of the data is also published annually in the "Air Pollution in the UK" series of reports, which can be found at https://uk-air.defra.gov.uk/library/annualreport/index .

A total of 158 monitoring stations in the AURN operated during this quarter. This includes five sites where Partisol gravimetric particulate samplers are co-located with automatic particulate analysers. (The gravimetric data are used in validating the performance of the automatic analysers). For data processing purposes the gravimetric sampler is treated as a separate station; and they are shown, and counted, separately in the data capture tables in section 4.

1.2 What this Report Covers

This report covers the three-month period January-March 2016, or "Quarter 1" (Q1) of the year. This report covers the main QA/QC activities; the relevant CMCU reports should be consulted for more detail on station operational issues.

The main reasons for any data loss at the stations have been provided. These were predominantly due to instrument or air conditioning faults, response instability or problems associated with the replacement of analysers and infrastructure.

1.3 Where to Find More Information

Further information on the AURN can be found in the following:

- UK-AIR, www.uk-air.defra.gov which contains information on individual stations along with real-time hourly data, graphs and statistics.
- The AURN Hub. This online resource for AURN stakeholders contains network-specific information relating to the AURN, including the LSO Manual, QA/QC audit and ESU service schedules, CMCU reports and supporting information.

[1] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF

1.4 Changes to the Network during this Quarter

Table 1-1 shows the changes that were made to the network during the period January – March 2016:

Table 1-1 Network Changes Jan - Mar 2016

Station	Pollutants	Date
Monitoring Stations Started Up:		
Southampton A33	NOx, PM_{10}	01/01/2016
Chilbolton Observatory	NOx, O_3, PM_{10}, $PM_{2.5}$, SO_2	11/01/2016
Aberdeen Wellington Road	NOx	09/02/2016
Nottingham Western Boulevard	NOx, PM_{10}	01/03/2016
Reading London Road	NOx, PM_{10}	04/03/2016
Derry Rosemount	NOx, O_3, PM_{10}, $PM_{2.5}$, SO_2	21/03/2016
Monitoring Stations Closed Down:		
Derry	NOx, O_3, PM_{10}, $PM_{2.5}$, SO_2	29/02/2016

Chilbolton Observatory replaced the rural Harwell monitoring station, which closed down at the end of 2015. Derry Rosemount replaced Derry which closed down during the quarter.

The other four new monitoring stations shown in Table 1-1 – Aberdeen Wellington Road, Nottingham Western Boulevard, Reading London Road and Southampton A33 - all started operation as part of an ongoing expansion of the AURN, necessary to ensure the network remains compliant with the requirements of the EU Air Quality Directive.

2 Methodology

The intercalibration requires the coordination and close cooperation of QA/QC unit, Management Units, ESU's and LSO's in making sure the entire operation runs smoothly and is the result of many months of planning. Leading up to the intercalibration, a draft schedule of visits is prepared and circulated to MU's and ESU's for approval. ESU ozone photometers are calibrated at Ricardo Energy & Environment and all QA/QC equipment and cylinders are tested, calibrated and verified before use.

QA/QC visits are always undertaken before any ESU visits, to allow the performance of the sites to be quantified for the six-month period prior to the visit. During the QA/QC visit, the LSO usually attends to demonstrate their competence in performing routine calibrations. The audits are used to transport independent calibration standard gases and test apparatus to all of the sites, to quantify the performance of the entire measurement process at the monitoring stations. The results obtained from these tests are fed into the ratification process, where any correction of datasets can be applied to account for any performance anomalies.

ESU visits are normally undertaken within a three-week period following the QA/QC visit. At this time, the analysers and sampling systems are all cleaned and serviced in accordance with manufacturer's specifications. The analysers are then set up ready for the following six-month period, until the next round of intercalibrations and servicing.

This scheduling has proven to be very successful in delivering reliable operation of monitoring stations and high quality data. The programme is iterative: improvements and enhancements are continually added to further improve performance and analyse results.

The QA/QC visits fulfil a number of important functions:

- A "health check" on the production of provisionally scaled data, which is rapidly disseminated to the public soon after collection.
- Identification of poorly performing analysers and infrastructure, together with recommendations for corrective action.
- A measure of network performance, by examining for example, how different NOx analysers around the network respond to a common gas standard. This test checks how "harmonised" UK measurements are; i.e. that a 200ppb NO_2 pollution episode in (for example) Belfast would be reported in exactly the same way at every other site in the UK, regardless of the location or the analyser used to record the event.
- Assessment of the area around the monitoring station: has the environment changed in the last six months? Is the location still representative of the site classification?

The QA/QC audits test the following aspects of analyser performance:

1. Analyser accuracy and precision. These are basic checks to ensure analysers respond to known concentrations of gases in a reliable manner.
2. Instrument linearity. This test refines the response checks on analysers, by assessing whether doubling a concentration of gas to the analyser results in a doubling of the analyser signal response. If an analyser's response characteristics are not linear, data cannot be reliably scaled into concentrations.
3. Instrument signal noise. This test checks that an analyser responds to calibration gases in a stable manner with time. A "noisy" analyser may not provide high quality data which may be difficult to process at lower concentrations.
4. Analyser response time. This test checks that the analyser responds quickly to a change in gas concentrations. If analyser response is too slow, data may not accurately reflect ambient concentrations.
5. Leak and flow checks. These tests ensure that ambient air reaches the analysers, without being compromised in any way. Leaks in the sampling system can affect the ability of the analyser to sample ambient air reliably.

6. NOx analyser converter efficiency. This test evaluates the ability of the analyser to measure NO_2. An inefficient converter severely compromises the data from the analyser.
7. FDMS K_0 evaluation. The analyser uses this factor to calculate mass concentrations, so the value is calculated to determine its accuracy compared to the stated value.
8. Particulate analyser flow rate checks. These tests ensure that the flow rates through critical parts of the analyser are within specified limits. There are specific analyser flow rates that are set to make sure particle size fractions and mass concentration calculations are performed correctly.
9. SO_2 analyser hydrocarbon interference. This test evaluates the analyser's ability to remove interfering hydrocarbon gases from the sample gas. A failed test could have significant implications for analyser data.
10. Evaluation of site cylinder concentrations. These tests use a set of Ricardo Energy & Environment certified cylinders that are taken to all the sites. The concentrations of the site cylinders are used to scale pollution datasets, so it is important to ensure that the concentrations of gases in the cylinders do not change.
11. Competence of Local Site Operators (LSO) in undertaking calibrations. As it is the calibrations by the LSO's that are used to scale pollution datasets, it is important to check that these are undertaken competently.
12. Zero "calibration" of all automatic PM analysers. This test allows the baseline performance of PM analysers to be evaluated, to determine whether any remedial action is required.

Once all data have been collected, a "Network Intercalibration" is conducted. This utilises the audit gas cylinders transported to each site in the Network. These cylinders are recently calibrated by the Calibration Laboratory at Ricardo Energy & Environment, and allow us to examine how different site analysers respond when they are supplied with the same gas used at other sites. For ozone analysers, the calibration is undertaken with recently calibrated ozone photometers.

The technique used to process the intercalibration results is broadly as follows:

- The analyser responses to audit gas are converted into concentrations, using provisional calibration factors obtained from the Management Units on the day of the intercalibration. These factors are also used for the provisional data supplied to UK-AIR and other data dissemination media.
- These individual results are tabulated, and statistical analyses undertaken (e.g. network average result, network standard deviation, deviation of individual sites from the network mean etc.).

These results are then used to pick out problem sites, or "outliers", which are investigated further to determine reasons and investigate possible remedies for the outliers. The definition of an outlier is an analyser result that falls outside the following limits:

- ±10% of the network average for NOx, CO and SO_2 analysers,
- ±5% of the reference standard photometer for ozone analysers,
- ±2.5 % of the stated K_0 value for FDMS analysers,
- ±10% for particulate analyser flow rates,
- Particulate analyser average zero response within ±3.0 µg m^{-3}.
- ±10% for the recalculation of site cylinder concentrations.

Thus, the intercalibration investigates the quality of provisional data output by the Management Units for use in forecasting, interactive television services and the web. It also provides input into the ratification process by highlighting sites where close scrutiny of datasets is likely to be required.

Any outliers that are identified are rigorously checked to determine the cause, and any required corrective action to be taken, if necessary. There are a number of likely main causes for outlier results, as discussed below:

- Drift of an analyser between scheduled LSO calibrations. This is by far the most common cause of an outlier result, and one that is simply corrected for during ratification of data.

- Drift of site cylinder concentrations between intercalibrations. Site cylinders can sometimes become unstable, especially at low pressures. All site cylinder concentrations are checked every six months, and are replaced as necessary.
- Erroneous calibration factors. It can occasionally happen that an analyser calibration is unsuccessful, and results in unsuitable scaling factors being used to produce pollution datasets. These are identified and corrected during ratification.
- Pressurisation of the sampling system at the audit. Occasionally, an analyser can be very sensitive to small changes in applied flow rates of calibration gas. This is more difficult to identify and correct, and may have consequences for data quality.
- Leaks, sample switching valves, etc. Outliers can be generated if an analyser is not sampling ambient air properly. It is likely that if a leaking analyser is identified, data losses will result.

The procedures used to determine network performance are documented in Ricardo Energy & Environment Working Instructions. These methods are regularly updated and improved and are evaluated by the United Kingdom Accreditation Service (UKAS). Ricardo Energy & Environment holds ISO17025 accreditation for the on-site calibration of all the analyser types (NOx, CO, SO_2, O_3) and for the determination of the FDMS K_0 factor and particulate analyser flow rates used in the network. An ISO17025 certificate of calibration (Calibration Laboratory number 0401) for the analysers in the AURN is made available via the online AURN Hub.

2.1 Winter 2016 Intercalibration, January-February 2016

2.1.1 Overview of Winter Intercalibration

During January to February 2016, Ricardo Energy & Environment undertook an intercalibration of 156 of the 158 monitoring stations in operation in the AURN (two sites could not be audited due to health and safety issues which prevented access). The intercalibration exercise is a vital step in the process of data ratification. The audits are used to undertake a number of analyser and infrastructure performance checks that cannot be performed by Local Site Operators, with a view to ensuring confidence in the accuracy, consistency and traceability of air pollution measurements made at all the monitoring stations.

2.1.2 Methodology for FDMS Baseline Checks

As part of the QA/QC remit for continuous improvement, an ad hoc study of particulate matter (PM) analyser baseline response has been undertaken for the past two years. This study has been coordinated following investigations of issues identified both by CMCU during routine operation and by QA/QC unit during the ratification process.

This is carried out as follows: the size-selective inlet of the PM analyser is removed at the end of the routine six-monthly audit visit. It is replaced by a high efficiency ‘HEPA’ filter, which remains in place for several days before being removed and returned to the QA/QC Unit by the Local Site Operator (LSO). During the period when the HEPA filter is in place, the analyser is sampling particulate-free air and its ‘zero baseline response’ can be quantified. According to the requirements of the CEN standard method, this should be within ±3 µg m^{-3}. (The data from the zero baseline test period are deleted from the dataset and not reported).

The study initially concentrated on FDMS analysers, examining the baseline profile of the reference channels and the relationship with other neighbouring monitoring stations. It has become clear that, on a daily mean basis, regional reference PM concentrations regularly reach a minimum value that approaches 0 µg m^{-3}. A mean zero average concentration of 3 µg m^{-3} provides a trigger for further investigation, and possible drier replacement if deemed necessary. The test is equally valid for BAM instruments, and thus the tests are also carried out on these.

The routine QA/QC procedures have included checking of particulate analyser baselines for some time now. The CEN standard method for ambient particulate matter EN16450 states that action must be taken when baseline response is higher than 3 µg m^{-3} but does not state what the action should be. Up to now the only agreed action was to delete the data. However, as part of ongoing improvement activities a protocol has been agreed to enable baselines to be corrected where baseline responses exceed 3 µg m^{-3}. Accordingly, zero baseline correction – where it is deemed appropriate – has been incorporated into the data ratification protocols as of 2016. (The 2015 dataset was also reviewed, and zero baseline corrections applied where appropriate: this has been explained in the previous report in this series).

2.2 Overview of Data Ratification

Data for each station are supplied monthly by the CMCUs. Once initial monthly data files have been received, checked and loaded into MODUS, the process of data ratification begins. This process is required to refine data scaling based on all the calibration and audit data available, and to identify, withdraw or flag anomalous data due to instrument or sampling faults or where data fall outside the Uncertainties or Limits of Detection defined by the Data Quality Objectives (DQOs) of Directive 2008/50/EC (the Air Quality Directive) and the European Union's Implementing Provisions for Reporting.

3 Intercalibration Results

3.1 National Network Overview

During the winter 2016 intercalibration, audits were carried out on 156 monitoring stations out of 158 in operation at the time.

Two sites could not be audited due to health and safety issues which prevented access:

- Birmingham Tyburn Roadside: broken door hinge.
- Carlisle Roadside: there was no access to the monitoring station due to severe flooding. The site audit was therefore deferred until April.

The results of the intercalibration are summarised in Table 3-1 below:

Table 3-1 Summary of audited analyser performance – 156 UK stations

Parameter	Number of outliers	Number in network	% outliers in total
NOx analyser	18	137	13%
CO analyser	0	7	0%
SO_2 analyser	6	28	21%
Ozone analyser	27	81	33%
FDMS and BAM analysers	2x K_0, 5x flows 11x zero	3 PM_{10} BAM 2 $PM_{2.5}$ BAM 73 PM_{10} FDMS 80 $PM_{2.5}$ FDMS	11%
Gravimetric PM analysers	0	17	0%
Cylinders	8	172	5%
Total	69 analysers	428 analysers	16% of analysers

The number of analyser outliers identified (16%) is higher than at the summer 2015 intercalibration, but is comparable with the percentage identified the same time last year at the winter 2015 intercalibration (when 14% of analysers in use were identified as outliers).

3.2 Network Intercalibrations

The concentration of the audit cylinders was calculated averaged across all monitoring sites using the zero and scaling factors provided by the CMCU on the day of audit. How close the result is to the stated cylinder concentration is a good indication of the accuracy of the provisional results across the entire network. The results are given in Table 3-2 below. Certified cylinder concentrations are normalised for this purpose as several cylinders are used.

Table 3-2 Audit Cylinder Results

Parameter	Network Mean	Audit reference concentration	Network Accuracy %	%Std Dev
NO	488	482	1.2%	4.7
NO_2	474	497	4.6%	4.9
CO	20.9	21.3	2.1%	3.5
SO_2	460	449	2.4%	4.7

- **Oxides of Nitrogen**

  A total of 19 outliers (14% of the 137 analysers) were identified during this intercalibration. This is similar to the previous (summer 2015) exercise in which 22% of the analysers were identified as outliers. Of these outliers, 11 can be attributed to analyser drift, five to changes in site cylinder concentration, and three to issues experienced during the audit which compromised the results. All of the above outliers could be corrected with no data loss or impact on data quality.

  There were three converters which fell outside the ±5% acceptance limits. There were a further three converters identified where the initial result was outside the ±2% trigger for NO_2 rescaling.

- **Carbon Monoxide**

  There were no CO outliers identified at this intercalibration.

- **Sulphur Dioxide**

  A total of six outliers (21% of the 28 analysers) were identified at this intercalibration. This is a higher percentage than at the summer 2015 exercise, when 14% of the analysers were identified as outliers. All m-xylene interference tests were less than 23 ppb.

- **Ozone**

  A total of 27 outliers (33%) were identified during the winter 2016 exercise. This is worse than the previous (summer 2015) intercalibration, where 11 analysers were found to be outside the ±5% acceptance criterion.

- **Particulate Analysers**

  There were two calculated K_0 values outside the required ±2.5% of the stated values. This is similar to the previous (summer 2015) exercise where there was one such value.

  Five FDMS main flows were found to be outside the ±10% acceptance limits. No BAM total flows were found to be outside this limit. This total is better than the previous (summer 2015) exercise, when a total of eight analyser flow outliers were identified.

- **PM analyser zero tests**

  In the zero baseline tests carried out at the winter 2016 audit, a total of 12 analysers gave average responses to particle-free air that were outside ±3µg/m^3. It has now been agreed that QA/QC Unit may use these results to undertake zero baseline correction where appropriate.

- **Site Cylinder Concentrations**

  Eight of the 172 site cylinders (4.6%) used to scale ambient pollution data were found to be outside the ±10% acceptance limit. Seven of these were NO cylinders.

London Sites

The results of the intercalibration for the 19 London sites (including the two co-located Partisols) in operation at the time of the intercalibration are summarised in Table 3-3 below:

Table 3-3 Summary of audited analyser performance – London Sites

Parameter	Number of outliers	Number in region
NOx analyser	0	14
NOx converter	2	
CO analyser	0	2
SO_2 analyser	0	3
Ozone analyser	1	8
FDMS and BAM analysers	1	17
Gravimetric PM analysers	0	3

English Sites (Excluding London)

The results of the intercalibration for the 99 sites in England outside of London are summarised in Table 3-4 below:

Table 3-4 Summary of audited analyser performance – Sites in England

Parameter	Number of outliers	Number in region
NOx analyser	11	91
NOx converter	2	
CO analyser	0	1
SO_2 analyser	4	16
Ozone analyser	23	53
FDMS and BAM analysers	3	92
Gravimetric PM analysers	0	5

Scottish Sites

The results of the intercalibration for the 21 Scottish sites are summarised in Table 3-5 below:

Table 3-5 Summary of audited analyser performance – Scottish Sites

Parameter	Number of outliers	Number in region
NOx analyser	6	17
NOx converter	2	
CO analyser	0	1
SO_2 analyser	1	2
Ozone analyser	2	10
FDMS and BAM analysers	0	12
Gravimetric PM analysers	0	4

Welsh Sites

The results of the intercalibration for the 11 Welsh sites are summarised in Table 3-6 below:

Table 3-6 Summary of audited analyser performance – Welsh Sites

Parameter	Number of outliers	Number in region
NOx analyser	1	10
NOx converter	0	
CO analyser	0	2
SO_2 analyser	0	4
Ozone analyser	1	5
FDMS and BAM analysers	1	11
Gravimetric PM analysers	0	3

Northern Ireland Sites

The results of the intercalibration for the 7 sites in Northern Ireland, plus Mace Head in the Republic of Ireland, are summarised in Table 3-7 below:

Table 3-7 Summary of audited analyser performance – Northern Ireland Sites plus Mace Head

Parameter	Number of outliers	Number in region
NOx analyser	0	5
NOx converter	0	
CO analyser	0	1
SO_2 analyser	0	4
Ozone analyser	0	5
FDMS and BAM analysers	2	9
Gravimetric PM Analysers	n/a	0

3.3 Certification

The Network Certificate of Calibration is available on the AURN Hub (login page at https://aurnhub.defra.gov.uk/login.php). This certificate presents the results of the individual analyser scaling factors on the day of the audit, as calculated by Ricardo Energy & Environment using the audit cylinder standards, in accordance with our ISO17025 accreditation.

3.4 Calculation of Measurement of Uncertainty

The European Committee for Normalisation (CEN) have prepared a series of documents prescribing how analysers must be operated, to produce datasets that conform to the Data Quality Objectives of the EC Directives. The CEN documents for operation of air pollution analysers; BS EN14211:2012 (NOx), BS EN14212:2012 (SO_2), BS EN14626:2012 (CO) and BS EN14625:2012 (O_3) set out a series of performance criteria for analysers which must be achieved, both in the field and under laboratory conditions. The test requirements have been extensively reported in previous intercalibration summaries and should be referenced for further information.

The CEN operating methodologies are incorporated into the requirements of the air quality Directive 2008/50/EC. Member States had until June 2010 to ensure their monitoring networks are compliant. Older, non-compliant equipment still on site after this date needed to be replaced before June 2013. Ricardo Energy & Environment has taken steps to ensure the procedures used in the UK comply with the requirements ahead of any imposed deadlines. To this end, the procedures used for the intercalibrations have been fully compliant with the CEN protocols since January 2006.

To comply with the Directive, the uncertainty for gaseous analyser measurements must be less than ±15%. For PM analysers, the required measurement uncertainty is less than ±25%. For sites that have CEN-compliant instrumentation, it is possible to calculate the overall uncertainty of measuring air quality. This information is site and analyser specific and presented in Table 3-8 below:

Table 3-8 Analyser measurement uncertainties (%)

Site	Date of audit	O_3	CO	SO_2	NO_2	PM_{10}	$PM_{2.5}$
Armagh Roadside	15/02/2016				12.7	8.7	
Aston Hill	09/02/2016	11.2			12.2		
Auchencorth Moss	10/02/2016	11.2				9.7	16.4
Ballymena Ballykeel	17/02/2016			9.9		8.7	
Barnsley Gawber	28/01/2016	8.3		11.6	9.8		
Barnstaple A39	07/01/2016					8.7	16.4
Bath Roadside	05/01/2016				12.4		
Belfast Centre	26/02/2016	8.3	9.1	10.0	9.8	8.7	16.4
Belfast Stockman's Lane	25/02/2016				12.2	10.3	
Billingham	02/02/2016				12.2		
Birmingham Acocks Green	18/01/2016	11.2			12.5		16.4
Birmingham Tyburn	19/01/2016	8.1		12.4	13.1	8.7	16.4
Blackburn Accrington Road	11/01/2016				11.3		
Blackpool Marton	13/01/2016	8.3			9.8		16.4
Bottesford	22/02/2016	8.3					

Site	Date of audit	O_3	CO	SO_2	NO_2	PM_{10}	$PM_{2.5}$
Bournemouth	24/02/2016	11.2			12.2		
Bradford Mayo Avenue	12/01/2016				11.4		
Bristol St Paul's	08/01/2016	11.2			14.3	8.7	16.4
Bury Whitefield Roadside	25/01/2016				12.2	8.7	
Bush Estate	19/02/2016	11.2			12.2		
Cambridge Roadside	02/02/2016				13.2		
Camden Kerbside	16/02/2016				13.0	8.7	16.4
Canterbury	08/02/2016	11.2			12.4		
Cardiff Centre	13/01/2016	24.6	7.8	10.3	12.3	8.7	16.4
Charlton Mackrell	11/02/2016	10.4			14.7		
Chatham Centre Roadside	09/02/2016				12.3	8.7	16.4
Chepstow A48	15/01/2016				14.8	8.7	16.4
Chesterfield Loundsley Green	26/01/2016				11.1	8.7	16.4
Chesterfield Roadside	27/01/2016				11.2	8.7	16.4
Chilbolton	28/01/2016	11.2		10.4	19.5	8.7	16.4
Coventry Allesley	16/02/2016	8.6			9.8		16.4
Cwmbran	14/01/2016	9.2			13.1		
Derry	17/02/2016	11.2		10.3	12.5	8.7	16.4
Doncaster A630 Cleveland Street	28/01/2016				12.3		
Dumbarton Roadside	28/01/2016				11.1		
Dumfries	14/01/2016				12.6		
Ealing Horn Lane	03/02/2016					8.7	
Eastbourne	26/01/2016				12.2	8.7	16.4
Edinburgh St Leonards	09/02/2016	11.2		10.0	12.2	8.7	16.4
Eskdalemuir	25/01/2016	11.2			12.2		
Exeter Roadside	07/01/2016	7.3			13.6		
Fort William	20/01/2016				12.8		
Glasgow Great Western Road	27/01/2016				12.2		
Glasgow High Street	05/02/2016				12.7	8.7	16.4
Glasgow Kerbside	27/01/2016				9.8		
Glasgow Townhead	27/01/2016	8.3			12.3	8.7	16.4

Site	Date of audit	O_3	CO	SO_2	NO_2	PM_{10}	$PM_{2.5}$
Glazebury	12/01/2016	11.2			13.4		
Grangemouth	08/02/2016			9.8	11.8	8.7	16.4
Grangemouth Moray	08/02/2016				11.3		
Great Dun Fell	26/01/2016	11.4					
Hafod-yr-Ynys Roadside	14/01/2016				12.2		
Haringey Roadside	19/02/2016				14.3		
High Muffles	29/01/2016	11.2			12.2		
Honiton	06/01/2016				13.0		
Horley	25/01/2016				21.3		
Hull Freetown	13/01/2016	8.3		10.2	10.0		16.4
Hull Holderness Road	14/01/2016				13.0	8.7	
Inverness	18/01/2016				12.3		
Ladybower	26/01/2016	11.2		10.1	12.7		
Leamington Spa	25/02/2016	10.4			11.1	8.7	16.4
Leamington Spa Rugby Road	25/02/2016				12.2	15.2	16.4
Leeds Centre	11/01/2016	18.7	7.5	11.9	9.9	8.7	16.4
Leeds Headingley Kerbside	12/01/2016				21.4	8.7	16.4
Leicester A594 Roadside	17/02/2016				12.2	8.7	
Leicester University	17/02/2016	8.3			9.8		16.4
Leominster	08/02/2016	11.2			13.4		
Lerwick	21/01/2016	11.2		10.0	12.3		
Lincoln Canwick Road	23/02/2016				12.2		
Liverpool Queen's Drive Roadside	20/01/2016				12.3		
Liverpool Speke	21/01/2016	8.3		10.0	10.0		
London Bexley	10/02/2016				12.4		16.4
London Bloomsbury	08/02/2016	11.2		10.0	13.3	8.7	16.4
London Eltham	25/01/2016	10.4			11.8		16.9
London Haringey Priory Park South	19/02/2016	10.4			13.5		
London Harlington	04/02/2016	11.4			21.1	8.7	16.4
London Harrow Stanmore	16/02/2016						16.4
London Hillingdon	03/02/2016	8.3			10.1		

Site	Date of audit	O_3	CO	SO_2	NO_2	PM_{10}	$PM_{2.5}$
London Marylebone Road	27/01/2016	11.6		10.0	12.3	8.7	16.4
London N. Kensington	26/01/2016	11.4	7.6	10.0	15.1	8.7	16.4
London Teddington	17/02/2016	11.2			13.6		
London Teddington Bushy Park	17/02/2016					8.7	16.4
London Westminster	01/02/2016				22.0		
Lough Navar	16/02/2016	11.2				8.7	
Lullington Heath	27/01/2016	11.2		11.9	12.5		
Luton A505 Roadside	04/02/2016				12.2		
Mace Head	23/02/2016	n/a					
Manchester Piccadilly	13/01/2016	8.3		10.0	10.1	9.3	16.4
Manchester Sharston	18/02/2016	11.2		10.4	12.8		
Manchester South	13/01/2016	11.2		10.0	12.5		
Market Harborough	18/02/2016	8.3			9.8		
Middlesbrough	02/02/2016	11.2		10.0	12.4	8.7	16.4
Narberth	11/01/2016			11.1	12.5	8.7	
Newcastle Centre	03/02/2016	8.3			9.8	8.7	16.4
Newcastle Cradlewell Roadside	03/02/2016				11.6		
Newport	15/01/2016				11.1	8.7	16.4
Northampton Kingsthorpe	15/02/2016	7.2			13.1		
Norwich Lakenfields	03/02/2016	8.3			9.8	8.7	16.4
Nottingham Centre	22/02/2016	8.3		10.0	10.2	8.7	16.4
Nottingham Western Boulevard	24/02/2016				12.2		
Oldbury Birmingham Road	21/01/2016				13.0		
Oxford Centre Roadside	23/07/2015				11.7		
Oxford St Ebbes	05/02/2016	10.4			17.1	8.7	16.4
Peebles	09/02/2016	11.2			12.7		
Plymouth Centre	06/01/2016	8.3			9.8	8.7	16.4
Port Talbot Margam	12/01/2016	8.3	11.7	11.6	10.8	8.7	16.4
Portsmouth	23/02/2016	8.3			13.1	8.8	16.4

Site	Date of audit	O_3	CO	SO_2	NO_2	PM_{10}	$PM_{2.5}$
Preston	12/01/2016	8.3			10.0		16.4
Reading London Road	19/02/2016				12.4	9.3	
Reading New Town	25/02/2016	8.3			19.9		
Rochester Stoke	09/02/2016			10.0	12.2	8.7	16.4
Salford Eccles	12/01/2016				11.4	8.7	16.4
Saltash Callington Road	06/01/2016					8.7	16.4
Sandy Roadside	01/02/2016				12.3		16.4
Scunthorpe Town	13/01/2016			10.5	12.0	8.7	
Shaw Crompton Way	18/01/2016				12.2	9.3	
Sheffield Devonshire Green	27/01/2016	8.7			9.8	8.7	16.4
Sheffield Tinsley	27/01/2016				12.4		
Sibton	03/02/2016	11.2					
Southampton Centre	22/02/2016	8.3		10.0	19.8	8.7	16.4
Southend-on-Sea	11/02/2016	8.3			9.8		16.4
Southwark A2 Old Kent Road	02/02/2016				14.9	8.7	
St Osyth	11/02/2016	8.3			9.8		
Stanford-le-Hope Roadside	10/02/2016				12.2	8.7	16.4
Stockton-on-Tees A1305	01/02/2016				12.2		
Stockton-on-Tees Eaglescliffe	01/02/2016				12.2	9.3	n/a
Stoke-on-Trent A50 Roadside	22/01/2016				12.3	8.7	
Stoke-on-Trent Centre	20/01/2016	8.3			10.0		16.4
Storrington Roadside	26/01/2016				9.8	8.7	16.4
Strath Vaich	17/02/2016	11.2					
Sunderland Silksworth	04/02/2016	12.0			11.8		16.4
Sunderland Wessington Way	03/02/2016				12.2		
Swansea Roadside	12/01/2016				12.2	9.3	12.6
Thurrock	10/02/2016	11.2		10.0	12.2	8.7	
Tower Hamlets Roadside	09/02/2016				12.3		
Walsall Woodlands	21/01/2016	11.2			12.2		

Site	Date of audit	O_3	CO	SO_2	NO_2	PM_{10}	$PM_{2.5}$
Warrington	18/01/2016				18.6	8.7	16.4
Weybourne	04/02/2016	8.3					
Wicken Fen	02/02/2016	11.2		10.0	12.3		
Widnes Milton Road	19/01/2016				12.9	10.6	
Wigan Centre	14/01/2016	8.3			12.0		16.4
Wirral Tranmere	19/01/2016	8.3			10.7		16.4
Wrexham	21/01/2016			10.0	12.3		
Yarner Wood	10/02/2016	11.2			12.3		
York Bootham	14/01/2016					8.7	29.7
York Fishergate	15/01/2016				11.1	8.7	16.4
Total > 15 (gaseous) or > 25 (PM)	**-**	**2**	**0**	**0**	**10**	**0**	**1**

This table is updated and extended after every intercalibration to include upgraded sites and replacement analysers.

The ozone analyser at Mace Head and the $PM_{2.5}$ BAM at Stockton-on-Tees Eaglescliffe are not CEN compliant models and therefore no performance data have been included in the above table. (The Mace Head ozone analyser was replaced part way through quarter 1 of 2016).

4 Data Ratification Results

4.1 Data Capture – Network Overview

4.1.1 Overall Data Capture

The overall data capture for the period January-March 2016 is given in Table 4-1. The data capture target of the Air Quality Directive is 90% excluding periods of planned maintenance (e.g. calibrations, audits and servicing). An allowance of 5% is made for this, hence the target of 85% also shown in the table.

Table 4-1 Data Capture Summary, January-March 2016 (Quarter 1)

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Number of Sites	7	137	81	76	82	28	158
Number of sites < 85 %	2	21	6	25	24	4	36
Number of sites < 90%	2	24	7	36	36	4	47
Average	**86.68**	**91.44**	**94.27**	**80.76**	**84.17**	**88.79**	**89.26**

Average data capture was at least 85% for the gaseous pollutants – CO, NO_2, O_3 and SO_2. Average data capture was below 85% for both particulate metrics. However, it is important to note that most PM analysers in the Network underwent a zero test during quarter 1 (Q1) of 2016, which inevitably results in the loss of a few days' data.

4.1.2 Generic Data Quality Issues

The QA/QC audits continued to identify high particle analyser baselines and some data were deleted as a result. These zero tests, along with regional volatile comparisons, continue to provide evidence for poor FDMS drier performance. However, as explained above, the results of zero baseline tests are now being used to apply correction to data where high baselines have been identified.

4.2 Data Capture and Station-Specific Issues - England (Excluding Greater London)

A summary of data capture for England for January-March 2016 is given in Table 4-2:

Table 4-2 Data Capture for England, January-March 2016

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Barnsley Gawber		98.31	98.40			98.17	98.29
Barnstaple A39				81.41	82.92		82.17
Bath Roadside		98.44					98.44
Billingham		91.85					91.85
Birmingham Acocks Green		99.27	99.31		94.92		97.83
Birmingham Tyburn		99.54	99.68	71.02	94.64	93.13	91.60
Birmingham Tyburn Roadside		99.77	92.63	94.23	98.21		96.21

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Blackburn Accrington Road		98.44					98.44
Blackpool Marton		99.77	99.77		80.86		93.47
Bottesford			98.53				98.53
Bournemouth		99.77	99.86		95.60		98.41
Bradford Mayo Avenue		99.08					99.08
Brighton Preston Park		98.81	99.13		49.45		82.46
Bristol St Paul's		98.95	98.76	93.45	86.31		94.37
Bury Whitefield Roadside		77.84		90.93			84.39
Cambridge Roadside		96.11					96.11
Canterbury		98.35	98.12				98.24
Carlisle Roadside		0.00		0.00	0.00		0.00
Charlton Mackrell		99.40	98.72				99.06
Chatham Centre Roadside		98.08		87.13	42.45		75.89
Chesterfield Loundsley Green		94.09		77.47	77.88		83.15
Chesterfield Roadside		78.98		90.11	89.79		86.29
Chilbolton Observatory		88.07	88.89	77.38	88.17	34.45	75.39
Chilbolton Observatory (Partisol)				75.61	84.15		79.88
Coventry Allesley		99.22	99.86		96.38		98.49
Doncaster A630 Cleveland Street		98.53					98.53
Eastbourne		99.73		95.56	93.41		96.23
Exeter Roadside		96.38	0.00				48.19
Glazebury		98.72	98.81				98.76
Great Dun Fell			99.95				99.95
High Muffles		66.80	67.22				67.01
Honiton		98.67					98.67
Horley		99.31					99.31
Hull Freetown		97.94	98.49		91.07	98.26	96.44
Hull Holderness Road		98.53		94.18			96.36

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Ladybower		95.24	95.33			94.96	95.18
Leamington Spa		98.90	99.63	92.31	94.23		96.27
Leamington Spa Rugby Road		99.63		95.01	94.41		96.35
Leeds Centre	83.93	98.67	98.72	94.96	95.56	98.12	94.99
Leeds Headingley Kerbside		98.40		93.68	95.60		95.89
Leicester A594 Roadside		98.49		90.11			94.30
Leicester University		98.40	98.35		81.91		92.89
Leominster		99.54	99.73				99.63
Lincoln Canwick Road		98.40					98.40
Liverpool Queen's Drive Roadside		98.72					98.72
Liverpool Speke		98.40	98.26	71.75	73.53	92.99	86.99
Lullington Heath		96.75	97.66			21.52	71.98
Luton A505 Roadside		99.08					99.08
Manchester Piccadilly		98.40	97.80		90.34	97.16	95.92
Manchester Sharston		61.11	61.69				61.40
Manchester South		99.31	99.65				99.48
Market Harborough		95.60	99.82				97.71
Middlesbrough		98.12	98.03	95.42	95.33	98.12	97.01
Newcastle Centre		98.44	97.99	95.83	82.83		93.77
Newcastle Cradlewell Roadside		95.51					95.51
Northampton Kingsthorpe		45.60	99.50		98.90		81.33
Norwich Lakenfields		99.31	99.86	88.37	93.18		95.18
Nottingham Centre		98.31	98.31	93.09	90.89	98.03	95.72
Nottingham Western Boulevard		99.60		99.87			99.73
Oldbury Birmingham Road		98.26					98.26
Oxford Centre Roadside		97.94					97.94
Oxford St Ebbes		98.21		82.37	49.82		76.80

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Plymouth Centre		98.53	98.67	76.28	71.70		86.30
Portsmouth		94.96	99.68	69.23	95.28		89.79
Preston		99.63	99.73		96.38		98.58
Reading London Road		57.58		0.00			28.79
Reading New Town		98.95	99.08	92.54	92.99		95.89
Rochester Stoke		96.75	95.88	90.98	94.14	96.29	94.81
Salford Eccles		99.08		85.67	92.58		92.45
Saltash Callington Road				57.19	74.18		65.68
Sandy Roadside		99.31		62.64	98.26		86.74
Scunthorpe Town		98.03		93.45		98.21	96.57
Shaw Crompton Way		97.80					97.80
Sheffield Devonshire Green		98.44	97.85	87.41	90.06		93.44
Sheffield Tinsley		99.45					99.45
Sibton			99.73				99.73
Southampton A33 Roadside		93.27		97.99			95.63
Southampton Centre		98.12	98.63	72.44	88.05	98.67	91.18
Southend-on-Sea		97.80	91.53		88.05		92.46
St Osyth		94.87	99.36				97.12
Stanford-le-Hope Roadside		99.18		54.44	95.51		83.04
Stockton-on-Tees A1305 Roadside		98.72			24.73		61.72
Stockton-on-Tees Eaglescliffe		98.44		42.12	91.71		77.43
Stoke on Trent A50 Roadside		98.31		94.96			96.63
Stoke-on-Trent Centre		97.16	98.53		92.58		96.09
Storrington Roadside		40.11		85.03	87.82		70.99
Sunderland Silksworth		95.56	99.82		92.54		95.97
Sunderland Wessington Way		97.16					97.16
Thurrock		98.40	98.53	94.46		98.03	97.36
Walsall Woodlands		98.63	98.72				98.67

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Warrington		99.40		89.70	89.47		92.86
Weybourne			99.91				99.91
Wicken Fen		98.21	98.53			98.81	98.52
Widnes Milton Road		82.97					82.97
Wigan Centre		75.82	67.03		33.52		58.79
Wirral Tranmere		99.73	99.82		92.90		97.48
Yarner Wood		99.82	99.59				99.70
York Bootham				92.31	67.67		79.99
York Fishergate		98.40		95.15	94.23		95.92
Number of Sites	**1**	**91**	**53**	**45**	**52**	**16**	**99**
Number of sites < 85 %	**1**	**10**	**4**	**16**	**16**	**2**	**23**
Number of sites < 90%	**1**	**11**	**5**	**22**	**23**	**2**	**28**
Average	**83.93**	**93.71**	**94.66**	**81.23**	**83.21**	**88.43**	**89.77**

The following site-specific issues were identified:

- Barnstaple A39, PM_{10} and $PM_{2.5}$: PM_{10} rejected from the 24^{th} Mar to the end of the period, due to site temperature causing instability. There was a $PM_{2.5}$ data gap from 8^{th} Feb to ESU callout on 15^{th} Feb at which point the instrument's firmware was reloaded.
- Birmingham Tyburn PM_{10}: two instances of a valve fault in the instrument.
- Brighton Preston Park $PM_{2.5}$ (Partisol): site inaccessible due to electrical safety issues 21/01/16 – 01/03/16, so no gravimetric filters changed.
- Bury Whitefield Roadside NO_2: instrument failure resulted in loss of data from 1^{st} - 20^{th} Jan 2016 when a 'hot spare' could be installed.
- Carlisle Roadside – all: site out of action due to severe flooding.
- Chatham Centre Roadside PM_{10} and $PM_{2.5}$: noisy $PM_{2.5}$ data led to substantial data loss and eventual replacement of mass transducer. Some PM_{10} data lost due to zero test, and a few short PM_{10} gaps.
- Chesterfield Loundsley Green, PM_{10} and $PM_{2.5}$: power faults and flow problems.
- Chesterfield Roadside NO_2 and $PM_{2.5}$: NO_2 data rejected from service 10^{th} Feb 2016 to repair 24^{th} Feb due to baseline drift.
- Chilbolton Observatory, NO_2, O_3, PM_{10}, $PM_{2.5}$ and SO_2: some NO_2 and O_3 data not yet supplied by CMCU. SO_2 data rejected due to instability.$PM_{2.5}$ flow out by 6% at audit. PM_{10} instability and Z-score failure led to data deletion 7^{th} – 10^{th} Feb 2016.
- Exeter Roadside O_3: all O_3 data rejected due to suspected instrument fault. Measured concentrations had gradually decreased compared to other sites in the region.
- High Muffles NO_2 and O_3: At QAQC audit on 29^{th} Jan 2016, pump was found detached from manifold. Sampling tube was open at bottom, therefore the instruments had been sampling from inside the cabin. Repaired, and data deleted from the period 14^{th} Dec 2015 (the last date it was known to be attached) to 29^{th} Jan 2016.
- Leeds Centre CO: data rejected due to CO source fault, from 1^{st} Jan to ESU callout 14^{th} Jan 2016.

- Liverpool Speke PM_{10} and $PM_{2.5}$: five days of noisy PM_{10} data were rejected between 10th Mar and ESU callout 15th Mar: *the wrong type of TEOM filter was being used at the site.* $PM_{2.5}$ data gap from audit 21/01/16 to ESU callout 12/02/16 - two leaks found and repaired.
- Lullington Heath SO_2: data rejected between 5th Jan and the 15th Mar 2016, due to instability and noise. Lamp and photomultiplier tube replaced by ESU.
- Manchester Sharston NO_2 and O_3: new site – data not supplied by deadline.
- Northampton Kingsthorpe NO_2: NOx data rejected between LSO calibration on 16/12/15 and 19/02/16 due to sampling problem, also 5 days due to zero test.
- Oxford St Ebbes PM_{10} and $PM_{2.5}$: numerous gaps in both datasets. Following removal of both FDMS instruments for repair in December they were reinstalled 5th Jan 2016, but problems with instability and spiking continued for both PM metrics for the PM_{10} and $PM_{2.5}$ this period. The PM_{10} data in particular are patchy in January with numerous small gaps.
- Plymouth Centre PM_{10} and $PM_{2.5}$: some noisy data and outliers rejected including $PM_{2.5}$ between 16th – 21st January. Mass transducer replaced at service on 25th January.
- Portsmouth PM_{10}: PM_{10} data gap from Dec 2015 to 21/01/2016 - switching valve fault.
- Reading London Road: NO_2 and PM_{10}: new site, CMCU did not supply all data by the deadline.
- Saltash Callington Road PM_{10} and $PM_{2.5}$: both FDMS instruments performed poorly over Q1 of 2016 and substantial amounts of data had to be rejected. The ESU suspects this may be due to air conditioning unit problems. In Q4 of 2015 and the start of Jan 2016 the PM_{10} instrument was affected by water ingress. There were several callouts during February to investigate the problems.
- Sandy Roadside PM_{10}: leak in dryer block, mass transducer replaced.
- Stanford-le-Hope Roadside PM_{10}: data rejected from start of year up to engineer callout on 18th Jan.
- Stockton-on-Tees A1305 Roadside $PM_{2.5}$: the low data capture for $PM_{2.5}$ simply reflects that the $PM_{2.5}$ monitoring started up seven months after the NOx started up: this was intentional as a part of the phased expansion of the AURN.
- Storrington Roadside NO_2, PM_{10} and $PM_{2.5}$: NOx data rejected because they were noisy, and NOx:NO ratio changed, between ESU service on 24/02/16 and end of quarter. PM affected by various periods of poor quality data, also service and zero test.
- Wicken Fen SO_2: although no data have so far been rejected for Q1 of 2016, an issue of ongoing unusually high data is being investigated. A sampling fault, internal sampling and genuine local sources of this pollutant were all possible. A duplicate instrument has been installed at the site as of 14th Apr 2016 and the results will be reported to the Environment Agency on the completion of the investigation.
- Widnes Milton Road NO_2: no data 01/01/16 – 15/01/16 as instrument was off site for repair.
- Wigan Centre NO_2, PM_{10} and $PM_{2.5}$: gap in NOx and O_3 data 03/02/16 – 29/02/16. $PM_{2.5}$ rejected from 19/01/16 – 04/0216 due to data noise.
- York Bootham PM_{10}: no data 13/01/16 – 24/02/16. Leaks due to failed seals, pump failure and water ingress to PM head.

4.3 Data Capture and Station-Specific Issues - Greater London

A summary of data capture for Greater London for January-March 2016 is given in Table 4-3:

Table 4-3 Data Capture for Greater London, January-March 2016

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	Average
Camden Kerbside		99.22		92.63	93.59		95.15
Ealing Horn Lane				86.08			86.08
Haringey Roadside		95.38			97.22		96.30
London Bexley		99.59			75.64		87.61
London Bloomsbury		95.97	98.76	93.54	87.27	98.35	94.78
London Eltham		99.27	99.45		96.34		98.35
London Haringey Priory Park South		99.77	99.82				99.79
London Harlington		75.64	99.82	93.32	94.73		90.88
London Harrow Stanmore					65.29		65.29
London Hillingdon		99.73	99.73				99.73
London Marylebone Road	94.83	99.59	99.18	92.72	96.84	99.54	97.12
London Marylebone Road (Partisol)				98.90	93.41		96.15
London N. Kensington	98.31	98.21	98.12	93.04	91.44	97.85	96.16
London N. Kensington (Partisol)				95.60	98.90		97.25
London Teddington		99.59	99.82				99.70
London Teddington Bushy Park					82.83		82.83
London Westminster		98.99			72.53		85.76
Southwark A2 Old Kent Road		98.17		89.38			93.77
Tower Hamlets Roadside		63.92					63.92
Number of Sites	**2**	**14**	**8**	**9**	**13**	**3**	**19**
Number of sites < 85 %	**0**	**2**	**0**	**0**	**4**	**0**	**3**
Number of sites < 90%	**0**	**2**	**0**	**2**	**5**	**0**	**6**
Average	**96.57**	**94.50**	**99.34**	**92.80**	**88.16**	**98.58**	**90.88**

The following site-specific issues were identified:

- Ealing Horn Lane PM_{10}: some noisy data rejected.
- London Bexley $PM_{2.5}$: data rejected from the start of the year to 11^{th} Feb – dryer fault.
- London Bloomsbury $PM_{2.5}$: some outlier data rejected.

- London Harrow Stanmore $PM_{2.5}$: dryer fault, part replaced. Leaking O-ring between dryer and shuttle.
- London Teddington Bushy Park $PM_{2.5}$: some noisy and unstable data rejected.
- London Westminster $PM_{2.5}$ (Partisol): major leak affecting the latter part of January.
- Tower Hamlets NO_2: instrument fault. New analyser installed subsequently in April.

4.4 Data Capture and Station-Specific Issues - Wales

A summary of data capture for Wales for January-March 2016 is given in Table 4-4.

Table 4-4 Data Capture for Wales, January-March 2016

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	Average
Aston Hill		99.77	99.86				99.82
Cardiff Centre	97.34	98.53	98.40	13.64	93.86	98.17	83.33
Chepstow A48		99.36		80.63	94.37		91.45
Cwmbran		99.45	99.63				99.54
Hafod-yr-Ynys Roadside		98.26					98.26
Narberth		82.60	98.76	95.19		53.02	82.39
Newport		87.23		86.81	94.96		89.67
Port Talbot Margam (Partisol)				98.90			98.90
Port Talbot Margam	98.40	94.14	98.63	93.27	89.70	98.40	95.42
Swansea Roadside		97.80		94.69	95.19		95.89
Wrexham		83.79		97.80	97.80	99.82	94.80
Number of Sites	**2**	**10**	**5**	**8**	**6**	**4**	**11**
Number of sites < 85 %	**0**	**2**	**0**	**2**	**0**	**1**	**2**
Number of sites < 90%	**0**	**3**	**0**	**3**	**1**	**1**	**3**
Network mean	**97.87**	**94.09**	**99.06**	**82.62**	**94.31**	**87.35**	**93.59**

The following site-specific issues were identified:

- Cardiff Centre PM_{10}: cabin was found very hot at service – aircon set too high. Large amounts of poor quality data rejected: ESU callout in February found a broken valve bracket.
- Narberth NO_2 and SO_2: for NO_2, a period of unstable data from 9th Feb resulted in NOx analyser being removed for repair on 17th Feb, replaced at service on 24th Feb. For SO_2,the data baseline changed: ESU replaced lamp at callout on 11th Feb. SO_2 analyser also had a leak in the filter holder, resolved at the routine service 24th Feb.

4.5 Data Capture and Station-Specific Issues - Scotland

A summary of data capture for Scotland for January-March 2016 is given in Table 4-5:

Table 4-5 Data Capture for Scotland, January-March 2016

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	Average
Aberdeen		98.99	99.18	95.60	92.86		96.66
Aberdeen Union Street Roadside		84.80					84.80
Aberdeen Wellington Road		99.12					99.12
Auchencorth Moss			99.27	85.71	91.21		92.06
Auchencorth Moss				78.39	73.67		76.03
Bush Estate		98.63	98.58				98.60
Dumbarton Roadside		95.10					95.10
Dumfries		98.90					98.90
Edinburgh St Leonards	34.57	0.00	95.79	90.34	89.15	95.56	67.57
Eskdalemuir		98.58	98.72				98.65
Fort William		67.90	97.66				82.78
Glasgow Great Western Road		98.26					98.26
Glasgow High Street		85.81		94.51	89.29		89.87
Glasgow Kerbside		98.72					98.72
Glasgow Townhead		94.28	98.40	92.54	89.70		93.73
Grangemouth Moray		99.18					99.18
Grangemouth		97.66		94.23	80.54	97.85	92.57
Inverness		97.53		79.12	97.80		91.48
Lerwick			94.83				94.83
Peebles		98.31	98.72				98.51
Number of Sites	**1**	**17**	**10**	**8**	**8**	**2**	**21**
Number of sites < 85 %	**1**	**3**	**0**	**2**	**2**	**0**	**4**
Number of sites < 90%	**1**	**4**	**0**	**3**	**5**	**0**	**5**
Average	**34.57**	**88.93**	**98.06**	**88.80**	**88.03**	**96.70**	**92.71**

The following site-specific issues were identified:

- Auchencorth Moss (Partisol) PM_{10} a leak found in the instrument.

- Auchencorth Moss PM_{10}, $PM_{2.5}$: various noisy and unstable data rejected.
- Edinburgh St Leonards NO_2, CO: CO analyser removed for repair. Instability of response continued however. NO_2: problem with the sampling system had been suspected for some time. All data rejected following complete re-plumbing of inlet in early May 2016.
- Fort William NO_2: anomalies in the dataset, data fluctuating after calibrations.
- Glasgow High Street NO_2 and $PM_{2.5}$: auto-zero fault with NOx analyser, removed for repair and replaced with a 'hot swap' instrument from 12th Jan – 3rd Feb. Audit on 5th Feb found $PM_{2.5}$ K_0 to be out by 3.2%: FDMS reference measurement noisy due to aircon fault.
- Inverness PM_{10} (Partisol): repeated failures of the filter exchange mechanism.

4.6 Data Capture and Station-Specific Issues - Northern Ireland

A summary of data capture for Northern Ireland and Mace Head for January-March 2016 is given in Table 4-6:

Table 4-6 Data Capture for Northern Ireland (plus Mace Head), January-March 2016

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	Average
Armagh Roadside		70.05		86.77			78.41
Ballymena Ballykeel						99.91	99.91
Belfast Stockman's Lane		98.40		93.82			96.11
Belfast Centre	99.36	94.64	98.67	71.52	94.78	99.54	93.09
Derry Rosemount		99.25	99.62	0.00	100.00	0.00	59.77
Derry		99.66	99.86	88.32	91.26	99.66	95.75
Lough Navar			99.73	95.74			97.73
Mace Head			100.00				100.00
Number of Sites	**1**	**5**	**5**	**6**	**3**	**4**	**8**
Number of sites < 85 %	**0**	**1**	**0**	**2**	**0**	**1**	**2**
Number of sites < 90%	**0**	**1**	**0**	**4**	**0**	**1**	**2**
Average	**99.36**	**92.40**	**99.58**	**72.69**	**95.35**	**74.78**	**90.10**

The following site-specific issues were identified:

- Armagh Roadside, NO_2 and PM_{10}: some PM_{10} volatile measurements were regional outliers. NO_2 exhibited a step change in its baseline response. Lack of LSO calibrations.
- Belfast Centre PM_{10}: some data rejected due to poor regional agreement of volatiles. A callout due to data instability in early March found a cross-port dryer leak and other faults.
- Derry Rosemount PM_{10} and SO_2: data not received from CMCU by the deadline.
- Derry PM_{10}: failed V-seal.

4.7 Zero Baseline Correction

Until 2016, the only agreed action that could be taken in the event of a zero baseline response outside the range ±3 µg m^{-3} was to reject data. However, as of 2016, as part of ongoing improvement activities a protocol has been agreed to enable PM baselines to be corrected where baseline responses exceed 3 µg m^{-3}. Baseline correction has been incorporated into the data ratification protocols as of 2016.

There are a number of cases where zero baseline correction has been applied to PM_{10} data from Q1 of 2016, on the basis of the zero test result from the summer 2015 and/or the winter 2016 QAQC audit. These are as follows:

- Armagh Roadside: zero baseline correction of PM_{10} (-3.5 µg m^{-3}) from 01/01/16 to 31/03/16. This may need to be continued in Q2.
- Glasgow High Street: applied zero baseline correction to PM_{10} (+3.2 µg m^{-3}) from 01/01/16 to 31/03/16. Correction will need to be continued into Q2.
- Middlesbrough: applied zero baseline correction to PM_{10} (+3.9 µg m^{-3})) between 01/01/16 and 07/03/16.

It is possible that the zero tests carried out at the summer 2016 audits will reveal additional cases where zero baseline correction would be advisable. If this happens, any changes to previously ratified data will be dealt with according to the agreed protocols.

4.8 Data Intentionally Left Provisional

In some cases, it is necessary to leave data flagged as 'provisional', until further information can be obtained. The further information needed could be for example a missing calibration, the results of an investigation by the ESU, or a QAQC audit that has been delayed. The decision to leave data as 'provisional' is taken by the Quality Circle; it is important to record the following:

- Which data are to remain provisional: the monitoring station, pollutant, and period (start and end date and time).
- The reason.
- What data will be necessary in order to make the decision.
- When the decision is to be reviewed. This could be a specific date, or an event such as the next Quality Circle meeting. Data should never be left 'provisional' on an indefinite basis.

There were a number of cases where data from Jan-Mar 2016 were intentionally left provisional beyond the ratification deadline of 30th June 2016. These are summarised in Table 4-7 below.

Table 4-7 Cases Where Data from Quarter 1 of 2016 Have Intentionally Been Left Provisional

Monitoring Station	Pollutant(s)	Dates	Information Needed	When to Review
Chilbolton Observatory	All	Jan to Mar 2016	Jan & Mar 2016 dataset (not received from CMCU).	Receipt of data.
Derry Rosemount	All	All Q1	Q1 dataset (not received from CMCU).	Receipt of data.
Manchester Sharston	All	All Q1	Q1 dataset (not received from CMCU).	Receipt of data.
Nottingham Western Boulevard	All	All Q1	Q1 dataset (not received from CMCU).	Receipt of data.
Reading London Road	All	All Q1	Q1 dataset (not received from CMCU).	Receipt of data.
Stoke on Trent A50	NO	All Q1	NO Cylinder identified as -12.8% out at winter audit still needs changing: ESU told not to do this until after the forthcoming audit.	Summer 2016 audit.
Wigan Centre	O3	All Q1	Rescale needed as analyser type had been incorrectly entered.	When rescale done.
Yarner Wood	O_3, NOx	All Q1	ESU callout requested to investigate suspected flow fault.	Review after callout, at latest when ratifying Q2 data.

5 Changes to Previously Ratified Data

Occasionally there are circumstances where it is necessary to make changes to data which have previously been flagged as "Ratified". This may be for example where:

- A QAQC audit or other investigation has detected a problem which affects data back into an earlier ratification period.
- Long-term analysis has detected an anomaly between expected and measured trends which requires further investigation and possible data correction.
- Further research comes to light which indicates that new or tighter QAQC criteria are required to meet the data quality objectives. This may require review and revision of historic calibration data by applying the new criteria.

During ratification of the 2016 Q1 data, some changes were also made to data from 2015 that had previously been flagged as ratified. These changes, and the reasons, are shown in Table 5-1.

Table 5-1 Changes to 2015 Data Previously Marked as Ratified

Monitoring Station	Pollutant(s)	Dates	Nature of Change
Exeter Roadside	O_3	From Jan 2015 (service was 27th Jan 2015).	O_3 far too low – loss of agreement with other sites in area. Callout requested.
High Muffles	O_3	14th Dec 2015 – 29th Jan 2016.	QAQC audit found pump detached from manifold - internal sampling.
Lincoln Canwick Road	NOx	Q4 of 2015	Adjustment of baseline.
Newcastle Centre	NOx	Q4 of 2015	Reprocess due to instrument baseline drift.
Northampton Kingsthorpe	NOx	16th Dec 2015 - 19th Feb 2016.	Rejection of NOx data between the LSO calibration 16th Dec 2015 and 19th Feb 2016.
Southampton Centre	NO	15th Feb 2015 – 23 Feb 2016.	Rescale of NO from winter 2015 audit to winter 2016 audit.
Southend on Sea	O_3	1st Oct 2015 to 11th Feb 2016.	Ozone rescale from autumn 2015 audit to winter 2016 audit.
Stoke on Trent A50	NO	Summer 2015 22nd Jan 2016.	Rescale between summer 2015 audit and winter 2016 audit due to cylinder being 'out'.
Sunderland Silksworth	O_3	7th Oct 2015 to 14th Apr 2016.	Ozone rescaled from audit 7th Oct 2015 to the service 14th Apr 2016.
Walsall Woodlands	O_3	28th Oct 2015 to 21st Jan 2016.	Ozone rescale between audits.
Wicken Fen	O_3	15th Oct 2015 (autumn O_3 audit) to 2nd Feb 2016.	Ozone rescale ramped between the Audits 15th Oct and 2nd Feb.

6 Health and Safety Report

A summary of instances when an AURN station went to 'HIGH' risk status during the quarter is given in Table 6-1: both of these issues have now been resolved.

Table 6-1 Summary of Cases When an AURN Station Went to "High" Risk Status, Jan – Mar 2016

Station	Risk	Date went to 'High'	Date resolved	Action taken
Wigan Centre	Water ingress. Water trapped in roof void entered enclosure.	05/02/2016	23/02/2016	Repaired
Oxford St Ebbes	Electrical safety concern.	24/03/2016	04/04/2016	Resolved

Three sites – Birmingham Tyburn Roadside, Carlisle Roadside and Brighton Preston Park – were already at "High" risk at the beginning of the quarter due to problems that had emerged during Q4 of 2015. These were also resolved.

7 Equipment Upgrade Requirements

The ozone photometers used by QA/QC Unit for AURN intercalibrations are now 12-17 years old and have started to develop faults. The zero air generators and dilution calibrators are also nearing the end of their working lives.

Having researched the best instruments to replace the existing kit, QA/QC Unit has therefore made an application to the Environment Agency for the purchase of the following:

- 5x Portable Dilution Calibrators (this instrument combines an ozone generator and photometer with a dilution kit)
- 5x Portable Zero Air Generator Systems

Both are robust but lightweight and will reduce the overall amount of kit that our Field Team members need to carry – thus reducing manual handling risks.

In addition, the $PM_{2.5}$ BAM instrument at Stockton-on-Tees Eaglescliffe has been identified as a noncompliant model. CMCU are in the process of arranging its replacement.

8 Station Infrastructure Issues

The following station infrastructure issues have been identified by the QA/QC Unit this quarter:

- Wigan Centre – repaired
- Southampton Centre: this monitoring station went to "High" risk in Q2 of 2016 due to water ingress causing an electrical safety hazard. The Environment Agency are aware and discussions are under way in relation to funding a housing upgrade.

9 Conclusions and Recommendations

Conclusions

1. During Quarter 1 of 2016 a total of 158 AURN monitoring stations were in operation.
2. During this quarter, the winter 2016 intercalibration exercise was carried out, involving comprehensive performance tests on every analyser in the network. This allows the accuracy of the measured results to be determined, and a measurement uncertainty for each analyser to be determined, as required by the Data Quality Objective.
3. Data ratification for the quarter was completed by the deadline of 30th June 2016.
4. The mean data capture for ratified hourly average data was 89.3% (averaged over all pollutants O_3, NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$), for the three-month reporting period January to March 2016.
5. Mean data captures for individual pollutants were as follows: CO, 86.7%; NO_2, 91.4%; O_3, 94.3%; SO_2, 88.8%; PM_{10}, 80.8% and $PM_{2.5}$, 84.2%. The data capture target of the Air Quality Directive is 90% excluding periods of planned maintenance e.g. calibrations, audits and servicing). An allowance of 5% is made for this, hence a target of 85%. The mean data captures for all pollutants except PM_{10} and $PM_{2.5}$ met this target in Q1 of 2016.
6. The uncertainty of measurement for each analyser has been determined to ensure compliance with the Data Quality Objective. Thirteen analysers were found to be outside the required uncertainty.

Recommendations:

1. An application has been submitted to the Environment Agency for purchase of five new portable dilution calibrators and five new portable zero air generators, to replace existing kit which is nearing the end of its working life and becoming unreliable.
2. The non-compliant instrument at Stockton-on-Tees Eaglescliffe should be replaced with an appropriate instrument as soon as possible.

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