Eden District Council Penrith and Eamont Bridge LAQM NO2 Detailed Assessment

June 2013

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TABLE OF CONTENTS

Executive Summary ii
1 Introduction 1
1.1 Project Background 1
1.2 Legislative Background 1
1.3 Local Air Quality Management (LAQM) Review and Assessment 2
1.4 Summary of Review and Assessment Undertaken by Eden District Council 3
1.5 Scope and Methodology of the Detailed Assessment 4
2 Baseline Information 5
2.1 Traffic data 5
2.2 Air Quality Monitoring Data 6
2.2.1 Automatic Monitoring Data 6
2.2.2 Nitrogen Dioxide Diffusion Tube Data 6
2.2.3 Background Concentrations 11
3 Dispersion Modelling Methodology 12
4 Results 13
4.1 Model Verification and Adjustment 13
4.2 New Development in Penrith and Eamont Bridge 16
4.3 Modelled NO_2 Concentrations 18
4.4 Population Exposure 23
5 Conclusions and Recommendations 24

LIST OF FIGURES

Figure 1 - NO_2 Monitoring Sites and Modelled Roads in Penrith 8
Figure 2 - NO_2 Monitoring Sites and Modelled Roads in Eamont Bridge 9
Figure 3 - Shap 2012 Hourly Sequential Meteorological data 12
Figure 4 Junction with Victoria Road and Roper Street 17
Figure 5 Junction with Victoria Road and Southend Road 17

LIST OF TABLES

Table 1 - Air Quality Objectives included in the Regulations for LAQM In England 2
Table 2 - Traffic Data for Penrith and Eamont Bridge 5
Table 3 - NO_2 Passive Monitoring in Penrith and Eamont Bridge 6
Table 4 - Results of Nitrogen Dioxide Diffusion Tubes in Study Area 10
Table 5 - Background Concentrations 2012 11
Table 6 - Model Verification Results at Penrith High Street 14
Table 7 - Model Verification Results at Penrith Main Routes 14
Table 8 - Model Verification Results at Penrith Back Streets 15
Table 9 - Model Verification Results at Penrith street canyons with a gradient 15
Table 10 - Model Verification Results at Eamont Bridge 16
Table 11 - Modelled results at Specific Receptors 18

Executive Summary

Part IV of the Environment Act 1995 places a statutory duty on local authorities to review and assess the air quality within their area and take account of Government guidance when undertaking such work.

This report is a Detailed Assessment of nitrogen dioxide (NO_2) which covers Penrith town centre and the A6 through Eamont Bridge. Eden District Council commissioned the report following measured exceedences of the annual mean objective for NO_2 identified in the 2011 Annual Progress Report.

The Detailed Assessment has been undertaken in accordance with Defra's Technical Guidance LAQM.TG (09) methodologies, based on advanced atmospheric dispersion modelling of NO_2 traffic emissions, relying on updated emission factors and background pollutant concentrations released by Defra in 2013, and the latest monitoring, traffic and meteorological data for the year 2012.

Due to measured and modelled exceedences of the air quality objectives for NO_2 at the façade of properties both in Penrith and Eamont Bridge it is recommended the council declare AQMAs and carry out the following recommendations:

- Declare an AQMA from Corn Market all the way along Castlegate up to the roundabout on Cromwell Road.
- Install extra monitoring in that area at the façade of properties in the worst case locations along Castlegate.
- Declare an AQMA along Victoria Road (A6) from the junction with Southend Road to 60m north of the junction with Langton Street.
- Install new monitoring at the façade of properties along Victoria Road between Southend Road and Roper Street. Install monitoring at the façade of properties along Roper Street.
- Install further monitoring along Scotland Road and continue to monitor as SG27.
- Install further monitoring at relevant locations along Meeting House Lane, Benson Row and Friargate.
- Declare an AQMA along the A6 though Eamont Bridge from the start of the village to the north to The Beehive Inn.
- Install further monitoring in Eamont Bridge at site of relevant exposure.

1 Introduction

1.1 Project Background

Part IV of the Environment Act 1995 places a statutory duty on local authorities to review and assess the air quality within their area and take account of Government guidance when undertaking such work.

This report is a Detailed Assessment (DA) of nitrogen dioxide (NO_2) which covers Penrith town centre and the A6 through Eamont Bridge. Eden District Council commissioned the DA following measured exceedences of the annual mean objective for NO_2 identified in the 2011 Annual Progress Report.

This report takes account of detailed dispersion modelling undertaken by WYG Environment in 2011 for the planning application for a new Sainsbury's supermarket in Penrith.

This report will inform the Council for any need to declare an Air Quality Management Area (AQMA) in either Penrith town centre or in Eamont Bridge area. This report will focus on NO_2, as PM_{10} has previously been identified being below the objective levels in both study areas.

1.2 Legislative Background

The significance of existing and future pollutant levels are assessed in relation to the national air quality standards and objectives, established by Government. The revised Air Quality Strategy (AQS)[1] for the UK (released in July 2007) provides the over-arching strategic framework for air quality in the UK and contains national air quality standards and objectives established by the UK Government and devolved administrations to protect human health. The air quality objectives incorporated in the AQS and the UK Legislation are derived from the Limit Values prescribed in the EU Directives transposed into national legislation by member states.

The CAFE (Clean Air for Europe) programme was initiated in the late 1990s to draw together previous directives into a single EU Directive on air quality. The Directive 2008/50/EC[2] introduces new obligatory standards for $PM_{2.5}$ for Government but places no statutory duty on local Government to work towards achievement.

The Air Quality Standards (England) Regulations 2010[3] came into force on 11th June 2010 in order to align and bring together in one statutory instrument the Government's obligations to fulfil the requirements of the CAFE Directive.

The objectives for ten pollutants (benzene, 1,3-butadiene, carbon monoxide, lead, nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulates - PM_{10} and $PM_{2.5}$, ozone and Polycyclic Aromatic Hydrocarbons (PAHs)) have been prescribed within the Air Quality Strategy based on the Air Quality Standards (England) Regulations 2010.

This assessment focuses on those pollutants included in Air Quality Regulations for the purpose of Local Air Quality Management[4], in respect of pollutant sources affecting air quality within the Council's administrative area. The objectives set out in the AQS for these pollutants are presented in the table below.

The locations where the AQS objectives apply are defined in the AQS as locations outside buildings or other natural or man-made structures above or below ground where members of the public are regularly present and might reasonably be expected to be exposed [to pollutant concentrations] over

[1] The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (2007), Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland

[2] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe

[3] The Air Quality Standards Regulations 2010, Statutory Instrument No 1001, The Stationary Office Limited

[4] The Air Quality (England) (Amendments) Regulations 2002 (Statutory Instrument 3043)

the relevant averaging period of the AQS objective. Typically these include residential properties and schools/care homes for longer period (i.e. annual mean) pollutant objectives and high streets for short-term (i.e. 1-hour) pollutant objectives.

Table 1 - Air Quality Objectives included in the Regulations for LAQM In England

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Benzene	16.25 $\mu g/m^3$	Running annual mean	31.12.2003
	5.00 $\mu g/m^3$	Running annual mean	31.12.2010
1,3-Butadiene	2.25 $\mu g/m^3$	Running annual mean	31.12.2003
Carbon monoxide	10.0 mg/m^3	Running 8-hour mean	31.12.2003
Lead	0.5 $\mu g/m^3$	Annual mean	31.12.2004
	0.25 $\mu g/m^3$	Annual mean	31.12.2008
Nitrogen dioxide	200 $\mu g/m^3$ not to be exceeded more than 18 times a year	1-hour mean	31.12.2005
	40 $\mu g/m^3$	Annual mean	31.12.2005
Particles (PM_{10}) (gravimetric)	50 $\mu g/m^3$, not to be exceeded more than 35 times a year	24-hour mean	31.12.2004
	40 $\mu g/m^3$	Annual mean	31.12.2004
Sulphur dioxide	350 $\mu g/m^3$, not to be exceeded more than 24 times a year	1-hour mean	31.12.2004
	125 $\mu g/m^3$, not to be exceeded more than 3 times a year	24-hour mean	31.12.2004
	266 $\mu g/m^3$, not to be exceeded more than 35 times a year	15-minute mean	31.12.2005

1.3 Local Air Quality Management (LAQM) Review and Assessment

As established by the Environment Act 1995 Part IV, all local authorities in the UK are under a statutory duty to undertake an air quality assessment within their area and determine whether they are likely to meet the air quality objectives set down by Government for a number of pollutants. The process of review and assessment of air quality undertaken by local authorities is set out under the Local Air Quality Management (LAQM) regime and involves a phased three yearly assessment of local air quality. Where the results of the review and assessment process highlight that problems in the attainment of health-based objectives for air quality will arise, the authority is required to declare an Air Quality Management Area (AQMA) – a geographic area defined by high levels of pollution and exceedences of AQS objectives.

The LAQM regime was first set down in the 1997 National Air Quality Strategy (AQS)[5] and introduced the idea of local authority 'Review and Assessment'. The Government subsequently published policy and technical guidance related to the review and assessment processes in 1998. This guidance has since been reviewed and the latest documents include Policy Guidance (LAQM.PG (09))[6] and Technical Guidance (LAQM.TG (09))[7] released in February 2009 (updated in 2012) in anticipation of the Fourth Round of Review and Assessment. The guidance lays down a progressive, but continuous, framework for the local authorities to carry out their statutory duties to monitor, assess and review air quality in their area and produce action plans to meet the air quality objectives.

1.4 Summary of Review and Assessment Undertaken by Eden District Council

Eden District Council have been carrying out monitoring of air quality in the local authority area since 1996. A summary of the past rounds of review and assessment can be found in the table below.

Round	Date(s)	Summary
1	1998-2001	Concluded that all AQOs would be met for all pollutants. No AQMAs were declared.
2	2003	USA concluded that it was not necessary to declare any AQMAs within the District.
	2004-2005	The 2004 APR identified a potential exceedence of the NO_2 annual mean along Brunswick Road, Penrith. Recommended to relocate monitoring to the façade of the closest property. The 2005 APR indicated a need to carry out a Detailed Assessment on Brunswick Road. No AQMAs were declared.
3	2006	USA concluded that AQOs would be met for all pollutants except for NO_2 along Brunswick Road, however, the decision to carry out the Detailed Assessment was put on hold until further monitoring data could be gathered.
	2007-2008	Progress Report concluded that AQOs would be met for all pollutants at relevant receptor locations. No Detailed Assessment for NO_2 along Brunswick Road was carried out due to a fall in measured concentrations below the objective levels.
4	2009	USA concluded that all AQOs would be met for all pollutants.
5	2010-2011	The 2010 APR concluded that all AQOs would be met for all pollutants. The 2011 APR concluded that exceedences of the NO_2 annual mean objective were recorded at five locations in the borough. A detailed assessment was recommended.

[5] DoE, 1997, 'The United Kingdom National Air Quality Strategy', The Stationary Office

[6] Policy Guidance LAQM.PG(09) (2009), Part IV of the Environment Act 1995, Local Air Quality Management, Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland, The Stationery Office

[7] Technical Guidance LAQM.TG (09) (2009), Part IV of the Environment Act 1995, Local Air Quality Management, Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland, The Stationery Office

Round	Date(s)	Summary
6	2012	The 2012 USA is currently being completed by the local authority.

1.5 Scope and Methodology of the Detailed Assessment

The purpose of the Detailed Assessment is to provide the Local Authority with an opportunity to supplement the information they have gathered in their earlier Review and Assessment work and more accurately assess the impact of pollution sources on local receptors at identified hotspots through dispersion modelling. Dispersion modelling can be used to predict concentrations over a wider area than can be monitored. It is important to ensure, as far as possible, that the results of modelling reflect the results from local monitoring sites across the assessment area and allow comparison of pollutant concentrations against the AQS objectives. This Assessment will identify with reasonable certainty whether or not pollutant concentrations are likely to exceed the AQS objectives and, if so, define the extent and magnitude of the exceedences.

This assessment will take account findings of detailed dispersion modelling undertaken by WYG Environment as part of a planning application for a new Sainsbury's supermarket in Penrith located where the football stadium close to Victoria Road stood.

The dispersion modelling for the Assessment was carried out using the Cambridge Environmental Research Consultants (CERC) ADMS-Roads (v3.1) atmospheric dispersion model. Results from nitrogen dioxide monitoring sites located in the assessment area were used to verify and adjust the modelled results. Concentrations of oxides of nitrogen (NO_x) and NO_2 were predicted for the base year 2012.

The dispersion modelling was undertaken in accordance with the methodologies provided in the Technical Guidance (LAQM.TG (09)) for Detailed Assessments and amended tools released in 2013 by Defra, including the new Emission Factor Toolkit (EFT v5.2c), background pollutant maps and NO_x/NO_2 converter.

2 Baseline Information

2.1 Traffic data

Traffic data for the Detailed Assessment was provided by Cumbria County Council's, Highways and Transportation team.

As the traffic counts taken did not include a detailed breakdown of the traffic fleet, only percentage of heavy goods vehicles (HDV) was available for this assessment.

The average speed of vehicles was assumed to be the speed limit, although speed was reduced near to junctions and along narrow streets to account for stop / start emissions conditions.

In order to calculate NO_x exhaust emissions, traffic data were combined with the latest road-traffic emission factors. The most recent version of the Emission Factors Toolkit (EFT v5.2c)[8] released in 2013 was used. The new EFT includes updated vehicle fleet information and emission factors for NO_x based on COPERT4 (v8.1).

The traffic data used in this assessment is summarised in Table 2.

Maps and available geographic tools, have been used to identify if any street canyons existing in the modelled area so they could be incorporated into the modelling to account for reduced dispersion. Many of the roads in Penrith have been modelled as street canyons due to the narrow roads with buildings along either side. The A6 through Eamont Bridge also contains sections of street canyon. LAQM TG(09) provides guidance on modelling roads which have a steep gradient as the impact of HDV vehicles traveling up and down a slope will be different to their impact on a flat road. Roads with an increased gradient have been identified as Castlegate, Brunswick Road and Scotland Road. The gradient of these roads has been taken into account in the modelling.

Table 2 - Traffic Data for Penrith and Eamont Bridge

Road	Traffic flow (AADT)	HDV%
A6 King Street	6235	6.1%
Roper Street	3637	6.4%
A6 Victoria Road	11314	4.4%
A6 Bridge Lane	11140	5.1%
A592 Corn Market	7141	4.9%
A592 Castlegate	7803	4.8%
A592 Brunswick Road	13292	1.6%
A6 Duke Street	9546	1.4%
A6 Stricklandgate	11203	1.9%
Portland Place	4855	0.0%
Meeting House Lane	4845	0.2%
A6 Scotland Road	7794	2.9%
Benson Row	5060	0.5%
Friargate	6625	3.9%
Old London Road	2282	7.6%
Langton Street	4259	2.4%
A6 Middlegate	6796	2.2%
A6 Kemplay Bank	8433	7.2%

[8] Emission Factors Toolkit v5.2c – Available at http://laqm.defra.gov.uk/review-and-assessment/tools/emissions.html

2.2 Air Quality Monitoring Data

2.2.1 Automatic Monitoring Data

Currently no automatic monitoring is undertaken by the council.

2.2.2 Nitrogen Dioxide Diffusion Tube Data

Monitoring of NO_2 is undertaken using passive diffusion tubes at a number of sites throughout the county. Prior to 2011 monitoring in Penrith and Eamont Bridge was carried out using eleven diffusion tubes. Poor data capture at a number of these sites reduced reliability of annual mean concentrations. However results from these eleven sites indicated potential exceedences of the annual mean objective for NO_2 in Penrith (Victoria Road, Brunswick Road and Sticklandgate), Eamont Bridge and in Kirby Thore.

In 2011 as a response to the potential exceedences recorded in 2010 a number of additional monitoring locations were added in Penrith and Eamont Bridge. The total number of monitoring points in 2011 was forty. The number of monitoring locations was reduced in 2012 in order to focus on high pollution areas identified in 2011. This assessment uses the diffusion tube data from 2012 to verify the modelled concentrations. The diffusion tube data in the study area is presented in Table 3.

Table 3 – NO_2 Passive Monitoring in Penrith and Eamont Bridge

Site Name	Location	OS Grid Ref		Pollutants Monitored	Distance to kerb of nearest road (m)
Penrith Town Centre Tubes					
C1	Tavern Flats	351298	530006	NO_2	1
V3	25b King Street	351720	529966	NO_2	2
V5	Front Victoria road/ Langton Cottage	351713	529941	NO_2	1
V7	Café 15	351733	528918	NO_2	2.5
V9	Front 9b King Street	351651	530085	NO_2	2
V11	Victoria Road RAFA	351785	529852	NO_2	1
B14	4 Brunswick Road	351394	530344	NO_2	2
SG23	22 Stricklandgate (N)	351321	530516	NO_2	2
SG24	22 Stricklandgate (S)	351321	530516	NO_2	2
SG25	22 Stricklandgate (W)	351321	530516	NO_2	2
SG27	8 Scotland Road	351171	530649	NO_2	1
SG29	Front-The Royal (Town Hall)	351404	530426	NO_2	2

Site Name	Location	OS Grid Ref		Pollutants Monitored	Distance to kerb of nearest road (m)
31	3 Benson Row	351741	530313	NO_2	1
32	Opposite Penrith Nursery	351687	530387	NO_2	1
33	Middlegate	351485	530248	NO_2	7
36	Roper Street	351810	529861	NO_2	1
C4	Castlegate	351396	530051	NO_2	1
Eamont Bridge Tubes					
EB15	Glendale	352329	528475	NO_2	1
EB18	Cherry Cottage	352246	528667	NO_2	2.5
EB20	2 Kemplay Road	352213	528797	NO_2	2

The location of all monitoring sites within the modelled area is illustrated in Figure 1 Figure 2 below, together with roads included in the dispersion model.

Figure 1 – NO_2 Monitoring Sites and Modelled Roads in Penrith

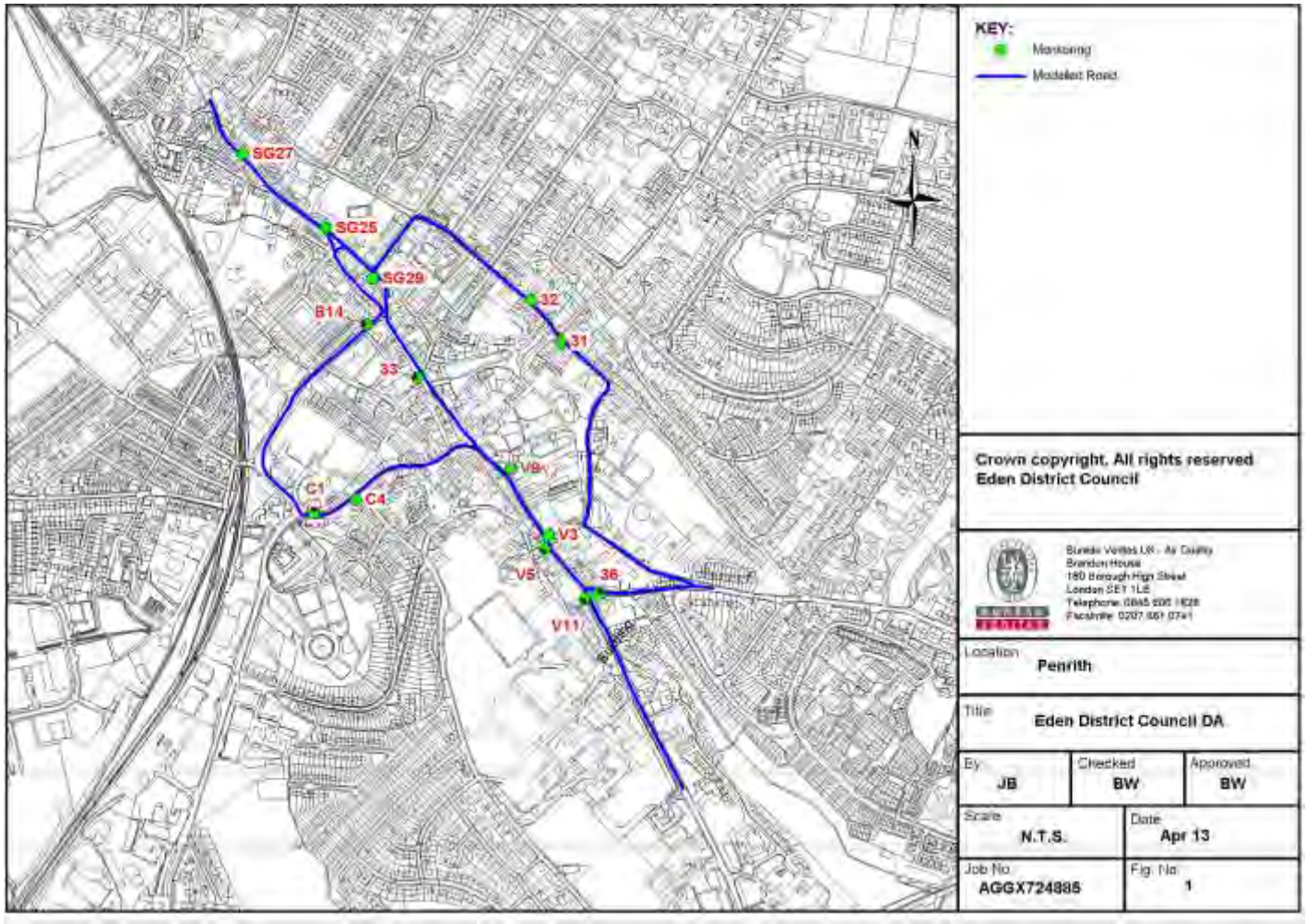
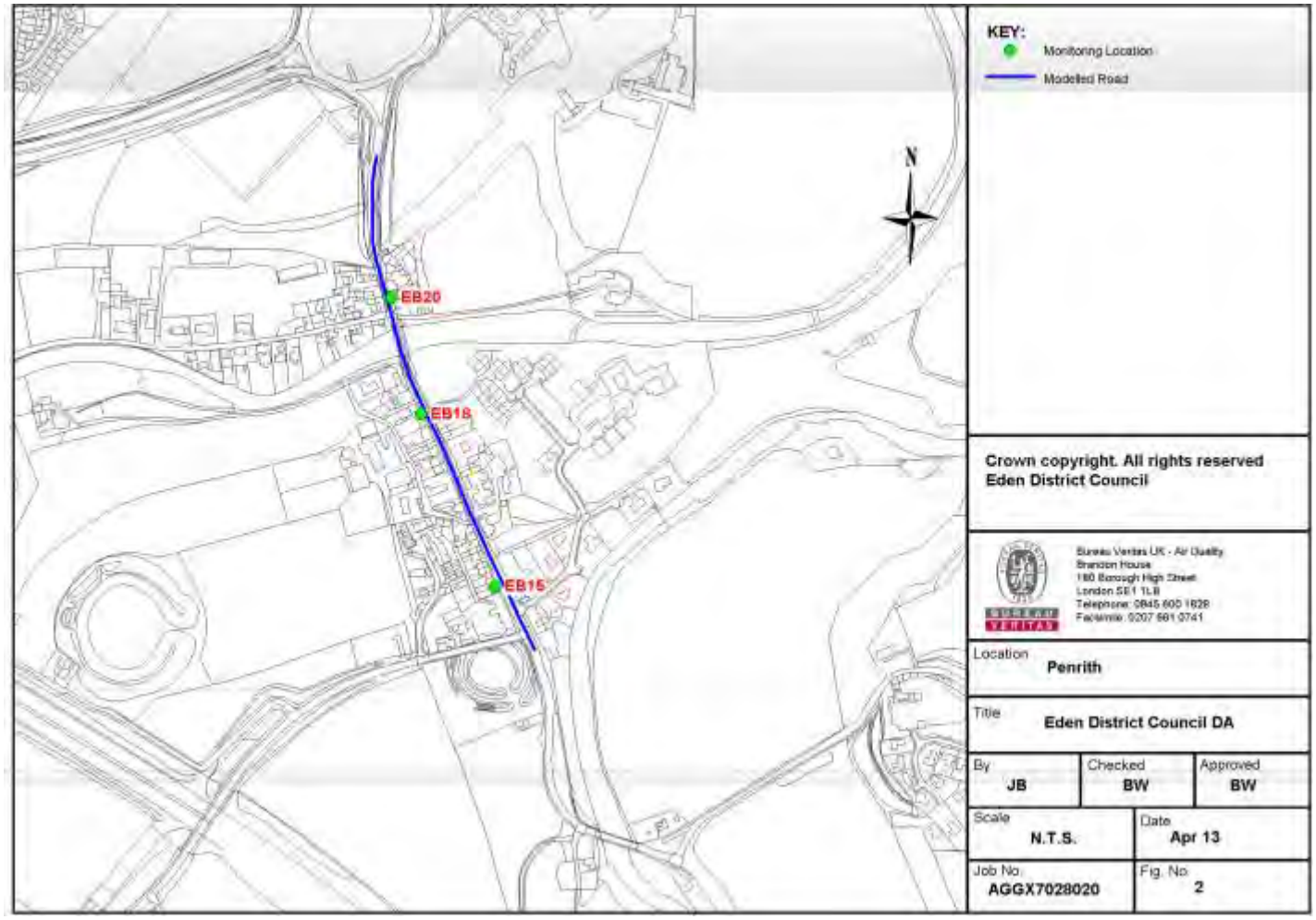


Figure 2 – NO_2 Monitoring Sites and Modelled Roads in Eamont Bridge



Where possible verification has been carried out using tubes which recorded over nine months of data in 2012 and therefore did not require annualisation. One diffusion tube location (site C4) on Castlegate is in a key location for this assessment due to the high recorded NO_2 concentrations in 2011 and 2012. Site C4 however was removed in error part way through 2012 and resinstalled later in the year, so only five months of data are available for 2012. The results for 2011 and 2012 have been annualised using the method set out in Box 3.2 LAQM TG(09). Due to the importance of this location for the assessment the annualised results have been included in the verification process despite the uncertainty associated with annualisation. Full details of the annualisation process are included in the appendix.

Results for all sites considered for model verification within in the study area have been presented in Table 4.

Table 4 - Results of Nitrogen Dioxide Diffusion Tubes in Study Area

Site ID	Location	Within AQMA?	Data Capture for Full Calendar Year 2012	Annual Mean NO_2 Concentrations ($\mu g/m^3$)	
			Months	2011 (bias adjusted 0.87)	2012 (bias adjusted 0.84)
C1	Tavern Flats	No	12	32.8	34.7
V3	25b King Street	No	11	33.1	**40.3**
V5	Front Victoria road/Langton Cottage	No	12	36.6	38.5
V9	Front 9b King Street	No	12	34.2	28.0
V11	Victoria Road RAFA	No	12	32.9	31.5
B14	4 Brunswick Road	No	12	37.3	39.0
EB15	Glendale	No	12	35.7	38.0
EB18	Cherry Cottage	No	12	**40.0**	**42.6**
EB20	2 Kemplay Road	No	12	34.5	38.9
SG23, 24, 25	22 Sticklandgate Triplicate	No	10	33.8	35.4
SG27	8 Scotland Road	No	12	33.5	37.8
SG29	Front-The Royal (Town Hall)	No	12	34.9	34.8
31	3 Benson Row	No	9	32.5	36.7
33	Middlegate	No	9	32.1	36.6
36	Roper Street	No	12	27.9	35.0
C4	Castlegate	No	5	**62.7***	**41.9***

* Data has been annualised.
Bold indicated exceedence of the annual mean objective for NO_2.

With regard to the application of a bias adjustment factor for the diffusion tubes, the LAQM TG(09) and the LAQM Support website recommend using the most applicable bias adjustment factor depending on the local circumstances. No colocation with an automatic monitor has taken place in Eden District Council therefore the national bias adjustment spreadsheet (v03_13)[9] has been used to provide a bias adjustment factor for 2012 based on the laboratory and method used (Laboratory used; ESG Glasgow, Method used; 50% TEA in Acetone, bias adjustment factor 0.84).

2.2.3 Background Concentrations

No background monitoring is undertaken within the administrative area of Eden District Council surrounding the study area. Therefore the LAQM background maps[10] released in 2012 were considered to determine the appropriate background pollutant concentrations for this assessment.

For the study area in Penrith one of the 1x1km square areas covered most of the modelled area (351500, 530500). The squares adjacent show little variation and the pollutant concentrations in the grid square mentioned were judged to be appropriate.

The background concentrations in Eamont Bridge were also selected using the background maps. The study area lay on the border of two separate 1x1km square areas. The two squares had a variation of 5µg/m^3 of NO_2 as one square is predominantly rural and the other includes the M6 motorway. The study area is only 400m from the M6 and therefore an average of the two squares was chosen.

Both areas included modelling of the main roads therefore the NO_x apportionment of primary A roads in each grid square was removed and the NO_2 concentration adjusted using the NO_2 adjustment for NO_x sector removal tool[11]. A summary of background concentrations used in the assessment is provided in Table 5.

Table 5 - Background Concentrations 2012

Penrith			
X	**Y**	**NO_x**	**NO_2**
351500	530500	18.4	13.0
Eamont Bridge			
352500	528500	16.0	11.6
351500	528500	24.0	16.7
average		20.4	14.1

[9] http://laqm.defra.gov.uk/bias-adjustment-factors/national-bias.html

[10] http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html

[11] http://laqm.defra.gov.uk/maps/maps2010.html#NO2adj

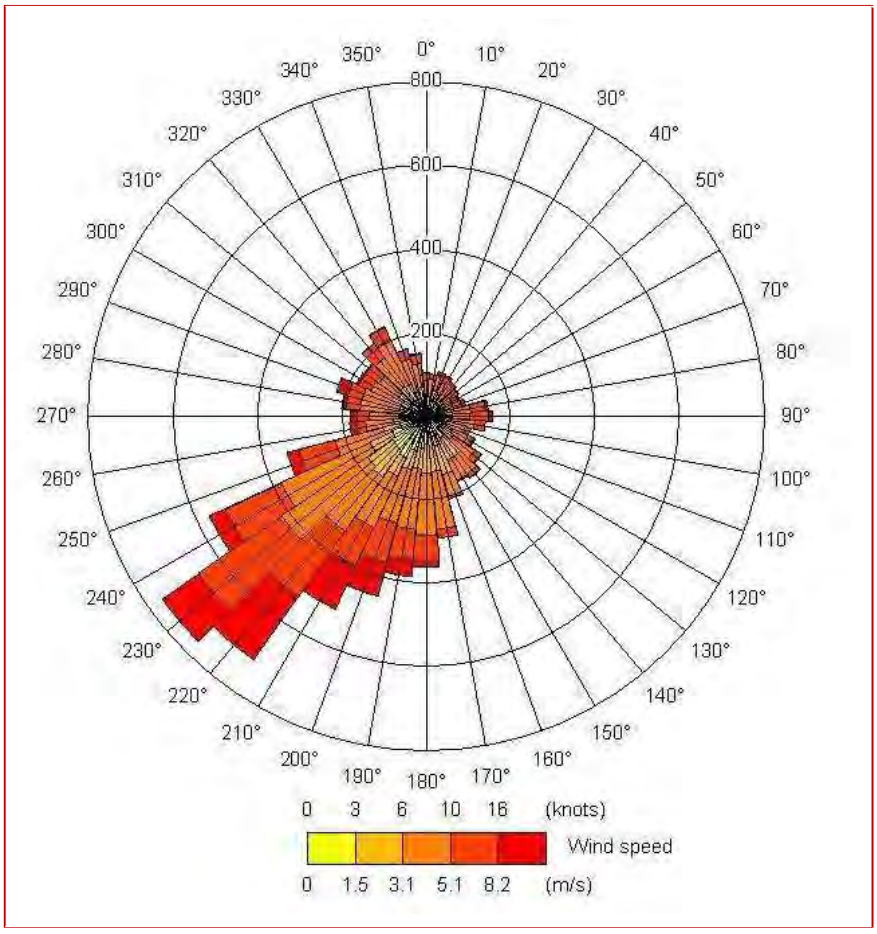
3 Dispersion Modelling Methodology

Detailed dispersion modelling of road-NO_x emissions was undertaken using ADMS-Roads (version 3.1) atmospheric dispersion model from Cambridge Environmental Research Consultants (CERC). Conversion to NO_2 was based on the latest NO_x /NO_2 conversion model released by Defra in August 2012 as part of the updated LAQM.TG (09) tools[12].

ADMS-Roads is an advanced Gaussian dispersion model, which has been extensively used in Local Air Quality Management and has formed the basis for many AQMA declarations. A number of validation studies have been completed, showing overall good agreement between model outputs and observations at continuous monitoring sites but that local verification is important to improve performance.

Dispersal of pollutant emissions is dependent (amongst other factors like topography and street canyon effects) upon the prevailing meteorological conditions at the time of emissions release. Hourly sequential meteorological data for 2012 from the closest Met Office station (Shap) has been used in this assessment. The wind rose derived from meteorological data is shown in Figure 3. There are 8,320 lines of usable meteorological data (95%). LAQM.TG(09) recommends that meteorological data should only be used if the percentage of usable hours is greater than 75%, and preferably 90%. Data is therefore adequate for the dispersion modelling.

Figure 3 - Shap 2012 Hourly Sequential Meteorological data



[12] http://laqm.defra.gov.uk/tools-monitoring-data/no-calculator.html

4 Results

4.1 Model Verification and Adjustment

Model verification was carried out at monitoring sites prior to predicting concentrations within the assessment area at sensitive receptor locations. The objectives of the model verification are:

- to evaluate model performance;
- to show that the baseline is well established; and
- to provide confidence in the assessment.

Comparison of the modelled and monitored results was carried out based on local NO_2 monitoring data. NO_2 was calculated from predicted NO_x concentrations, using the latest NO_x/NO_2 converter.

During the verification process, Bureau Veritas aim to ascertain whether all final modelled NO_2 concentrations are within 25% of the monitored NO_2 concentrations. Modelled results may not compare as well at some locations for a number of reasons including:

- Errors in traffic flow and speed data estimates;
- Model setup (including street canyons, road widths, receptor locations);
- Model limitations (treatment of roughness and meteorological data);
- Uncertainty in monitoring data (notably diffusion tubes, e.g. bias adjustment factors and annualisation of short-term data); and
- Uncertainty in emission factors.

The above factors were investigated as part of the model verification process to minimise the uncertainties as far as practicable. Some tube locations have been identified as not being applicable for verification purposes. In Eamont Bridge, tube EB15 was removed as it is close to a bus stop which has not been included in the model. In Penrith, tube V9 has not been used as it is located away from the main road in the vicinity of a car park which has not been included in the model. Tube SG29 was also removed as it is close to a bus stop which has not been included in the model.

In order to verify the model area five separate areas have been identified as requiring a separate verification factor. This approach allows local influence on NOx to NO_2 to be taken into account in the model by providing greater accuracy of model adjustment in each area, rather than just having one factor for the whole model. The five areas identified are;

- Eamont Bridge;
- Penrith High Street;
- Penrith main traffic routes (A6 south of High Street, A592, A6 north of High Street);
- Penrith back streets (Portland Place, Meeting House Lane, Benson Row, Friargate); and
- Penrith street canyons with a gradient (Castlegate and Scotland Road).

The model verification results are provided in Table 6 to Table 10. Final verified NO_2 concentrations in the modelled area are in good agreement with monitoring data, as modelled results at all sites are within ±25% of monitored concentrations. The resulting adjustment factors for road-NO_x contribution for each area are:

- Eamont Bridge – 3.1;
- Penrith High Street – 4.0;
- Penrith main traffic routes – 2.1;
- Penrith back streets – 4.9; and
- Penrith street canyons with gradients – 2.9.

The full verification methodology for each site is shown in Appendix 1.

Table 6 - Model Verification Results at Penrith High Street

Site	Within AQMA (Yes/No)	Modelled NO_2 2012 ($\mu g/m^3$)	Monitored NO_2 2012 ($\mu g/m^3$)	Percentage Difference	Difference (Modelled - Monitored) ($\mu g/m^3$)
T33	N	36.6	36.6	0%	0.0
Summary					
Number of sites	Within ±10%			1	
	Between ± 10-25%			0	
	Exceeds ±25%			0	
	Total			**1**	
In bold: exceedence of the NO_2 annual mean AQS objective of 40µg/m^3					

Table 7 – Model Verification Results at Penrith Main Routes

Site	Within AQMA (Yes/No)	Modelled NO_2 2012 ($\mu g/m^3$)	Monitored NO_2 2012 ($\mu g/m^3$)	Percentage Difference	Difference (Modelled - Monitored) ($\mu g/m^3$)
C1	N	36.4	34.7	5%	1.7
V3	N	37.2	**40.3**	-8%	-3.1
V5	N	35.8	38.5	-7%	-2.7
V11	N	32.7	31.5	4%	1.2
B14	N	**41.0**	39.0	5%	2.0
SG2345	N	36.3	35.4	3%	0.9
Summary					
Number of sites	Within ±10%			6	
	Between ± 10-25%			0	
	Exceeds ±25%			0	
	Total			**6**	
In bold: exceedence of the NO_2 annual mean AQS objective of 40µg/m^3					

Table 8 – Model Verification Results at Penrith Back Streets

Site	Within AQMA (Yes/No)	Modelled NO_2 2012 ($\mu g/m^3$)	Monitored NO_2 2012 ($\mu g/m^3$)	Percentage Difference	Difference (Modelled - Monitored) ($\mu g/m^3$)
T31	N	37.4	36.7	2%	0.7
T36	N	34.1	35.0	-3%	-0.9
		Summary			
Number of sites	Within ±10%			2	
	Between ± 10-25%			0	
	Exceeds ±25%			0	
	Total			**2**	
In bold: exceedence of the NO_2 annual mean AQS objective of 40µg/m³					

Table 9 – Model Verification Results at Penrith Street Canyons with a Gradient

Site	Within AQMA (Yes/No)	Modelled NO_2 2012 ($\mu g/m^3$)	Monitored NO_2 2012 ($\mu g/m^3$)	Percentage Difference	Difference (Modelled - Monitored) ($\mu g/m^3$)
SG27	N	36.2	37.8	-4%	-1.6
C4	N	**43.0**	**41.9**	3%	1.1
		Summary			
Number of sites	Within ±10%			2	
	Between ± 10-25%			0	
	Exceeds ±25%			0	
	Total			**2**	
In bold: exceedence of the NO_2 annual mean AQS objective of 40µg/m³					

Table 10 – Model Verification Results at Eamont Bridge

Site	Within AQMA (Yes/No)	Modelled NO_2 2012 ($\mu g/m^3$)	Monitored NO_2 2012 ($\mu g/m^3$)	Percentage Difference	Difference (Modelled - Monitored) ($\mu g/m^3$)
EB18	N	**40.8**	**42.6**	-4%	-1.8
EB20	N	**40.8**	38.9	5%	1.8
Summary					
Number of sites	Within ±10%			2	
	Between ± 10-25%			0	
	Exceeds ±25%			0	
	Total			**2**	

In bold: exceedence of the NO_2 annual mean AQS objective of 40µg/m^3

4.2 New Development in Penrith and Eamont Bridge

Penrith

An area in Penrith to the south of the town centre where the football ground was previously located has been redeveloped to include a shopping and residential area. As a result of the redevelopment, a new road layout along Victoria Road has been created in 2012. Two new traffic lights have been put on Victoria Road at the junction with Southend Road (Figure 5) and at the junction with Roper Street (Figure 4). A new road linking the development with Victoria Road has also been added.

A detailed dispersion model for air quality was undertaken by WYG Environment as part of the planning application for this development. The air quality report concluded that an increase in traffic in the area of the development was expected and that this would lead to exceedences of the annual mean objective for NO_2 at locations of relevant exposure. The report stated the data was based on 'worst case assumptions' and that due to highways improvements along Victoria Road congestion was expected to decrease along Victoria Road.

The reported figures in the planning application do appear to have been conservative based upon data provided by Cumbria County Council for the purpose of this Detailed Assessment. Data from the WYG assessment indicated the worst impact area is likely to be at the junction of Victoria Road and Roper Street.

The completion of this development was still ongoing at the time of writing and the council expects final traffic flows along Victoria Road to increase during 2013 as a result.

Eamont Bridge

In 2011/12 significant changes were made to the Kemplay roundabout at the junction of the A6 with the A66 at Eamont Bridge. The changes include additional lanes and traffic light controls at all entries and exits to the roundabout. This is may have affected the traffic flows through Eamont Bridge, particularly at peak times.

Figure 4 Junction with Victoria Road and Roper Street

Figure 5 Junction with Victoria Road and Southend Road

4.3 Modelled NO_2 Concentrations

Annual average NO_2 concentrations were predicted for 2012 at a number of specific receptors across the modelled area representing relevant public exposure, located at the facade of properties. Receptor locations are shown in Appendix 2. Additionally, predictions were made to a 5m grid spacing across the assessment area to produce NO_2 concentration contour maps for year 2012. NO_2 concentrations were modelled at a height of 1.5m above ground, which represents the average respirable height of an adult.

Results at specific receptors are provided in Table 11. Contours are shown in Appendix 3 for the modelled areas.

Table 11 - Modelled results at Specific Receptors

Specific Receptor	X(m)	Y(m)	Z(m)	Total Modelled NO_2 2012 µg/m^3
1	351333.0	530016.0	1.5	**44.1**
2	351396.0	530051.0	1.5	**43.9**
3	351942.1	529603.3	1.5	17.5
4	351860.9	529682.3	1.5	17.8
5	351853.0	529762.6	1.5	20.1
6	351811.4	529796.1	1.5	19.3
7	351724.8	529930.3	1.5	33.7
8	351708.6	529963.5	1.5	**44.0**
9	351657.2	530037.9	1.5	33.2
10	351639.0	530068.5	1.5	20.5
11	351601.4	530104.0	1.5	**42.2**
12	351540.1	530122.3	1.5	22.3
13	351408.0	530061.8	1.5	25.2
14	351384.9	530052.1	1.5	**44.0**
15	351349.2	530025.9	1.5	**42.8**
16	351421.3	530070.9	1.5	24.6
17	351788.3	530077.1	1.5	27.6
18	351839.7	529950.3	1.5	23.9
19	351938.1	529875.3	1.5	25.1
20	351816.5	529872.8	1.5	31.9
21	351766.6	529904.9	1.5	22.5

Specific Receptor	X(m)	Y(m)	Z(m)	Total Modelled NO_2 2012 µg/m^3
22	351787.9	529841.8	1.5	21.1
23e	352207.1	528815	1.5	**44.2**
24e	352207.1	528781.8	1.5	**42.8**
25e	352239.9	528678.8	1.5	37.2
26e	352255.4	528648.8	1.5	35.0
27e	352271.2	528639.9	1.5	35.2
28e	352289	528601.8	1.5	25.0
29e	352304.8	528536.1	1.5	35.6
30e	352323.8	528491.1	1.5	20.0
31	351687.6	530387.4	1.5	33.6
32	351280.9	530201.6	1.5	18.6
33	351291.0	530241.1	1.5	26.5
34	351310.3	530272.6	1.5	25.3
35	351325.0	530288.8	1.5	29.0
36	351363.3	530300.4	1.5	30.1
37	351425.1	530346.5	1.5	24.0
38	351392.9	530383.9	1.5	21.2
39	351376.4	530422.9	1.5	30.3
40	351317.3	530508.3	1.5	37.8
41	351300.6	530536.4	1.5	24.3
42	351246.3	530573.3	1.5	24.4
43	351194.8	530623.8	1.5	**50.6**
44	351159.2	530648	1.5	25.3
45	351119.1	530704.5	1.5	21.0
46	351402.4	530449.9	1.5	34.3
47	351422.8	530444.9	1.5	26.8
48	351442.6	530502.2	1.5	27.6

Specific Receptor	X(m)	Y(m)	Z(m)	Total Modelled NO_2 2012 µg/m^3
49	351505.2	530535.4	1.5	28.0
50	351534.1	530502.3	1.5	22.2
51	351592.2	530473.9	1.5	27.2
52	351612.1	530441.9	1.5	37.4
53	351650.0	530425.1	1.5	26.9
54	351738.2	530317.6	1.5	38.9
55	351782.0	530288.7	1.5	35.6
56	351822.3	530261.5	1.5	24.8

In bold: exceedence of the NO_2 annual mean AQS objective of 40µg/m^3
e = receptor is in Eamont Bridge

Penrith Modelled Results:

Specific receptor results in Penrith indicated four potential areas of exceedence at the façade of properties (receptors 1, 2, 14, 15, 8, 11, and 43). Discussion regarding each of these locations will help to inform conclusions in each area.

Castlegate (A6)

Receptors 1, 2, 14 and 15 are all located on Castlegate which is known to have high pollutant concentrations from monitoring carried out in 2011 and 2012. Whilst the monitoring results in 2012 are limited in reliability due to only five months of data being available the concentrations were still all consistently high. As a result it would be expected that high concentrations would be predicted in this area. The combination of a very narrow street canyon coupled with a steep gradient and slow moving traffic is causing an exceedence of the annual mean objective for NO_2. Modelled contours indicate a potential exceedence area extending from Corn Market all the way along Castlegate up to the roundabout on Cromwell Road. As a result of the monitored and modelled exceedences it is recommended that an AQMA is declared from Corn Market all the way along Castlegate up to the roundabout on Cromwell Road. Additionally it would be recommended to install extra monitoring in that area at the façade of properties in the worst-case locations. Recommended AQMA areas and new monitoring locations are shown in Appendix 4.

Victoria Road (A6)

Receptor 8 is located at the façade of a property on Victoria Road (A6) opposite monitoring location V3, which recorded an exceedence of the NO_2 annual mean objective in 2012 of 40.3 $\mu g/m^3$. This part of the A6 narrows into a street canyon and houses are located within the canyon. Modelled contours indicate the exceedence area where pollutant concentrations are likely to be above 40$\mu g/m^3$ are not widespread along the A6 but rather are concentrated at worst-case locations in narrow street canyons. The concentrations of NO_2 along Victoria Road at site V3 have increased by 7$\mu g/m^3$ from 2011 to 2012. Concentrations at V5 have increased by 2$\mu g/m^3$ and concentrations at site 36 have increased by 7$\mu g/m^3$. Whilst V5 and 36 are still below the objective limit of 40$\mu g/m^3$ both are close to or within 10% of the limit (36$\mu g/m^3$) indicating a potential breech of air quality objectives in the area. Site V11 is outside of the street canyon and has not shown the increase in concentrations recorded elsewhere.

The impact of the new development may have had an impact upon air quality in this area due to the increase in traffic. As traffic is expected to be higher in 2013 compared to 2012, air quality would be expected to deteriorate.

As a result of the new development traffic along with modelled and monitored exceedences, it is recommended that an AQMA is declared along Victoria Road (A6) from the junction with Southend Road to 60m north of the junction with Langton Street. Additionally, new monitoring should be installed at the façade of properties along Victoria Road between Southend Road and Roper Street also along Roper Street close to the junction.

Recommended AQMA areas and new monitoring locations are shown in Appendix 4.

King Street (A6)

Receptor 11 is also located on the A6 within a street canyon. The street canyon is again very narrow and will be a busy section of road with the traffic from the High Street one way system merging back into the A6 going south. The properties are all commercial, therefore there is no need to declare an AQMA in this area.

Scotland Road (A6)

Receptor 43 is located on Scotland Road (A6). The receptor is close to the monitoring location SG27 which recorded an annual mean NO_2 concentration of 37.8$\mu g/m^3$ in 2012 (this is a 4$\mu g/m^3$ rise in concentrations since 2011). The section along Scotland Road is a street canyon and is on a slight gradient, which has been taken into account when modelling. Contours at this location indicate the pollutant concentrations at the façade of properties are close to the objective levels for annual mean NO_2. Due to uncertainties related to traffic breakdown along the A6 (only AADT and %HDV were available) and as monitoring at a worst case location in the area has recorded concentrations below

40µg/m^3 it would not be recommended to declare an AQMA at this location. It would be recommended the council continue to monitor at the façade of properties in this location and add in extra monitoring in this area.

Recommended new monitoring locations are shown in Appendix 4.

Brunswick Road (A6)

The location around monitoring location B14 on Brunswick Road is an area which historically has been identified as being close to exceeding the objective levels for NO_2. In 2012, the monitoring point recorded a concentration of 39.0µg/m^3. The modelled contours indicate a potential exceedence of the annual mean objective at facades near to the junction with Duke Street. Analysis of the model verification for this location indicates the modelled results are over predicting concentrations at this location as a result of uncertainties identified in the verification section. The recommendation for this area would be to continue monitoring at property facades and re-evaluate the situation should any potential future exceedences be recorded. If exceedences at B14 and SG27 occur it would be recommended to create an AQMA linking to the two areas. It would be recommended to link the areas if this occurs as it will aid decision making regarding the air quality action plan.

Meeting House Lane, Benson Row and Friargate

The roads running parallel to the High Street and back to the A6 such as Meeting House Lane, Benson Row and Friargate are another area where potential exceedences of the annual mean objective have been identified, with monitoring at tube 33 recording a concentration of 36.6µg/m^3 in 2012 which is within 10% of the objective. Modelled contours indicate potential areas of exceedence at junctions within street canyons in this area with the hotspots being located where Meeting House Lane meets with Benson Row and Burrowgate. Also, an area of potential high pollution is identified along Friargate. Due to uncertainties related to traffic flow and speeds in the modelled domain it is not recommended an AQMA be declared in this area. It is recommended further monitoring be included along these roads at locations of relevant exposure.

High Street (A6)

The High Street contains areas of pollutant contours over 40µg/m^3 however as there is no relevant exposure along this road there is no need to consider an AQMA in this area. The single monitoring location is sufficient to inform the council if there is any chance of exceeding the hourly objective which is unlikely as the concentration in 2012 was 36µg/m^3.

Analysis of UK continuous NO_2 monitoring data has shown that it is unlikely that the hourly mean NO_2 objective, of 18 hourly means over 200µg/m^3, would be exceeded where the annual mean objective is below 60µg/m^3 [13]. All sites are below the 60µg/m^3 level in 2012, therefore, the NO_2 hourly mean AQS objective is expected to be met at all relevant locations. Concentrations along Castlegate did exceed this 60µg/m^3 limit in 2011 and improved data capture in 2013 should indicate if the short-term objective is likely to be an issue in that area.

Eamont Bridge Modelled Results:

Specific receptor results in Eamont Bridge indicated exceedences of the annual mean objective for NO_2 occurring at two locations (23e and 24e). Both of these locations are located to the north of the actual bridge. To the south of the bridge monitoring has indicated an exceedence of the annual mean objective (site EB18 - 42.6µg/m^3 in 2012). Modelled contours indicate a potential exceedence area along the A6 though Eamont Bridge from the start of the village to the north to The Beehive Inn. Based on monitored and modelled exceedences of the annual mean objective for NO_2 it is recommended that the Council declare this area as an AQMA. Recommended AQMA areas and recommended new monitoring locations are shown in Appendix 4.

[13] Analysis of the relationship between annual mean nitrogen dioxide concentration and exceedences of the 1-hour mean AQS Objective – AEA - 2008

4.4 Population Exposure

Technical Guidance LAQM.TG(09) requires local authorities to estimate the number of people exposed to pollutant concentrations above the relevant air quality objectives.

In the recommended AQMA in Penrith, fewer than 34 homes are included therefore approximately 60-80 people are likely to be exposed. In Eamont Bridge, around 30 homes are included in the area so approximately 50-100 people are likely to be exposed.

5 Conclusions and Recommendations

As part of the Local Air Quality Management (LAQM) regime, a Detailed Assessment based on detailed dispersion modelling of NO_2 emissions from road-traffic was carried out for Penrith and Eamont Bridge, due to measured exceedences of the NO_2 annual mean Air Quality Strategy (AQS) Objective.

The Detailed Assessment has been undertaken in accordance with Defra's Technical Guidance LAQM.TG (09) methodologies, based on advanced atmospheric dispersion modelling of NO_2 traffic emissions, relying on updated emission factors and background pollutant concentrations released by Defra in 2013, and the latest monitoring, traffic and meteorological data for the year 2012.

Due to measured and modelled exceedences of the air quality objectives for NO_2 at the façade of properties both in Penrith and Eamont Bridge it is recommended the council declare AQMAs and carry out the following recommendations:

- Declare an AQMA from Corn Market all the way along Castlegate up to the roundabout on Cromwell Road;
- Install extra monitoring in that area at the façade of properties in the worst case locations along Castlegate;
- Declare an AQMA along Victoria Road (A6) from the junction with Southend Road to 60m north of the junction with Langton Street;
- Install new monitoring at the façade of properties along Victoria Road between Southend Road and Roper Street. Install monitoring at the façade of properties along Roper Street;
- Install further monitoring along Scotland Road and continue to monitor at SG27;
- Install further monitoring at relevant locations along Meeting House Lane, Benson Row and Friargate;
- Declare an AQMA along the A6 though Eamont Bridge from the start of the village to the north to The Beehive Inn;
- Install further monitoring in Eamont Bridge at site of relevant exposure.

As part of the further assessment and continuing air quality management in Penrith and Eamont Bridge, the Council should consider gathering detailed traffic data with a breakdown in traffic type. Additionally, depending on future monitoring result and results of the further assessment, if exceedences are recorded on Scotland Road, the Council may wish to consider a consolidated AQMA covering the A6 from Bridge Street around Castlegate and Brunswick Road and along Scotland Road. This would simplify action planning in the town and provide a town-wide approach to tackling air quality pollution.

Appendix 1 – Model Verification

Model Verification Results at Penrith High Street

Site	Background NO_2 ($\mu g/m^3$)	Background NO_x ($\mu g/m^3$)	Monitored Road Contribution NO_x ($\mu g/m^3$)	Modelled Road Contribution NO_x ($\mu g/m^3$)	Ratio of Monitored Road NO_x/Modelled Road NO_x	Adjustment Factor (Regression) for Modelled Road Contribution	Adjusted Modelled Road Contribution NO_x ($\mu g/m^3$)	Adjusted Modelled Total NO_x ($\mu g/m^3$)	Modelled Total NO_2 ($\mu g/m^3$)	Monitored Total NO_2 ($\mu g/m^3$)	% Difference NO_2 [(Modelled - Monitored)/ Monitored]
T33	13	18.4	51.7	12.8	4.1	4.05	51.7	71.9	36.6	36.6	0%

In bold, exceedence of the NO_2 annual mean AQS objective of $40\mu g/m^3$

Model Verification Results at Penrith Back Streets

Site	Background NO_2 ($\mu g/m^3$)	Background NO_x ($\mu g/m^3$)	Monitored Road Contribution NO_x ($\mu g/m^3$)	Modelled Road Contribution NO_x ($\mu g/m^3$)	Ratio of Monitored Road NO_x/Modelled Road NO_x	Adjustment Factor (Regression) for Modelled Road Contribution	Adjusted Modelled Road Contribution NO_x ($\mu g/m^3$)	Adjusted Modelled Total NO_x ($\mu g/m^3$)	Modelled Total NO_2 ($\mu g/m^3$)	Monitored Total NO_2 ($\mu g/m^3$)	% Difference NO_2 [(Modelled - Monitored)/ Monitored]
T31	13	18.4	51.7	10.3	5.0	5.32	54.9	73.3	37.9	36.7	3%
T36			47.4	8.2	5.8		43.4	61.8	33.3	35.0	-5%

In bold, exceedence of the NO_2 annual mean AQS objective of $40\mu g/m^3$

Model Verification Results at Penrith Main Routes

Site	Background NO_2 (µg/m^3)	Background NO_x (µg/m^3)	Monitored Road Contribution NO_x (µg/m^3)	Modelled Road Contribution NO_x (µg/m^3)	Ratio of Monitored Road NO_x/Modelled Road NO_x	Adjustment Factor (Regression) for Modelled Road Contribution	Adjusted Modelled Road Contribution NO_x (µg/m^3)	Adjusted Modelled Total NO_x (µg/m^3)	Modelled Total NO_2 (µg/m^3)	Monitored Total NO_2 (µg/m^3)	% Difference NO_2 [(Modelled - Monitored)/ Monitored]
C1	13	18.4	**46.9**	24.8	1.9	2.06	**51.1**	**69.5**	36.4	34.7	5%
V3			**61.3**	25.8	2.4		**53.1**	**71.5**	37.2	**40.3**	-8%
V5			**56.5**	24.1	2.3		**49.6**	**68.0**	35.8	38.5	-7%
V11			**39.2**	20.3	1.9		**41.9**	**60.3**	32.7	31.5	4%
B14			**57.8**	30.6	1.9		**63.0**	**81.4**	**41.0**	39.0	5%
SG2345			**48.5**	24.6	2.0		**50.7**	**69.1**	36.3	35.4	3%

In bold, exceedence of the NO_2 annual mean AQS objective of 40µg/m^3

Model Verification Results at Penrith street canyons with a gradient

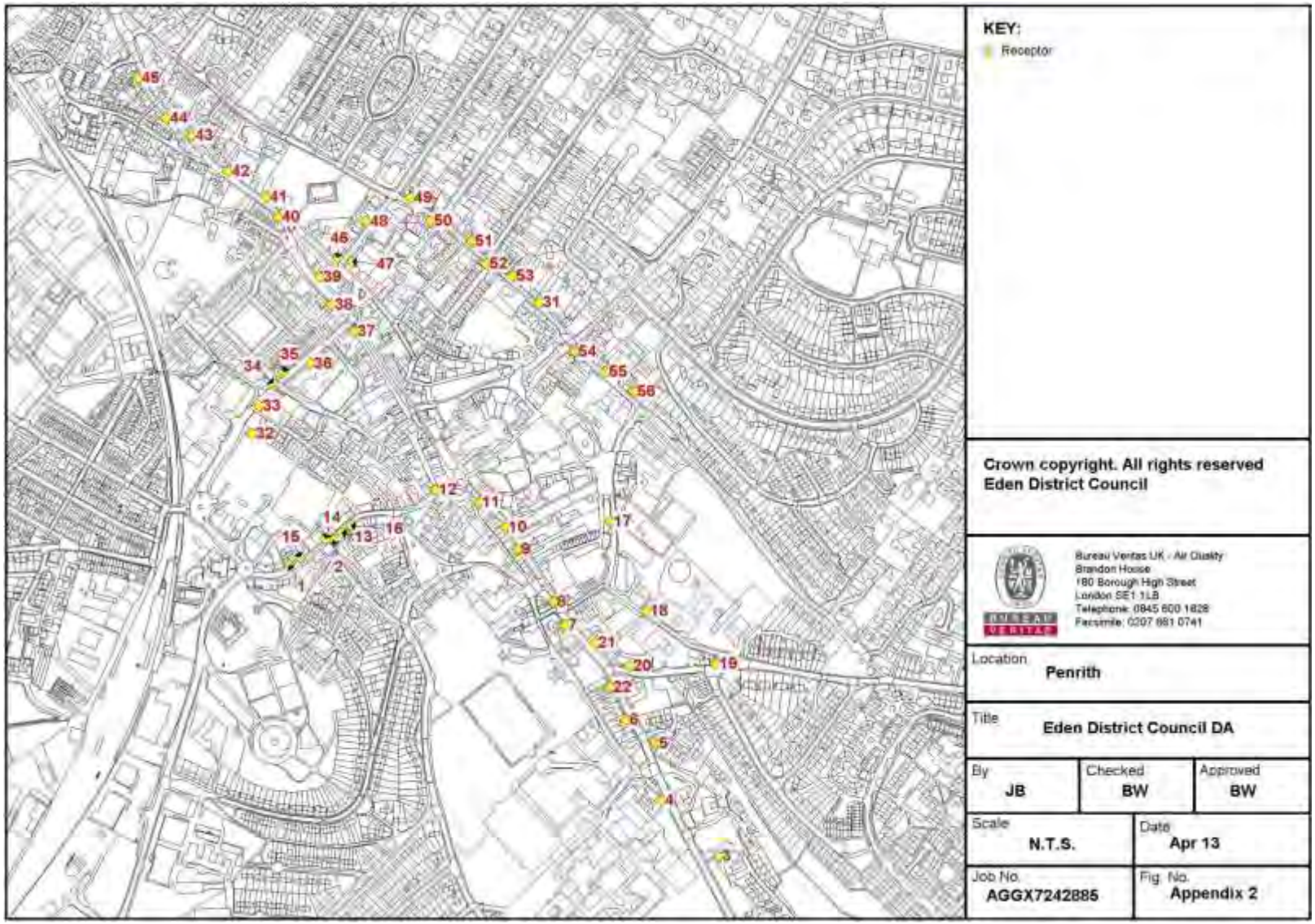
Site	Background NO_2 (µg/m^3)	Background NO_x (µg/m^3)	Monitored Road Contribution NO_x (µg/m^3)	Modelled Road Contribution NO_x (µg/m^3)	Ratio of Monitored Road NO_x/Modelled Road NO_x	Adjustment Factor (Regression) for Modelled Road Contribution	Adjusted Modelled Road Contribution NO_x (µg/m^3)	Adjusted Modelled Total NO_x (µg/m^3)	Modelled Total NO_2 (µg/m^3)	Monitored Total NO_2 (µg/m^3)	% Difference NO_2 [(Modelled - Monitored)/ Monitored]
SG27	13	18.4	54.5	17.3	3.2	2.92	50.5	68.9	36.2	37.8	-4%
C4			65.4	23.5	2.8		68.4	86.8	**43.0**	**41.9**	3%

In bold, exceedence of the NO_2 annual mean AQS objective of 40µg/m^3

Model Verification Results at Eamont Bridge

Site	Background NO_2 ($\mu g/m^3$)	Background NO_x ($\mu g/m^3$)	Monitored Road Contribution NO_x ($\mu g/m^3$)	Modelled Road Contribution NO_x ($\mu g/m^3$)	Ratio of Monitored Road NO_x/Modelled Road NO_x	Adjustment Factor (Regression) for Modelled Road Contribution	Adjusted Modelled Road Contribution NO_x ($\mu g/m^3$)	Adjusted Modelled Total NO_x ($\mu g/m^3$)	Modelled Total NO_2 ($\mu g/m^3$)	Monitored Total NO_2 ($\mu g/m^3$)	% Difference NO_2 [(Modelled - Monitored)/ Monitored]
EB18	14.1	20	64.9	19.4	3.3	3.09	60.1	80.1	**40.8**	**42.6**	-4%
EB20			55.0	19.4	2.8		59.9	79.9	**40.8**	38.9	5%

Appendix 2 – Specific Receptor Locations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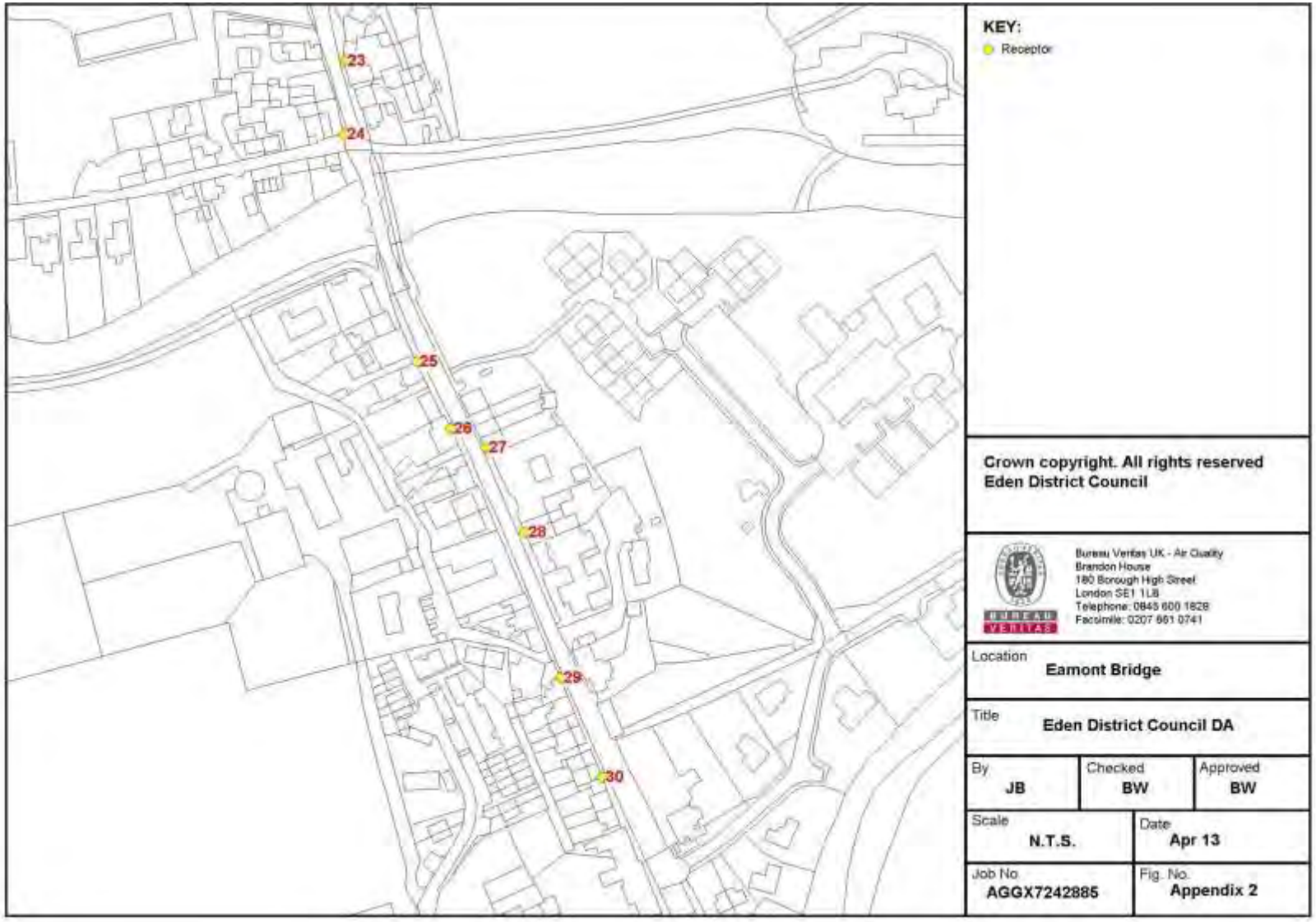
Receptor
Crown copyright. All rights reserved
Eden District Council
Bureau Veritas UK - Air Quality
Brandon House
180 Borough High Street
London SE1 1LB
Telephone: 0845 600 1828
Facsimile: 0207 661 0741
Location
Penrith
Title
Eden District Council DA
By
JB
Checked
BW
Approved
BW
Scale
N.T.S.
Date
Apr 13
Job No.
AGGX7242885
Fig. No.
Appendix 2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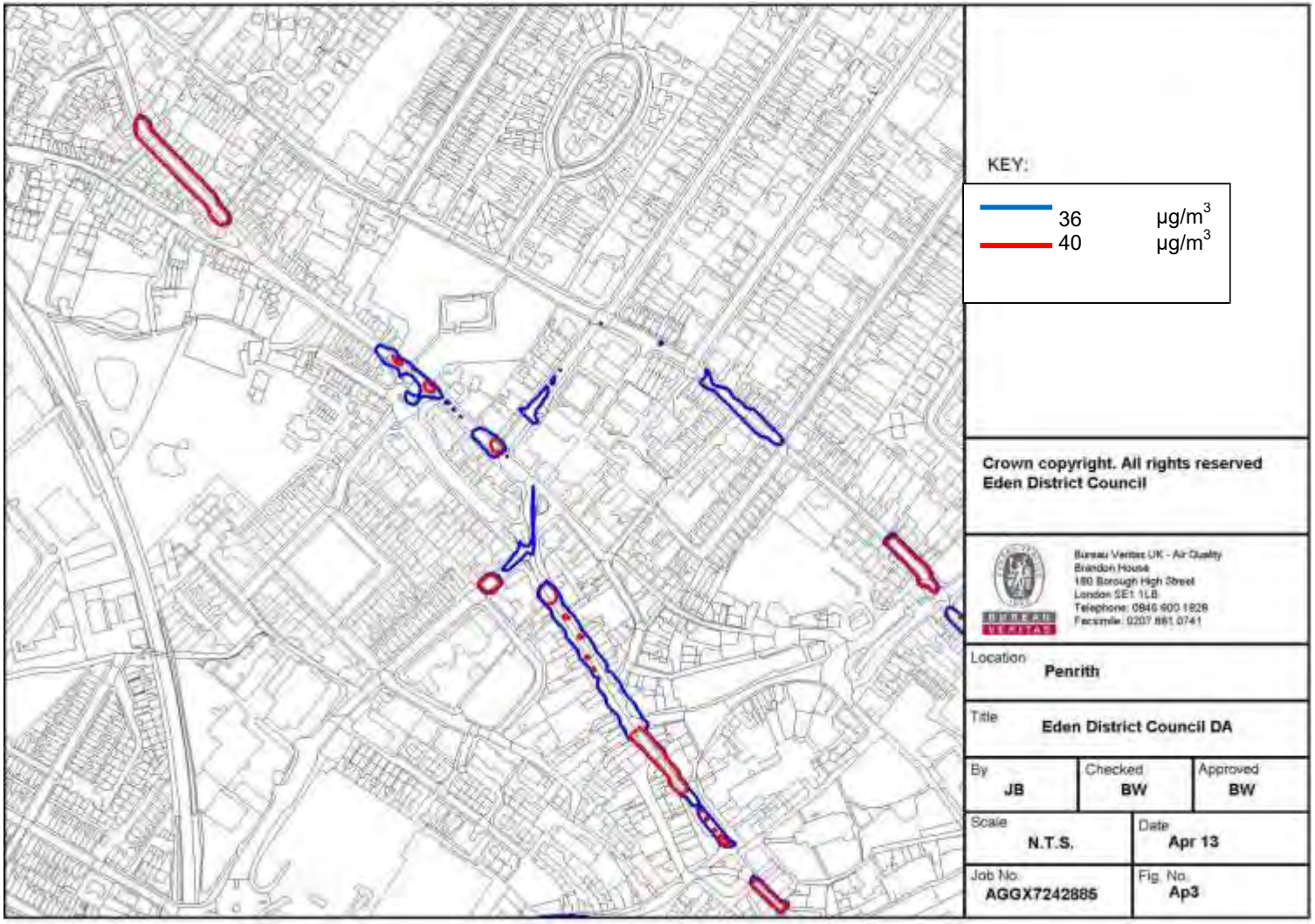
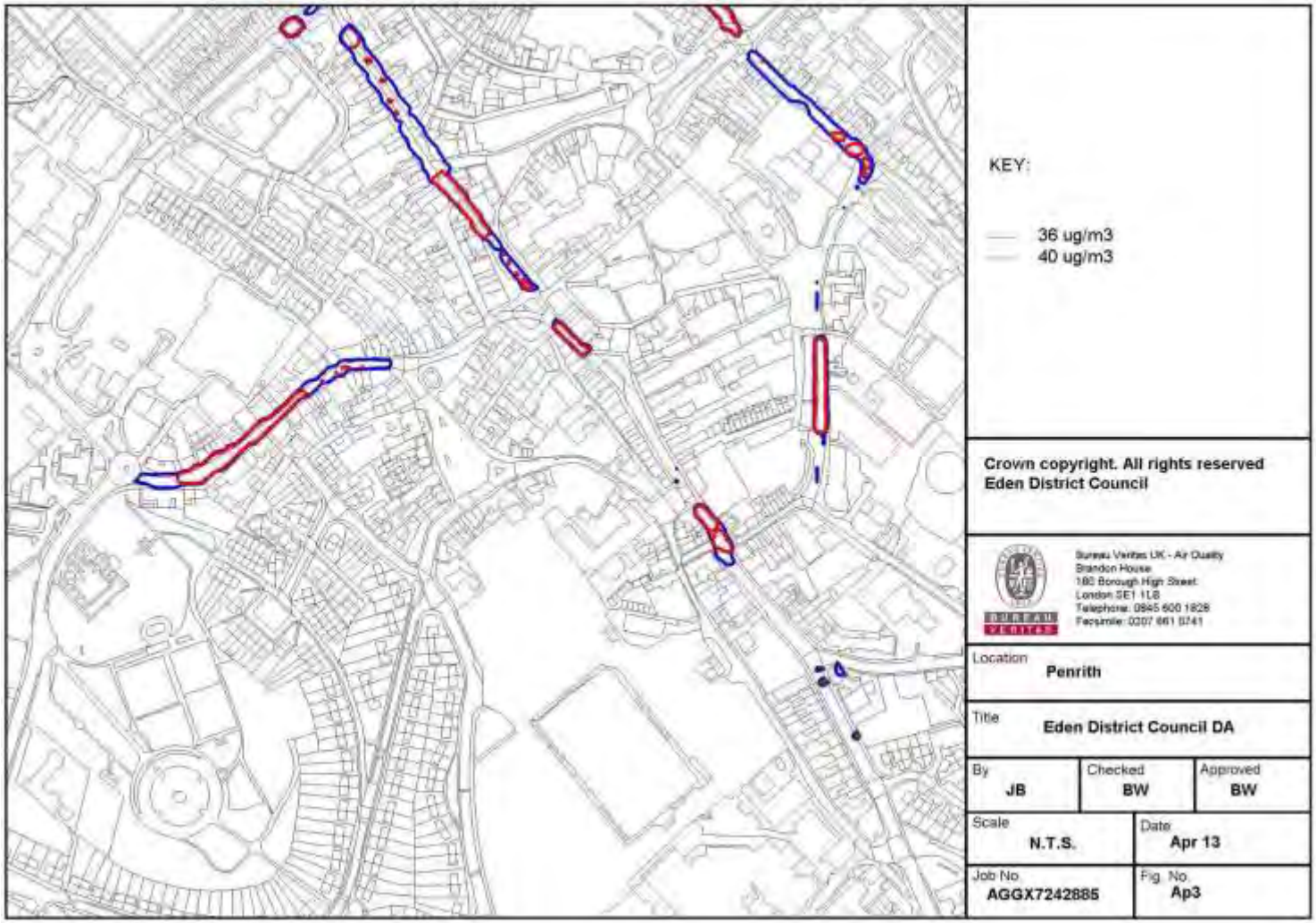
KEY:
Receptor
Crown copyright. All rights reserved
Eden District Council
Bureau Veritas UK - Air Quality
Brandon House
180 Borough High Street
London SE1 1LB
Telephone: 0845 600 1828
Facsimile: 0207 661 0741
Location
Eamont Bridge
Title
Eden District Council DA
By
JB
Checked
BW
Approved
BW
Scale
N.T.S.
Date
Apr 13
Job No.
AGGX7242885
Fig. No.
Appendix 2

Appendix 3 – Modelled Contours

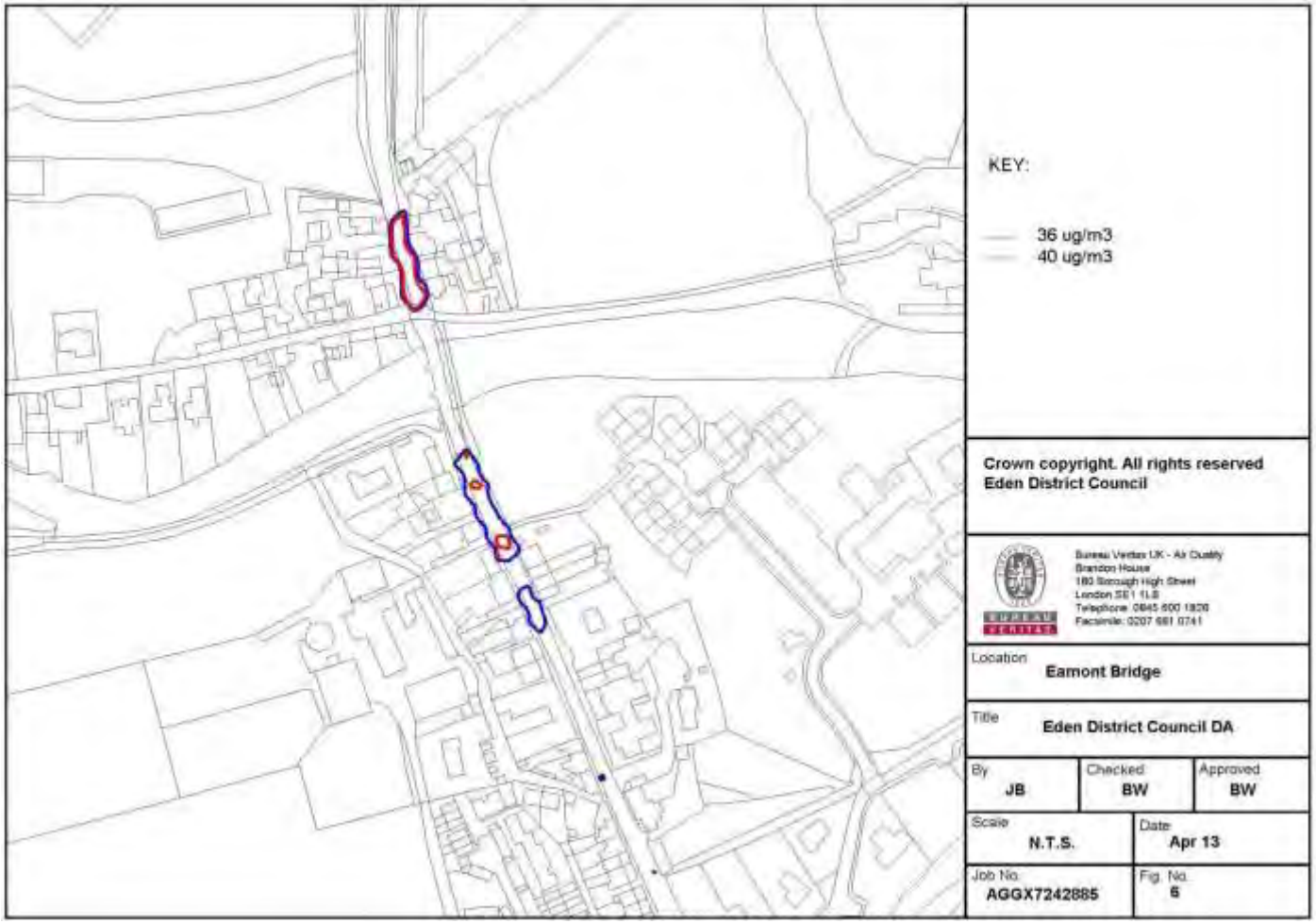
Modelled NO_2 Contour Concentrations – Northern Penrith 2012



Modelled NO_2 Contour Concentrations – Southern Penrith 2012

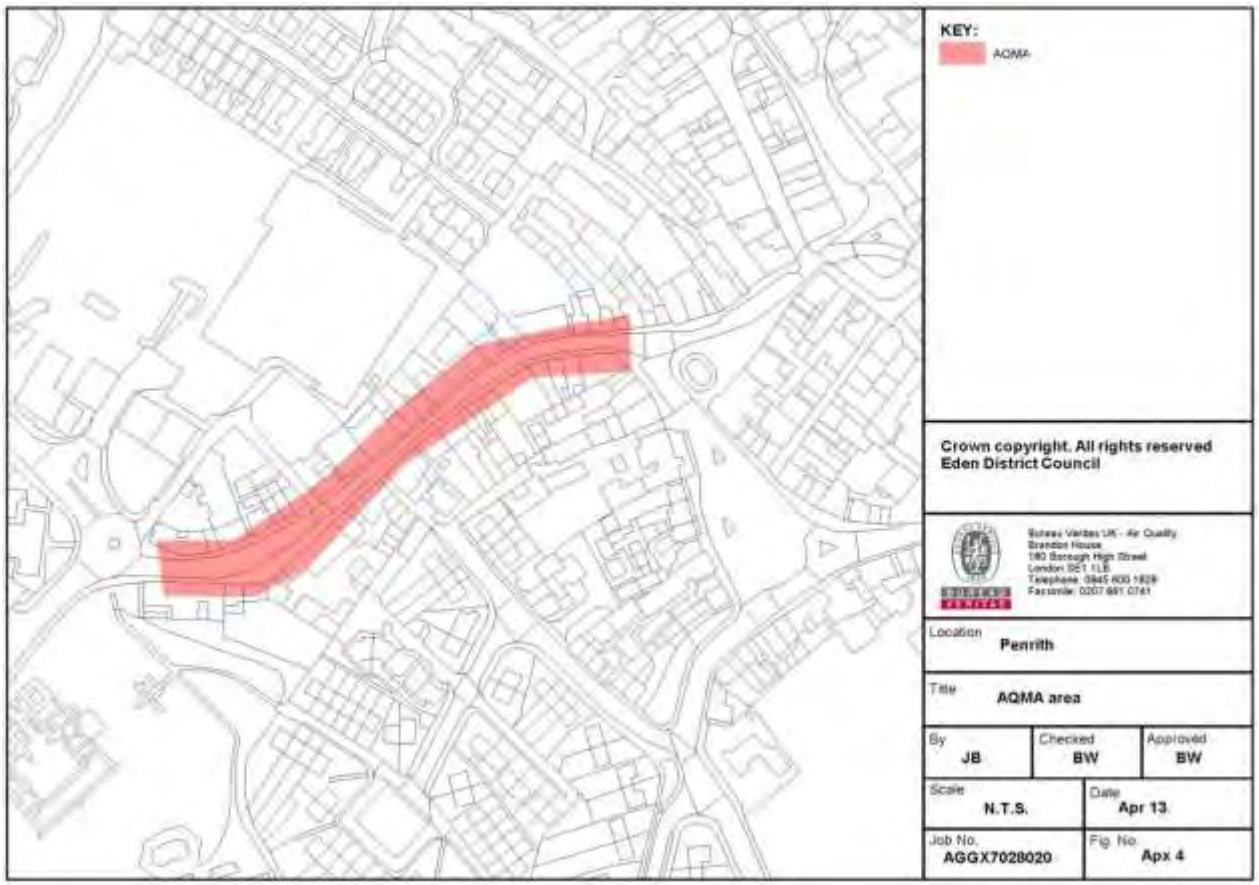


Modelled NO_2 Contour Concentrations – Eamont Bridge 2012

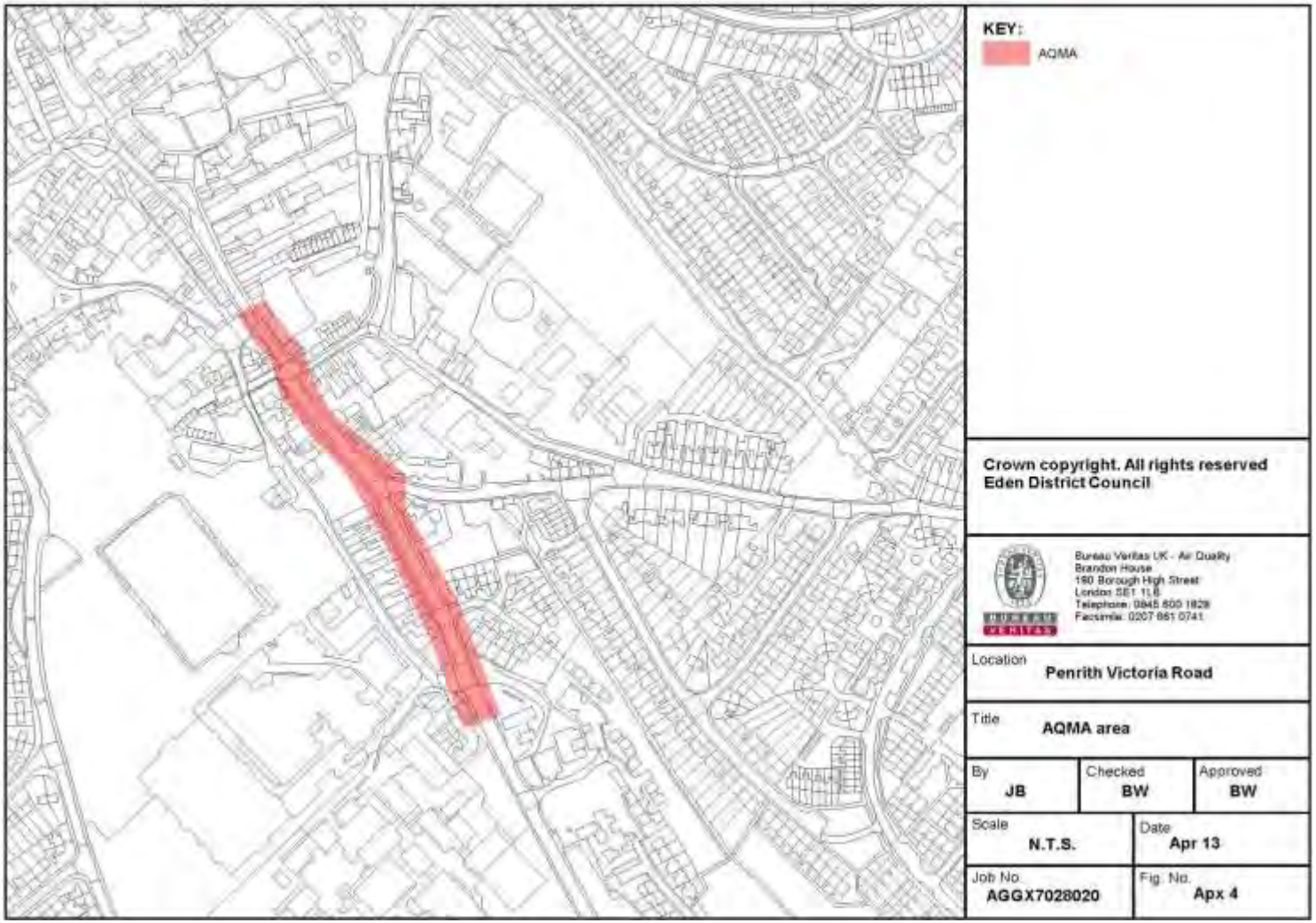


Appendix 4 – Recommended AQMA areas and recommended new monitoring locations

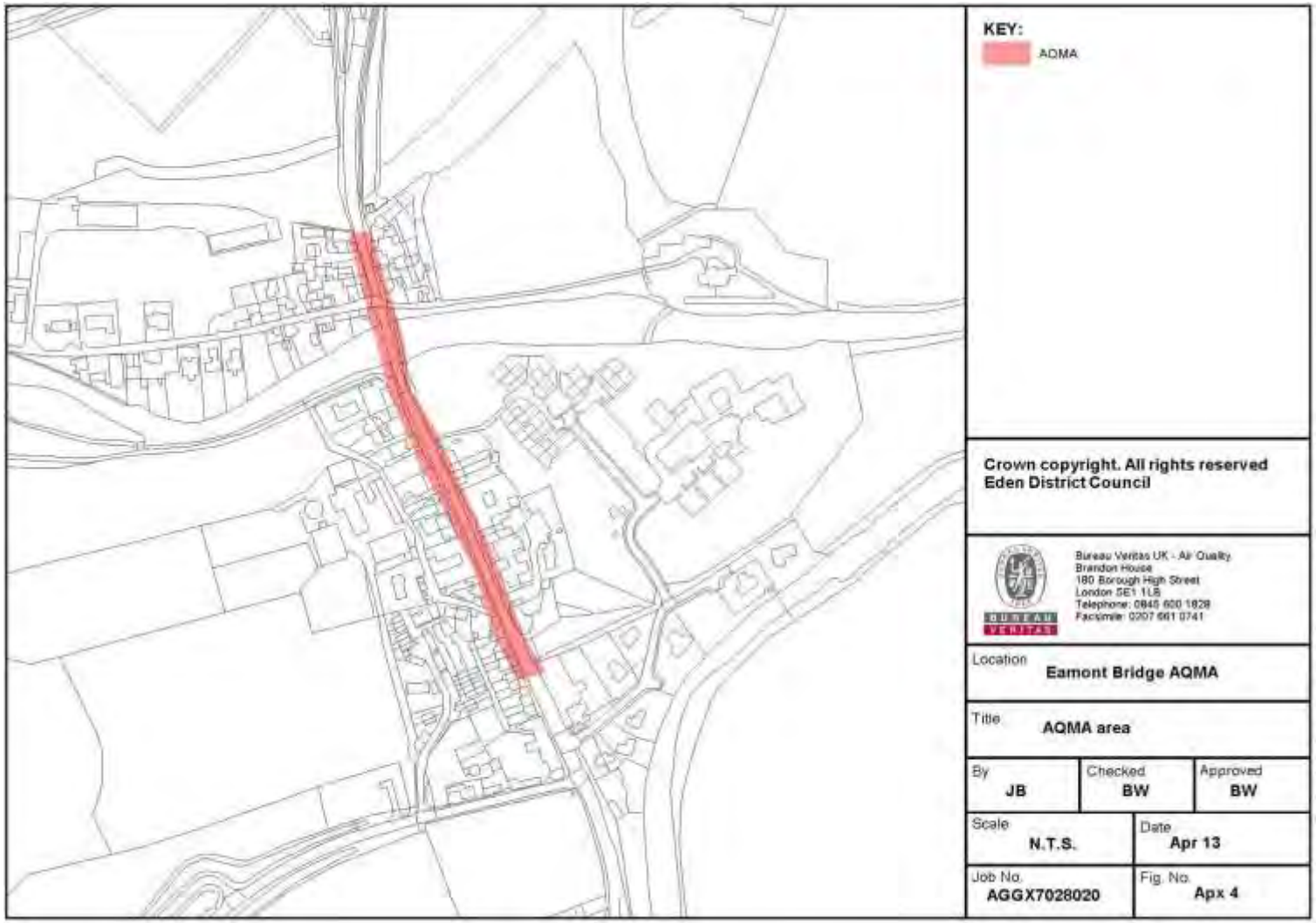
Castlegate AQMA



Victoria Road AQMA

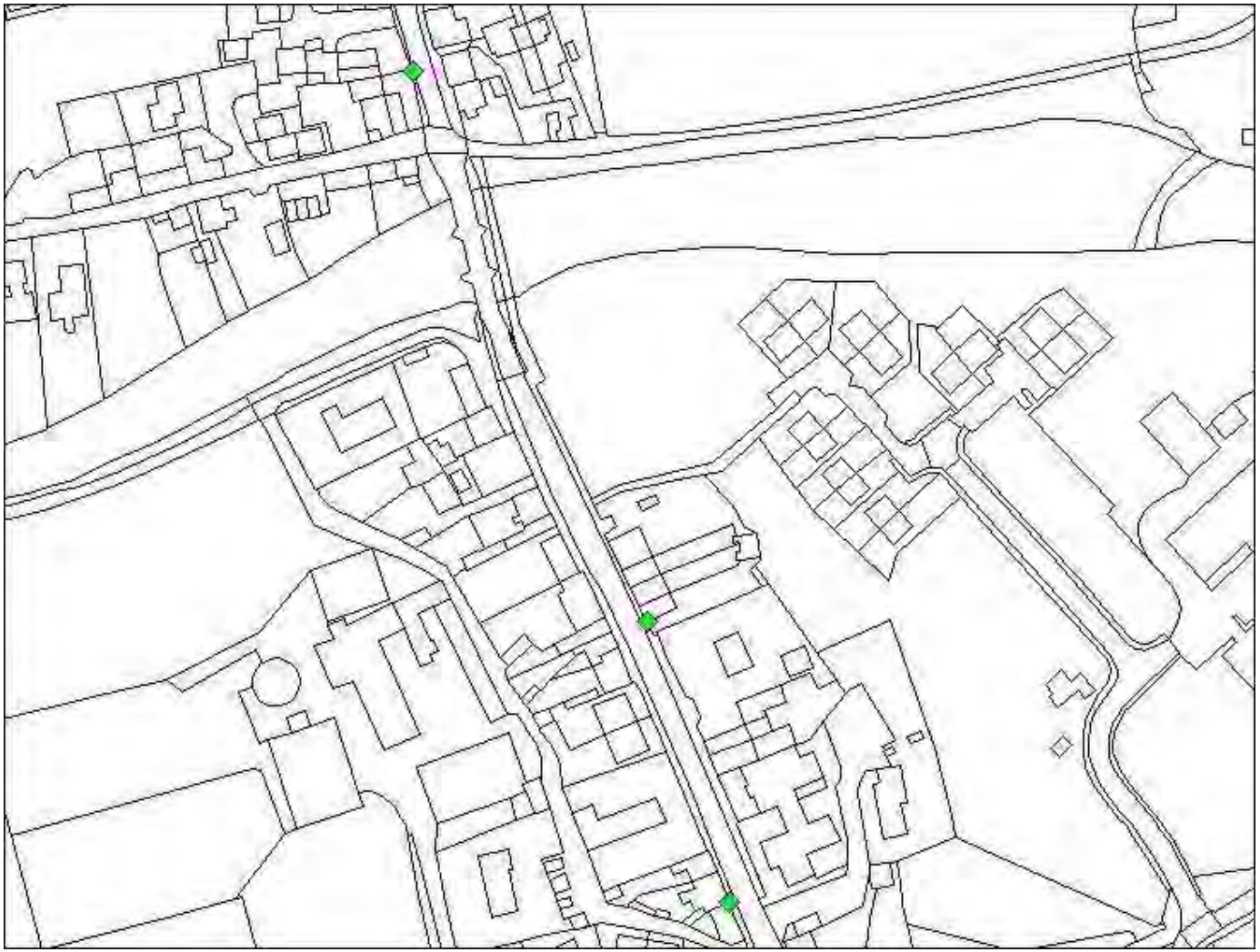


Eamont Bridge AQMA



New monitoring locations Penrith

New monitoring locations Eamont Bridge



Appendix 5 - Short-Term to Long-Term Monitoring Data Adjustment

Site	Uncorrected Diffusion Tube Mean (µg/m^3)	Annualisation factor Eskdalemuir	Annualisation factor Peebles	Annualisation factor Blackpool	Average Annualisation factor	Annualised Bias Adjusted Concentration (µg/m^3)
C4	65.0	0.9	0.7	0.8	0.8	41.9