QAQC Report for the Automatic Urban and Rural Network, July-September 2016

Report for Defra and the Devolved Administrations

Defra contract number 21316

ED 60071201_2016Q3 | Issue 1 | Date 07/08/2017

Customer:

Defra and the Devolved Administrations

Customer reference:

21316

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07 August 2017

Ricardo Energy & Environment reference:

Ref: ED60071201_2016Q3- Issue 1

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 UK Environment Agency, 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.

A total of 163 monitoring stations in the AURN operated during this quarter, of which 73 were Local Authority owned stations affiliated to the national network. Some are co-located and separately named gravimetric particulate analysers at stations with automatic analysers. Many affiliated stations have additional Defra-funded analysers installed on site.

During this quarter, the summer 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.

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.

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%. Ratified hourly average data capture for the network averaged 89.40% for all pollutants (O_3, NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$) during the 3-month reporting period July-September 2016. Average data capture for all pollutants except PM_{10} were above 85%. There were 31 stations with data capture less than 85% for the period (53 below 90%). Principal reasons for data loss are given here for stations which fail to make the 85% data capture target for the quarter.

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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 EU Directives on Air Quality. However, in addition, the data and information from the AURN is 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 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 affiliated stations.

Dissemination of the data from the AURN via UK-AIR (the UK online Air Information Resource, https://uk-air.defra.gov.uk) and other media such as 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.

A total of 163 monitoring stations in the AURN operated during this quarter. This includes five sites where Partisol gravimetric particulate samplers were co-located with automatic particulate analysers. (The gravimetric data have historically been used in validating the performance of the automatic analysers; several of the Partisols are now considered to have served their purpose and the Environment Agency took the decision to discontinue their operation, as of September 2016). 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.

The main reasons for data loss at the stations are discussed in section 4.

1.2 What This Report Covers

This report covers the three-month period July-September 2016, or "Quarter 3" 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:

- 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.
- UK-AIR, https://uk-air.defra.gov.uk/ , which contains information on individual stations along with real-time hourly data, graphs and statistics.

1.4 Changes to the Network during this Quarter

Table 1-1 shows the changes that were made to the network during the period July - September 2016:

Table 1-1 Network Changes Jul - Sep 2016

New Stations	Pollutants	Date Started
Sheffield Barnsley Road	NO_2	01/08/2016
Cannock A5190 Roadside	NO_2	10/08/2016
Birkenhead Borough Road	NO_2	18/08/2016
Christchurch Barrack Road	NO_2	01/09/2016
Birmingham A4540 Roadside	NO_2 O_3 $PM_{2.5}$ PM_{10}	09/09/2016

In addition, a NO_2 analyser was installed at York Bootham on 18/08/2016.

The Birmingham A4540 Roadside station replaced Birmingham Tyburn Roadside, which had to be moved due to a change of use of the adjacent Council premises.

2 Methodology

2.1 Overview of QA/QC Activities

The QA/QC activities consist of the following key parts:

- QA/QC audits of all analysers in the network every six months (three months for ozone).
- Ratification of the data on a three-monthly basis, and upload ratified data to the Data Dissemination Unit.
- Assessment of new station locations in conjunction with the CMCU, and assessment of compliance with the siting criteria in the Directive.
- Investigation of instances of suspected poor quality data.

2.2 Summer 2016 QA/QC Audits

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.

2.3 Network Intercalibration

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 the web/interactive TV services.
- 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.

2.4 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.

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. Until 2016 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}.

2.5 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 Summer Intercalibration, July-September 2016

During July to September 2016, Ricardo Energy & Environment undertook an intercalibration of 163 monitoring stations in operation in the AURN.

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

Table 3-1 Summary of audited analyser performance – 163 UK stations

Parameter	Number of outliers	Number in network	% outliers in total
NOx analyser	20	138	14.5%
CO analyser	1	7	14.3%
SO_2 analyser	6	28	21.4%
Ozone analyser	17	80	21.3% (4 deviated by more than 10% from the reference standard.)
FDMS and BAM analysers	4x K_0, 3x flows (33x zero tests)	4 PM_{10} BAM 3 $PM_{2.5}$ BAM 65 PM_{10} FDMS 70 $PM_{2.5}$ FDMS 1 $PM_{2.5}$ Fidas	4.9%
Gravimetric PM analysers	3	17	17.6%
Cylinders	8	173	4.6%
Total	**54 analysers**	**413 analysers**	**13.1% of analysers**

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 appended to this report.

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 (in volume units, ppb or ppm)

Parameter	Network Mean	Audit reference concentration	Network Accuracy %	%Std Dev
NO (ppb)	461	458	+0.7	3.7
NO_2 (ppb)	440	458	-3.8	4.8
CO (ppm)	21.2	20.9	+1.2	2.8
SO_2 (ppb)	468	484	-3.3	4.9

Oxides of Nitrogen
A total of 20 outliers were identified during this intercalibration. This is similar to the previous (winter 2016) exercise in which 19 of the analysers were identified as outliers. Of these outliers, 11 can be attributed to analyser drift, five to changes in site cylinder concentration, one to a poor converter result 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 four converters which fell outside the ±5% acceptance limits. There were a further four converters identified where the initial result was outside the ±2% trigger for NO_2 rescaling.

Carbon Monoxide
There was a single outlier identified at this intercalibration. No outliers were identified at the previous exercise.

Sulphur Dioxide
A total of six outliers were identified at this intercalibration. This is identical to the winter 2016 exercise. All m-xylene interference tests were less than 27 ppb.

Ozone
A total of 17 outliers were identified during the summer 2016 exercise. This is better than the previous (winter 2016) intercalibration, where 27 analysers were found to be outside the ±5% acceptance criterion. Just four of the outliers had a calibration response more than 10% from the reference photometer.

Particulate Analysers
There were four calculated K_0 values outside the required ±2.5% of the stated values. This is worse than the previous (winter 2016) exercise where two outliers were identified.

Three FDMS main flows were found to be outside the ±10% acceptance limits. No BAM total flows were found to be outside this limit. Three Partisol total flows were found to be outside the ±10% acceptance limits. This total is similar to the previous (winter 2016) exercise, when a total of five analyser flow outliers were identified.

PM analyser zero tests
In the zero baseline tests carried out at the summer 2016 audit, a total of 33 analysers gave average responses to particle-free air that were outside ±3 µg m^{-3}. The QA/QC Unit now regularly use these results to undertake zero baseline correction where appropriate.

Site Cylinder Concentrations

Eight of the 173 site cylinders (4.6%) used to scale ambient pollution data were found to be outside the ±10% acceptance limit. Five were NO cylinders, two SO_2 and one CO.

London Sites

The results of the intercalibration for the 15 London sites in operation at the time of the intercalibration are summarised in Table 3-3 below.

English Sites (Excluding London)

The results of the intercalibration for the 105 English (outside London) sites are summarised in Table 3.4 below.

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

Parameter	Number of outliers	Number in region
NOx analyser	14	91
NOx converter	2	
CO analyser	0	1
SO_2 analyser	1	16
Ozone analyser	11	53
FDMS and BAM analysers	2	92
Gravimetric PM analysers	2	5

Scottish Sites

The results of the intercalibration for the 18 Scottish sites are summarised in Table 3.5 below.

Table 3-4 Summary of audited analyser performance – Scottish Sites

Parameter	Number of outliers	Number in region
NOx analyser	5	19
NOx converter	2	
CO analyser	1	1
SO_2 analyser	1	3
Ozone analyser	3	10
FDMS and BAM analysers	0	12
Gravimetric PM analysers	1	4

Welsh Sites

The results of the intercalibration for the 10 Welsh sites are summarised in Table 3.6 below.

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

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

Northern Ireland sites (plus Mace Head)

The results of the intercalibration for the Northern Ireland sites (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

Parameter	Number of outliers	Number in region
NOx analyser	0	5
NOx converter	0	
CO analyser	0	1
SO_2 analyser	1	3
Ozone analyser	0	4
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-AEA 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}	$PM_{2.5}$
Aberdeen Union Street Roadside	19-Jul				12.5		
Aberdeen Wellington Road	19-Jul				13.3		
Aberdeen	18-Jul	11.2			12.5	8.7	16.4
Armagh Roadside	19-Aug				11.2	8.7	
Aston Hill	08-Aug	11.2			12.2		
Auchencorth Moss	10-Aug	11.2					16.4
Ballymena Ballykeel	18-Aug			9.8	12.2	20.6	
Barnsley Gawber	28-Jul	8.3		11.7	9.8		
Barnstaple A39	06-Jul					8.7	16.4
Bath Roadside	04-Jul				12.2		
Belfast Centre	23-Aug	8.3	7.5	***22.0***	11.5		16.4
Belfast Stockman's Lane	23-Aug				12.4	9.3	
Billingham	01-Aug				12.3		
Birmingham A4540 Roadside	21-Jul	11.2			12.3	8.7	16.4
Birmingham Acocks Green	22-Jul	11.2			12.2		16.4
Birmingham Tyburn	21-Jul	7.3		12.4	13.2	8.7	16.4
Blackburn Accrington Road	14-Jul				11.7		
Blackpool Marton	14-Jul	8.3			9.8		16.4
Bottesford	23-Aug	8.3					
Bournemouth	24-Aug	11.2			12.2		
Bradford Mayo Avenue	11-Jul				12.4		
Brighton Preston Park	26-Jul	11.2			12.3		
Bristol St Paul's	04-Jul	11.2			12.2	8.7	16.4
Bury Whitefield Roadside	15-Jul				***19.2***		
Bush Estate	10-Aug	11.2			12.2		

Site	Date of audit	O_3	CO	SO_2	NO_2	PM_{10}	$PM_{2.5}$
Cambridge Roadside	02-Aug				13.0		
Camden Kerbside	16-Aug				13.0	8.7	16.4
Cannock A5190 Roadside	10-Aug				12.2		
Canterbury	11-Aug	11.2			12.2		
Cardiff Centre	13-Jul	11.2		10.2	12.3	8.7	16.4
Carlisle Roadside	15-Jul				11.6	8.7	16.4
Charlton Mackrell	10-Aug	10.4			12.2		
Chatham Centre Roadside	11-Aug				12.2	8.7	16.4
Chepstow A48	15-Jul				***20.6***	8.7	16.4
Chesterfield Loundsley Green	27-Jul				11.9	8.7	16.4
Chesterfield Roadside	26-Jul				11.1	8.7	16.4
Chilbolton	28-Jul	11.2		10.0	***19.4***	8.7	16.4
Coventry Allesley	20-Jul	8.4			9.8		16.4
Cwmbran	14-Jul	9.6			***18.9***		
Derry Rosemount	18-Aug	11.2		10.3	12.3	8.7	16.4
Doncaster A630 Cleveland Street	28-Jul				12.2		
Dumbarton Roadside	25-Jul				13.2		
Dumfries	12-Jul				12.2		
Ealing Horn Lane	01-Aug					8.7	
Eastbourne	26-Jul				***16.1***	8.7	16.4
Edinburgh St Leonards	09-Aug	11.2	7.5	10.3	12.2	8.7	16.4
Eskdalemuir	12-Jul	11.2			12.2		
Exeter Roadside	07-Jul	7.2			13.1		
Fort William	20-Jul	11.2			12.2		
Glasgow Great Western Road	27-Jul				12.4		
Glasgow High Street	28-Jul				12.2	8.7	16.4
Glasgow Kerbside	27-Jul				11.7		
Glasgow Townhead	27-Jul	8.3			12.2	8.7	16.4
Glazebury	13-Jul	11.2			12.2		
Grangemouth Moray	08-Aug			13.3	12.0		
Grangemouth	08-Aug			9.8	11.8	8.7	16.4
Great Dun Fell	13-Jul	11.4					
Greenock A8 Roadside	07-Jul				9.8		
Hafod-yr-Ynys Roadside	14-Jul				12.2		
Haringey Roadside	17-Aug				14.7		

Site	Date of audit	O_3	CO	SO_2	NO_2	PM_{10}	$PM_{2.5}$
High Muffles	29-Jul	11.3			12.2		
Honiton	06-Jul				12.2		
Horley	25-Jul				13.8		
Hull Freetown	13-Jul	8.3		10.8	9.8		16.4
Hull Holderness Road	13-Jul				12.4	8.7	
Inverness	21-Jul				12.3		
Ladybower	26-Jul	12.3		10.6	12.5		
Leamington Spa Rugby Road	19-Aug				12.2	8.7	16.4
Leamington Spa	24-Aug	10.6			11.1	8.7	16.4
Leeds Centre	11-Jul	***17.6***	7.9	12.8	9.8	8.7	16.4
Leeds Headingley Kerbside	12-Jul				12.5	8.7	16.4
Leicester A594 Roadside	16-Aug				12.2	8.7	
Leicester University	16-Aug	8.3			9.8		16.4
Leominster	18-Aug	11.2			12.2		
Lerwick	20-Jul	11.2			12.2		
Lincoln Canwick Road	25-Aug				12.2		
Liverpool Queen's Drive Roadside	21-Jul				12.4		
Liverpool Speke	21-Jul	8.3		10.0	9.8	8.7	16.4
London Bexley	09-Aug				12.6		16.4
London Bloomsbury	08-Aug	11.2		10.2	***15.1***	8.7	16.4
London Eltham	29-Jul	10.4			11.7		16.4
London Haringey Priory Park South	17-Aug	10.4			***16.1***		
London Harlington	03-Aug	11.2			***32.2***	8.7	16.4
London Harrow Stanmore	16-Aug						16.4
London Hillingdon	11-Aug	8.3			9.8		
London Marylebone Road	27-Jul	11.2		10.0	14.6	8.7	16.4
London N. Kensington	26-Jul	11.2	7.5	10.1	14.3	8.7	16.4
London Teddington Bushy Park	15-Aug						16.4
Tower Hamlets Roadside	11-Aug				13.0		
London Westminster	01-Aug				***18.1***		
Lough Navar	16-Aug	11.2				8.7	
Lullington Heath	27-Jul	11.2		10.0	12.2		
Luton A505 Roadside	01-Aug				12.2		
Mace Head	17-Aug	8.3					

Site	Date of audit	O_3	CO	SO_2	NO_2	PM_{10}	$PM_{2.5}$
Manchester Piccadilly	14-Jul	8.3		12.7	11.6		16.4
Manchester Sharston	14-Jul	11.2		***16.0***	***18.6***		
Market Harborough	17-Aug	8.3			9.8		
Middlesbrough	02-Aug	11.6		10.3	12.3	8.7	16.4
Narberth	11-Jul			10.6	12.2	8.7	
Newcastle Centre	04-Aug	8.3			9.8	8.7	16.4
Newcastle Cradlewell Roadside	04-Aug				11.2		
Newport	13-Jul				14.0	8.7	16.4
Northampton Kingsthorpe	15-Aug	7.2			13.0		
Norwich Lakenfields	03-Aug	8.3			10.8	8.7	16.4
Nottingham Centre	18-Aug	8.4		10.0	10.2	8.7	16.4
Nottingham Western Boulevard	18-Aug				12.2	8.7	
Oldbury Birmingham Road	20-Jul				13.0		
Oxford Centre Roadside	25-Jul				***16.7***		
Oxford St Ebbes	25-Jul	11.1			11.2	8.7	16.4
Peebles	09-Aug	11.2			12.8		
Plymouth Centre	05-Jul	8.3			9.8	8.7	16.4
Port Talbot Margam	12-Jul	8.3	11.5	11.6	9.8	8.7	16.4
Portsmouth	01-Sep	8.3			***15.5***	8.7	
Preston	14-Jul	8.3			9.8		16.4
Reading London Road	07-Jul				***17.8***	9.3	
Reading New Town	06-Jul	8.3			9.8	8.7	16.4
Rochester Stoke	10-Aug			10.0	13.7	8.7	16.4
Salford Eccles	12-Jul				11.1	8.7	16.4
Saltash Callington Road	05-Jul					8.7	16.4
Sandy Roadside	01-Aug				12.3	8.7	16.4
Scunthorpe Town	12-Jul			11.7	11.8	8.7	
Shaw Crompton Way	15-Jul				13.8	9.3	
Sheffield Barnsley Road	03-Aug				12.2		
Sheffield Devonshire Green	27-Jul	8.4			9.9	8.7	16.4
Sheffield Tinsley	27-Jul				11.4		
Sibton	03-Aug	11.2					
Southampton A33 Roadside	24-Aug				12.3	8.7	
Southend-on-Sea	08-Aug	9.6			10.4		16.4

Site	Date of audit	O_3	CO	SO_2	NO_2	PM_{10}	$PM_{2.5}$
Southwark A2 Old Kent Road	04-Aug				12.7	8.7	
St Osyth	08-Aug	8.3			9.8		
Stanford-le-Hope Roadside	12-Aug				12.2	8.7	16.4
Stockton on Tees A1035 Roadside	01-Aug				12.2		16.4
Stockton-on-Tees Eaglescliffe	02-Aug				12.2	9.3	12.6
Stoke on Trent A50 Roadside	19-Jul				12.5	8.7	
Stoke-on-Trent Centre	19-Jul	8.4			11.2		16.4
Storrington Roadside	28-Jul				9.8	8.7	16.4
Strath Vaich	21-Jul	11.2					
Sunderland Silksworth	03-Aug	11.2			11.8		16.4
Sunderland Wessington Way	04-Aug				12.2		
Swansea Roadside	12-Jul				13.6	9.3	12.6
Thurrock	09-Aug	11.3		11.0	12.8	8.7	
Walsall Woodlands	18-Jul	11.2			12.2		
Warrington	18-Jul				11.1	8.7	16.4
Weybourne	04-Aug						
Wicken Fen	02-Aug	12.3		10.2	12.3		
Widnes Milton Road	19-Jul				12.3	9.8	
Wigan Centre	12-Jul	8.3			11.9		
Wirral Tranmere	19-Jul	8.3			9.8		16.4
Wrexham	20-Jul			11.7	15.0		
Yarner Wood	09-Aug	11.2			13.9		
York Bootham	14-Jul					8.7	16.4
York Fishergate	14-Jul				11.7	9.0	16.4
Total > 15% (gaseous) or > 25% (PM)	**-**	**1**	**0**	**2**	**8**	**0**	**0**

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

There are a number of analysers where the calculated uncertainty is higher than the Directive compliance limit. The most common cause of this is noisy response as measured during the audit. This is generally an indication of poor instrument performance, and these are reviewed at the Quality Circle to assess the impact on reported data. High noise on particulate analysers are reported to CMCU and ESUs prior to each service to ensure the necessary repair procedures are carried out by the engineer.

4 Data Ratification Results

4.1 Data Capture – Network Overview

4.1.1 Overall Data Capture

The overall data capture for the period July-September 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, July-September 2016

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Number of stations	7	143	80	76	81	29	163
Number of stations < 85 %	1	20	9	20	20	4	31
Number of stations < 90%	2	29	12	31	30	6	53
Network mean	90.77	91.17	91.48	84.38	85.13	90.64	89.40

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. Evidence is being collected by the QA/QC Unit and both CMCUs to develop a method for correcting 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 July-September 2016 is given in Table 4-2:

Table 4-2 Data Capture for England, July-September 2016

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Barnsley Gawber		98.46	98.51			97.19	98.05
Barnstaple A39				91.98	86.55		89.27
Bath Roadside		86.46					86.46
Billingham		99.59					99.59
Birkenhead Borough Road		98.30					98.30
Birmingham A4540 Roadside		96.98	74.10	77.32	72.78		80.29
Birmingham Acocks Green		96.88	98.82		96.11		97.27
Birmingham Tyburn		97.15	96.69	47.15	93.84	92.21	85.41
Birmingham Tyburn Roadside		97.75	97.07	77.39	91.77		91.00
Blackburn Accrington Road		78.31					78.31

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Blackpool Marton		88.27	98.60		93.89		93.58
Bottesford			99.50				99.50
Bournemouth		94.25	99.91		98.91		97.69
Bradford Mayo Avenue		94.97					94.97
Brighton Preston Park		65.35	98.19		97.83		87.12
Bristol St Paul's		97.19	93.89	91.35	57.65		85.02
Bury Whitefield Roadside		99.14		85.78			92.46
Cambridge Roadside		61.46					61.46
Cannock A5190 Roadside		97.92					97.92
Canterbury		97.24	98.55				97.89
Carlisle Roadside		94.07		92.12	92.26		92.81
Charlton Mackrell		98.37	97.87				98.12
Chatham Centre Roadside		99.46		95.29	74.28		89.67
Chesterfield Loundsley Green		63.86		95.24	95.34		84.81
Chesterfield Roadside		96.20		95.15	96.11		95.82
Chilbolton Observatory		88.77	98.32	78.94	84.06	95.15	89.05
Chilbolton Observatory				79.35	92.39		85.87
Christchurch Barrack Road		85.19					85.19
Coventry Allesley		98.87	99.00		93.39		97.09
Doncaster A630 Cleveland Street		99.64					99.64
Eastbourne		98.96		90.31	27.63		72.30
Exeter Roadside		99.50	9.19				54.35
Glazebury		98.19	96.56				97.37
Great Dun Fell			99.77				99.77
High Muffles		99.46	99.91				99.68
Honiton		98.32					98.32
Horley		98.32					98.32
Hull Freetown		97.96	98.28		90.99	98.23	96.37
Hull Holderness Road		97.87		86.23			92.05
Ladybower		99.64	99.73			98.64	99.34
Leamington Spa		91.98	88.09	90.17	92.12		90.59

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Leamington Spa Rugby Road		84.83		89.90	89.72		88.15
Leeds Centre	98.28	97.28	98.37	93.07	95.24	97.46	96.62
Leeds Headingley Kerbside		98.41		95.61	96.11		96.71
Leicester A594 Roadside		97.46		91.98			94.72
Leicester University		99.55	99.82		96.56		98.64
Leominster		58.74	59.01				58.88
Lincoln Canwick Road		99.37					99.37
Liverpool Queen's Drive Roadside		89.18					89.18
Liverpool Speke		97.60	96.11	94.47	94.43	97.78	96.08
Lullington Heath		90.08	91.21			80.03	87.11
Luton A505 Roadside		97.64					97.64
Manchester Piccadilly		84.92	93.39		74.09	86.82	84.81
Manchester Sharston		97.96	90.13				94.04
Market Harborough		95.20	74.14				84.67
Middlesbrough		97.06	97.55	94.20	90.58	96.74	95.23
Newcastle Centre		97.55	97.60	93.75	87.32		94.06
Newcastle Cradlewell Roadside		96.38					96.38
Northampton Kingsthorpe		99.32	99.50		98.91		99.25
Norwich Lakenfields		66.94	70.38	29.35	27.85		48.63
Nottingham Centre		98.01	98.28	93.03	92.98	97.74	96.01
Nottingham Western Boulevard		98.23		81.48			89.86
Oldbury Birmingham Road		76.36					76.36
Oxford Centre Roadside		98.23					98.23
Oxford St Ebbes		0.00		0.00	0.00		0.00
Plymouth Centre		98.37	97.10	95.83	94.34		96.41
Portsmouth		98.60	99.28	36.82	92.16		81.71
Preston		98.23	98.28		93.84		96.78
Reading London Road		89.45		95.52			92.48
Reading New Town		98.05	98.37	93.48	86.01		93.98
Rochester Stoke		98.28	97.96	86.10	83.97	96.38	92.54

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
Salford Eccles		90.26		91.26	92.21		91.24
Saltash Callington Road				83.79	76.27		80.03
Sandy Roadside		98.78		95.47	93.30		95.85
Scunthorpe Town		99.14		92.12		99.05	96.77
Shaw Crompton Way		97.87					97.87
Sheffield Barnsley Road		99.52					99.52
Sheffield Devonshire Green		97.46	98.37	88.99	95.29		95.03
Sheffield Tinsley		98.01					98.01
Sibton			97.06				97.06
Southampton A33 Roadside		98.41		77.76			88.09
Southampton Centre		0.00	0.00	0.00	0.00	0.00	0.00
Southend-on-Sea		92.93	93.03		87.32		91.09
St Osyth		95.65	98.01				96.83
Stanford-le-Hope Roadside		92.66		80.16	74.05		82.29
Stockton-on-Tees A1305 Roadside		98.51			96.38		97.44
Stockton-on-Tees Eaglescliffe		98.23		71.74	50.05		73.34
Stoke on Trent A50 Roadside		98.64		93.57			96.11
Stoke-on-Trent Centre		98.10	98.46		92.84		96.47
Storrington Roadside		99.59		94.52	93.61		95.91
Sunderland Silksworth		92.12	89.76		82.07		87.98
Sunderland Wessington Way		86.59					86.59
Thurrock		98.23	98.55	92.21		97.55	96.64
Walsall Woodlands		98.51	98.51				98.51
Warrington		97.60		90.72	95.92		94.75
Weybourne			94.70				94.70
Wicken Fen		69.43	96.38			95.92	87.24
Widnes Milton Road		99.18					99.18
Wigan Centre		86.41	86.78		56.34		76.51
Wirral Tranmere		98.37	98.05		85.33		93.92
Yarner Wood		97.24	92.12				94.68

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	All
York Bootham		48.28		94.02	86.23		76.18
York Fishergate		97.87		85.87	88.13		90.62
Number of Sites	**1**	**97**	**53**	**46**	**53**	**17**	**104**
Number of sites < 85 %	**0**	**14**	**6**	**14**	**15**	**3**	**19**
Number of sites < 90%	**0**	**22**	**9**	**20**	**23**	**4**	**36**
Average	**98.28**	**90.42**	**91.26**	**81.97**	**82.40**	**83.94**	**89.27**

The following site-specific issues were identified:

Barnstaple A39
Air conditioning problems continued to cause poor quality data, especially on the $PM_{2.5}$ FDMS. This continued into Q4.

Bath Roadside
The main switching valve was faulty from 20-30 September, and these data have been deleted.

Birmingham A4540 Roadside
The performance of the FDMS analysers has been poor since commissioning on 9 September, particularly the $PM_{2.5}$. This has required a new mass transducer and drier, and problems continued into Q4.

Birmingham Tyburn
The PM_{10} data was of poor quality following service on 8 August up to an engineer's visit on 20 September, though no specific fault was noted.

Blackburn Accrington Road
A sampling fault identified in Q2 continued into Q3; data from 1-18 July have been deleted. Some additional data in Q2 have also been deleted, these were from a hotspare instrument installed following failure of the site instrument in May.

Brighton Preston Park
The NOx analyser was removed for repair on 29 July following a period of poor data and several status warnings recorded. Data from 14-29 July have been deleted.

Bristol St Pauls
Data from the $PM_{2.5}$ FDMS were poor following an engineer's visit on 5 August, where a pump fault was found. Most of the data were deleted from 4 July to 15 August.

Cambridge Roadside
The analyser appeared to fail the converter test at audit; however the engineer who attended found the filter holder was leaking. Data have been deleted from the LSO calibration on 25 July to the ESU visit on 5 August. The CMCU experienced communications problems following upgrade of the site telephone system in September; data from 10-30 September have not been supplied.

Chatham Centre Roadside
This site narrowly missed the 90% target due to some data loss caused by a faulty flow sensor on 31 August. Some spurious spikes were removed during ratification.

Chesterfield Loundsley Green
A shift in NOx profile and NO_2/NO_X ratios was observed following the service on 3 August. The reason for this is not clear but data from previous quarters was reviewed and data from 27 April to 3 August were deleted.

Chilbolton
The NOx analyser was removed for workshop repair on 15 August due to a detector fault. There were also periods of poor quality data from both FDMS analysers, resulting in data loss during ratification. The PM_{10} Partisol also failed to make the data capture target due to an LSO error resulting in a set of filters being exposed twice, thus losing 15-20 and 23-28 July being lost. Both Partisols had been removed for workshop repair up to 8 July.

Christchurch Barrack Road
This site has been left provisional as it was commissioned during this quarter.

Eastbourne
The $PM_{2.5}$ FDMS suffered from a number of faults during the quarter. The mass transducer was replaced (and again in Q4); data have been deleted from 27 July to the end of the quarter.

Exeter Roadside
The ozone analyser continued to give spurious low data and unusual daily profiles and the analyser was removed for lamp replacement in the workshop. This was returned to site on 23 September; in total, data have been rejected from 1 January 2015 until the repair.

Leamington Spa Rugby Road
This station was serviced on 15 August, before the audit on 19 August. The service introduced some instability in the FDMS analysers, and as a result the data from both have been deleted between the service and audit. The NOx analyser was found to have a fault by the service engineer, and he removed it from site for workshop repair, returning it on 18 August.

Leominster
The station was switched off on 30 August due to water ingress through the roof. The roof repair was completed early in 2017.

Liverpool Queens Drive Roadside
The station suffered communications failure on 26 August, and the LSO was unable to attend to investigate. The problem rectified itself on 4 September.

Lullington Heath
All the analysers suffered periods of instability following a series of short power cuts.

Manchester Piccadilly
At the service on 28 July, the engineer found the SO_2 sample inlet was connected to the collocated hydrocarbon sampler rather than the SO_2 analyser. While carrying out the service, it rained heavily and water entered the enclosure through the door. The site was switched off while the water drained.

The $PM_{2.5}$ data was found to be a regional outlier from 10 June to 15 July, though this was not reflected in the zero test result. The data were deleted during ratification.

Market Harborough
The ozone analyser developed a fault but the station could not be visited as it was at high risk due to electrical test failure. This was rectified on 28 July.

Norwich Lakenfields
The station was switched off from 20 August to 14 September due to air conditioning problems. The PM_{10} FDMS then suffered loss of firmware then more short data losses due to further air conditioning faults. The $PM_{2.5}$ suffered a power supply fault then similar data losses due to the air conditioning.

Nottingham Western Boulevard

The PM_{10} data from 3 to 18 August were noisy and unstable, and were deleted during ratification.

Oldbury Birmingham Road

A power supply fault resulted in the site being offline from 9 September. Further data were lost in Q4.

Oxford St Ebbes

Continuing from the previous quarter, the sample inlets are compromised by overhanging trees. All data have been deleted.

Portsmouth

The LSO discovered a fault with the PM_{10} FDMS on 7 July. The analyser was removed for workshop repair, and was not reinstalled until 22 August. Once reinstalled, air conditioning faults resulted in further data loss up to 22 September, when the LSO attended to adjust the air conditioning.

Saltash Callington Road

The PM_{10} FDMS required a replacement mass transducer, resulting in loss of data to 8 July. Following this, both FDMS units were adversely affected by high enclosure temperatures, resulting in periodic data loss.

Southampton A33 Roadside
The FDMS analyser suffered persistent problems during the quarter. A new mass transducer was fitted on 12 August due to frequent spurious peaks being recorded. Following a callout for a valve fault and drier replacement on 22 September, data became very unstable and have been deleted to the end of the quarter.

Southampton Centre
The station remained switched off pending enclosure replacement.

Stanford-le-Hope Roadside
The profiles of the $PM_{2.5}$ and PM_{10} at this station occasionally deviate significantly from other local sites, and some data have been deleted where this occurs. Some noisy $PM_{2.5}$ data from 31 July to 8 August were deleted during ratification.

Stockton-on-Tees Eaglescliffe
The agreement between $PM_{2.5}$ and PM_{10} at this site, and with other local sites, is often very poor at this station between the end of July and mid-September, and often noisy. Substantial periods of data from both instruments have been deleted.

Sunderland Silksworth
The ESU attended the station on 14 September as a result of persistently unstable ozone data and excessively high volatile mass concentrations. The ozone analyser was removed for workshop repair, and a large leak found in the $PM_{2.5}$ main flow.

Sunderland Wessington Way
The LSO found the ozone generator in the NOx analyser was faulty on 22 September; the ESU installed a hotspare on 27 September.

Wicken Fen
Investigations into the anomalous SO2 data at this station were ongoing during this quarter. In addition, an engineer attended on 1 July but was unable to repair a detector fault, and so he removed the analyser for workshop repair. This was returned on 14 July. See section 4.7 for details of the SO_2 problems during 2015 and 2016.

Wigan Centre
Following service completion on 19 July CMCU observed instrument response instability and requested LSO replacement of both reference and sensor filters. Due to staff shortages the LSO was unable to visit the site until 28 July but found he was not able to access the station due to building contractors digging up the ground around the cabin. On 3 July the building contractors accidentally severed the power line to the site. Power was restored on 11 August.

York Bootham
This site was previously in the AURN for PM_{10} only: NOx was affiliated part way through the quarter, from 16th August.

4.3 Data Capture and Station-Specific Issues - Greater London

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

Table 4-3 Data Capture for Greater London, July-September 2016

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	Average
Camden Kerbside		99.59		95.52	91.80		95.64
Ealing Horn Lane				82.61			82.61
Haringey Roadside		95.43					95.43
London Bexley		96.88			92.35		94.61
London Bloomsbury		98.19	98.01	93.12	95.20	97.42	96.39
London Eltham		99.28	96.24		63.68		86.40
London Haringey Priory Park South		99.77	99.82				99.80
London Harlington		99.64	99.77				99.71
London Harlington				99.91	99.86		99.89
London Harrow Stanmore					96.38		96.38
London Hillingdon		97.37	97.37				97.37
London Marylebone Road	88.81	98.28	94.29	97.06	96.78	97.96	95.53
London Marylebone Road				97.83	92.39		95.11
London N. Kensington	98.91	98.87	98.96	92.21	95.56	97.87	97.06
London N. Kensington				92.39	100.00		96.20
London Teddington		28.62	28.62				28.62
London Teddington Bushy Park					94.57		94.57
London Westminster		51.86			98.91		75.38
Southwark A2 Old Kent Road		32.29		92.98			62.64
Tower Hamlets Roadside		95.79					95.79
Number of Sites	**2**	**14**	**8**	**9**	**12**	**3**	**20**
Number of sites < 85 %	**0**	**3**	**1**	**1**	**1**	**0**	**4**
Number of sites < 90%	**1**	**3**	**1**	**1**	**1**	**0**	**5**
Average	**93.86**	**85.13**	**89.14**	**93.73**	**93.12**	**97.75**	**89.26**

The following site-specific issues were identified:

Ealing Horn Lane

The PM_{10} analyser suffered numerous temperature-related issues during the quarter, resulting in intermittent data gaps. Some more data have been deleted during ratification.

London Eltham

Following completion of the zero test on 1 August, the response of the analyser became spurious and cyclic. The analyser appears to return to normal response on 18 August; no reason for the change was given.

London Westminster

Leak and IZS fault, requiring ESU callout to repair.

London Teddington

The station was switched off on 27 July in advance of refurbishment of the building. It is envisaged the refurbishment will be completed in early 2018 and at this point it may be possible to reopen the monitoring station.

Southwark A2 Roadside

The NOx converter was found to have failed at the summer audit; addition valve faults and channel imbalance resulted in the deletion of data from 24 June to 30 August.

4.4 Data Capture and Station-Specific Issues – Wales

A summary of data capture for Wales for July-September 2016 is given in Table 4-4.

Table 4-4 Data Capture for Wales, July-September 2016

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	Average
Aston Hill		98.28	93.43				95.86
Cardiff Centre	96.92	96.06	97.15	74.64	87.64	92.80	90.87
Chepstow A48		95.11		94.43	50.45		80.00
Cwmbran		99.46	99.68				99.57
Hafod-yr-ynys Roadside		98.32					98.32
Narberth		95.29	97.87	88.90		77.58	89.91
Newport		95.43		77.63	87.23		86.76
Port Talbot Margam				98.91			98.91
Port Talbot Margam	97.55	92.16	97.92	86.23	92.98	79.03	90.98
Swansea Roadside		98.32		94.84	93.30		95.49
Wrexham		98.28		91.30	90.22	93.57	93.34
Number of Sites	**2**	**10**	**5**	**8**	**6**	**4**	**11**
Number of sites < 85 %	**0**	**0**	**0**	**2**	**1**	**2**	**1**
Number of sites < 90%	**0**	**0**	**0**	**4**	**3**	**2**	**3**

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	Average
Average	**97.24**	**96.67**	**97.21**	**88.36**	**83.64**	**85.75**	**92.73**

Chepstow A48

A leak was found in the main flow on the $PM_{2.5}$ analyser at the service on 15 August. This station was also identified as a regional outlier, and so data have been deleted from 13 June to 15 August.

Narberth

A substantial leak in the SO_2 filter holder was found at the summer audit. Data from 11 July to the service on 26 July were rejected.

Newport

Both FDMS analysers performed poorly this quarter. The $PM_{2.5}$ had a drier fault, resulting in the loss of data from 6 July to 6 August. The PM_{10} analyser was very noisy, necessitating a repeat of the zero test. Both PM datasets required baseline correction back to Q1 for PM_{10}.

4.5 Data Capture and Station-Specific Issues – Scotland

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

Table 4-5 Data Capture for Scotland, July-September 2016

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	Average
Aberdeen		99.14	99.23	91.58	95.56		96.38
Aberdeen Union Street Roadside		99.91					99.91
Aberdeen Wellington Road		94.61					94.61
Auchencorth Moss			93.25	98.91	100.00		97.39
Auchencorth Moss (FDMS)				60.19	83.70		71.94
Bush Estate		58.06	58.06				58.06
Dumbarton Roadside		52.04					52.04
Dumfries		98.69					98.69
Edinburgh St Leonards	56.57	96.74	96.78	53.13	84.38	89.76	79.56
Eskdalemuir		95.70	99.86				97.78
Fort William		97.19	95.56				96.38
Glasgow Great Western Road		75.45					75.45
Glasgow High Street		97.28		91.76	94.61		94.55
Glasgow Kerbside		98.51					98.51
Glasgow Townhead		98.51	98.60	96.20	96.15		97.36
Grangemouth		77.26		88.32	90.08	96.92	88.15
Grangemouth Moray		89.36					89.36

Name	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2	Average
Greenock A8 Roadside		99.41					99.41
Inverness		98.64		93.48	93.48		95.20
Lerwick			99.77				99.77
Peebles		98.46	98.14				98.30
Strath Vaich			45.97				45.97
Number of Sites	**1**	**18**	**10**	**8**	**8**	**2**	**22**
Number of sites < 85 %	**1**	**4**	**2**	**2**	**2**	**0**	**6**
Number of sites < 90%	**1**	**5**	**2**	**3**	**2**	**1**	**8**
Average	**56.57**	**90.28**	**88.52**	**84.19**	**92.24**	**93.34**	**87.49**

Auchencorth Moss (FDMS)

The PM_{10} FDMS suffered loss of firmware on 28 July, rectified at service on 17 August. A further period of data was lost from 23 to 30 September due to a filter seat problem. The $PM_{2.5}$ was a regional outlier, showing poor agreement with the PM_{10} at times; data 7 to 14 July, 18 to 20 July, and 2 to 6 August were deleted.

Bush Estate

The sample manifold fan failed, resulting in the loss of all data from 16 August to 22 September.

Dumbarton Roadside

Instrument out of service 18 August – 10 October due to valve fault initially misdiagnosed as molybdenum converter failure.

Edinburgh St Leonards

The CO analyser suffered a power supply fault, resulting in significant gaps in the data, and large spurious peaks. The SO_2 analyser was erratic for much of August, some data were deleted. Similarly, the FDMS analysers were also unreliable, with a number of faults; the PM_{10} had a leak on the chiller unit repaired on 8 September, when the engineer noted non-approved filters were in use.

Glasgow Great Western Road

The NOx analyser was removed for workshop repair from 4 to 23 August due to apparently random errors being flagged, which could not be replicated in the workshop. The analyser was returned to station, and no recurrence was noted.

Grangemouth

The NOx analyser failed the converter test at the summer service on 16 August, and was removed for workshop repair. No problems with the converter were identified at audit. Delays in administration resulted in a delay in returning the analyser to site.

Grangemouth Moray

Some data were lost due to autocal run-on. Data were lost 22 to 29 September due to pump failure.

Straith Vaich

The data look low and anomalous up to a station visit on 5 September; data have been deleted.

4.6 Data Capture and Station-Specific Issues - Northern Ireland

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

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

Name	CO	NO_2	O_3	PM_{10}	PM_{25}	SO_2	Average
Mace Head			100.00				100.00
Armagh Roadside		95.47		53.67			74.57
Ballymena Ballykeel		98.37				91.08	94.72
Belfast Centre	98.32	98.19	98.37	86.46	91.26	97.74	95.06
Belfast Stockman's Lane		99.41		95.61			97.51
Derry Rosemount		90.81	99.59	92.89	79.35	94.66	91.46
Lough Navar			99.00	89.54			94.27
Number of Sites	**1**	**5**	**4**	**5**	**2**	**3**	**7**
Number of sites < 85 %	**0**	**0**	**0**	**1**	**1**	**0**	**1**
Number of sites < 90%	**0**	**0**	**0**	**3**	**1**	**0**	**1**
Average	**98.32**	**96.45**	**99.24**	**83.63**	**85.30**	**94.49**	**92.51**

Armagh Roadside
Noisy PM_{10} data have been deleted up to a filter change on 5 July. Following the audit on 19 August, the LSO was unavailable to remove the zero filter until 30 August. Concerns were raised about the quality of data on 8 September. Investigations were carried out on 22 September. Repairs were finally carried out on 24 October.

4.7 Wicken Fen SO_2

4.7.1 Background

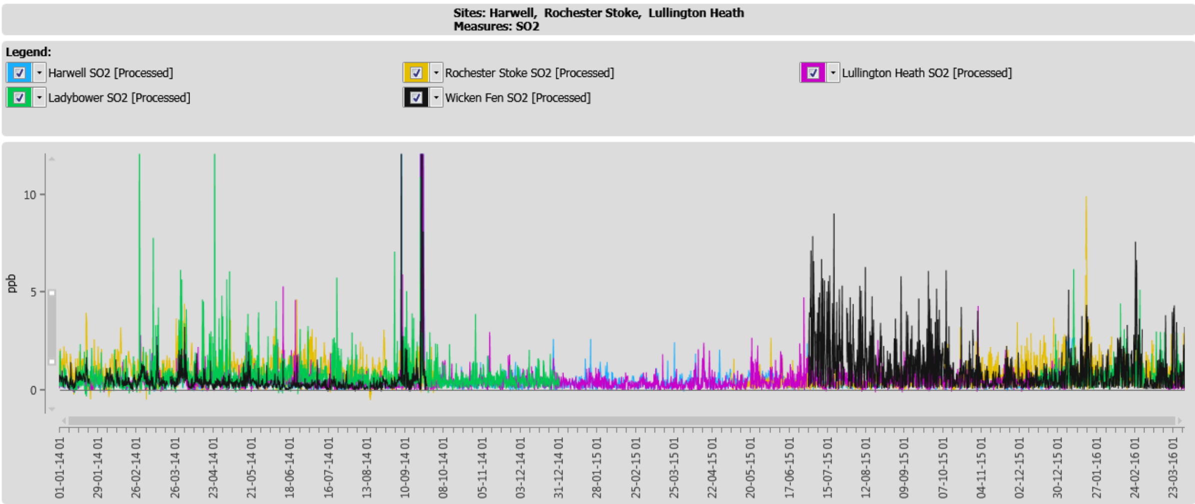
Following a cabin upgrade in late 2014, sulphur dioxide (SO_2) measurements at the rural Wicken Fen monitoring station in Cambridgeshire showed an unexpected increase, and became much more erratic. Before the cabin upgrade, measured SO_2 concentrations at Wicken Fen were similar to those from other rural monitoring stations in eastern England, e.g. Harwell, Lullington Heath, Ladybower and Rochester Stoke. Events following the cabin upgrade were as follows:

- Wicken Fen was recommissioned on 12th Dec 2014 after a cabin upgrade.
- Shortly after, there was a callout on 17th Dec 2014 for high, erratic SO_2 measurements. A leak was found in connecting tubing, which was repaired.
- 23rd Mar 2015: an ESU callout due to high data. The ESU found nothing wrong, but set up investigation to see if high values noted especially in the afternoon were associated with high temperatures.
- 9th Jul 2015: Analyser ports were reported to be loose, and it was recorded that SO_2 measurements were unstable due to this issue. The air conditioning unit was also found not to be working and was repaired.

- 27th Jul 2015: routine service took place.

However, SO_2 at Wicken Fen remained high, frequently much higher than measured at the other rural sites (Figure 4-1). Quarters 1 and 2 of 2015 were rejected: Q3 and Q4 of 2015 were given the benefit of the doubt as it was not possible to rule out a genuine source as the cause of the high erratic measurements.

Figure 4-1 Comparison of Wicken Fen SO_2 with Other Rural AURN Sites, Jan 2014 - Mar 2016



4.7.2 Details of investigation

To investigate the problem, a duplicate SO_2 analyser, and a completely separate new inlet, were installed at Wicken Fen in April 2016. The duplicate analyser sampled through the new inlet, while the original analyser remained in place sampling through the old inlet. The details of the study are as follows:

1. 22nd Apr 2016: beginning of study: duplicate analyser began sampling through a new and completely separate inlet.
2. 6th Jun 2016: the inlets were swapped, so that original analyser was sampling through new inlet and vice versa.
3. 29th Jun 2016: an LSO calibration was carried out. The LSO left the instruments as found.
4. 2nd Aug 2016: QAQC audit. Both analysers were connected to the *new* inlet and left that way. The filter holder in the duplicate instrument was also found to be loose and was tightened.
5. 5th Sep 2016: ESU service, both instruments were serviced.
6. The datasets from both instruments underwent AURN data ratification procedures.

4.7.3 Results

The plots below show the processed SO_2 data, from the **original analyser (in black)** and the **duplicate (in green).**

1. In the initial period of the study between 22nd Apr 2016 and 6th Jun 2016, the *duplicate* analyser gave even higher and more variable measurements than the original. (Figure 4-2) shows the two datasets: the original analyser is shown in black, the duplicate in green.) The duplicate analyser's results were higher than those from other rural sites (Figure 4-3).
2. When the inlets were swapped on 6th Jun, there was no obvious change in the data from either instrument (Figure 4-4 and Figure 4-5).
3. However, at the time of the LSO visit on 29th Jun, there was a clear step change in the duplicate instrument dataset, becoming lower and less noisy, although LSO said he left both instruments as found (Figure 4-5). There was no clear change in the original instrument's dataset (Figure 4-4).

4. On 2nd Aug, after both analysers were changed so they were both sampling from the new inlet, and the loose filter holder in the duplicate instrument was tightened, the data from the duplicate analyser became lower and less spiky than that from the original analyser.
5. From this point onwards the duplicate analyser gave results consistent with other rural sites in the east of England (Figure 4-6).

Figure 4-2 Measurements from Original and Duplicate Analyser at Wicken Fen, Apr – Sep 2016.

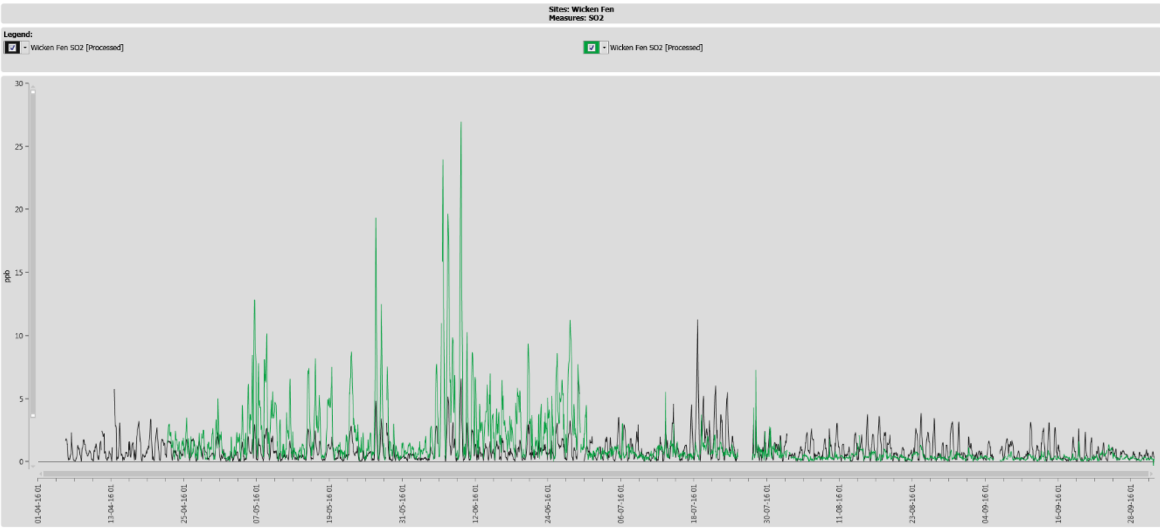


Figure 4-3 SO_2 Measurements from Original and Duplicate Analyser at Wicken Fen, and other Rural Sites for comparison, Apr - Sep 2016.

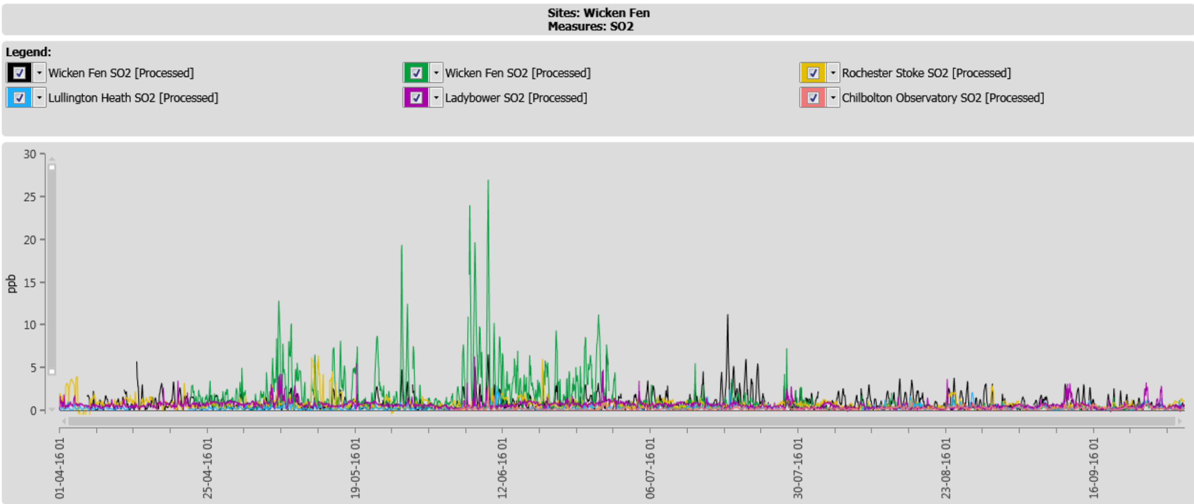


Figure 4-4 SO_2 Measurements from Original Analyser at Wicken Fen, Apr – Sep 2016.

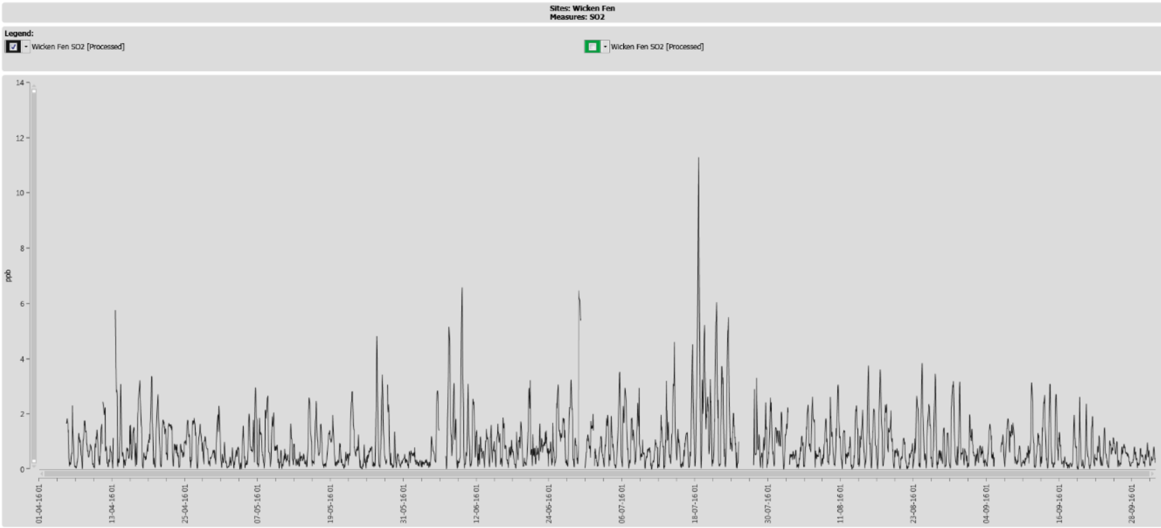


Figure 4-5 SO_2 Measurements from Duplicate Analyser at Wicken Fen, Apr - Sep 2016.

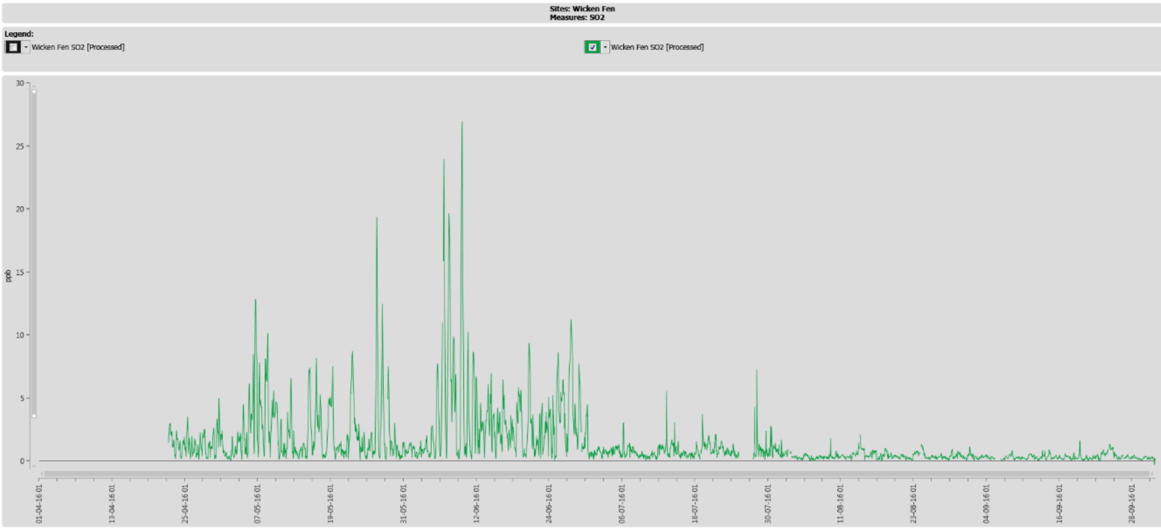
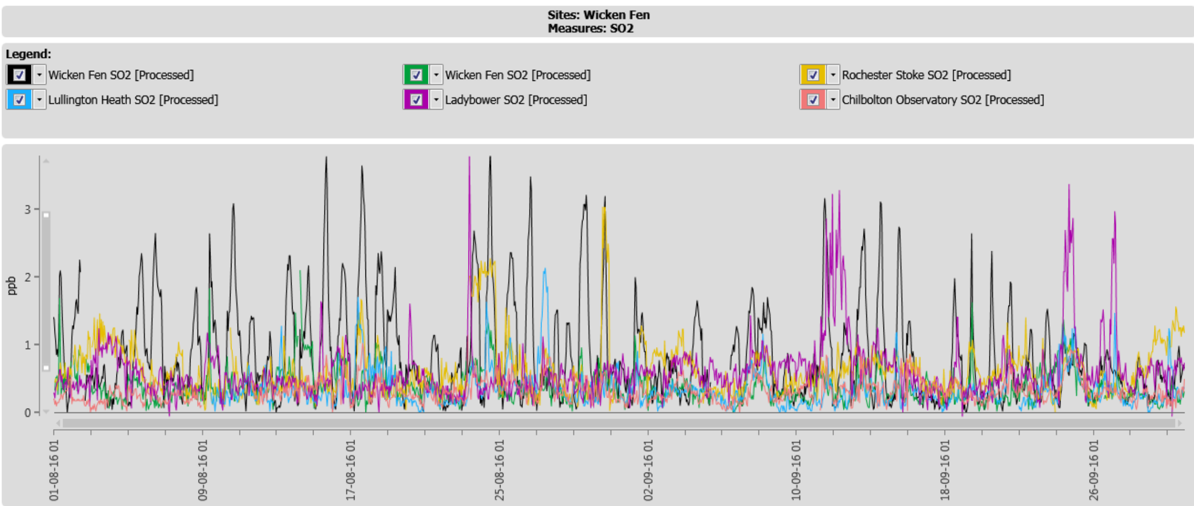


Figure 4-6 SO_2 Measurements at Rural Sites in Eastern England, Aug - Sep 2016.



4.7.4 Conclusions of Wicken Fen Investigation

1. The original SO_2 analyser was faulty and was recording high and noisy data regardless of the inlet used.
2. The duplicate analyser was producing even higher and more erratic data than the original, during the earlier part of the study. This is believed to have been caused by the filter holder being loose. When this was remedied on 2nd Aug 2016, the results became consistent with those from other rural sites.
3. The choice of inlet used made no difference to either analyser's dataset.

4.7.5 Recommendations of Wicken Fen Investigation

1. The duplicate analyser should be left in place, sampling through the new inlet. This should replace the original analyser which is faulty and should be repaired, or disposed of if beyond economic repair.
2. The remaining data from the original analyser, from Q3 and Q4 of 2015, and 2016, should be rejected.
3. The data from the duplicate analyser, from the start of the study on 22nd Apr to the point when the filter holder was tightened, should also be rejected. The data from this point onwards are valid.
4. The study highlights the importance of the filter holder being properly tightened as if this is loose it can cause noisy data.
5. Previously, inlet ports have been reported as being loose, more than once, on the original analyser. This should also be checked regularly.

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.

Details of changes made during July to September 2016, to data previously ratified, are shown in Table 5-1.

Table 5-1 Changes to Data Previously Marked as Ratified, July - September 2016

Monitoring Station	Pollutant(s)	Dates	Nature of Change
Birmingham Tyburn Roadside	O_3	15/03/16 - 30/06/16	O_3 rescaled
Blackburn Accrington Road	NOx	13/05/16-03/06/16	Data deleted
Bradford Mayo Avenue	NOx	2016 Q2	Erratic autocal zeros, require reprocessing, which goes back into Q2.
Canterbury	NOx	2016 Q2	Changes resulting from converter efficiency rescales.
Chepstow A48	$PM_{2.5}$	2016 Q2	Delete $PM_{2.5}$ data 18/06/16 to 05/08/16 due to leak on the main flow.
Chesterfield Loundsley Green	NOx	2016 Q2	Diurnal pattern is unusual and suspicious. Delete data from end of April (~27/04/16) to Service (03/08/16) due to poor diurnals. Need to check Q1 2016 as well
Chesterfield Roadside	PM_{10}	2016 Q2	To apply baseline adjustment from 01/05/16 to 02/08/16 (date of dryer change). NOx reprocessed Q2
Coventry Allesley	$PM_{2.5}$	2016 Q1 & Q2	Correct baseline 01/01/16 to 03/08/16 (service)
Derry Rosemount	NOx	2016 Q2	NOx: Sensitivity rescale needs to be amended for Q2 2016.
Glasgow High Street	NOx	2016 Q2	Processing of Q2 & Q3 2016 required. Re-instate data in between data gaps.
Grangemouth Moray	NOx	End of Q2	Re-process zero at end of Q2 for consistency with Q3.
High Muffles	NOx	End of Q2	To check processing of NO/NOx baselines and end of Q2/start of Q3.
Leeds Centre	$PM_{2.5}$	Q2	To apply baseline correction 17/04/16 to 20/07/16.

Monitoring Station	Pollutant(s)	Dates	Nature of Change
Leeds Headingley Kerbside	$PM_{2.5}$	2016 Q2	To apply baseline correction 17/04/16-30/09/16 and probably into Q4 2016
Leominster	NOx, O_3	Q2	NOx: Reprocess baseline for Q2 16 – looks as the data is floating. O_3: change in zero Q2/Q3 2016.
London Bexley	NOx	2016 Q2	NOx: Zero processing changed Q2 2016 needs to be looked at and reprocessed
London Marylebone Road	O_3	Q2	Reprocessed between winter and summer service
London North Kensington	CO	Q2	Baseline adjusted
Newport	PM_{10}	Q1-Q2	Baseline corrected 15/3-30/6/16
Saltash Callington Road	$PM_{2.5}$	2016 Q1 & Q2	To apply zero baseline adjustment from end of March (21/03/16) to gap in July (03/07/16).
Sheffield Devonshire Green	$PM_{2.5}$	2016 Q2	To apply baseline correction 25/04/16 to 24/08/16.
Stockton-on-Tees A1305	$PM_{2.5}$	2016 Q2	To re-do baseline correction applied in Q2.
Wicken Fen and its duplicate SO_2 analyser	SO_2	2016 Q2	Concluded that original analyser and inlet are faulty. Summarised in Section 4.7

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:

Table 6-1 Summary of "High" Risk Station Safety Status Incidents, July – September 2016

Station	Risk	Date went to 'High'	Date resolved
Leominster	Sagging roof	01/07/2016	23/01/2017
Aston Hill	Failed SET*	06/07/2016	by 08/08/2016
Market Harborough	Failed SET	06/07/2016	by 08/08/2016
London Bloomsbury	Failed SET	12/07/2016	by 08/08/2016
London Hillingdon	Failed SET	12/07/2016	by 25/07/2016
London Westminster	Failed SET	12/07/2016	by 25/07/2016
Reading New Town	Failed SET	12/07/2016	by 25/07/2016
Wrexham	Failed SET	12/07/2016	by 18/07/2016

Station	Risk	Date went to 'High'	Date resolved
Yarner Wood	Failed SET	12/07/2016	by 01/08/2016
Norwich Lakenfields	Failed SET	12/07/2016	by 01/08/2016
Southend on Sea	Failed SET	12/07/2016	by 25/07/2016
Glasgow High Street	Not known	12/07/2016	by 18/07/2016
Saltash Callington Road	Failed SET	14/07/2016	by 25/07/2016
Northampton Kingsthorpe	Failed SET	14/07/2016	by 01/08/2016
Manchester Piccadilly	Water Ingress	28/07/2016	by 01/08/2016
Ladybower	Failed SET	08/08/2016	12/09/2016
Glasgow Great Western	Failed SET	09/08/2016	02/09/2016
Glasgow Kerbside	Failed SET	09/08/2016	12/09/2016
Strathvaich	Failed SET	09/08/2016	05/09/2016
Lullington Heath	Not known	08/09/2016	12/09/2016

*SET-Site Electrical Test, periodic inspection of fixed electrical installations. Often known as PIR, Periodic Inspection Report

7 Equipment Upgrade Requirements

No equipment upgrades are required at the present time.

The Environment Agency have recently made a capital purchase of the following items:

- Five Teledyne T750 ozone photometer/dilution units.
- Five Teledyne T751 zero gas generators.

These will replace several of the ozone photometers used in intercalibrations, of which three have now reached the end of their working lives and are not economic to repair.

8 Station Infrastructure Issues

No new specific station infrastructure issues have been identified by the QA/QC Unit this quarter.

9 Conclusions and Recommendations

Conclusions

1. During Quarter 3 of 2016 there was a total of 163 AURN monitoring stations in operation.
2. Data ratification for this quarter was completed by the deadline of 31 December 2016.
3. Ratified hourly average data capture for the network averaged 89.40% for all pollutants (O_3, NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$) during the 3-month reporting period July-September 2016. Average data capture for all pollutants except PM_{10} were above 85%. There were 31 stations with data capture less than 85% for the period (53 below 90%). 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%.
4. During this quarter, the summer 2016 intercalibration exercise was carried out, involving comprehensive performance tests on every ozone 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.
5. The uncertainty of measurement for each analyser has been determined to ensure compliance with the Data Quality Objective. Eleven analysers were found to be outside the required uncertainty. The most common cause of this is noisy response as measured during the audit. This usually indicates poor instrument performance; such cases are reviewed at the Quality Circle to assess the impact on reported data, and may be reported to CMCU and ESUs prior to service to ensure the necessary repair procedures are carried out by the engineer reducing the chance of the recurrence in the next quarter.

Recommendations:

1. The LA-owned CO analyser at Port Talbot Margam is very old, reads in ppm rather than ppb (so its calibration factors are inconsistent with those for the other CO analysers in the network), and does not perform well, being prone to drifting. It is recommended that this be replaced with a more reliable EA-owned CO analyser from storage, that the EA already own. This recommendation was put to the Environment Agency in an email of 02/12/2016.

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