NEWRY AND MOURNE DISTRICT COUNCIL

LAQM FURTHER MODELLING 2009

BV/AQ/AGGX0952/DRAFT

MARCH 2009

BUREAU VERITAS

Move Forward with Confidence

This page is left blank intentionally

DOCUMENT CONTROL SHEET

Issue/Revision	Issue 1	Issue 2	Final	
Remarks	Draft for Comment			
Date	March 2009			
Submitted to	Kevin Scullion			
Prepared by	Sharon Atkins			
Signature				
Approved by	Lakhu Luhana			
Signature				
Project number	ADIX0952			
File reference				

This page is left blank intentionally

TABLE OF CONTENTS

1 Executive Summary

Part III of the Environment (Northern Ireland) Order 2002[1] places a statutory duty on local authorities to periodically review and assess the air quality within their area and take account of Government guidance when undertaking such work.

Newry and Mourne District Council undertook a detailed assessment of air quality as part of the first round of review and assessment. This was completed in April 2005 and concluded that there was a risk of exceeding the air quality objectives for nitrogen dioxide (NO_2) and PM_{10} in Newry. The Council declared five AQMAs for the annual mean NO_2 objective and the 24-hour PM_{10} objective which came into operation on 11th April 2006. These five areas were named as:

- Newry (Canal Street) Air Quality Management Order 2006
- Newry (Water Street) Air Quality Management Order 2006
- Newry (Bridge Street) Air Quality Management Order 2006
- Newry (St Mary Street) Air Quality Management Order 2006
- Newry (Kilmorey Street) Air Quality Management Order 2006

Bureau Veritas has been commissioned by Newry and Mourne District Council to provide a further modelling assessment of air quality within the five Air Quality Management Areas in Newry, and two identified new hotspots (Patrick Street and Sandy Street). In addition, to consider scenario testing of action plan measures to provide technical input into the Council's Air Quality Action Plan.

The assessment has been undertaken in accordance with LAQM.TG(09)[2] Guidance methodologies and aims, through assessment of monitoring data and modelled predictions,

- to assess current levels of air quality in the declared AQMAs against the prescribed objectives;
- to determine the likelihood of exceedences of the prescribed objectives in the newly identified hotspots, Patrick Street and Sandy Street in Newry; and
- to assess the likely improvement in air quality through proposed action plan measures, where information has been available to achieve this.

The findings of this report from the updated monitoring and modelled results are as follows:

- Exceedences of the annual mean NO_2 objective continue to be monitored and modelled within the Canal Street, Water Street and Kilmorey Street AQMAs and confirm the need for these declarations. The PM_{10} objectives are predicted to be met in these AQMAs in all years modelled;
- Bridge Street and St Mary's Street AQMAs meet the prescribed air quality objectives for both NO_2 and PM_{10}. Monitoring data for the last three years show compliance with the prescribed air quality objectives within these AQMA. It is recommended that the Council consider revocation of these AQMAs.
- The PM_{10} objectives are predicted to be met in all AQMAs. Monitoring data at roadside sites on Trevor Hill and Bridge Street (AQMA) show levels are well below the objectives. It is recommended that the Council consider amending the AQMA orders to reflect this.
- There is a risk of exceedences of the annual mean nitrogen dioxide objective outside the current AQMA declarations: in Sandy Street (near the junction with Trevor Hill) and, to a lesser extent, in Patrick Street (a small area near the junction with Monaghan Street). It is

[1] S.I. 2002/3153

[2] Defra (2009), Local Air Quality Management Technical Guidance LAQM.TG(09)

recommended that the Council consider declaration of these areas as AQMAs to incorporate areas of relevant exposure.

2 Introduction

2.1 Project Background

The Environment (Northern Ireland) Order 2002 gives local authorities duties and responsibilities that are designed to secure improvements in air quality, particularly at the local level. Part III of the Order requires each local authority in Northern Ireland to periodically review and assess air quality in its area, and determine whether the prescribed objectives are likely to be achieved by the relevant future year. Bureau Veritas was commissioned by Newry and Mourne District Council (N&MDC) to undertake further modelling in Newry, to include the five AQMAs declared in April 2006, in addition to two new areas where monitoring results have shown exceedences of the annual mean objective.

2.2 Legislative Background

The significance of existing and future pollutant levels are assessed in relation to the national air quality standards and objectives, established by the UK Government and devolved administrations. The revised Air Quality Strategy (AQS)[3] 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[4] introduces new obligatory standards for $PM_{2.5}$ for Government but places no statutory duty on local government to work towards achievement.

The objectives for ten pollutants (benzene, 1,3-butadiene, carbon monoxide, lead, nitrogen dioxide, sulphur dioxide particulates - PM_{10} and $PM_{2.5}$, ozone and PAHs - Polycyclic Aromatic Hydrocarbons) have been prescribed within the Air Quality Standards (Northern Ireland) Regulations 2007 which came into operation on 28th May 2007.

This assessment focuses on those pollutants included in Air Quality Regulations for the purpose of Local Air Quality Management, 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 UK Government and the devolved administrations have also set new national air quality objectives for $PM_{2.5}$. These objectives have not been incorporated into LAQM Regulations, and authorities have no statutory obligation to review and assess air quality against them.

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 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.

[3] 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

[4] 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

Table 2.1 – Air Quality Objectives included in the Air Quality Regulations for the purpose of Local Air Quality Management in Northern Ireland

Pollutant	Objective	Concentration measured as	Date to be achieved by and maintained thereafter
Benzene	16.25 µg/m^3	running annual mean	31.12.2003
	3.25 µg/m^3	running annual mean	31.12.2010
1,3 Butadiene	2.25 µg/m^3	running annual mean	31.12.2003
Carbon monoxide	10.0 µg/m^3	maximum daily running 8-hour mean	31.12.2003
Lead	0.5 µg/m^3	annual mean	31.12.2004
	0.25 µg/m^3	annual mean	31.12.2008
Nitrogen dioxide [a]	200 µg/m^3, not to be exceeded more than 18 times a year	hourly mean	31.12.2005
	40 µg/m^3	annual mean	31.12.2005
Particles (PM_{10}) (gravimetric) [b]	50 µg/m^3, not to be exceeded more than 35 times a year	24 hour mean	31.12.2004
	40 µg/m^3	annual mean	31.12.2004
Sulphur dioxide	350 µg/m^3 not to be exceeded more than 24 times a year	1 hour mean	31.12.2004
	125 µg/m^3 not to be exceeded more than 3 times a year	24 hour mean	31.12.2004
	266 µg/m^3 not to be exceeded more than 35 times a year	15 minute mean	31.12.2005

a EU Limit values in respect of nitrogen dioxide to be achieved by 1st January 2010. There are, in addition, separate EU limit values for carbon monoxide, sulphur dioxide, lead and PM_{10}, to be achieved by 2005, and benzene by 2010.

b Measured using the European gravimetric transfer sampler or equivalent.

2.3 Local Air Quality Management (LAQM) Review and Assessment

Part III of the Environment (Northern Ireland) Order 2002[5] places a statutory duty on local authorities to periodically review and assess the air quality within their area. This involves consideration of present and likely future air quality against air quality objectives, established for the protection of human health, set out in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland (AQS) [6]. 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.

[5] S.I. 2002/3153

[6] 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

The UK Government and devolved administrations publish policy and technical guidance related to the review and assessment processes and the latest documents include Policy Guidance (LAQM.PG (09))[7] and Technical Guidance (LAQM.TG (09))[8]. The guidance lays down a progressive, but continuous, framework for 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.

2.4 Summary of Review and Assessment in Newry and Mourne

The First Round involved the assessment of the sources of seven air pollutants of concern to health: benzene, 1,3-butadiene, carbon monoxide, lead, nitrogen dioxide (NO_2), fine particulates (PM_{10}) and sulphur dioxide, and predicted concentrations were compared with UK air quality objectives. Newry and Mourne District Council's second stage review and assessment (completed in August 2004) met the criteria of the Updating and Screening Assessment (USA). The USA identified potential exceedences of the NO_2 and PM_{10} AQS objectives in the vicinity of several roads in Newry City centre. As such, a detailed assessment was undertaken to further assess air quality in the vicinity of these roads.

The Detailed Assessment was completed in April 2005 and concluded that there was a risk of exceeding the air quality objectives for NO_2 and PM_{10} in Newry. Newry and Mourne District Council declared five AQMAs for the annual mean NO_2 objective and the 24-hour PM_{10} objective which came into operation on 11th April 2006. These five areas were named as:

- Newry (Canal Street) Air Quality Management Order 2006
- Newry (Water Street) Air Quality Management Order 2006
- Newry (Bridge Street) Air Quality Management Order 2006
- Newry (St Mary Street) Air Quality Management Order 2006
- Newry (Kilmorey Street) Air Quality Management Order 2006

As part of the Councils second USA (completed in October 2006), a three stage Review and Assessment of Air Quality was undertaken, including the five areas where AQMAs have been declared. The USA concluded that there was little likelihood of the air quality objectives for NO_2 and PM_{10} being exceeded outside the existing AQMAs.

In 2007, the Council completed a Further Assessment for the five AQMAs. The results showed that NO_2 annual average concentrations within the AQMA were still likely to exceed the AQS objective along Canal Street, Water Street and Kilmorey Street. It should be noted that the Further Assessment did not find that the NO_2 annual mean objective would be exceeded in two of the declared AQMAs, Bridge Street and St Mary Street. The Council decided to maintain these AQMAs until a further period of monitoring was completed which supported the AQMAs being revoked. Newry and Mourne District Council are currently drawing up their Air Quality Action Plan to set out measures which work towards improving air quality in the AQMAs.

[7] 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

[8] 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

2.5 Scope and Methodology of the Further Modelling Assessment

The aim of the further modelling is to provide Newry and Mourne District Council with an opportunity to supplement the information gathered in the previous LAQM reports and consider whether the AQMAs are still required or if they need to be amended (increased or reduced).

The methodology is based on dispersion modelling and includes the following:

- Review of additional monitoring since the previous Further Assessment – including continuous monitoring and diffusion tubes;
- Extension of the dispersion model to incorporate two new hotspots - Patrick Street and Sandy Street – as identified through monitoring data;
- Update of the dispersion model to incorporate the latest traffic count data available;
- Update of methodologies from LAQM.TG(03) to the latest guidance and tools from LAQM.TG(09);
- Consideration to scenario testing of Action Plan measures, where information has been available to provide quantification of expected emissions improvements.

Detailed dispersion modelling was carried out as part of the further modelling based on the ADMS-Roads (v2.3) atmospheric dispersion model. Monitoring results from nitrogen dioxide diffusion tube sites installed in the assessment areas were used to verify the modelled results. NO_x and NO_2 concentrations were predicted for the baseline (verification) year 2007, 2008, and future year 2010. The dispersion modelling was undertaken in accordance with the methodologies provided in the Technical Guidance (LAQM.TG(09)) Guidance for Detailed and Further Assessments.

3 Baseline Information

3.1 Air Quality Management Areas

Newry and Mourne District Council declared five AQMAs for the annual mean NO_2 objective and the 24-hour PM_{10} objective which came into operation on 11th April 2006. The five areas were:

- **Newry (Canal Street) Air Quality Management Order 2006**

  An area encompassing Canal Street between its junction with Chequer Hill; and Barrack Street to the north and Sugar Island to the south and including New Street to the east and adjacent land and properties. Canal Street is a narrow street which has a steep incline. The buildings on either side of the street form a canyon effect.

- **Newry (Water Street) Air Quality Management Order 2006**

  An area encompassing Water Street between its junction with Trevor Hill to the north and High Street to the south, including adjacent land and properties.

- **Newry (Bridge Street) Air Quality Management Order 2006**

  An area encompassing Bridge Street between its junction with William Street to the north and Dublin Road to the south, and also including Basin view Terrace up to the junction with Dublin Road including adjacent land and properties.

- **Newry (St Mary Street) Air Quality Management Order 2006**

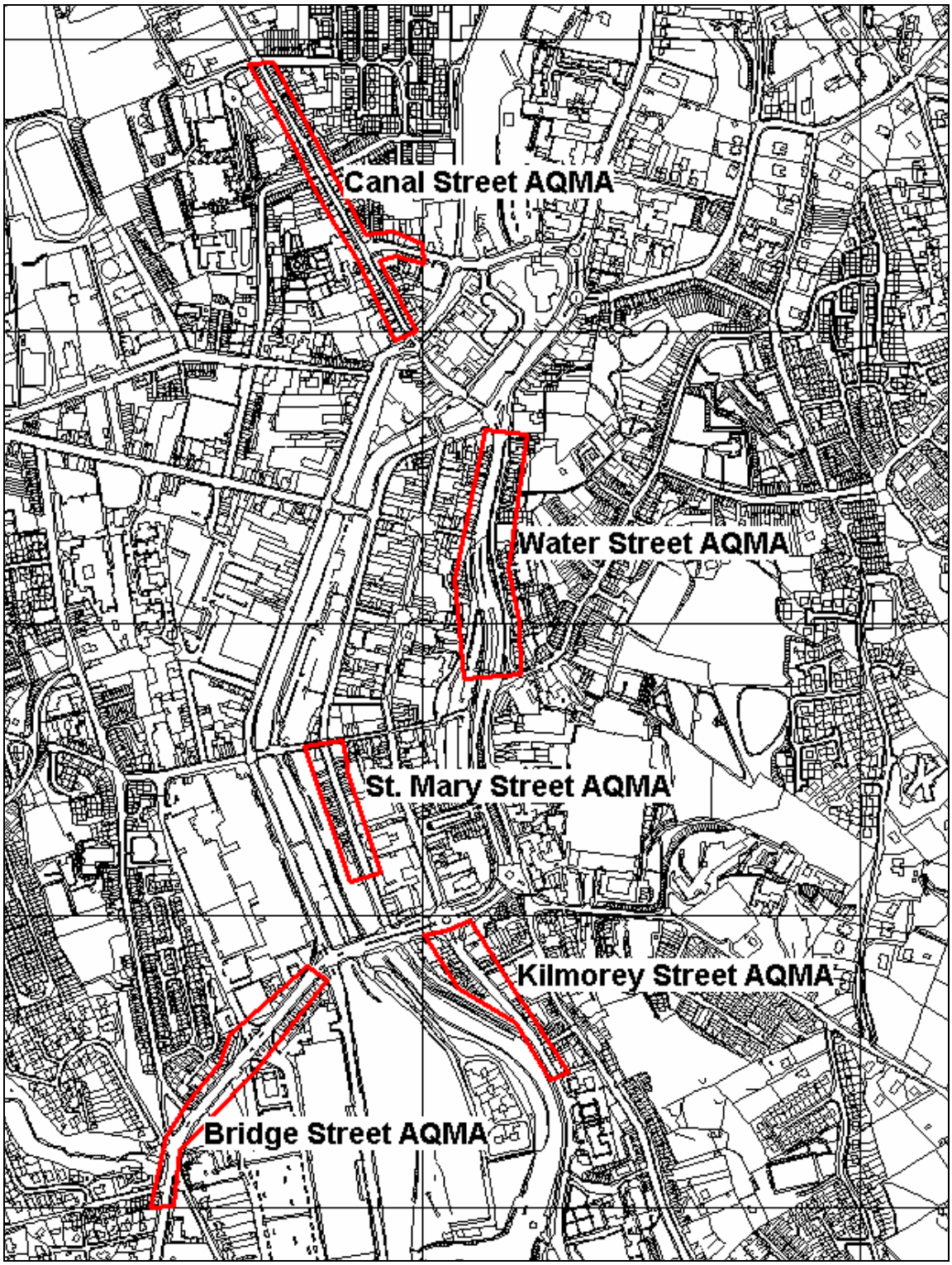
  An area encompassing St Mary Street between its junction with Mill Street to the north and William Street to the south, including adjacent land and properties.

- **Newry (Kilmorey Street) Air Quality Management Order 2006**

  An area encompassing Kilmorey Street between its junction with William Street to the north and Custom House Lane to the south, including adjacent land and properties.

The declared AQMAs are shown in Figure 3.1.

Figure 3.1 – Newry Air Quality Management Areas



3.2 Traffic Data

Newry and Mourne District Council provided updated traffic counts for the roads in the AQMAs and newly identified hotspots. Data included 2008 12-hour traffic counts, with breakdown of traffic flows into vehicle categories. The 12-hour counts were projected to a 24-hour count using automatic traffic count data to establish the factor for conversion of 12:24 hours[9]. Traffic data were projected to future years using traffic forecast of 2.0% per year[10].

Speed data were provided for the Further Assessment 2007 and have been incorporated into this assessment. For road links where speed data were unavailable, free flowing vehicle speeds have been assumed to be the speed limit. Speeds have been reduced near junctions to 20kph and along congested sections of the road by 10kph to account for stop/ start emissions. The traffic data used in this assessment are summarised in Appendix 1.

3.3 Air Quality Monitoring Data

3.3.1 Continuous Monitoring data

Newry and Mourne District Council currently operate three continuous monitoring stations in Newry City centre.

- Monaghan Row Background Site (PM_{10})
- Trevor Hill Roadside Site (NO_2, PM_{10})
- Bridge Street (AQMA) Roadside Site (NO_2, PM_{10})

NO_2 concentrations are measured using a chemiluminescent analyser and PM_{10} concentrations are monitored using a Tapered Element Oscillating Microbalance (TEOM). AEA ratify the data. Data from the TEOMs have been Volatile Correction model (VCM) corrected. The ratified results from the NO_2 and PM_{10} continuous monitoring for 2007 are shown in Table 3.1 and 3.2. There are exceedences of the annual mean NO_2 objective at the Trevor Hill Roadside site in 2007 and 2008. This site is outside an AQMA, but there is no relevant exposure. All other prescribed objectives are met at the continuous monitoring sites.

Table 3.1: Newry NO_2 continuous analyser concentrations (µg/m^3) in 2007 - 2008

Location	Description	2007	2008
Bridge Street Roadside (AQMA)	Annual Mean NO_2 > 40 µgm^3	27 µgm^3	24 µgm^3
	NO_2 Hourly Mean > 200 µgm^3 (18 times per year permitted)	0	0
	% Data Capture	99%	96%
Trevor Hill Roadside	Annual Mean NO_2 > 40 µgm^3	**41 µgm^3**	**46 µgm^3**
	NO_2 Hourly Mean > 200 µgm^3 (18 times per year permitted)	9	5
	% Data Capture	69%**	69%**

*Exceedences of prescribed objectives are highlighted in bold.
** Data capture below recommended 90%.

[9] 12:24 ratio provided from six automatic traffic count locations in the Newry area providing a factor of 1.29.

[10] Projected data trends provided by DoE for the Further Assessment 2007.

Table 3.2: Newry PM_{10} continuous analyser concentrations (µg/m^3) 2007 - 2008

Location	Description	2007 (Uncorrected)	2007 (VCM corrected)**	2008 (Uncorrected)	2008 (VCM corrected)***
Monaghan Row Background	Annual Mean PM_{10} > 40 µgm^3	15 µgm^3	14 µgm^3	18 µgm^3	18 µgm^3
	24-Hour Mean > 50 µgm^3 (35 times per year permitted)	1	4	12	13
	% Data Capture	96%	76%	73%	72%
Bridge Street Roadside (AQMA)	Annual Mean PM_{10} > 40 µgm^3	21 µgm^3	21 µgm^3	29 µgm^3	28 µgm^3
	24-Hour Mean > 50 µgm^3 (35 times per year permitted)	8	9	17	18
	% Data Capture	94%	75%	42%	42%
Trevor Hill Roadside	Annual Mean PM_{10} > 40 µgm^3	23 µgm^3	22 µgm^3	26 µgm^3	26 µgm^3
	24-Hour Mean > 50 µgm^3 (35 times per year permitted)	4	6	12	11
	% Data Capture	92%	76%	55%	55%

*Exceedences are highlighted in bold.
** Data from FDMS for VCM correction is not available for first 3 months of 2007, resulting in reduced data capture.
***Sites have been upgraded to TEOM FDMS from end March 2008; all other dates have been VCM corrected to gravimetric equivalent.

3.3.2 Nitrogen Dioxide Diffusion Tube data

In addition to the continuous monitoring network, Newry and Mourne District Council currently operate 33 NO_2 diffusion tubes sites within the District. The 2006 – 2008 results are shown in Table 3.3. The 2006 and 2007 tubes are prepared and analysed by Harwell Scientific using the 50% TEA[11] in acetone method. The 2008 tubes are prepared and analysed by Gradko also using the 50% TEA in acetone method. The laboratory methods are currently UKAS accredited.

To take account of the bias in the diffusion tubes analysed by Harwell Scientific, in the absence of a local co-location study with sufficient data capture, the bias adjustment factors have been derived from the Review and Assessment Helpdesk co-location studies[12]. The bias adjustment factor for Harwell 50% TEA in Acetate is 0.79 in 2006 based on 13 studies. The bias adjustment factor for Harwell 50% TEA in Acetate is 0.817 in 2007 based on 18 studies. For 2008 data, the local co-location study at Bridge Street Roadside site has been used to derive a bias adjustment factor of 0.81. The bias adjustment calculation is shown in Appendix 2.

[11] TEA = triethanolamine

[12] http://www.uwe.ac.uk/aqm/review/mguidance.html

Table 3.3 - Diffusion Tube Results in Newry 2006 -2008

AQMA	LOCATION	X	Y	2006 Annual Mean	No. Months	2007 Annual Mean	No. Months	2008 Annual Mean	No. Months
Canal Street AQMA				Bias=0.79		Bias=0.817		Bias=0.81	
	Lower Canal Street	308466	327000	**43**	12	**41**	12	34	9
	Canal Street (Pub)	308485	326976	**52**	12	**60**	12	**49**	12
	Catherine Street	308454	327008	31	4	**43**	12	36	12
	Erskine Street	308525	327043	25	4	25	5	20	11
	Barrack Street	308378	327178	33	4	33	11	27	12
	Convent 1	308487	326959	-	-	37	7	**58**	7
	Catherine Street 2	-	-	-	-	31	7	-	-
	Convent 2	308488	326957	-	-	-	-	22	5
	Canal St Building Site	308485	326976	-	-	-	-	25	7
	New Street	-	-	**44**	8	-	-	-	-
Water Street AQMA	North Street	308714	326608	33	11	34	11	27	11
	High Street	308805	326378	32	12	31	12	25	12
	Water Street	308688	326593	**45**	12	**46**	12	**40**	12
	Lower Water Street	308659	326485	28	12	28	10	22	12
	Trevor Hill 1,2,3	308700	326718	39	10	**41**	11	33	12
Kilmorey Street AQMA	33 Kilmorey Street	308668	325918	**52**	12	**52**	12	**43**	12
	52 Kilmorey Street	308727	325869	**43**	12	**48**	12	39	12
	River Street	308673	325884	22	4	29	12	26	12
Bridge Street AQMA	Basin View Terrace	308239	325607	35	12	33	11	32	11
	18 Bridge Street	308419	325868	37	12	36	12	-	-
	60 Bridge Street	308325	325792	30	11	30	9	-	-
	4 Bridge Street	308443	325896	-	-	-	-	31	12
	Bridge Street 1,2,3	308336	325770	-	-	-	-	24	12

* Annualised results where data is <9 months is based on Belfast and Derry background sites with >90% data capture

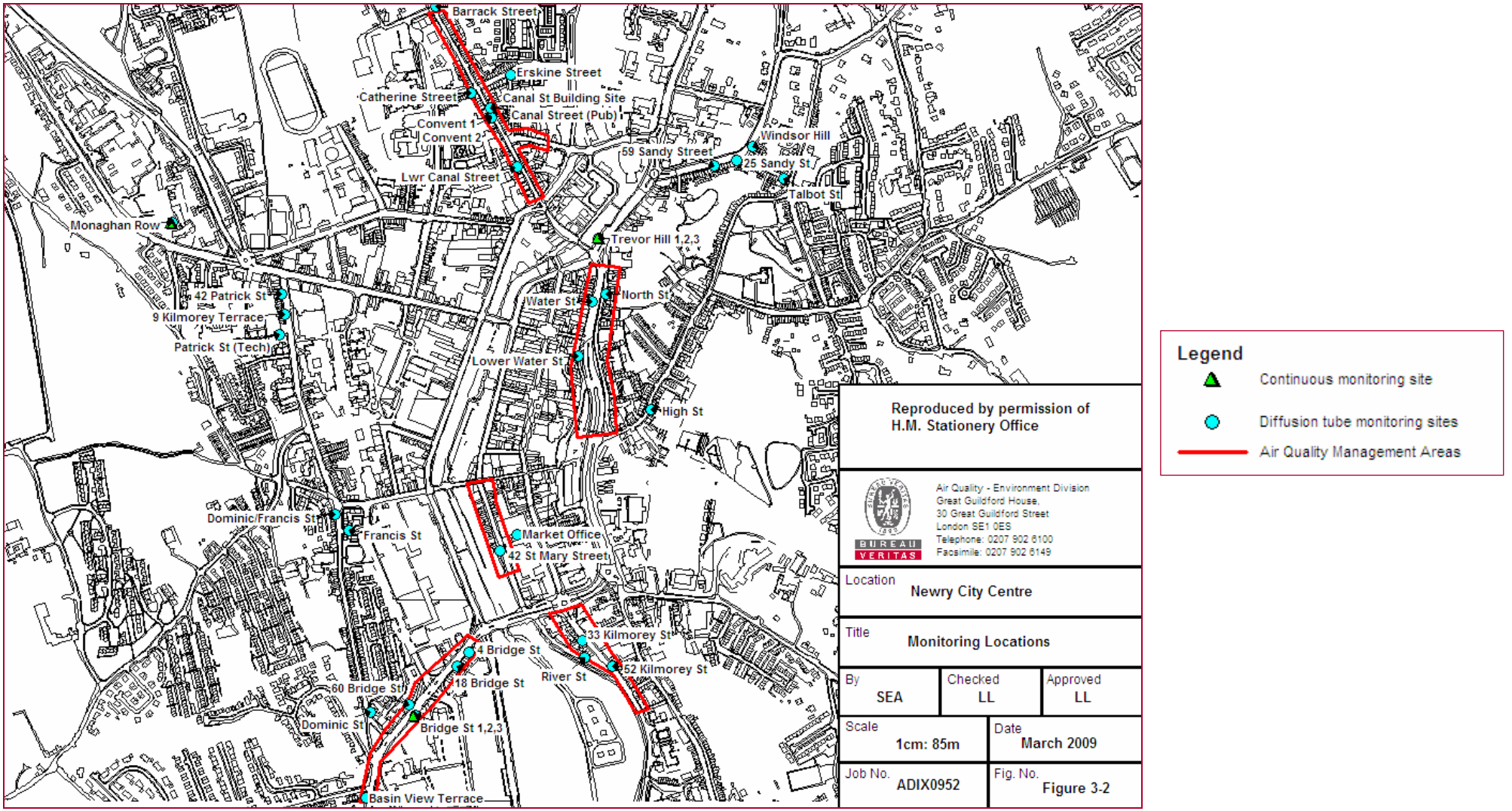
In bold, exceedence of the NO_2 annual mean AQS objective (40 µg/m^3)

Table 3.3 (Continued) - Diffusion Tube Results in Newry 2006 - 2008

AQMA	LOCATION	X	Y	2006 Annual Mean	No. Months	2007 Annual Mean	No. Months	2008 Annual Mean	No. Months
St Mary Street AQMA	42 St Mary Street	308505	326097	29	12	29	12	23	12
	18 St Mary Street	-	-	32	6	-	-	-	-
Dominic St / Patrick St Area	Dominic Street	308248	325776	23	4	29	11	23	12
	Dominic/Francis Street	308177	326170	31	11	31	12	29	12
	Francis Street	308205	326138	33	4	39	12	32	12
	42 Patrick Street	308072	326608	**43**	10	**48**	11	35	12
	Patrick Street (Tech)	308067	326527	21	4	25	11	21	12
	9 Kilmorey Terrace	308078	326567	-	-	-		25	5
Sandy Street Area	25 Sandy Street	308973	326873	**42**	4	**49**	12	**41**	11
	59 Sandy Street	308929	326861	**47**	12	**45**	12	**56**	10
	Talbot Street	309067	326836	28	4	29	12	30	7
	Glinn Ree Court	-	-	31	12	34	12	-	-
	Windsor Hill	309006	326900	-	-	-		25	5
Background	Monaghan Row	307855	326749	14	12	13	11	13	12
	Market Office	308539	326129	-	-	22	7	18	12
	Balmoral Park	-	-	33	10	19	5	-	-
	Hill Street	-	-	-	-	24	7	-	-
	Abbey Yard	-	-	30	8	30	7	-	-
	Dublin Road	-	-	27	8	-	-	-	-
	Fairlawn's Way	-	-	22	8	-	-	-	-
	Derrybeg Villas	-	-	32	8	-	-	-	-
	Rathfriland Road	-	-	35	7	-	-	-	-
	Edward Street	-	-	31	8	-	-	-	-
	Armagh Road	-	-	22	8	-	-	-	-

* Annualised results where data capture is <9 months is based on Belfast and Derry background sites with >90% data capture
In bold, exceedence of the NO_2 annual mean AQS objective (40 µg/m^3)

Figure 3.2 – Newry Monitoring Sites



3.3.3 Background Concentrations

Local monitoring data and LAQM.TG (09) updated background maps were considered in determining appropriate background for this assessment. NO_2 concentrations from the background maps for year 2007 are approximately 8 - 10µg/m^3 within the Newry area. However, this is likely to be under estimated, as the NO_2 annual mean at the nearest background diffusion tube monitoring site in Newry on Monaghan Row was 13.4µg/m^3 in 2007 and 13.0 µg/m^3 in 2008. To avoid underestimations in background, the results from the nearest monitoring site were therefore used in the model assessment to derive background NO_2 and NO_X. Background NO_x and NO_2 concentrations for future years were derived from the projection factors from the background maps provided through the Air Quality Archive website[13]. For PM_{10}, the continuous monitoring results from the Monaghan Row background site were used.

Table 3.4 - Background Concentrations for Newry (µg/m^3)

Pollutant	2007 Background (µg/m^3)	2008 Background (µg/m^3)	2010 Background (µg/m^3)*
NO_x	17.9	17.4	14.9
NO_2	13.4	13.0	11.6
PM_{10}	14.1	13.9	13.6

* Projected from 2007.

[13] http://www.airquality.co.uk/archive/index.php

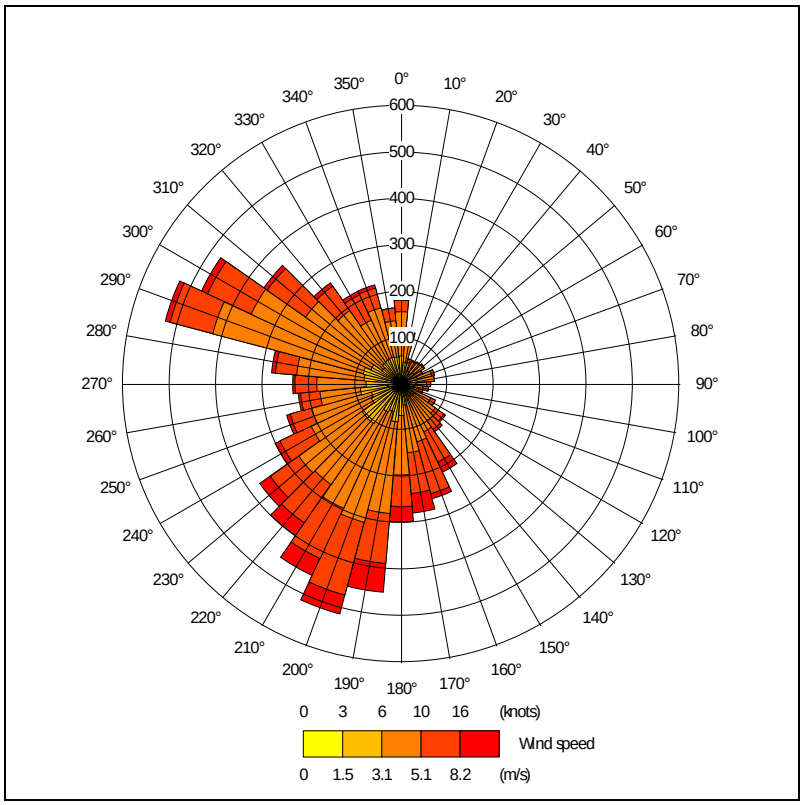
4 Dispersion Modelling Methodology

Detailed dispersion modelling of NO_x was undertaken based on ADMS-Roads (version 2.3) atmospheric dispersion model from Cambridge Environmental Research Consultants (CERC). Conversion to NO_2 was based on the updated NO_X/NO_2 conversion model released in February 2009 as part of LAQM.TG(09) tools.

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. The street canyon option was activated for sections of Newry modelled where properties on both side are close to the road: Canal Street, Kilmorey Street, St Mary's Street, Water Street and Bridge Street AQMAs, and Patrick Street (north section at junction with Monaghan Street.

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 from the closest Met Office station (Glenanne) was used in this assessment, based on the year 2007. The wind rose for meteorological data is shown in Figure 4.1 and shows the dominant south-westerly prevailing wind direction.

Figure 4.1 – Glenanne 2007 Hourly Sequential Meteorological Data



5 Results

5.1 Model Verification and adjustment

Model verification at specific locations was carried out prior to predicting concentrations within the AQMAs and new hotspots (Patrick Street and Sandy Street) through contour mapping. 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

The Further Assessment 2007 indicated that the model was under-predicting when compared with 2005 monitored results at a number of locations, notably Kilmorey Street, Water Street and Canal Street. In the Further Assessment, half of the diffusion tube monitoring locations used for model verification, predicted concentrations that differed by 25% or more. In addition, the average difference between modelled and monitored data at the diffusion tube locations was -31% i.e. there was a significant under-prediction in the modelling.

The model has been updated to include new traffic data and verified on 2007 monitoring results. These updates have improved the model performance and provided greater certainty in the modelled results, as demonstrated in the sections below.

5.1.1 Nitrogen dioxide

Comparison of the modelled and monitored results for NO_2 was carried out based on local monitoring data from diffusion tubes in Newry and Bridge Street continuous monitoring station. Predicted NO_2 was derived based on the latest NO_x/NO_2 conversion model released in February 2009[14].

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).

The above factors were all investigated as part of the model verification process to minimise the uncertainties as far as practicable. Street canyon width was adjusted to make sure that the diffusion tubes at façade of properties were effectively within street canyons.

The model verification results are provided in Table 5.1.

Overall, predicted concentrations are in reasonably good agreement with monitoring data, as all adjusted modelled NO_2 results are within ±25% of monitored concentrations, with the exception of Bridge Street continuous analyser (model is over-predicting by >25%). Fourteen out of the twenty-one monitoring sites used for verification are within ±10%. The model correctly predicts exceedences of the objective at sites where monitored exceedences are occurring.

[14] http://www.airquality.co.uk/archive/laqm/tools.php

Table 5.1 – Model verification results at NO_2 monitoring sites in Newry

Site	Within AQMA (yes/no)	Monitored NO_2 2007 ($\mu g/m^3$)	Predicted Total NO_2 2007($\mu g/m^3$)	Difference predicted / monitored 2007 ($\mu g/m^3$)	Difference predicted / monitored 2007 (%)
Barrack Street	Yes	32.5	**40.7**	8.1	25.0
Canal St (Pub)	Yes	**59.9**	**57.6**	-2.2	-3.7
Lower Canal Street	Yes	**40.9**	**40.1**	-0.9	-2.1
Bridge Street continuous	Yes	27.0	34.2	7.2	26.5
18 Bridge Street	Yes	36.4	35.1	-1.3	-3.4
60 Bridge Street	Yes	30.4	26.2	-4.2	-13.8
Basin View Terrace	Yes	32.7	26.9	-5.8	-17.6
Trevor Hill	No	**41.3**	**49.6**	8.3	20.1
Lower Water Street	Yes	27.9	30.2	2.3	8.6
Water Street	Yes	**46.4**	**45.7**	-0.7	-1.5
River Street	Yes	29.3	27.2	-2.1	-7.2
52 Kilmorey Street	Yes	**47.8**	**46.7**	-1.1	-2.4
33 Kilmorey Street	Yes	**51.5**	**52.6**	1.1	2.2
St Mary's Street	Yes	28.8	28.8	0.0	0
Dominic/ Francis Street	No	31.3	27.8	-3.5	-11.4
Francis Street	No	39.5	34.3	-5.2	-13.2
Dominic Street	No	29.2	32.0	2.8	9.5
Patrick Street (Tech)	No	24.5	24.4	-0.1	-0.3
42 Patrick Street	No	**47.7**	**49.5**	1.8	3.9
25 Sandy Street	No	**49.4**	**46.2**	-3.2	-6.6
59 Sandy Street	No	**45.0**	**48.1**	3.1	6.9
Summary					
Number of sites	Within ±10%			14	
	Between ± 10-25%			6	
	Exceeds ±25%			1	
	Total			21	

In bold: exceedence of NO_2 annual mean AQS objective
* Monitored results in 2008 were 36 $\mu g/m^3$ at Catherine Street, showing better agreement at this site with the model predictions

5.1.2 PM_{10}

Comparison of the modelled and monitored results for PM_{10} was carried out based on local monitoring data from the Bridge Street and Trevor Hill continuous monitoring stations. The road emissions contribution has been adjusted to take into account measured roadside concentrations of PM_{10} from the exhaust and other factors such as brake / clutch dust, tyre and road wear and resuspension. Overall, predicted concentrations are in reasonably good agreement with monitoring data, as all adjusted modelled PM_{10} results are within +/-12% of monitored concentrations.

The full verification methodology is shown in Appendix 3.

5.2 Modelled Results

Annual average NO_2 concentrations and 24-hour PM_{10} concentrations were predicted for the baseline year 2007, 2008 and 2010 at a number of specific receptors representing relevant public exposure, located at the facade of properties. These results are shown in Appendix 4 and Appendix 5. Additionally, predictions were made to a 5m-grid spacing across the assessment areas to produce pollutant concentration contour maps for the baseline year 2007 (see Appendix 6). Model results were predicted at 1.5m from the ground to represent relevant exposure.

5.2.1 NO_2 Modelled Concentrations

The model predicts exceedences of the annual mean NO_2 objective in 2007 and 2008 at receptors relevant of public exposure (facade of properties), within three AQMAs: Canal Street, Water Street and Kilmorey Street. There are also predicted exceedences of the annual mean objective at receptor locations along Patrick Street (near the junction with Monaghan Street) and Sandy Street (near the junction with Trevor Hill). Concentrations are not predicted to exceed the objective at receptors in the St Mary's Street and Bridge Street AQMAs. This is consistent with monitoring results for 2007 and 2008.

Predicted results for the year 2010 show a slight decrease on 2007 and 2008 concentrations. This is due to the predicted reduction in background pollution and improvements in vehicle emissions that compensate expected traffic growth. Nevertheless, the objective is still likely to be exceeded by this date within the Canal Street, Water Street and Kilmorey Street AQMAs, in addition to the two new hotspot areas modelled Patrick Street and Sandy Street.

Nitrogen dioxide also has an hourly objective of 200 µg/m^3 not to be exceeded more than 18 times in one year. The hourly mean concentration is not calculated directly by the ADMS-Roads model. However, research[15] has indicated that the hourly NO_2 objective is unlikely to be exceeded at a roadside location where the annual mean NO_2 concentration is less than 60µg/m^3. The model predictions in Canal Street indicate concentrations above 60µg/m^3. Monitoring data in 2006 - 2008 in Canal Street shows concentrations are up to 60 µg/m^3, but have not been recorded above this. It is likely that the model is over-predicting at a number of locations in this assessment area. Given measured concentrations in 2006 - 2008 are below this, the short-term AQS NO_2 objective at these locations is unlikely to be exceeded at present.

5.2.2 PM_{10} Modelled Concentrations

The model results show no predicted exceedences of the annual mean PM_{10} objective of 40µg/m^3 in 2007, 2008 and 2010 at all receptors modelled in the AQMAs and new hotspot areas modelled. A maximum annual mean concentration of 30µg/m^3 is predicted in the Water Street AQMA.

The model predicts no exceedences of the 24-hour mean PM_{10} objective in 2007 at receptors relevant of public exposure (facade of properties) in all areas assessed. The 24-hour mean objective is also predicted to be met at all locations modelled in 2008 and 2010.

5.3 Scenario Testing

Three AQMAs are predicted to exceed the annual mean NO_2 objective: Canal Street AQMA, Water Street AQMA and Kilmorey Street AQMA. Scenarios 1-3 focus on consideration to these three areas and likely impacts on NO_2 levels. Scenario 4 focuses on impacts of energy efficiency measures to reduce overall background concentrations.

[15] AEAT (May 2008) Analysis of the relationship between annual mean nitrogen dioxide concentration and exceedences of the 1-hour mean AQS Objective. A report produced for the Department for Environment, Food and Rural Affairs, the Scottish Government, the Welsh Assembly Government and the Department of the Environment in Northern Ireland.

5.3.1 Scenario 1: Predicted results using 2008 monitoring data for model verification to show the influence of annual variations in pollutant concentrations

The dispersion modelling undertaken in this report has been verified using 2007 monitoring data for the baseline year of the model 2007. Annual mean pollutant concentrations will vary from year in the AQMAs due to a number of factors, which may include changes to pollution sources in the local area in addition to factors outside the influence of the local authority such as regional transboundary pollution issues and variations in weather conditions. The latter can have a significant influence on pollutant concentrations. To examine the influence of these annual variations in pollutant concentrations, the model results for the three AQMAs where exceedences of the annual mean NO_2 objective were predicted – Canal Street, Water Street and Kilmorey Street – have been re-verified using 2008 monitoring data. The 2008 monitored results were lower than in 2007 and thus verified modelled results are lower by 12 – 16%, as presented below.

Model verification undertaken for the three AQMAs using 2008 monitoring data; indicate predicted concentrations are in reasonably good agreement with monitoring data, with all adjusted modelled NO_2 results within ±25% of monitored concentrations. Six out of the nine monitoring sites used for verification are within ±10%, three within ±10 – 25%.

Table 5.2 – Comparison of model verification using 2007 and 2008 monitored data

AQMA	Concentrations at receptors	Predicted Annual Mean NO_2 2008 using 2007 data (µg/m^3)	Predicted NO_2 2008 using 2008 data (µg/m^3)	Difference 2007 verification/ 2008 verification (µg/m^3)	Difference 2007 verification/ 2008 verification (%)
Canal Street	Average	**50**	**42**	-8	-16
	Maximum	**66**	**55**	-11	-17
Water Street	Average	**45**	38	-7	-16
	Maximum	**56**	**48**	-8	-14
Kilmorey Street	Average	39	34	-5	-13
	Maximum	**60**	**53**	-7	-12

*Exceedences of the annual mean objective are shown in bold.

The results indicate that there is significant variability in the concentrations in the AQMAs from year to year. While there are exceedences in the three AQMAs under both scenarios, consideration to 2008 monitoring data for verification shows the reduction required to meet the objective is much lower. This has implications in terms of future consideration of when prescribed objectives are being met and when it will be appropriate to revoke the AQMAs. It is expected that local authorities will need to consider measurements carried out over several years or more to take account of variable weather conditions, as well as the national trends in emissions, and local factors that may affect the AQMAs, including measures introduced as part of the Action Plan.

5.3.2 Scenario 2: Effect of reduction of Heavy Duty Vehicles (HDVs) in each area (50%, 75% and 90% reduction)

Article 22 of the Road Traffic (NI) Order 1981 provided Department of Regional Development Road Service with powers to make Traffic Regulations Orders (TRO's). TRO's can prohibit, restrict or regulate traffic or particular types of vehicle on any part of a road, a single road, or a number of roads and may be in force for a specified time period or permanently. These powers remain within the Road Traffic Regulations (NI) Order 1997. The Environment (NI) Order 2002 authorises the Department of Regional Development to make TRO's in pursuit of air quality objectives.

In 1992, Road Service made the Traffic Weight Restriction (Newry) Order (NI) 1992, which prohibited vehicles exceeding 7.5 tonnes maximum gross weight in Canal Street. Canal Street is one of the AQMAs where exceedences of the annual mean NO_2 have been predicted in this assessment. Action 5 of the Newry Air Quality Action Plan 2009 refers to review of signage in Canal Street to ensure it is adequate with respect to the weight restrictions and to raise awareness of the TRO among motorists.

Residents of Canal Street have expressed their concern that vehicles exceeding the 7.5 tonne limit that do not fall within the exempt category are using Canal Street.

Scenario 2 therefore considers the implications of enforcing the TRO in Canal Street. In addition, consideration has been made to reductions in HDV movements in Water Street and Kilmorey Street AQMAs as may be achievable through construction of the proposed Southern Relief Road. If this scheme is implemented, it is expected that a large proportion of HDVs would be diverted to the Southern Relief Road instead of passing through Water Street and Kilmorey Street. Three scenarios have been considered: reduction of heavy-duty vehicles in the AQMAs by 50%, 75% and 90%. The results are shown in the table below. It should be noted that HDVs contribute disproportionately to pollutant emissions (The Further Assessment 2007 source apportionment indicated HDV contributed 20 – 40% to total NO_X emissions despite being only a relatively small fraction of the vehicle fleet) and therefore targeting these vehicle types can have significant results. Under the 90% HDV reduction scenario, such as may be achievable if access for HDVs was restricted to delivery vehicles only within the AQMAs, the reduction in NO_2 concentrations could result in the annual mean objective being met in two of the AQMAs, Water Street and Kilmorey Street. In Canal Street, the area of exceedence would be substantially reduced.

Table 5.3 – Impact assessment of reductions in Heavy Duty Vehicles in the AQMAs

AQMA	Concentrations at receptors	Predicted Annual Mean NO_2 2007 ($\mu g/m^3$)	Predicted Annual Mean NO_2 2007 ($\mu g/m^3$) with 50% HDV reduction	Predicted Annual Mean NO_2 2007 ($\mu g/m^3$) with 75% HDV reduction	Predicted Annual Mean NO_2 2007 ($\mu g/m^3$) with 90% HDV reduction
Canal Street	Average	**52**	**46**	**43**	**41**
	Maximum	**67**	**60**	**56**	**53**
Water Street	Average	**46**	37	32	28
	Maximum	**57**	**46**	39	34
Kilmorey Street	Average	**40**	33	29	26
	Maximum	**61**	**50**	**43**	38

*Exceedences of the annual mean objective are shown in bold.

5.3.3 Scenario 3: Effect of replacement of heating systems in Canal Street Redevelopment from oil/coal to natural gas

Within the Canal Street AQMA work carried out by the South Ulster Housing Association is nearing completion. This has involved the demolition of 38 old dwellings, the majority of these had open fires with some oil-fired systems, and the replacement of these with 44 new energy efficient homes, 29 using gas central heating boilers and 15 using oil fired boilers. Action 16 of the Newry Air Quality Action Plan is for 'Completion of final phase of Canal Street redevelopment by South Ulster Housing Association by May 2009.' Scenario 3 considers the benefits of the new heating systems to the Canal Street AQMA concentrations of NO_X and PM_{10}.

In 2009, in the Canal Street AQMA, the Northern Ireland 1 x 1km background data sets[16] show domestic emissions contribute 2µg/m^3 NO_X (18% of the total background NO_X) and 4.4µg/m^3 PM_{10} (26% of the total background PM_{10}). The improvement through replacement of heating systems will help reduce this background element. The results show the most significant reductions are achieved with respect to PM_{10} background concentrations.

[16] http://www.airquality.co.uk/archive/laqm/tools.php?tool=background06

Table 5.4 – Reduction in NO_X and PM_{10} emissions through improvements to domestic fuel emissions in the Canal Street Redevelopment

Fuel type	Annual Domestic Fuel Usage	Emission Rate NOx per household	Total Emission NOx per household (tonne)	Emission Rate PM_{10} per household (kilotonne)	Total Emission PM_{10} per household (tonne)
Solid Fuel	3.5 tonnes*	2.3 kilotonne/Mt***	0.00805 tonne	11 kilotonne/Mt***	0.0385
	0.0000035 Mt				
Oil	2194 Litres*	3.2 kilotonne/Mt***	0.0056 tonne	0.139 kilotonne/Mt***	0.000245
	1.76tonne				
	0.00000176 Mt				
Gas	17614 Kwh**	0.0073 kilotonne/Mth***	0.004387 tonne	0.0000528 kilotonne/Mth***	0.0000317
	601.01 therms				
	0.00060101 Mth				
Canal Street Redevelopment	**Total NO_X from domestic emissions (tonnes)**	**% Reduction in NO_X**	**Total PM_{10} from domestic emissions (tonnes)**	**% Reduction in PM_{10}**	
38 Homes solid fuel (previous fuel use)	0.3059	-30.7	1.463	-99.7	
29 homes with gas, 15 homes with oil (2009 fuel use)	0.2119		0.0046		

* Source: Determining the impact of domestic solid fuel burning on concentrations of PAHs and sulphur dioxide in Northern Ireland, Defra 2003
** Source: http://www.berr.gov.uk/files/file45735.xls
*** Source: http://www.naei.org.uk/emissions/selection.php

5.3.4 Scenario 4: Effect of NIHE Energy Efficiency Programme on background concentrations

From 2006 to the end of 2008 Northern Ireland Housing Executive (NIHE) carried out 89 heating system replacements to their housing stock. Fifty-two of these were gas installations and the remainder oil. By the end of 2010, NIHE plan to undertake a further 256 heating installation replacements to their housing stock in Newry City, but due to financial constraints completion is likely to be delayed until 2013. The majority of these are expected to be adaptations to gas systems.

Action 16 of the Newry Air Quality Action Plan is for 'Completion of NIHE programme for replacing solid fuel appliances and electric heating systems in their housing stock by 2013. Programme to include provision of solar panels for water heating where appropriate and increasing energy efficiency of the home.' Scenario 4 considers the potential benefits of the new heating systems to Newry City background concentrations of NO_X and PM_{10}. Emissions data have been utilised as shown in table 5.4 above.

In 2010, in Newry City, the Northern Ireland 1 x 1km background data sets[17] show domestic emissions contribute on average 1.35µg/m^3 NO_X (15% of the total background NO_X) and 3.1µg/m^3 PM_{10} (20% of the total background PM_{10}). The improvement through replacement of heating systems

[17] http://www.airquality.co.uk/archive/laqm/tools.php?tool=background06

will help reduce this background element. The results show the most significant reductions are achieved with respect to PM_{10} background concentrations.

Table 5.5 – Reduction in NO_X and PM_{10} emissions through NIHE programme improvements to domestic fuel emissions in Newry City

Newry City	Total NO_X from domestic emissions (tonnes)	% Reduction in NO_X	Total PM_{10} from domestic emissions (tonnes)	% Reduction in PM_{10}
256 homes solid fuel (current fuel use)	2.06	-45.5	9.86	-99.9
256 homes with gas (fuel use once completed)	1.12		0.00812	

6 Conclusions and Recommendations

As part of the Local Air Quality Management (LAQM) regime, a further modelling assessment was carried out for the five AQMAs declared in Newry for the annual mean NO_2 objective and the 24-hour PM_{10} objective, which came into operation on 11th April 2006. This included consideration to impact assessment of proposed action plan measures, where information was available to assess these. In addition, two new hotspot areas Patrick Street and Sandy Street were modelled to assess compliance with the prescribed objectives for NO_2 and PM_{10}.

This assessment was based on advanced atmospheric dispersion modelling of traffic emissions, relying on updated background pollutant concentrations, monitoring, traffic and meteorological data.

The findings of this report from the updated monitoring and modelled results are as follows:

- Exceedences of the annual mean NO_2 objective continue to be monitored and modelled within the Canal Street, Water Street and Kilmorey Street AQMAs and confirm the need for these declarations. The PM_{10} objectives are predicted to be met in these AQMAs in all years modelled.
- Bridge Street and St Mary's Street AQMAs meet the prescribed air quality objectives for both NO_2 and PM_{10}. Monitoring data for the last three years show compliance with the prescribed air quality objectives within these AQMA. It is recommended that the Council consider revocation of these AQMAs.
- The PM_{10} objectives are predicted to be met in all AQMAs. Monitoring data at roadside sites on Trevor Hill and Bridge Street (AQMA) show levels are well below the objectives. It is recommended that the Council consider amending the AQMA orders to reflect this.
- There is a risk of exceedences of the annual mean nitrogen dioxide objective outside of AQMA declarations in Sandy Street (near the junction with Trevor Hill) and, to a lesser extent, in Patrick Street (a small area near the junction with Monaghan Street). It is recommended that the Council consider declaration of these areas as AQMAs to incorporate areas of relevant exposure.

Appendix 1 – Traffic Data

Table A1-1 – Newry traffic data

Road Name	X	Y	%HDV	AADT 2007	AADT 2008	AADT 2010
Clanrye Avenue	307995	326714	3.7	3447	3516	3586
Upper Edward Street	308035	326685	3.1	8962	9141	9324
Monaghan Street	308039	326657	3.5	19165	19548	19939
Monaghan Row	307954	326676	1.9	8259	8424	8592
Camlough Road	307975	326705	4.5	13375	13642	13915
Canal Street @ Erskine Street	308459	327018	3.8	18302	18668	19041
Erskine Street	308475	327023	1.9	730	744	759
Catherine Street	308437	327012	1.4	7074	7216	7360
Canal Street (North of New Street)	308510	326926	3.8	17167	17510	17861
New Street @ Canal Street	308546	326916	3.6	15542	15853	16170
Canal Street (South of New Street)	308526	326899	2.6	6104	6226	6351
Downshire Road (North of New Street)	308821	326931	12.8	20624	21036	21457
Downshire Road (South of New Street)	308812	326891	11.8	24207	24691	25185
New Street @ Downshire Road	308778	326915	3.7	15670	15983	16303
Sandy Street	308849	326848	7.8	20431	20840	21257
Trevor Hill	308796	326825	9.7	30202	30806	31423
Abbey Way	308703	326639	10.5	23113	23575	24047
Sugar Island	308632	326731	2.8	10431	10640	10852
The Mall (North of Margaret Street)	308531	326535	2.6	4042	4123	4205
Margaret Street (East of The Mall)	308553	326544	2.0	2011	2052	2093
The Mall (South of Margaret Street)	308531	326535	2.5	2683	2736	2791
Margaret Street (West of The Mall)	308512	326554	1.5	5205	5309	5415
The Mall (North of Mill Street)	308465	326255	0.6	4707	4801	4897
Mill Street (East of The Mall)	308480	326238	0.8	2124	2167	2210
The Mall (South of Mill Street)	308468	326221	0.4	2692	2746	2800
Mill Street (West of The Mall)	308443	326231	0.6	5411	5519	5630
Abbey Way (North of High Street)	308692	326325	10.3	23587	24058	24539
High Street	308743	326332	1.3	5310	5416	5524
Abbey Way (South of High Street)	308685	326287	10.7	23067	23529	23999
Abbey Way @ Boat Street	308716	326083	10.5	23343	23810	24286
Boat Street	308745	326024	1.9	10093	10295	10501
William Street @ Boat Street	308704	326031	12.4	20080	20482	20892
William Street (East of Kilmorey Street)	308630	325994	14.3	21637	22070	22511
Kilmorey Street	308657	325944	12.1	17224	17569	17920
William Street (West of Kilmorey Street)	308564	325972	9.7	25688	26202	26726
Buttercrane Quay	308457	325977	5.1	13054	13315	13582
William Street @ Buttercrane Quay	308474	325941	6.1	24502	24992	25492
Fathom Line	308492	325860	6.0	7008	7149	7292
Bridge Street	308443	325911	5.6	16007	16327	16654
Dominic Street @ Bridge Street	308238	325795	2.2	4749	4844	4941
Bridge Street @ Drumalane Road	308284	325721	5.8	15823	16140	16462
Drumalane Road	308271	325629	3.4	2930	2988	3048
Dublin Road	308247	325605	5.8	15395	15703	16017
The Glen	308204	325616	1.5	1558	1589	1621
Patrick Street	308163	326237	2.4	12069	12310	12556
Francis Street	308216	326190	3.0	9782	9978	10178
Dominic Street	308184	326159	2.4	7914	8072	8234
Kiln Street	308141	326215	1.4	1096	1118	1140
Merchants Quay	308525	326720	3.4	10617	10830	11046

Appendix 2 – Bias Adjustment Calculation

Table A2-1 – Bias Adjustment Calculation (2008)

Bridge Street Roadside Site	
Bias factor A	0.81 (0.7 – 0.96)
Bias B	23% (4% - 42%)
Diffusion Tubes Mean:	31µg/m^3
Mean CV (Precision):	4
Automatic Mean:	25µg/m^3
Data Capture for periods used:	96%
Adjusted Tubes Mean:	25 (21 – 29) µg/m^3

Appendix 3 – Model Verification (2007)

Table A3-1 – Model verification NO_2- Canal Street

Site	Background NO_2 ($\mu g/m^3$)	Background NO_x ($\mu g/m^3$)	Monitored Total 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]
Barrack Street	13.4	17.9	64.5	46.6	22.1	2.10	3.3	72.7	90.6	40.7	32.5	25.0
59 Canal Street - now Canal St (Pub)			175.3	157.4	44.4	3.54		145.9	163.8	57.6	59.9	-3.7
Lower Canal St			91.5	73.6	21.5	3.42		70.6	88.5	40.1	40.9	-2.1

Table A3-2 – Model verification NO_2 – Bridge Street

Site	Background NO_2 ($\mu g/m^3$)	Background NO_x ($\mu g/m^3$)	Monitored Total 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]
Bridge Street 1	13.4	17.9	49.3	31.4	28.6	1.10	1.8	51.4	69.3	34.16	27.0	26.5
18 Bridge Street			76.1	58.2	30.2	1.93		54.4	72.3	35.13	36.4	-3.4
60 Bridge Street			58.4	40.5	16.3	2.48		29.4	47.3	26.21	30.4	-13.8
Basin View Terrace			64.9	47.0	17.3	2.71		31.2	49.1	26.92	32.7	-17.6

Table A3-3 – Model verification NO_2 - Water Street

Site	Background NO_2 ($\mu g/m^3$)	Background NO_x ($\mu g/m^3$)	Monitored Total 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]
Trevor Hill	13.4	17.9	92.88	75.0	57.8	1.30	1.9	107.9	125.8	49.63	41.3	20.1
Lower Water Street			51.50	33.6	21.5	1.56		40.1	58.0	30.24	27.9	8.6
Water Street			112.36	94.5	49.1	1.92		91.6	109.5	45.73	46.4	-1.5

Table A3-4 – Model verification NO_2 – Kilmorey Street

Site	Background NO_2 ($\mu g/m^3$)	Background NO_x ($\mu g/m^3$)	Monitored Total 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]
River Street	13.4	17.9	55.3	37.4	17.3	2.2	1.8	31.8	49.7	27.2	29.3	-7.2
52 Kilmorey Street			118.0	100.1	51.9	1.9		95.4	113.3	46.7	47.8	-2.4
33 Kilmorey Street			134.0	116.1	66.0	1.8		121.2	139.1	52.6	51.5	2.2

Table A3-5 – Model verification NO_2 – St Mary's Street

Site	Background NO_2 ($\mu g/m^3$)	Background NO_x ($\mu g/m^3$)	Monitored Total 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]
St Mary's Street	13.4	17.9	54.0	36.1	13.5	2.7	2.7	36.1	54.0	28.8	28.8	0

Table A3-6 – Model verification NO_2 – Patrick Street

Site	Background NO_2 ($\mu g/m^3$)	Background NO_x ($\mu g/m^3$)	Monitored Total 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]
Dominic/ Francis Street	13.4	17.9	61.0	43.1	9.8	4.41	3.4	33.3	51.2	27.8	31.3	-11.4
Francis Street			86.4	68.5	15.2	4.52		51.8	69.7	34.3	39.5	-13.2
Dominic Street			55.1	37.2	13.1	2.83		44.9	62.8	32.0	29.2	9.5
Patrick Street (Tech)			43.0	25.1	7.3	3.44		24.9	42.8	24.4	24.5	-0.3
42 Patrick Street			117.5	99.6	31.5	3.16		107.5	125.4	49.5	47.7	3.9

Table A3-7 – Model verification NO_2 – Sandy Street

Site	Background NO_2 ($\mu g/m^3$)	Background NO_x ($\mu g/m^3$)	Monitored Total 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]
25 Sandy Street	13.4	17.9	124.9	107.0	34.9	3.06	2.7	93.4	111.3	46.2	49.4	-6.6
59 Sandy Street			106.7	88.8	37.9	2.34		101.3	119.2	48.1	45.0	6.9

Table A3-8 – Model verification PM_{10}

Site	Background PM_{10} ($\mu g/m^3$)	Monitored Total PM_{10} ($\mu g/m^3$)	Monitored Road Contribution PM_{10} ($\mu g/m^3$)	Modelled Road Contribution PM_{10} ($\mu g/m^3$)	Ratio of Monitored Road PM_{10}/ Modelled Road PM_{10}	Adjustment Factor for Modelled Road Contribution	Adjusted Modelled Road Contribution PM_{10} ($\mu g/m^3$)	Modelled Total PM_{10} ($\mu g/m^3$)	% Difference PM_{10} [(Modelled - Monitored)/ Monitored]
Bridge Street Roadside site	14.1	20.7	6.6	1.0	6.4	5.1	5.3	19.4	-6.4
Trevor Hill Roadside site		21.9	7.8	2.0	3.8		10.4	24.5	11.8

Appendix 4 – Modelled Specific Receptor Results for Nitrogen dioxide

Figure A4-1 – Canal Street AQMA 2007

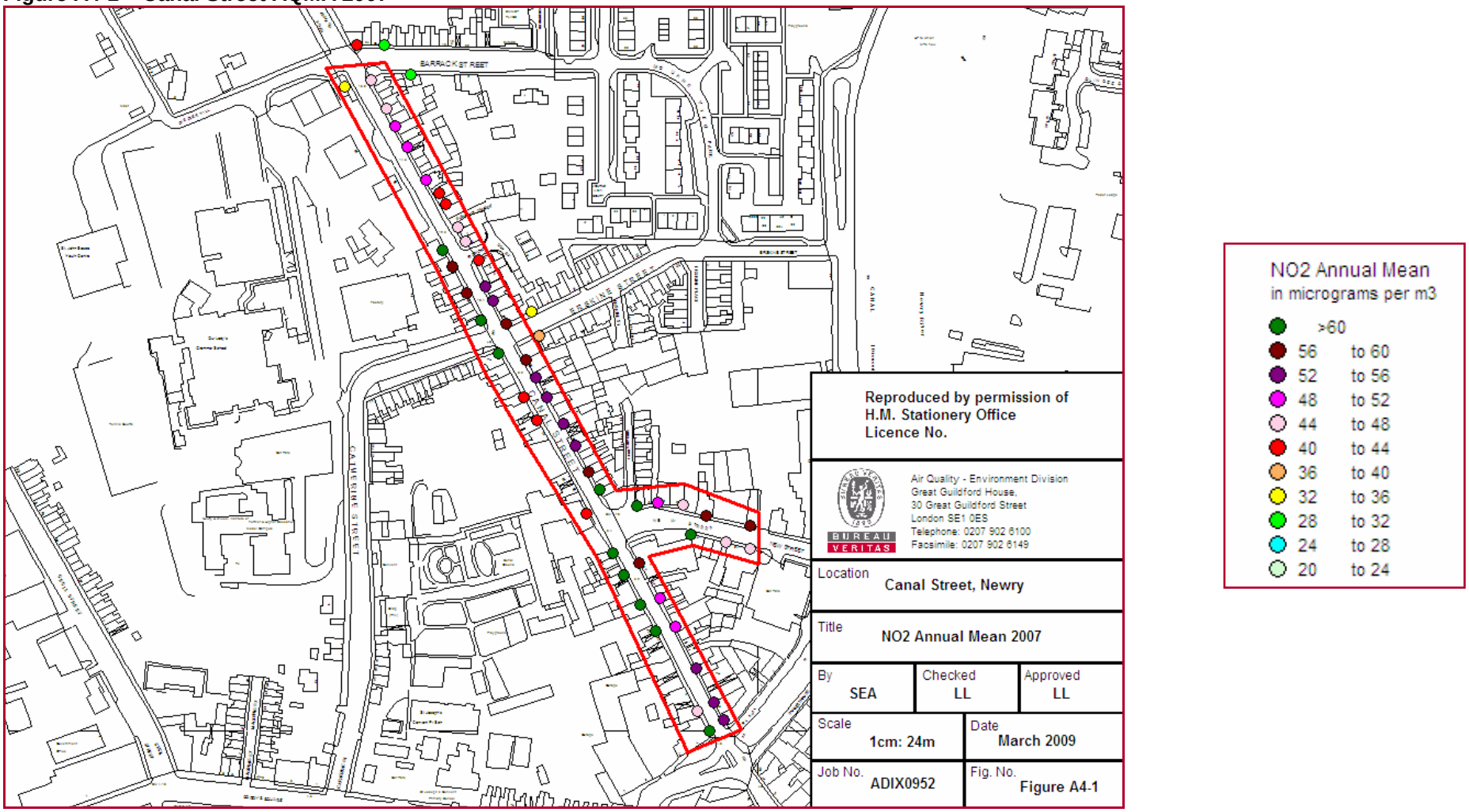


Figure A4-2 – Canal Street AQMA 2008

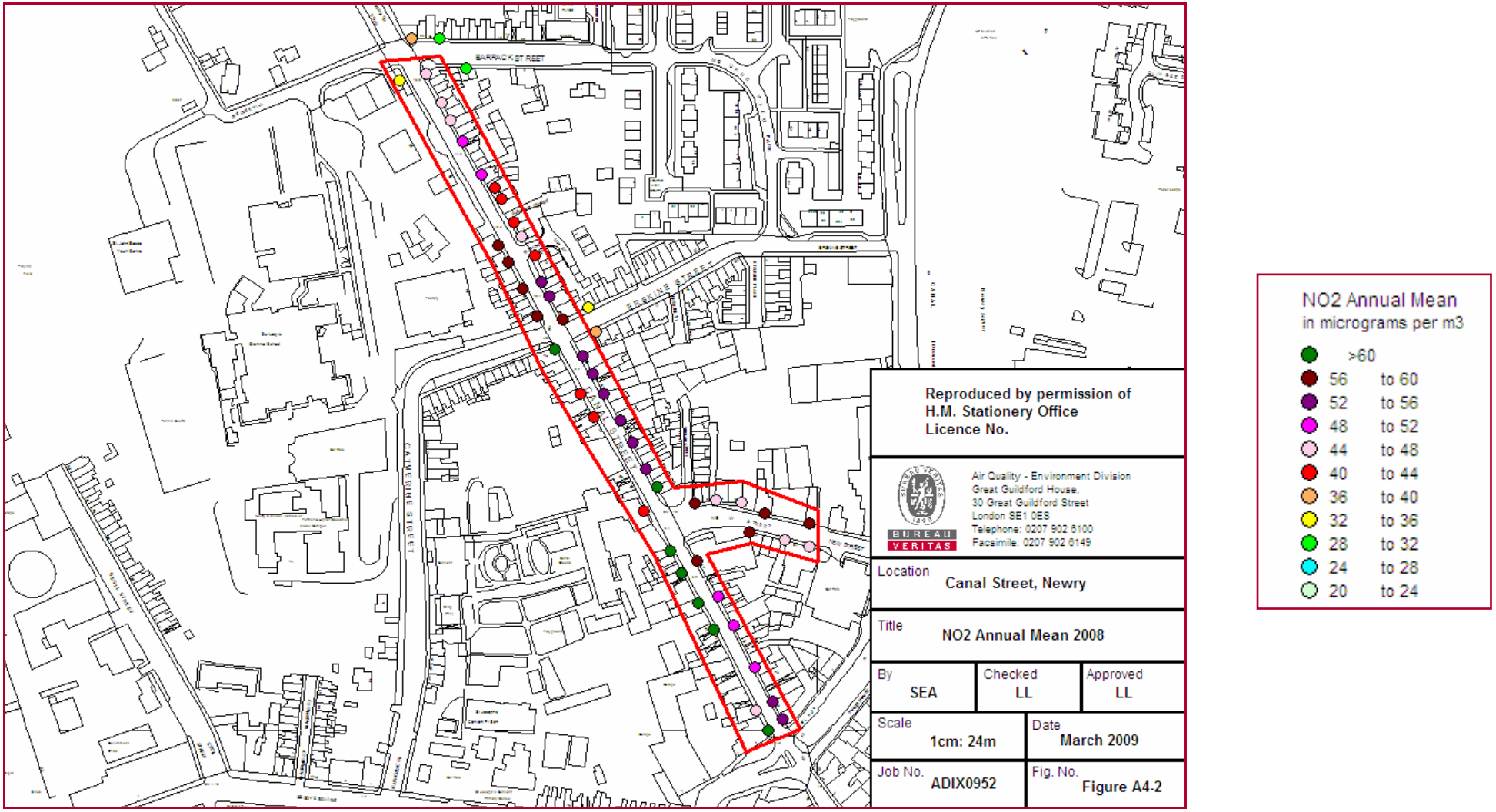


Figure A4-3 – Canal Street AQMA 2010

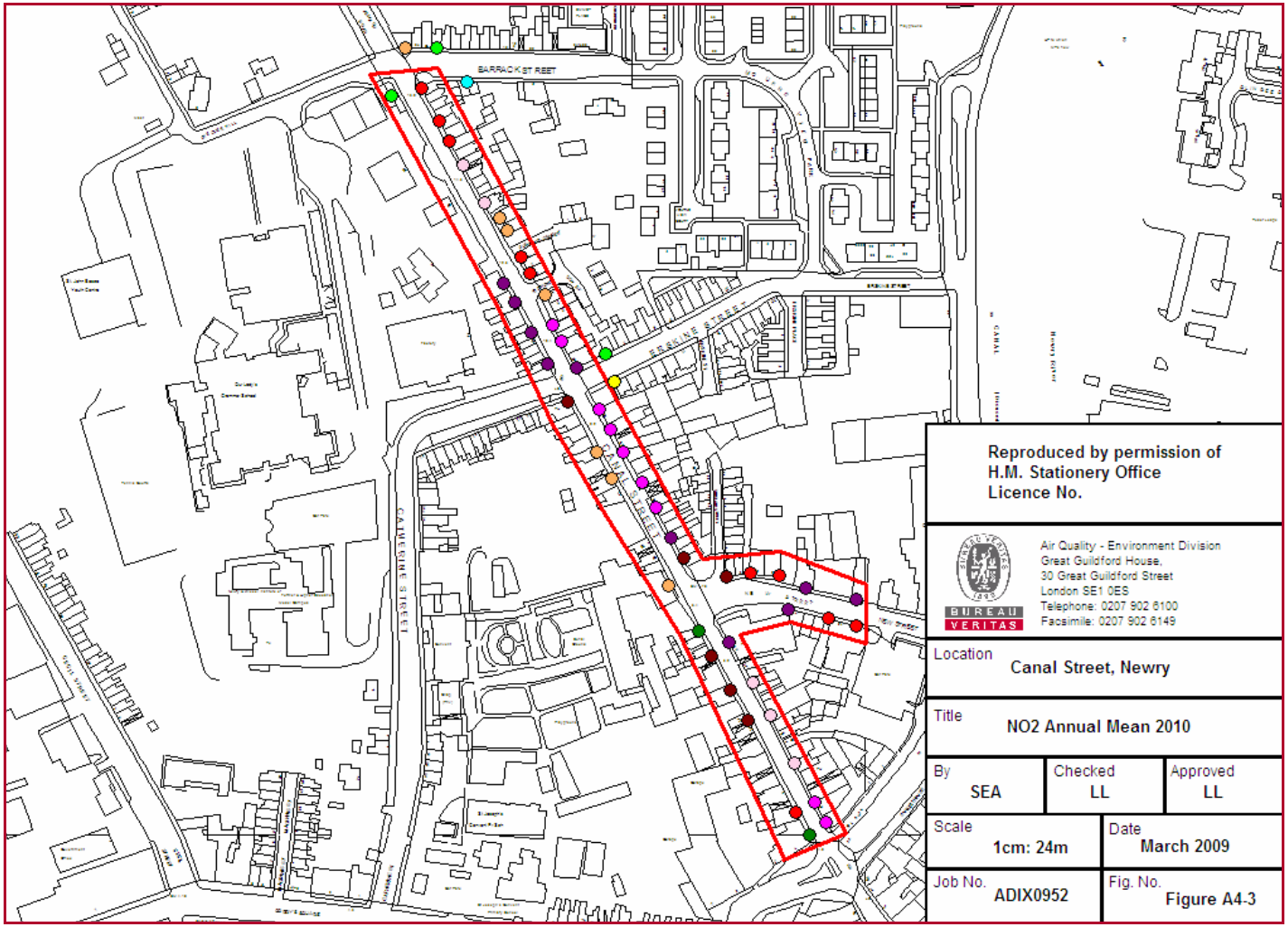
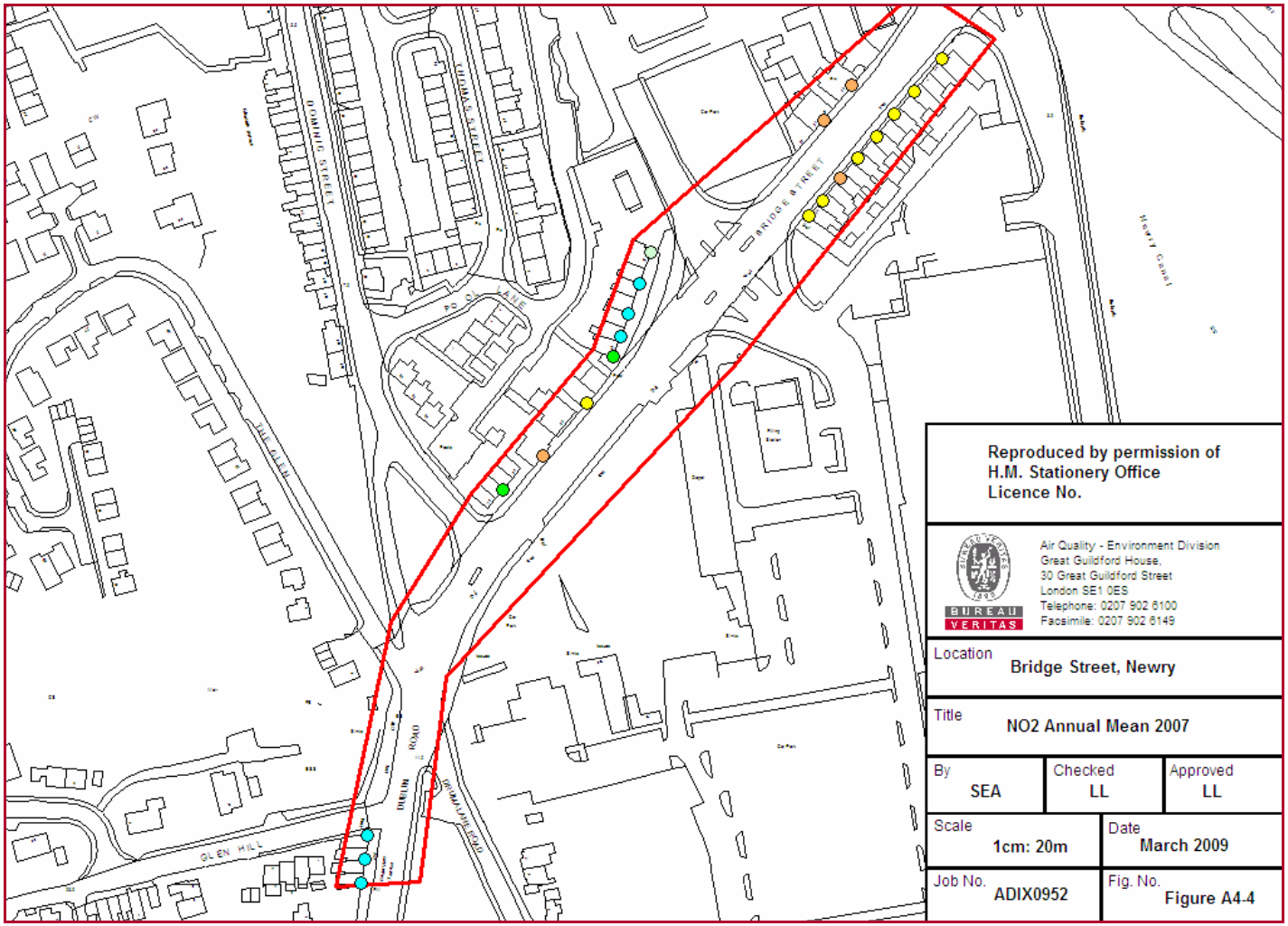


Figure A4-4 – Bridge Street AQMA 2007



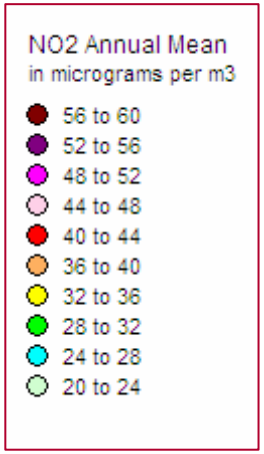


Figure A4-5 – Bridge Street AQMA 2008

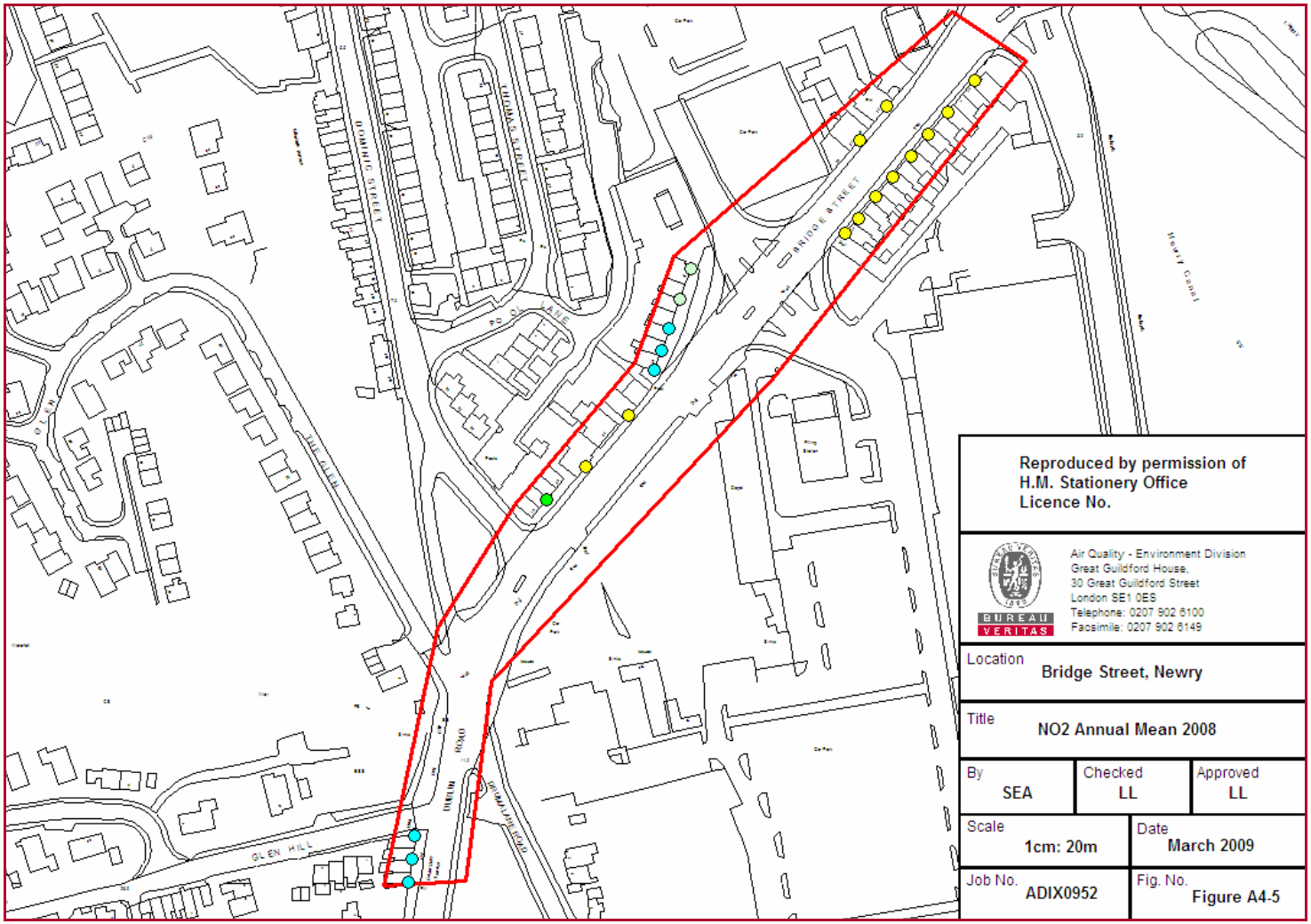


Figure A4-6 – Bridge Street AQMA 2010

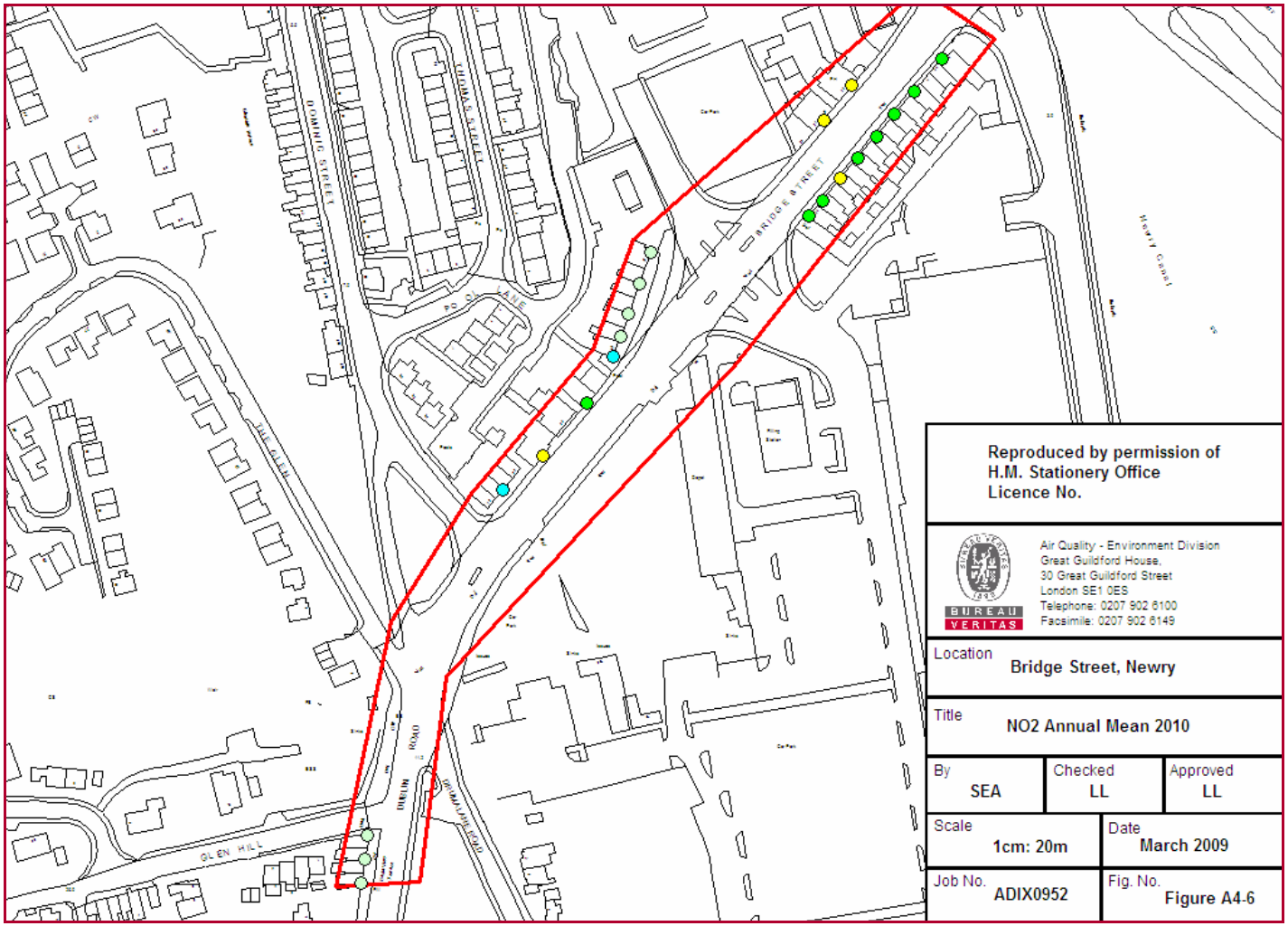


Figure A4-7 – Water Street AQMA 2007

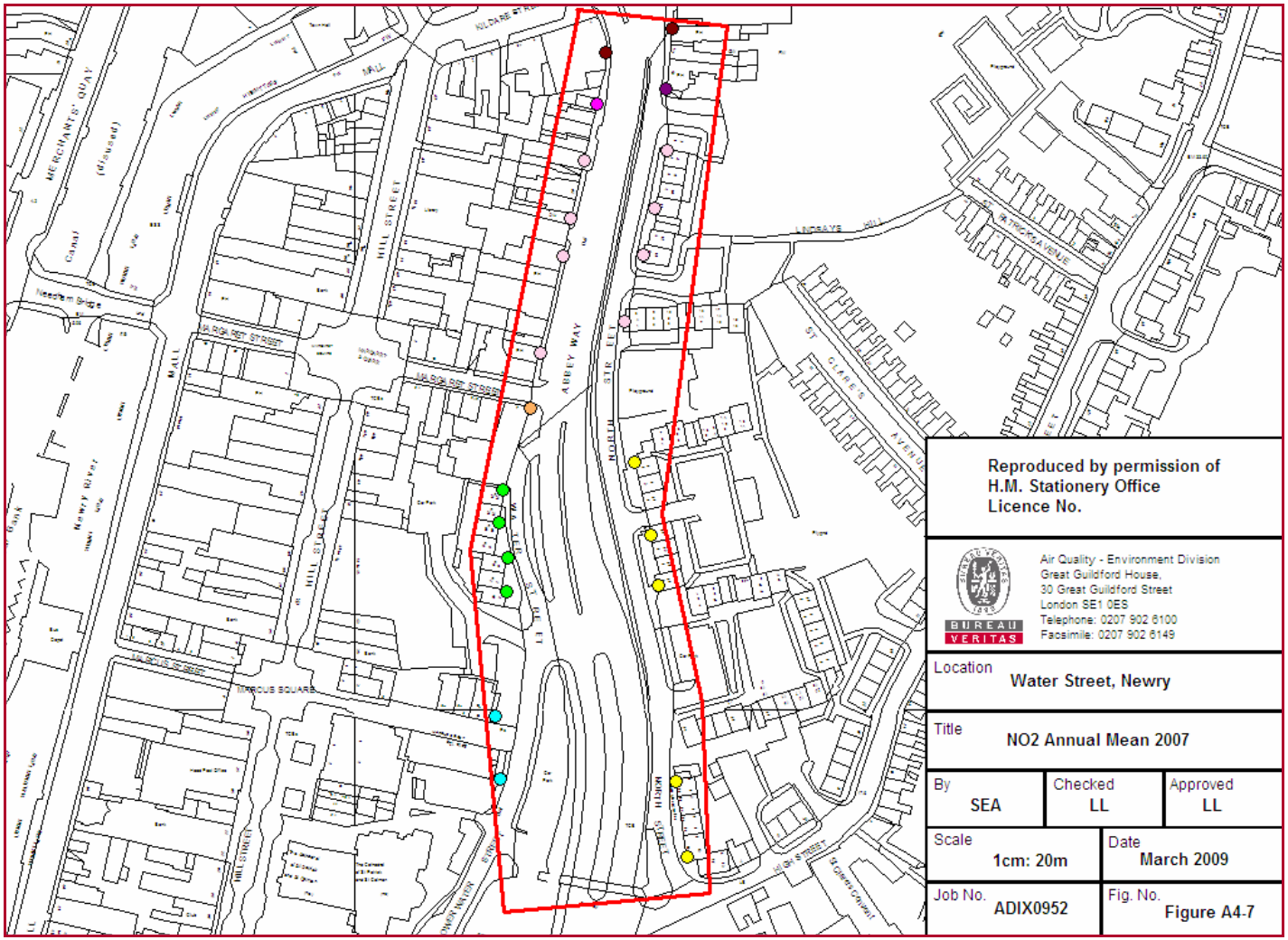


Figure A4-8 – Water Street AQMA 2008

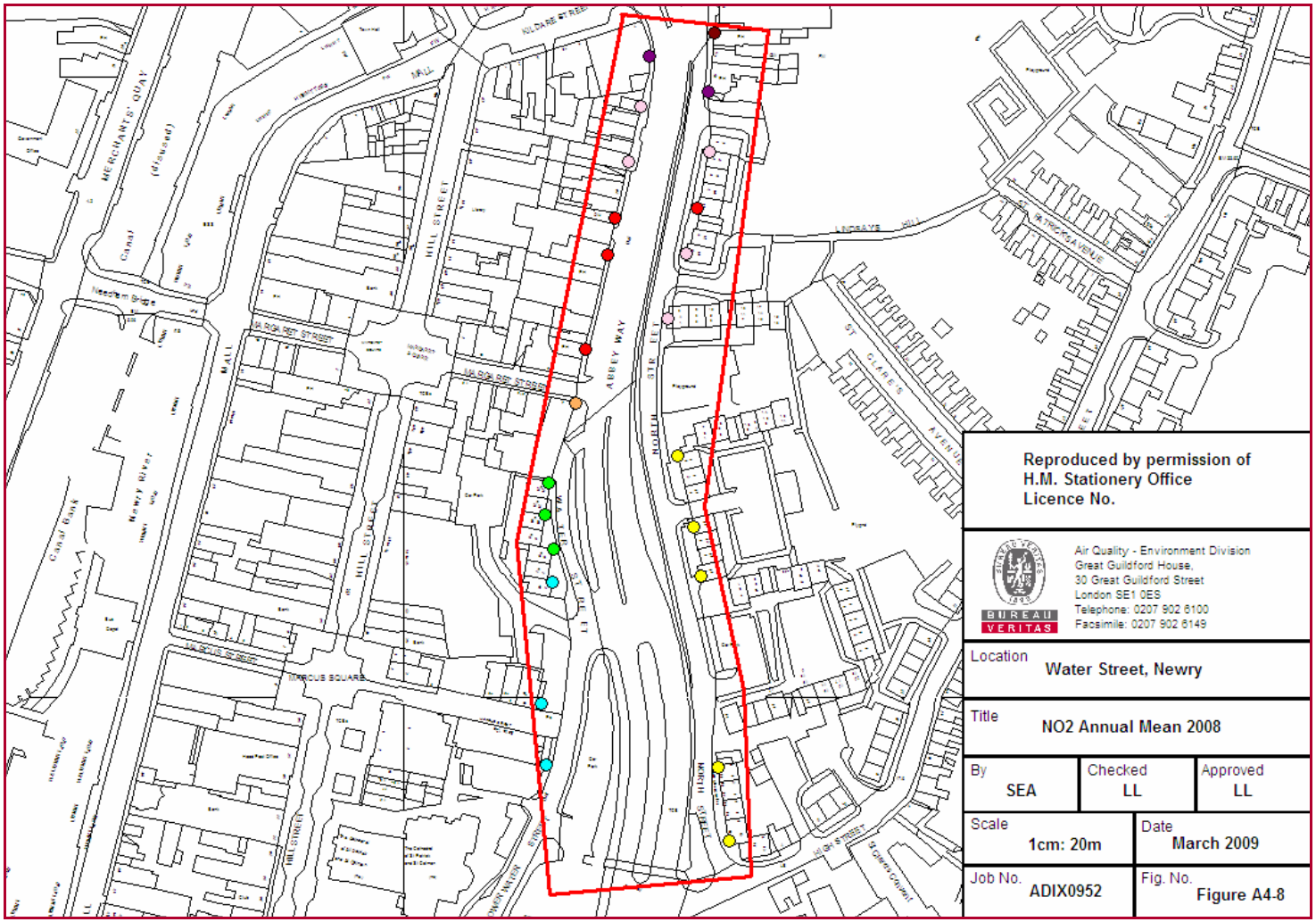


Figure A4-9 – Water Street AQMA 2010

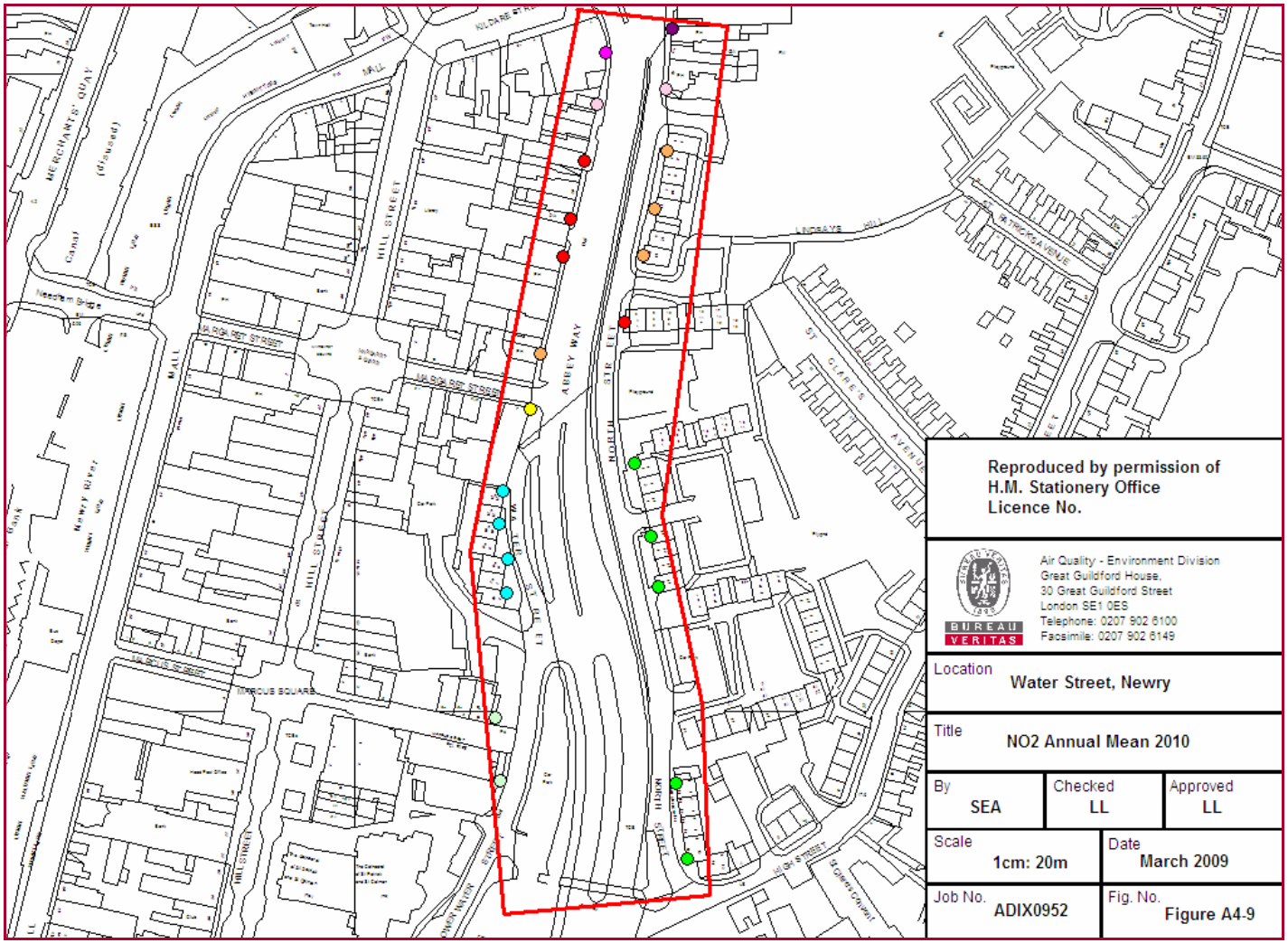
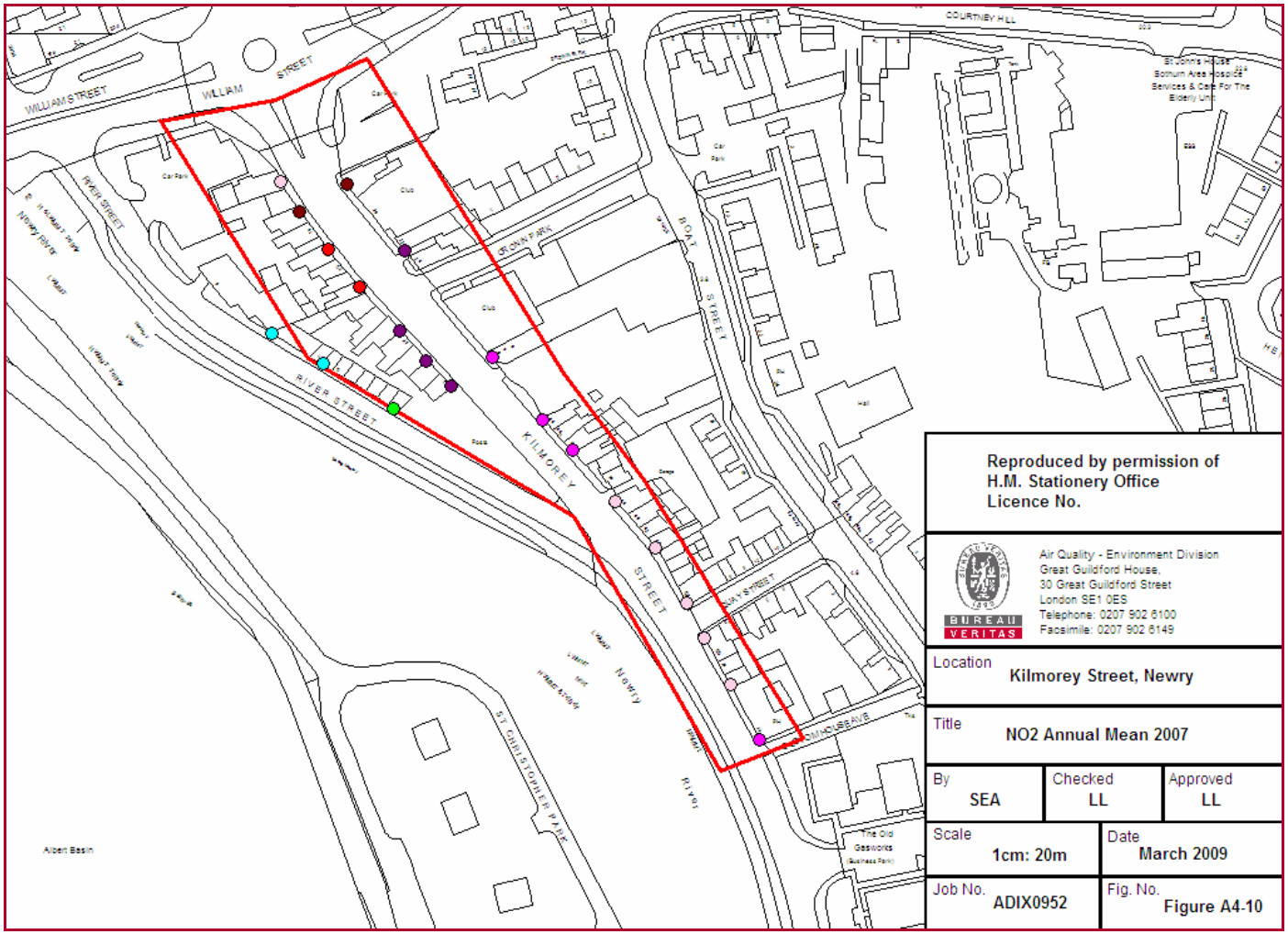


Figure A4-10 – Kilmorey Street AQMA 2007



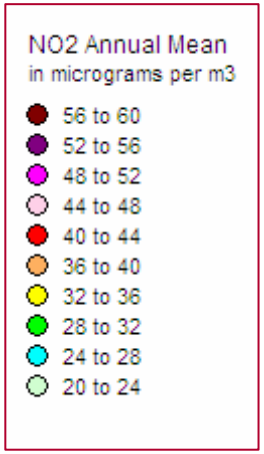


Figure A4-11 – Kilmorey Street AQMA 2008

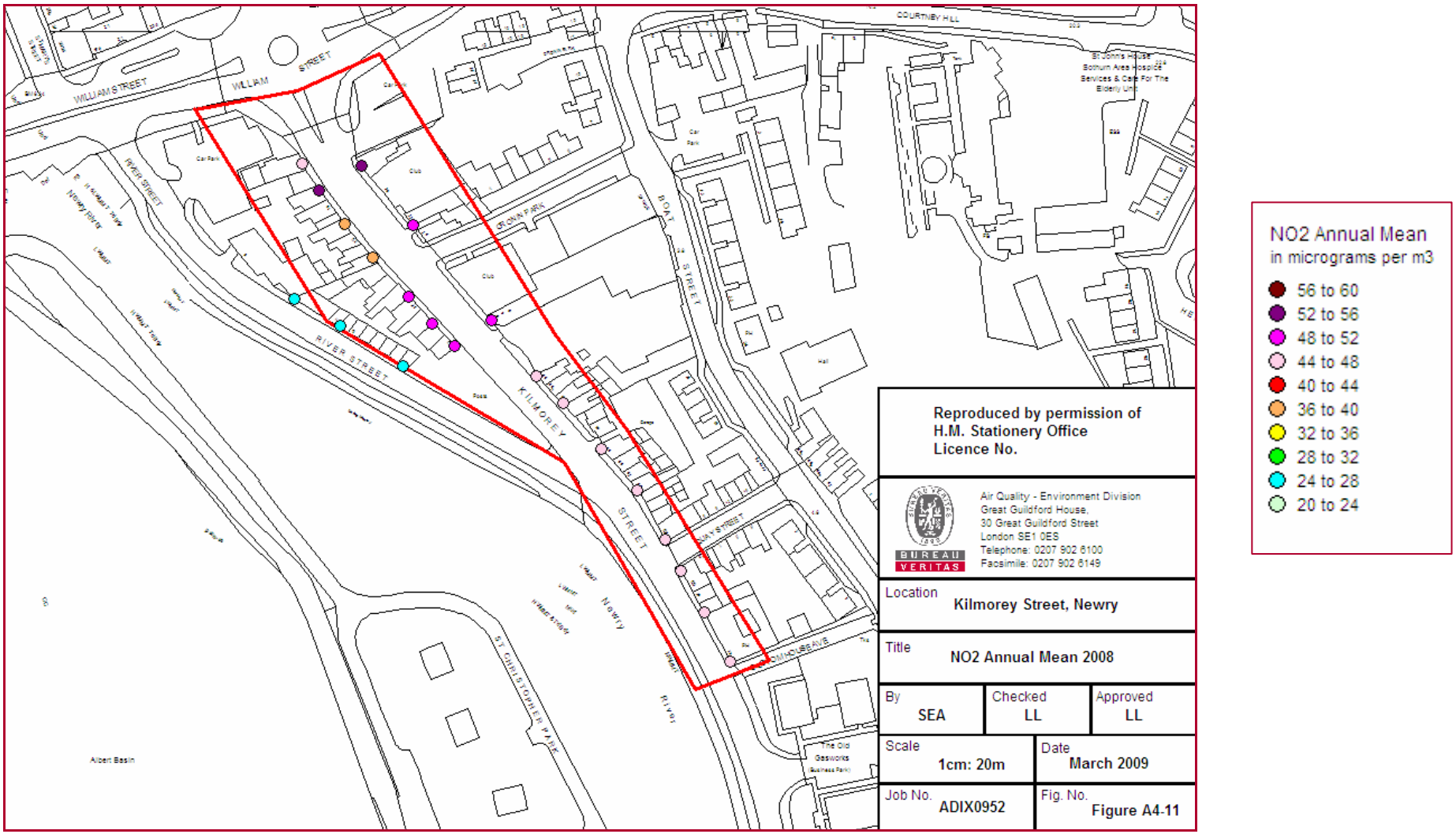


Figure A4-12 – Kilmorey Street AQMA 2010

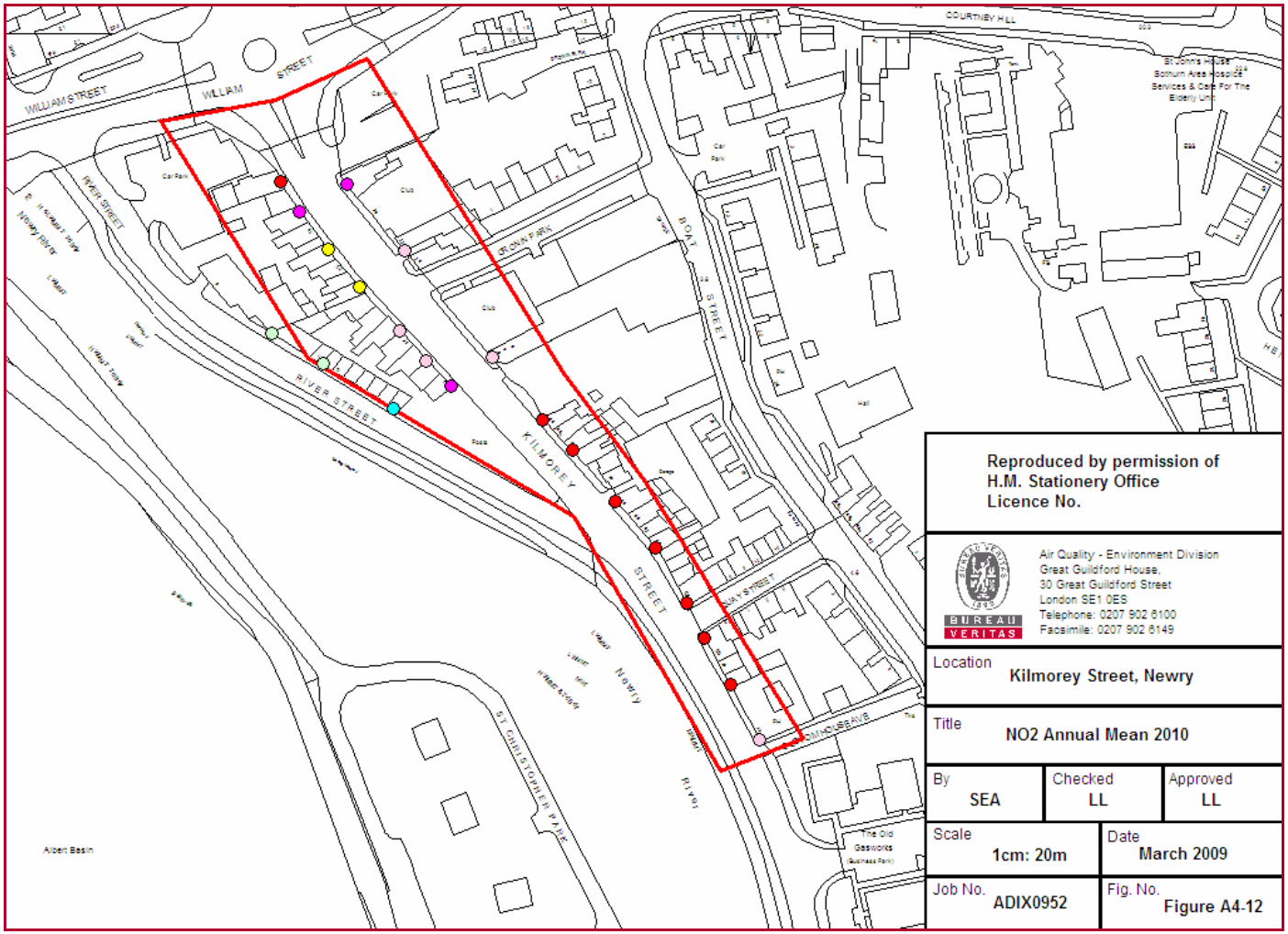
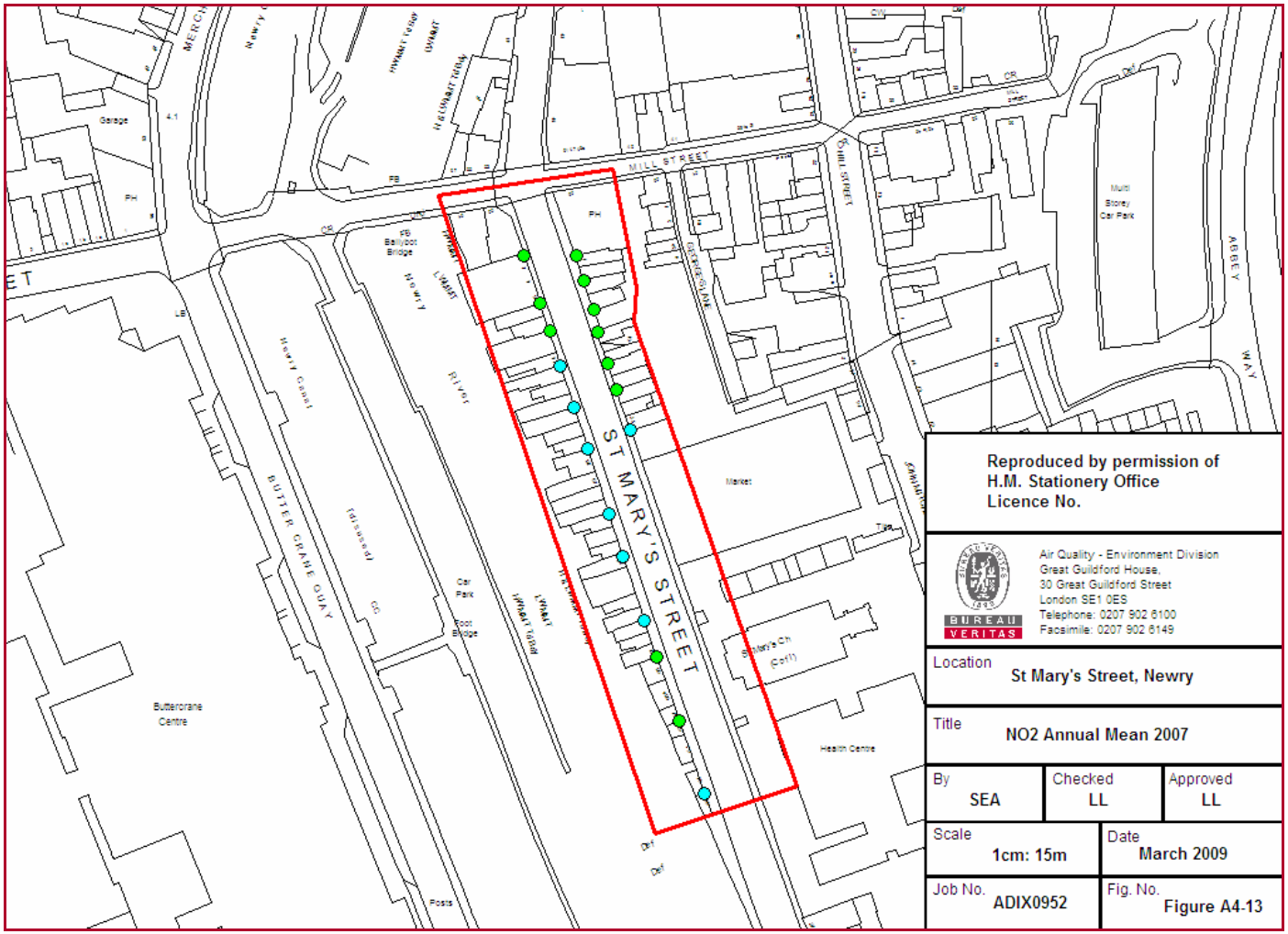


Figure A4-13 – St Mary's Street AQMA 2007



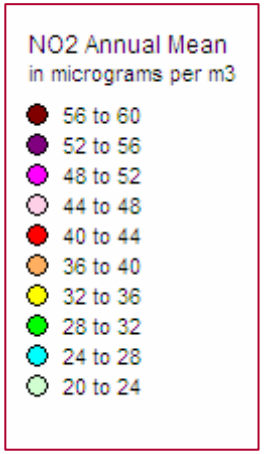


Figure A4-14 – St Mary's Street AQMA 2008

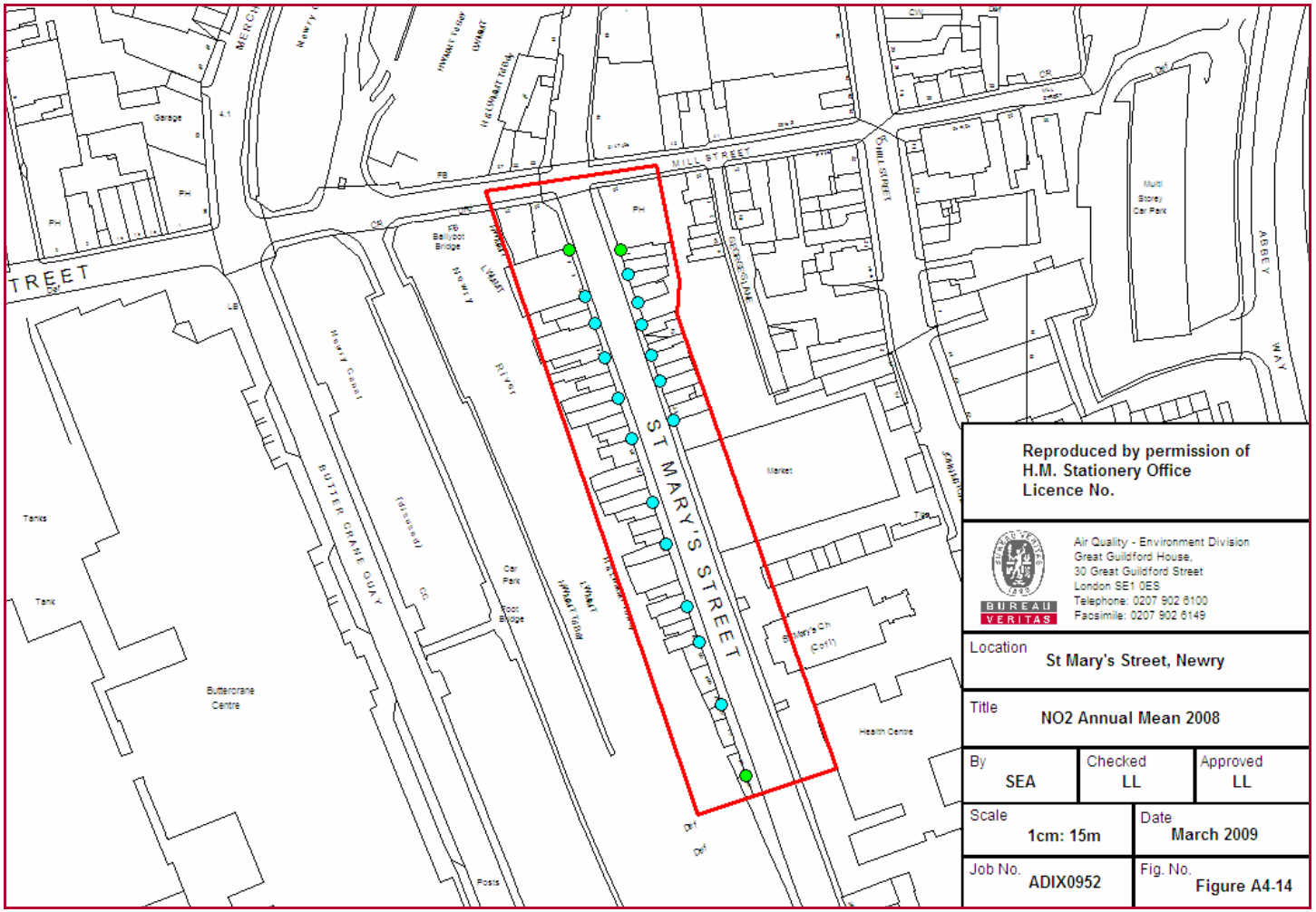
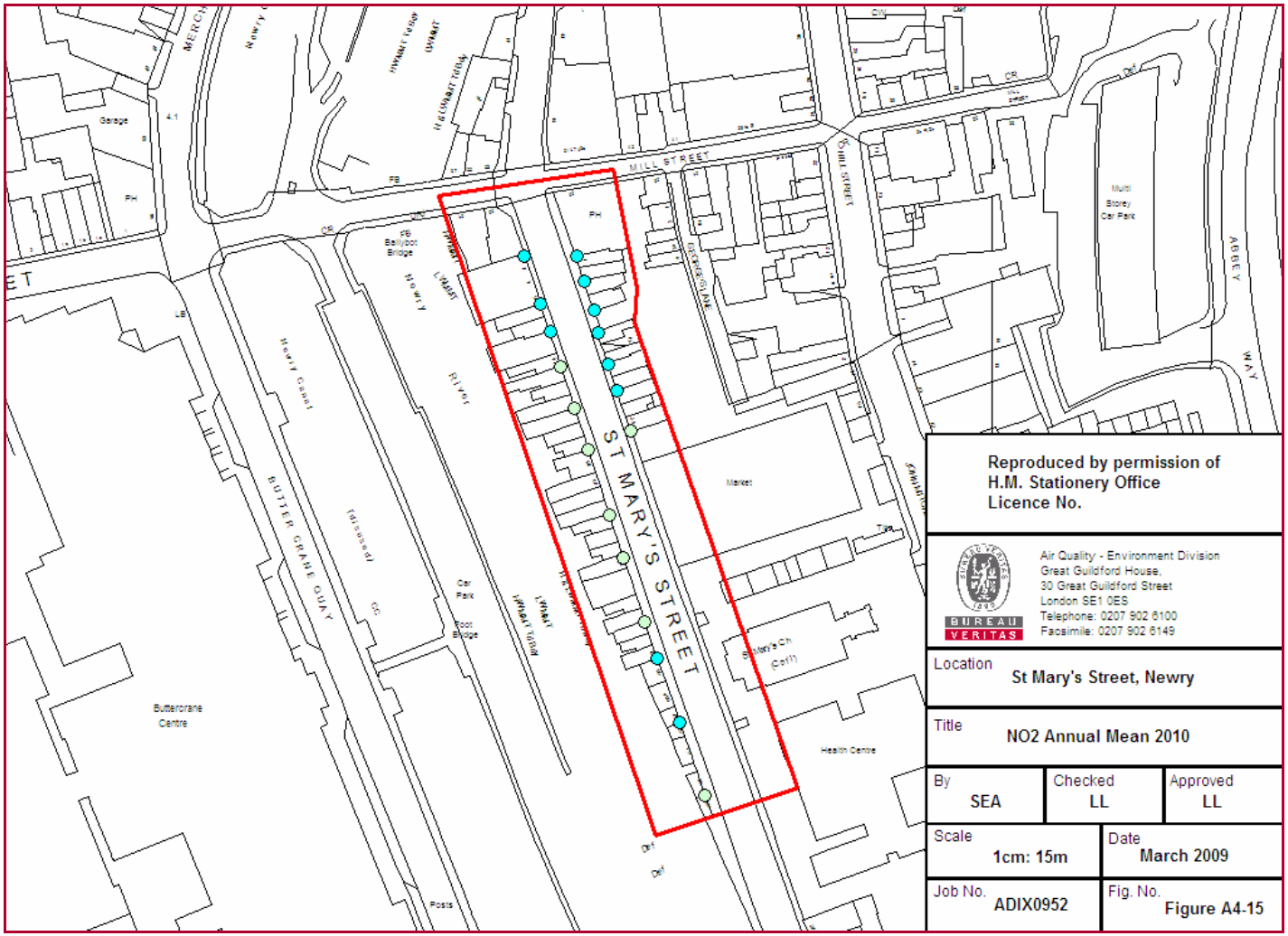


Figure A4-15 – St Mary's Street AQMA 2010



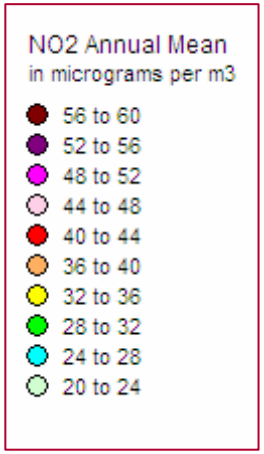


Figure A4-16 – Patrick Street AQMA 2007

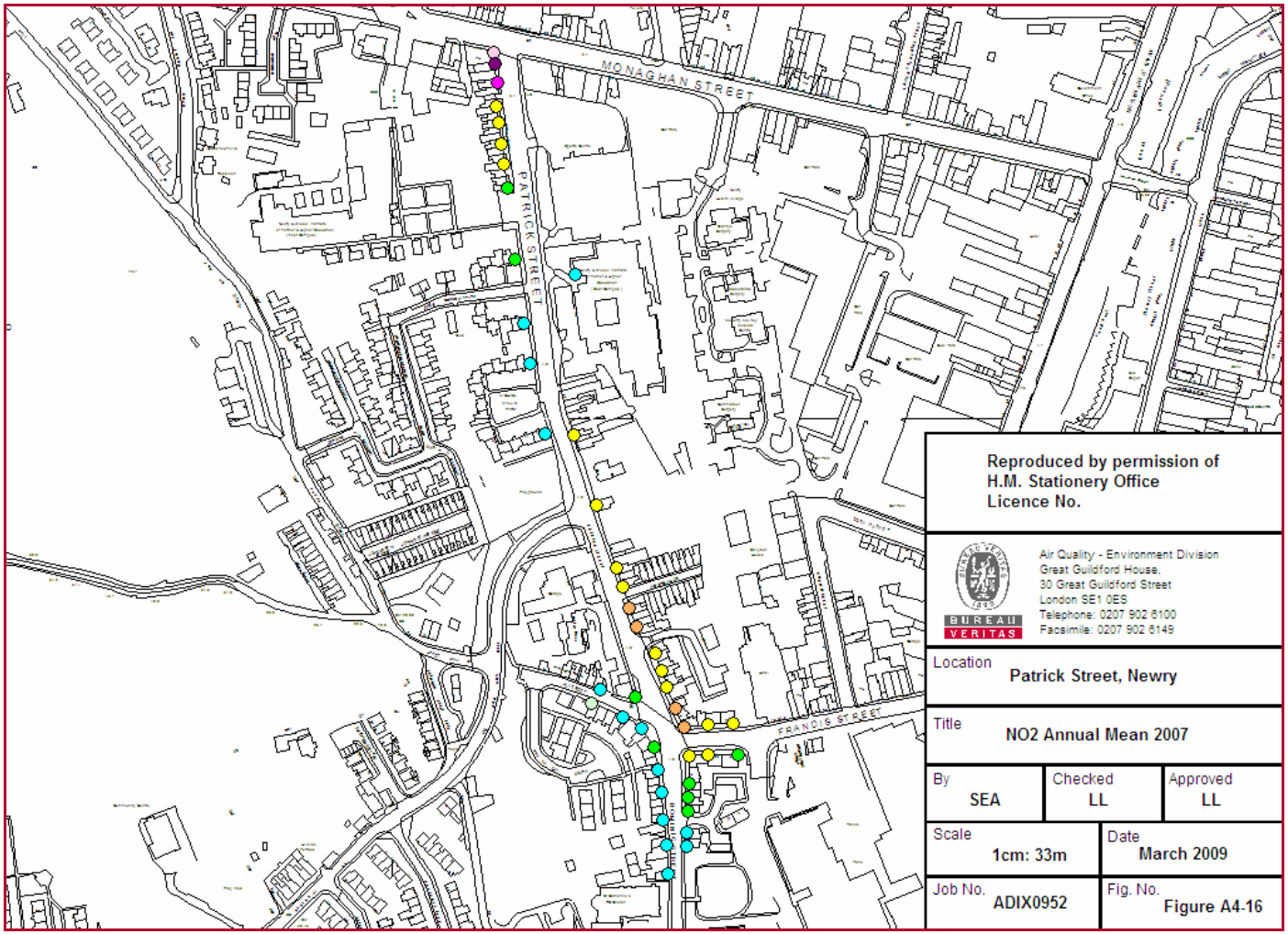


Figure A4-17 – Patrick Street AQMA 2008

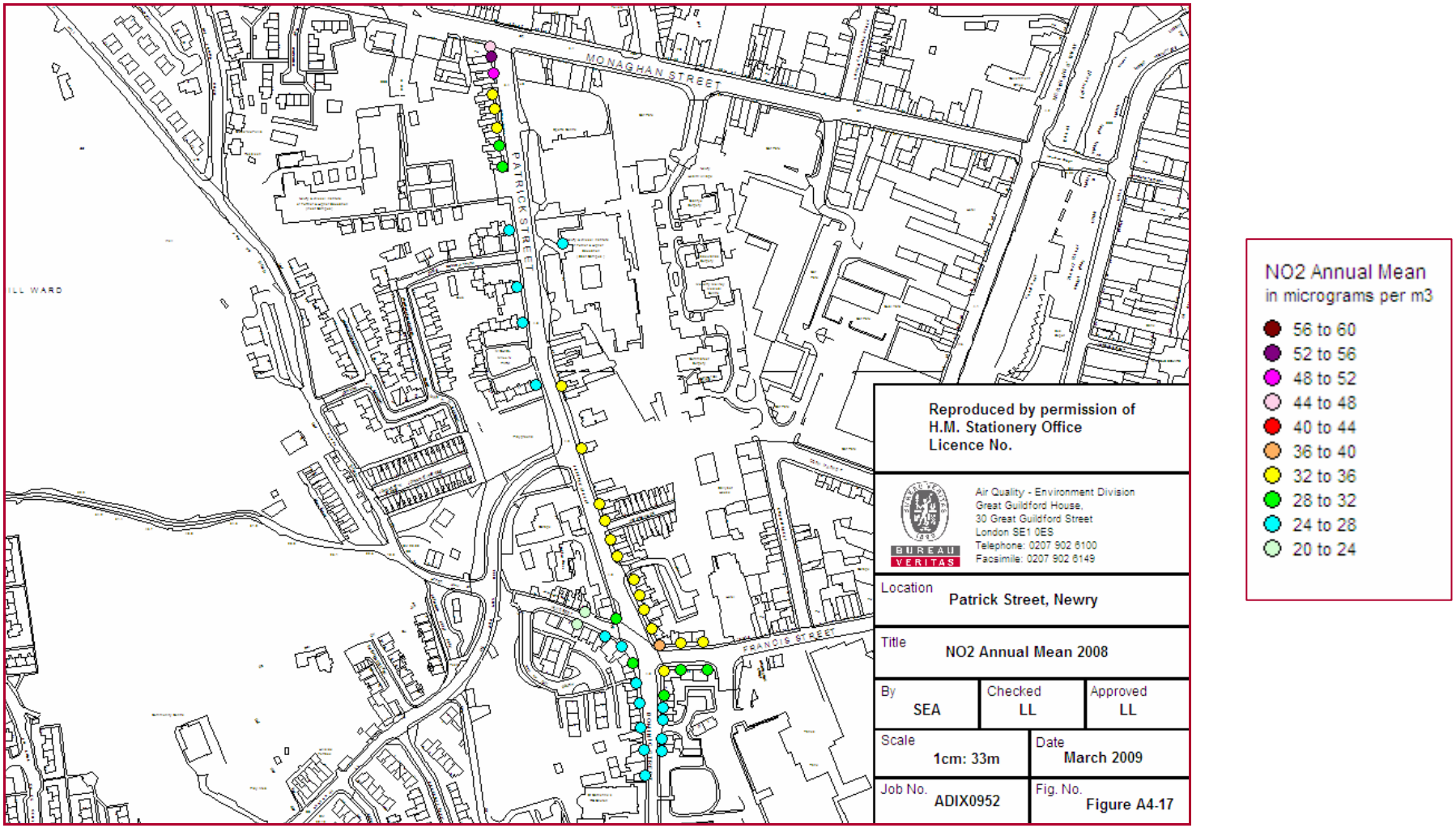


Figure A4-18 – Patrick Street AQMA 2010

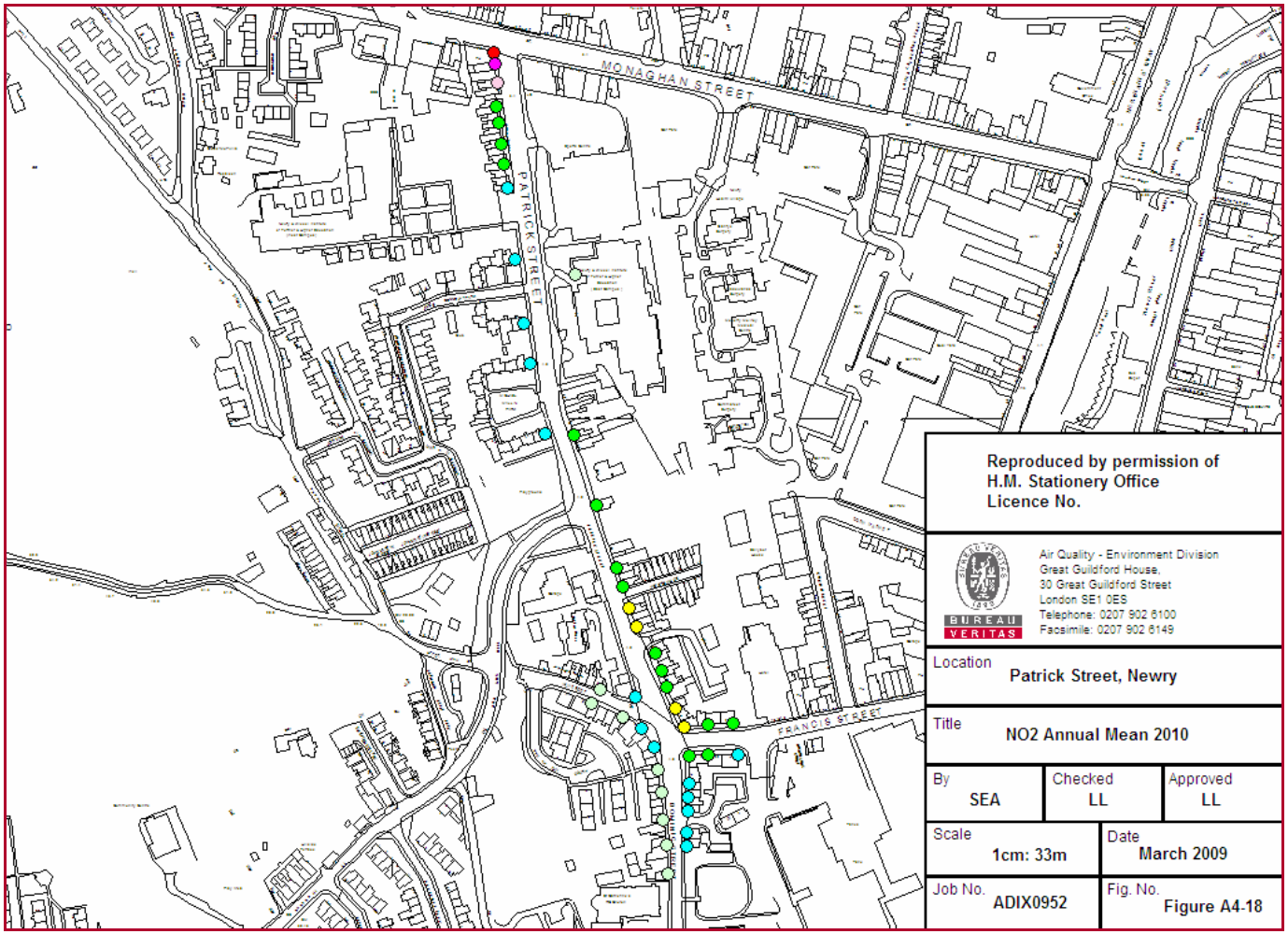
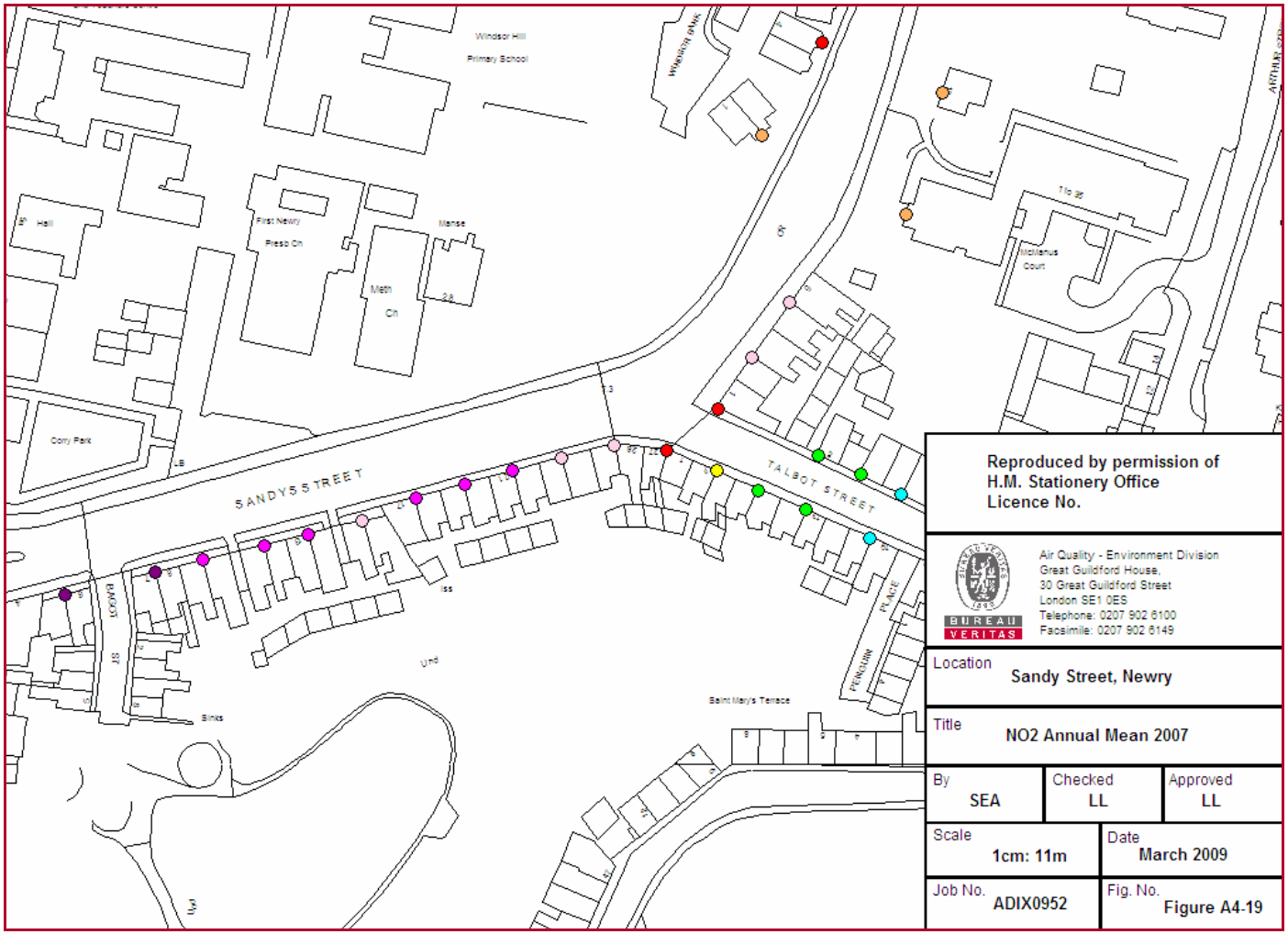


Figure A4-19 – Sandy Street AQMA 2007



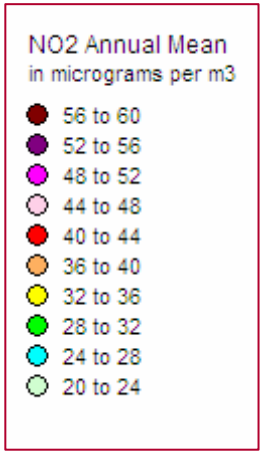


Figure A4-20 – Sandy Street AQMA 2008

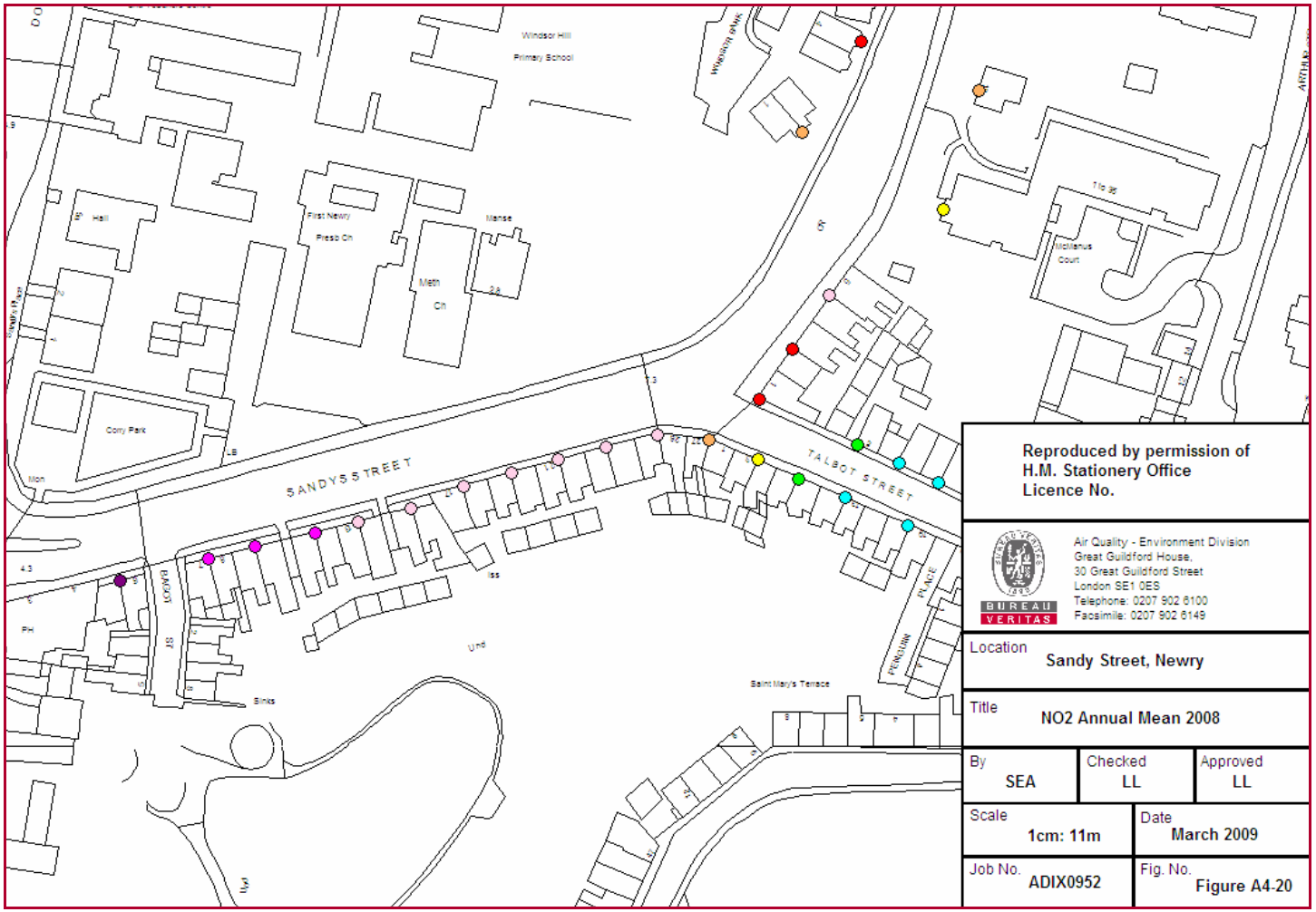
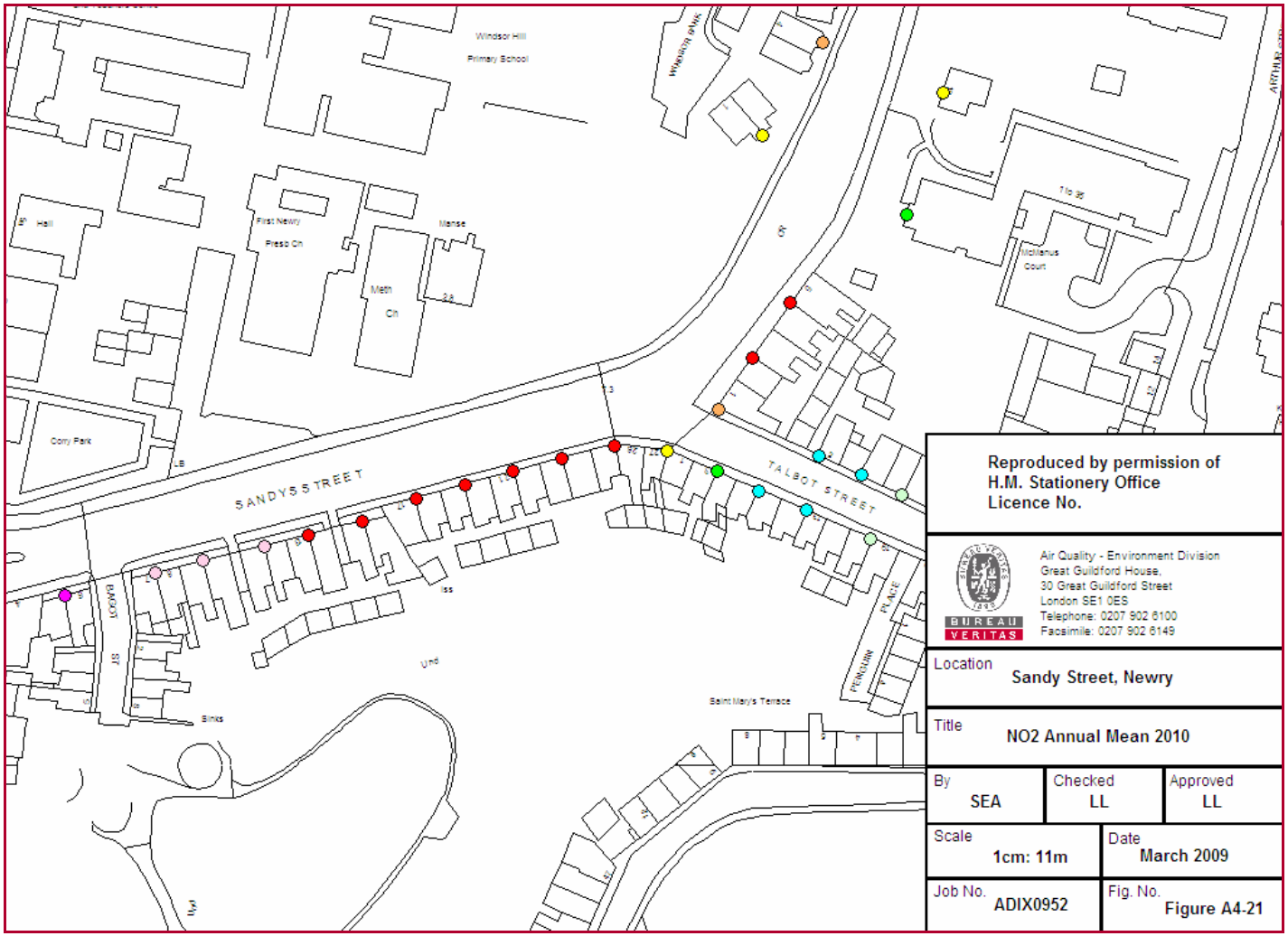


Figure A4-21 – Sandy Street AQMA 2010

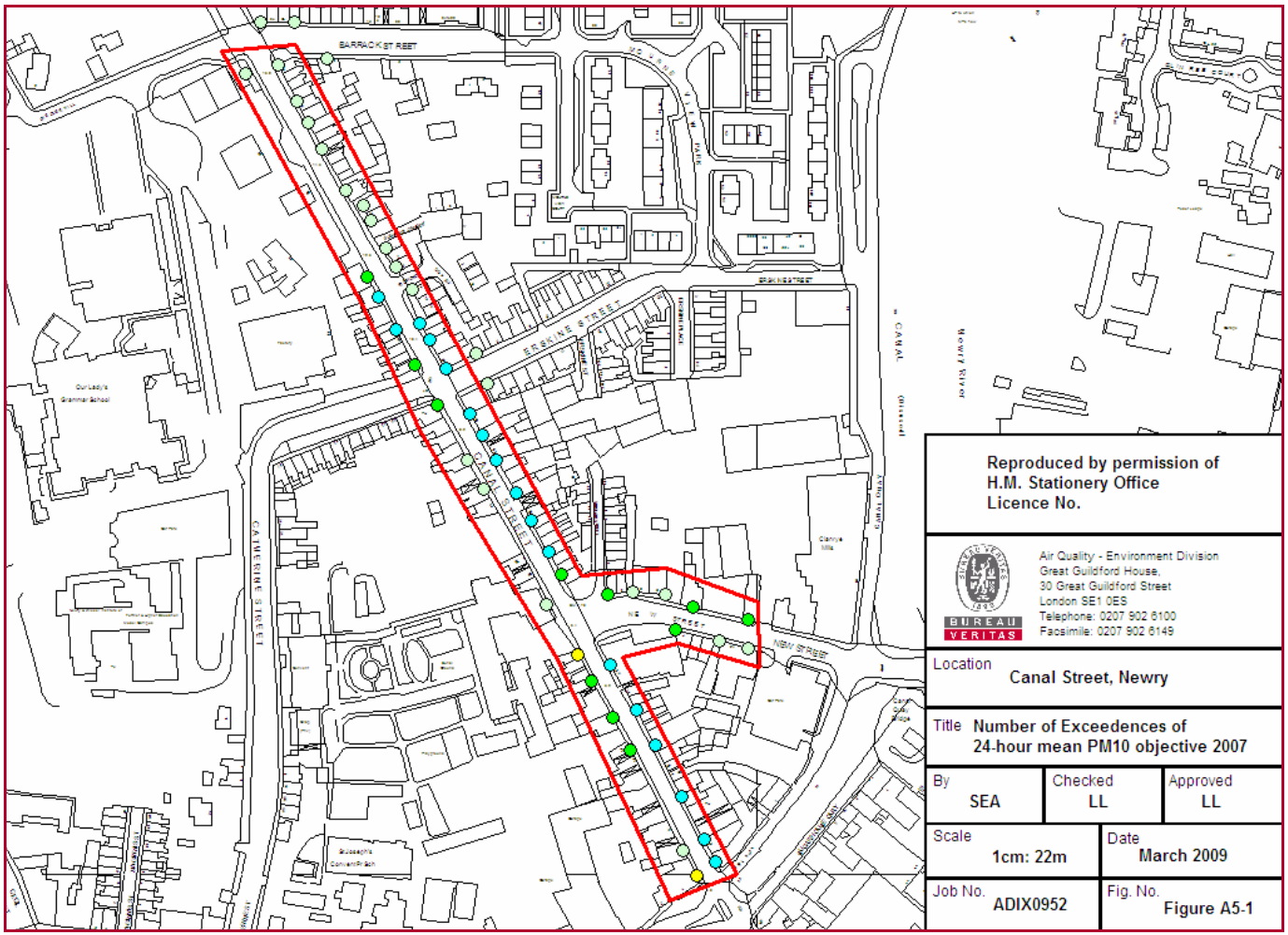


NO2 Annual Mean
in micrograms per m3

- 56 to 60
- 52 to 56
- 48 to 52
- 44 to 48
- 40 to 44
- 36 to 40
- 32 to 36
- 28 to 32
- 24 to 28
- 20 to 24

Appendix 5 – Modelled Specific Receptor Results for PM_{10}

Figure A5-1 – Canal Street AQMA 2007



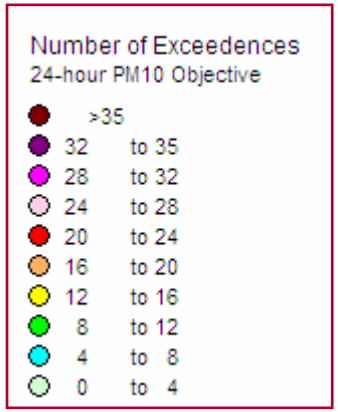


Figure A5-2 – Canal Street AQMA 2008

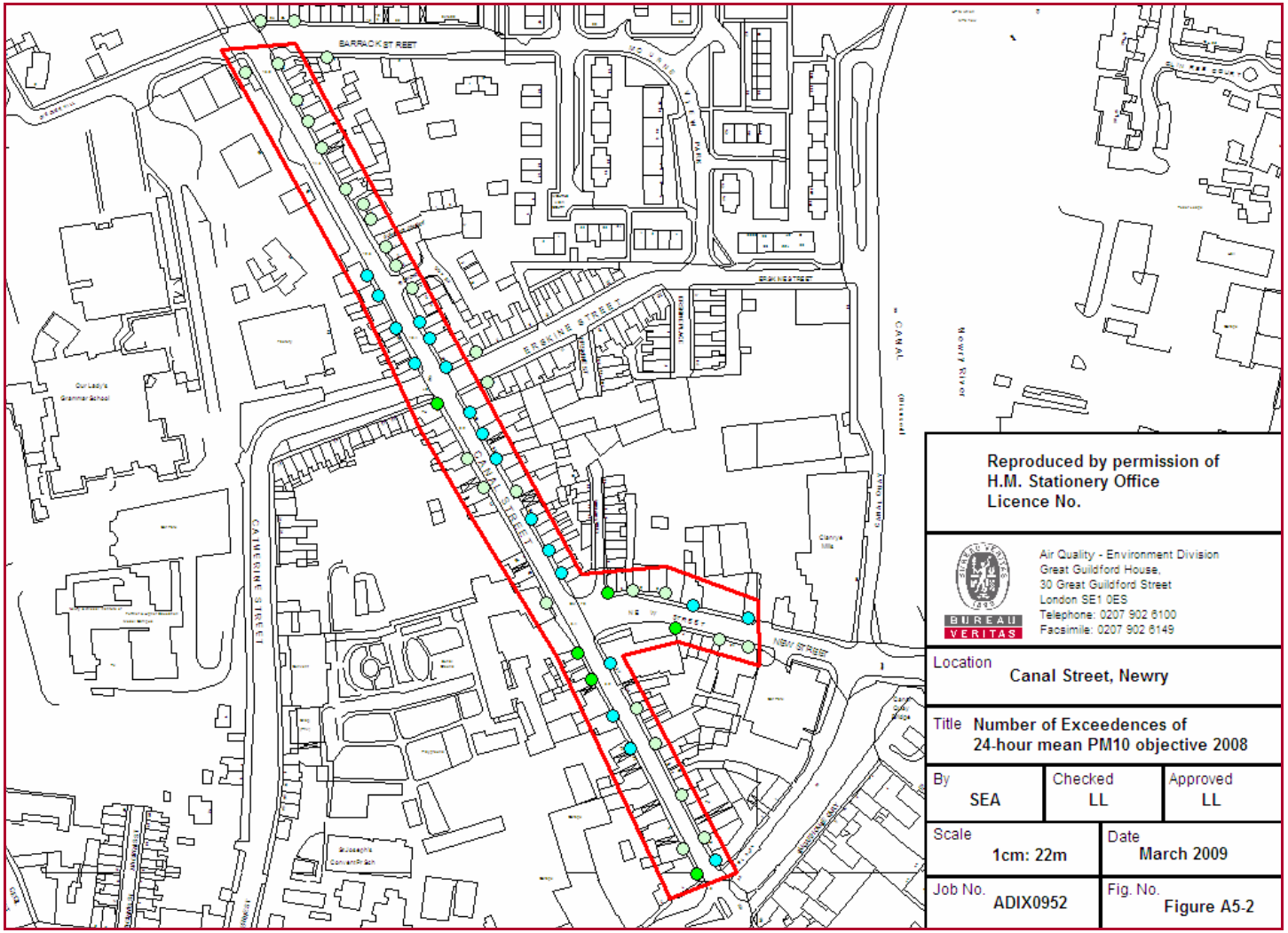


Figure A5-3 – Canal Street AQMA 2010

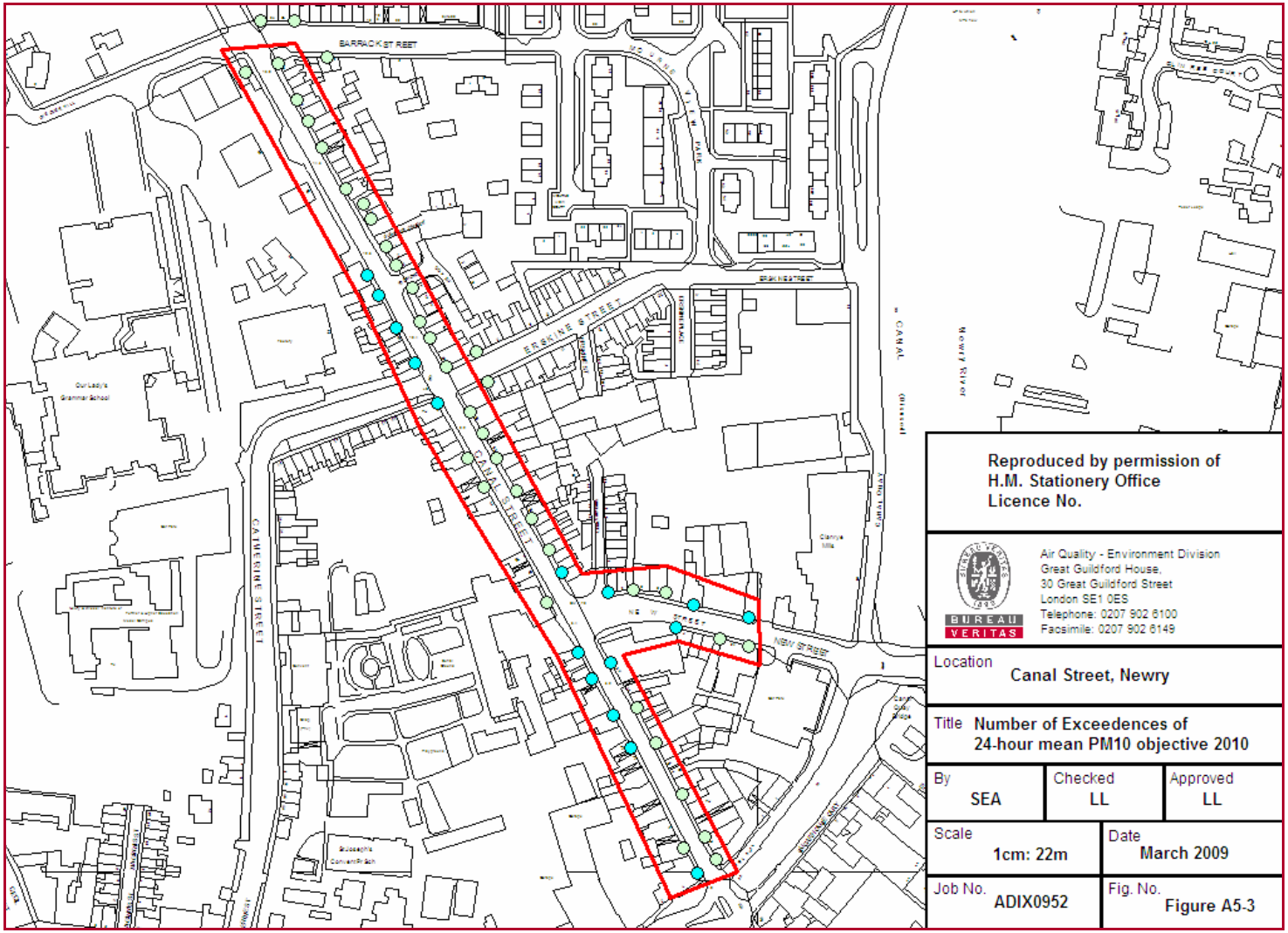


Figure A5-4 – Bridge Street AQMA 2007

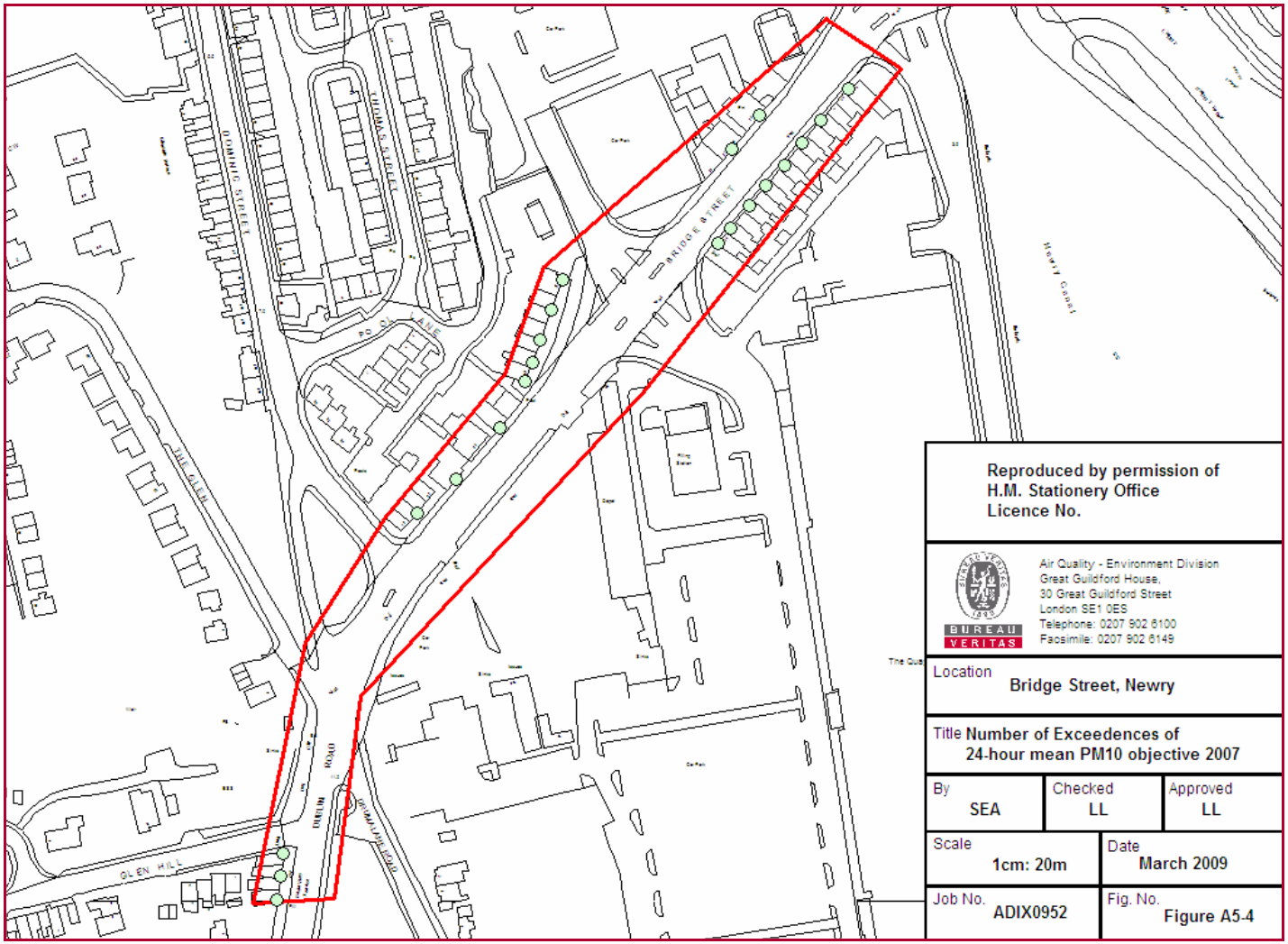
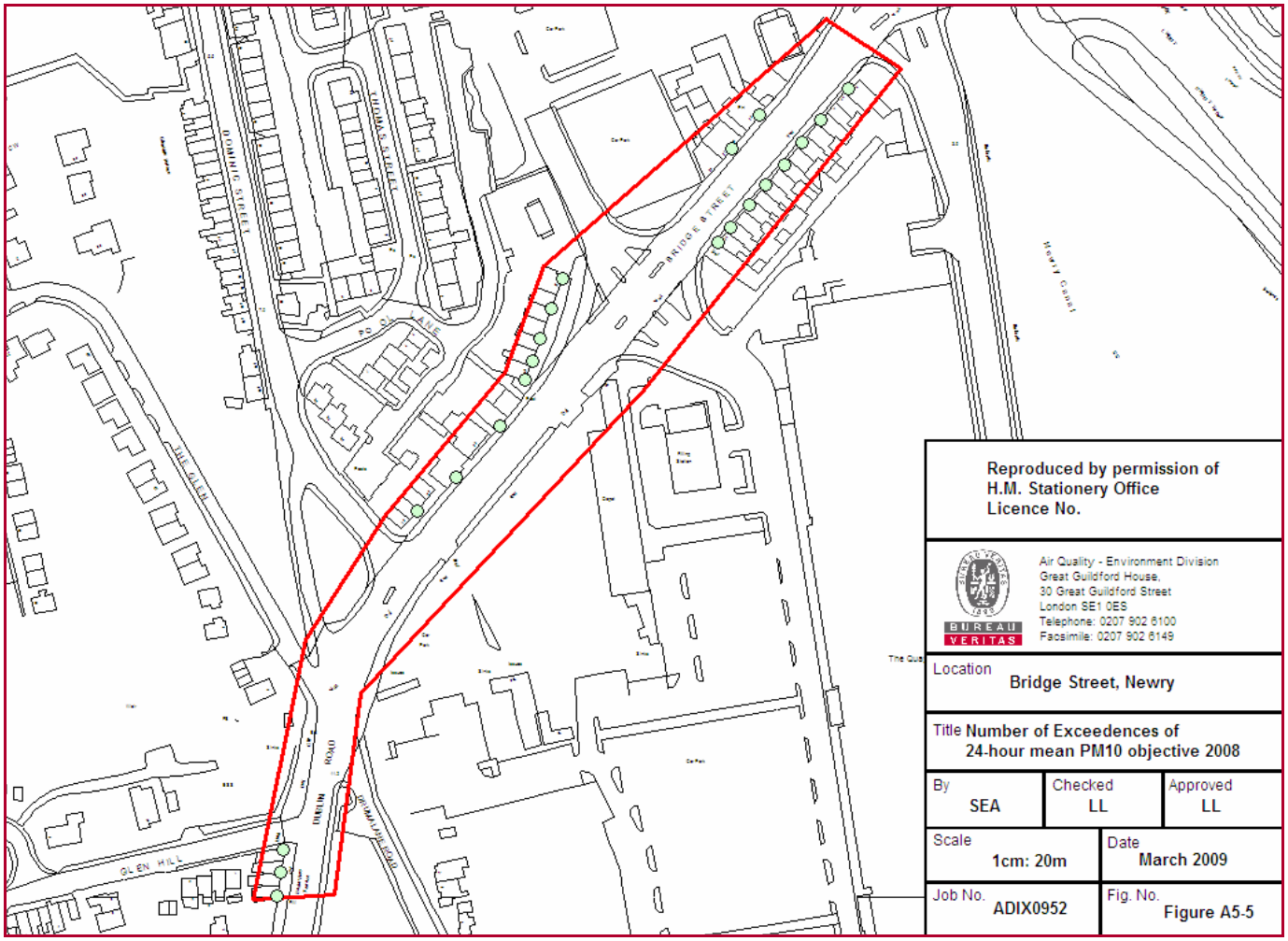


Figure A5-5 – Bridge Street AQMA 2008



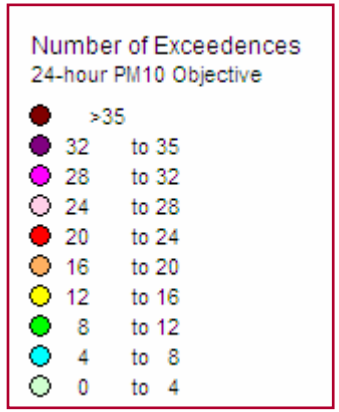


Figure A5-6 – Bridge Street AQMA 2010

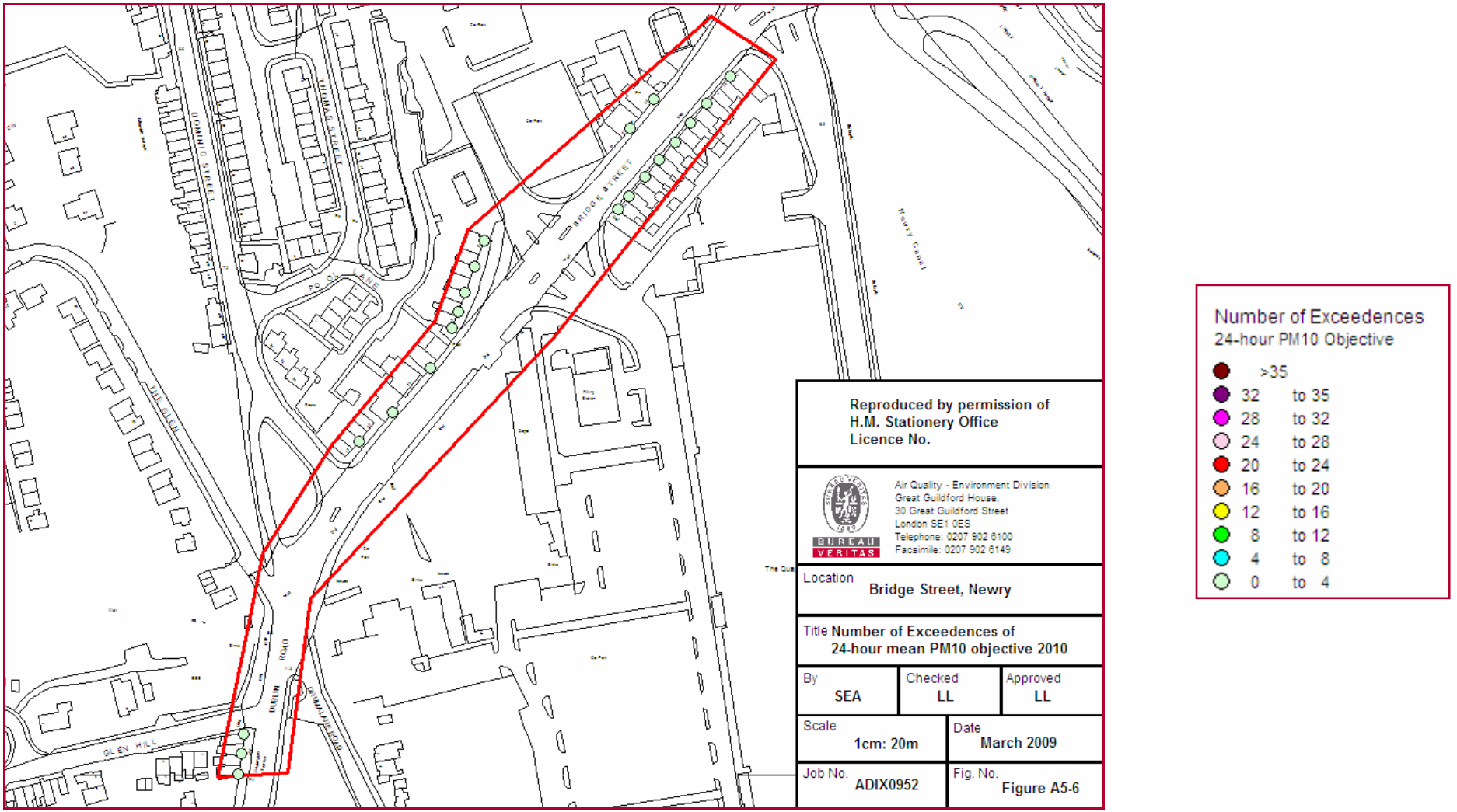


Figure A5-7 – Water Street AQMA 2007

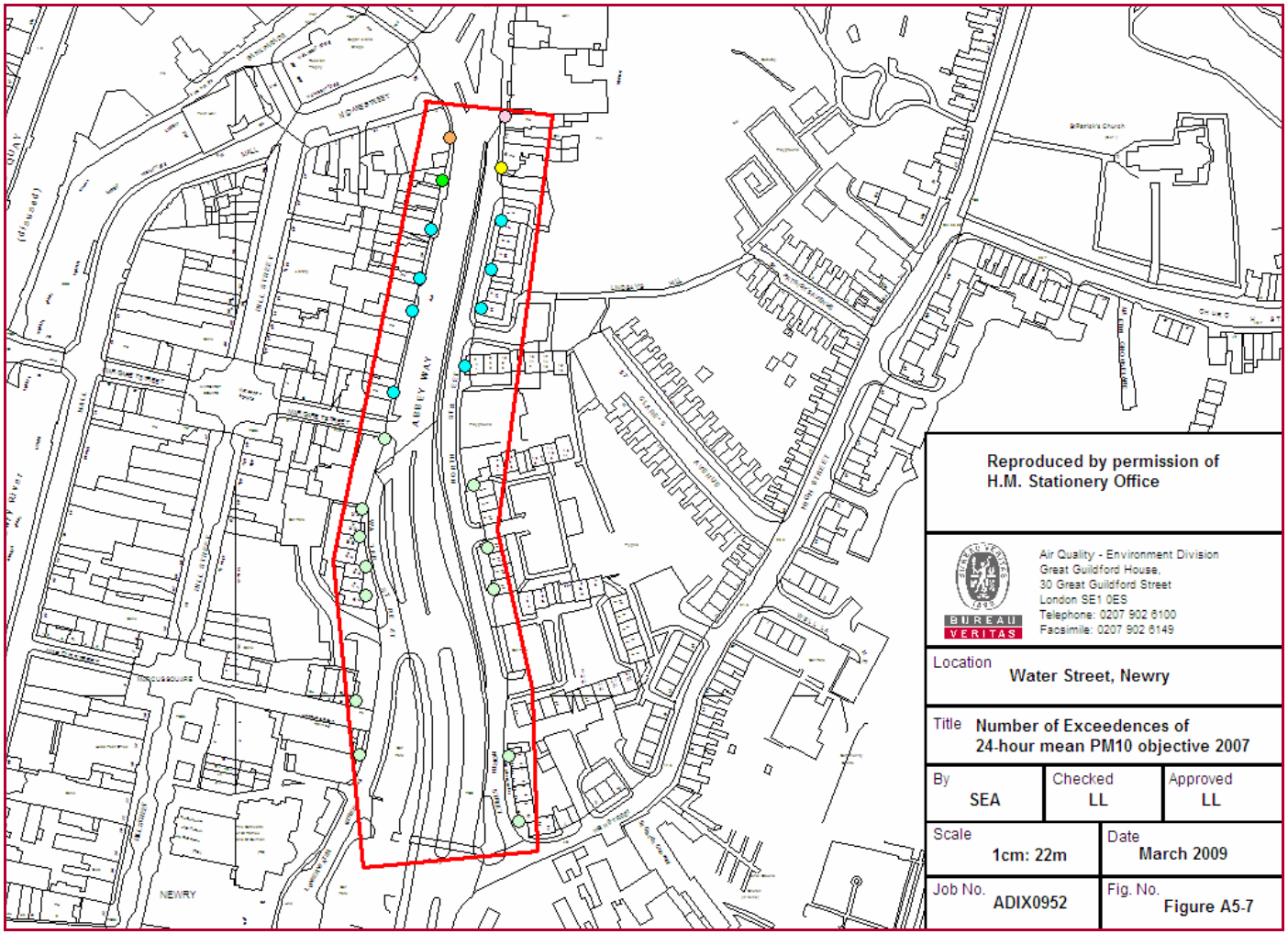


Figure A5-8 – Water Street AQMA 2008

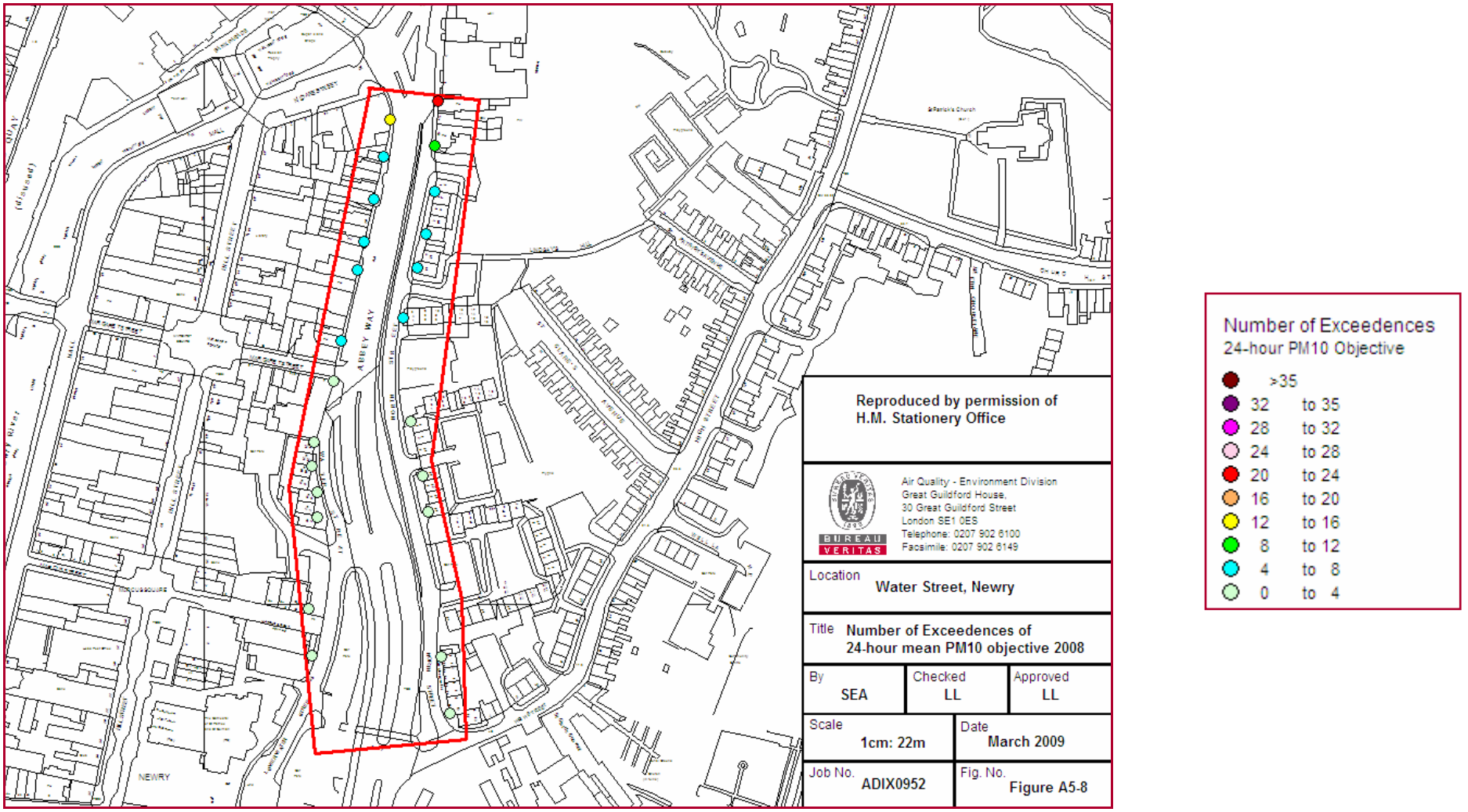


Figure A5-9 – Water Street AQMA 2010

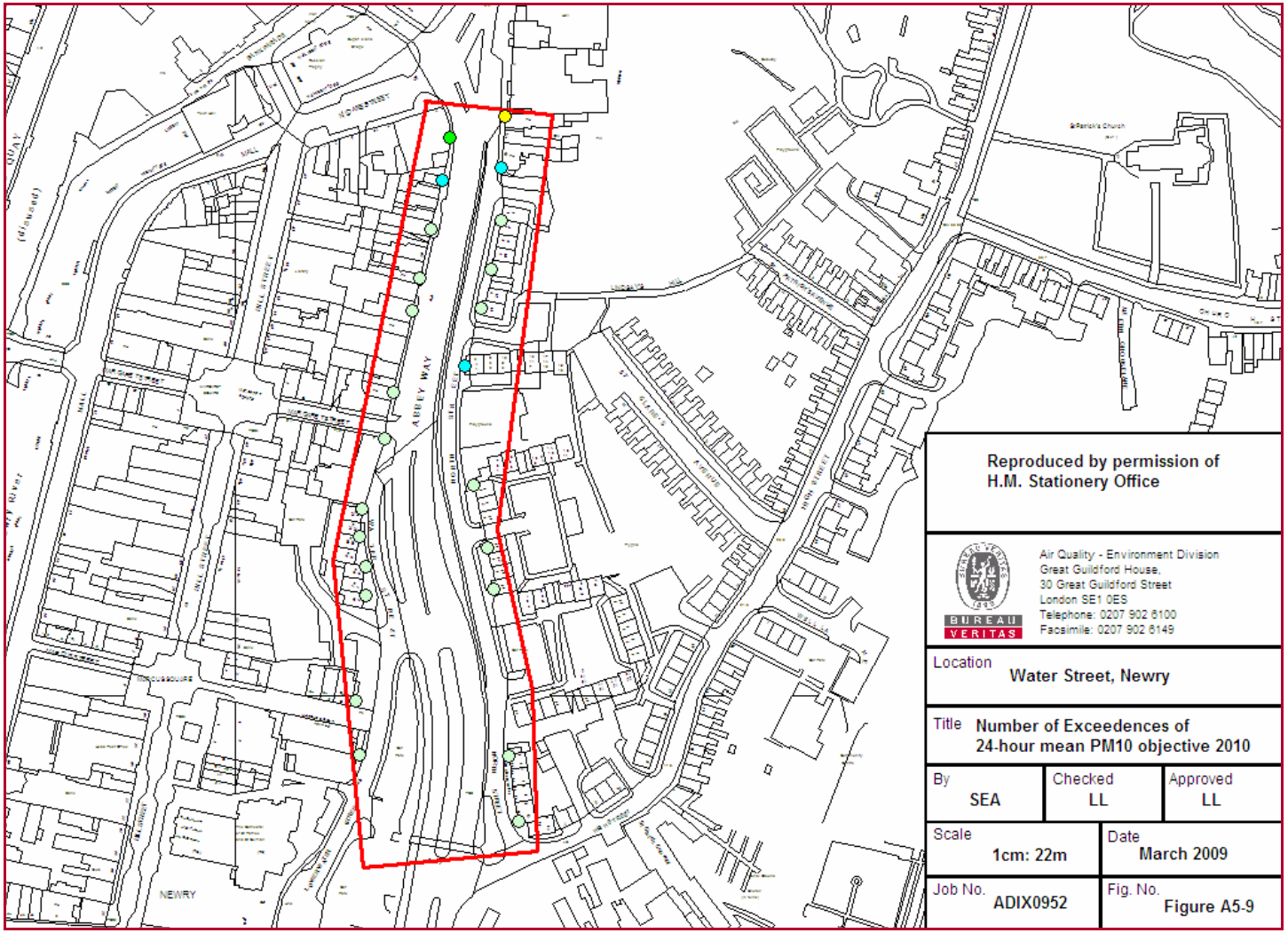
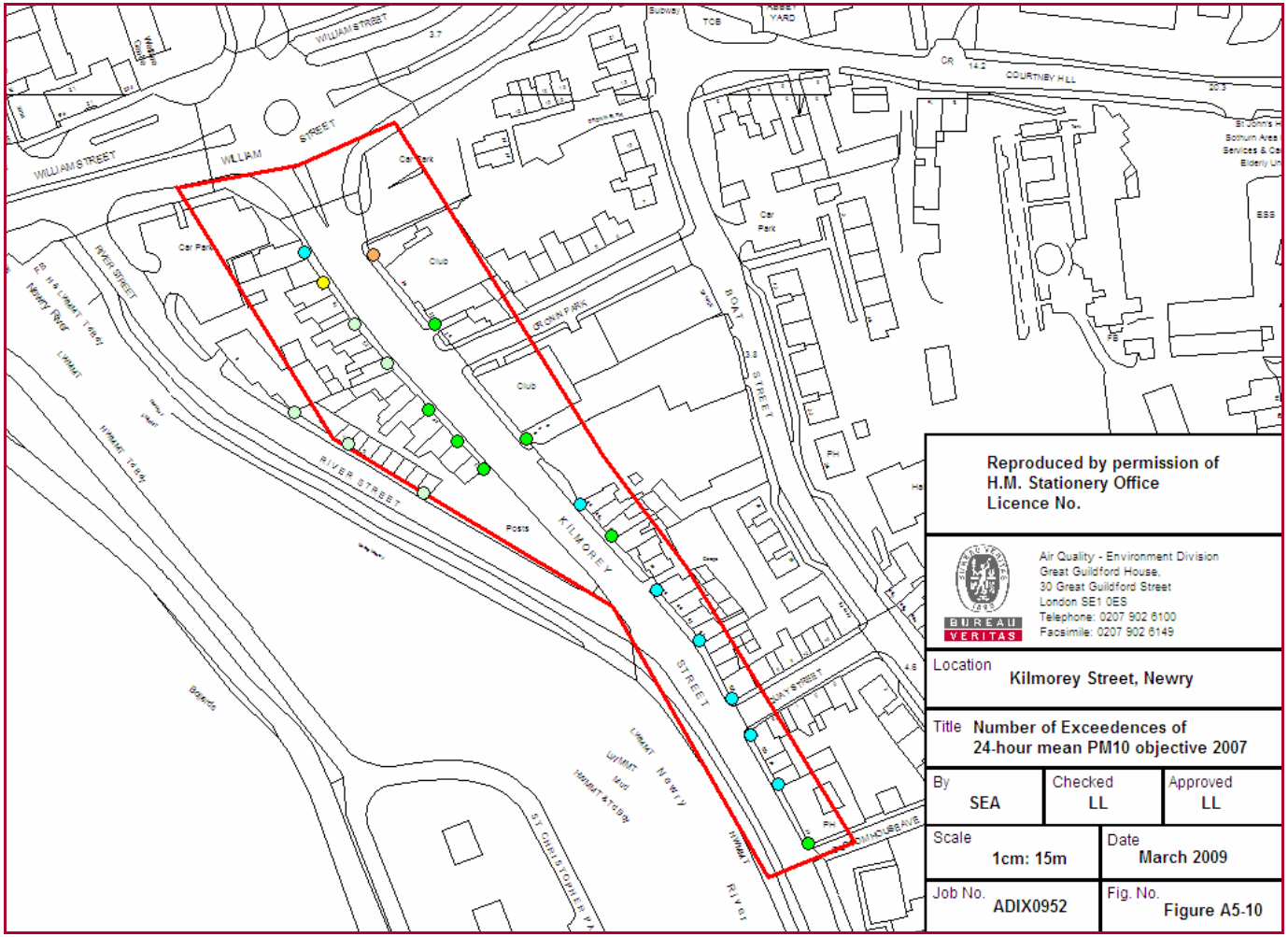


Figure A5-10 – Kilmorey Street AQMA 2007



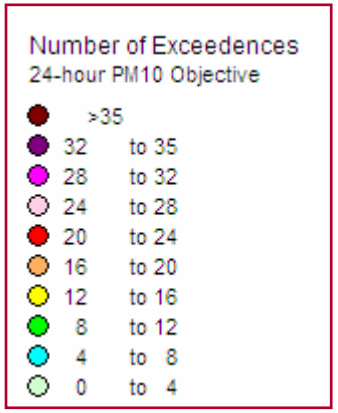


Figure A5-11 – Kilmorey Street AQMA 2008

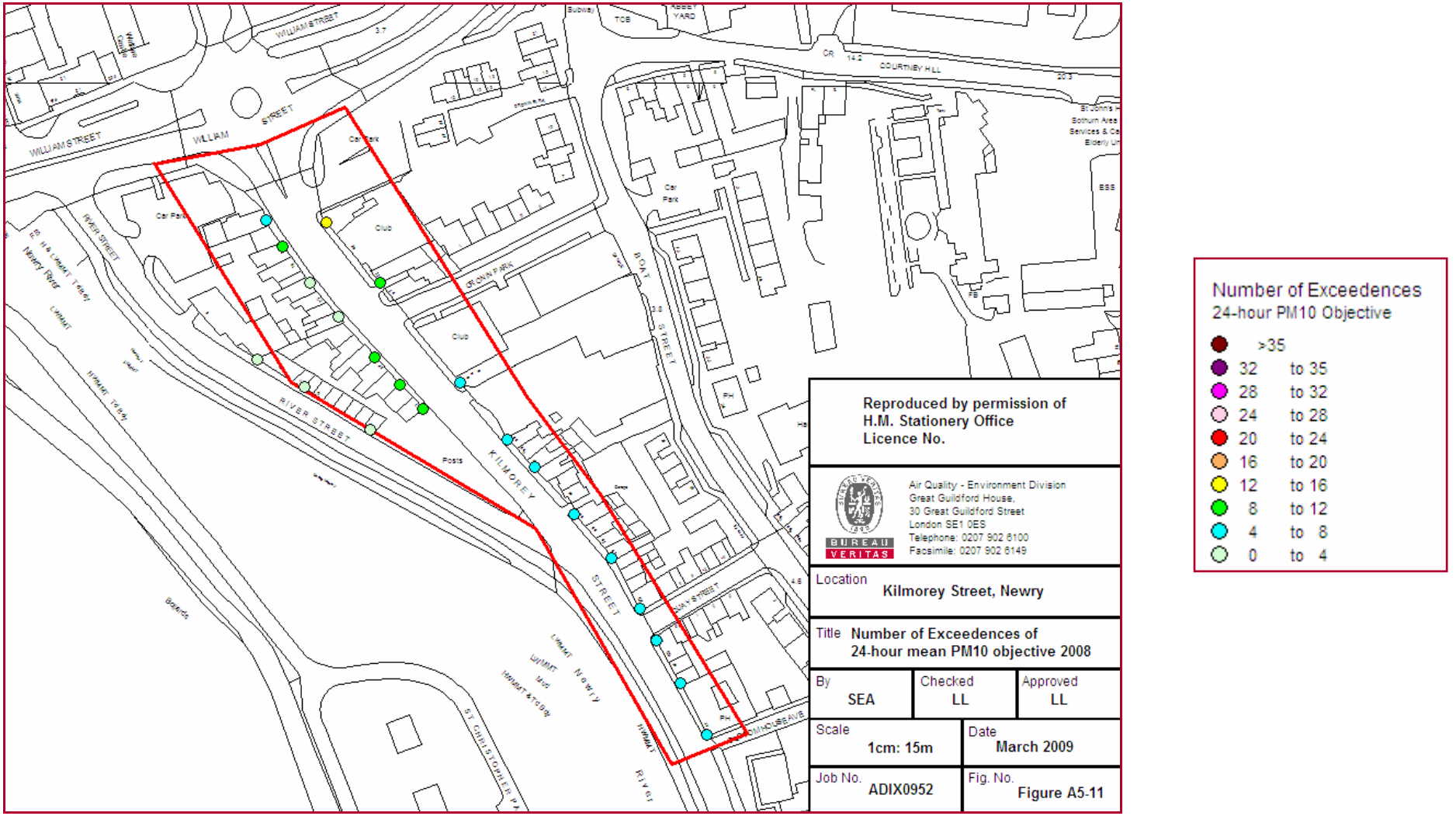
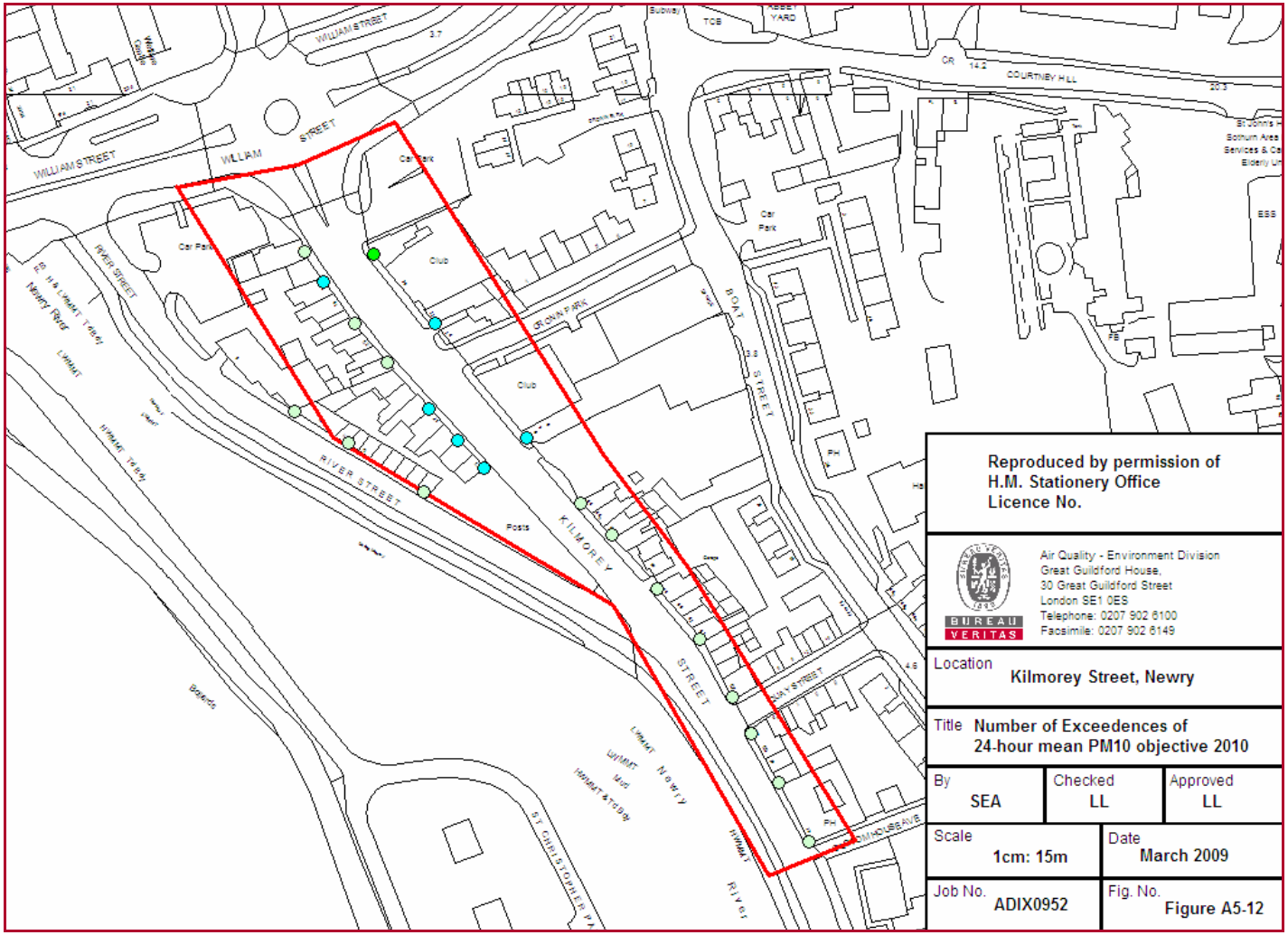


Figure A5-12 – Kilmorey Street AQMA 2010



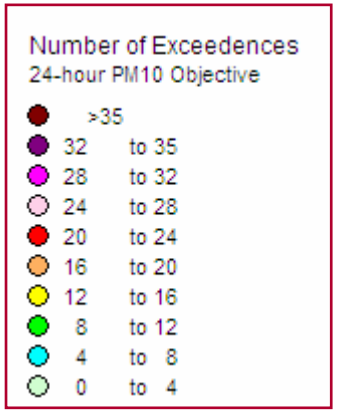


Figure A5-13 – St Mary's Street AQMA 2007

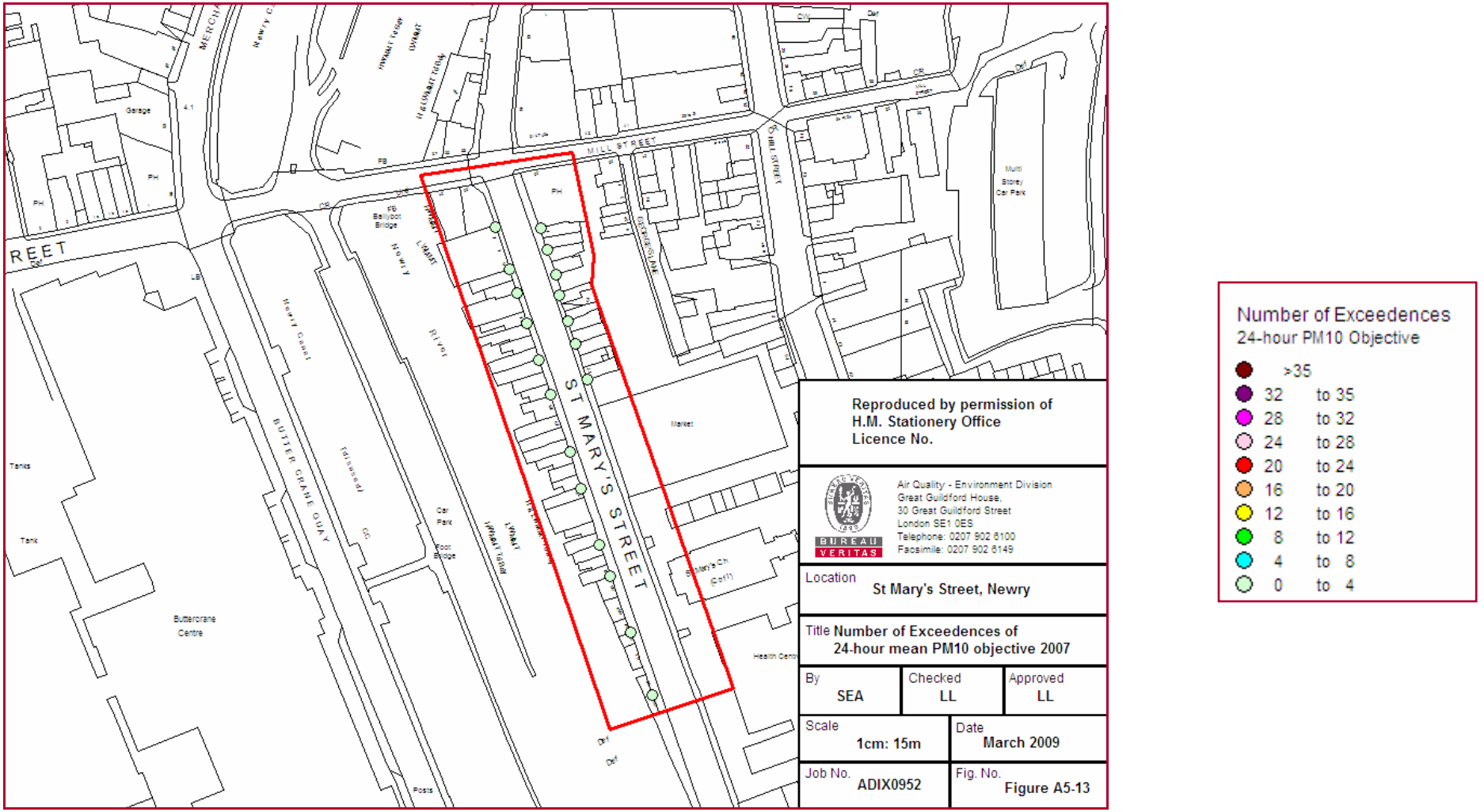


Figure A5-14 – St Mary's Street AQMA 2008

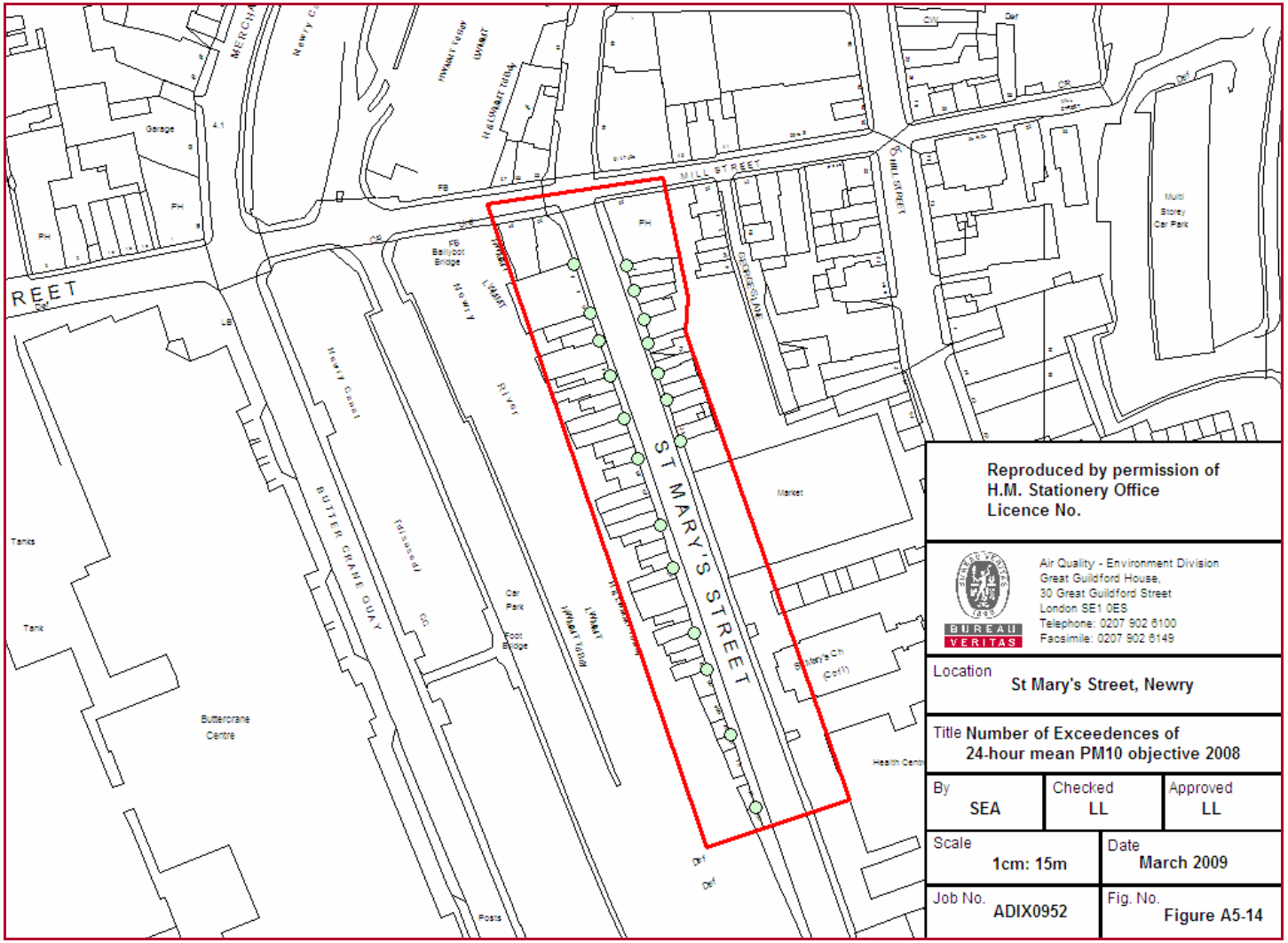
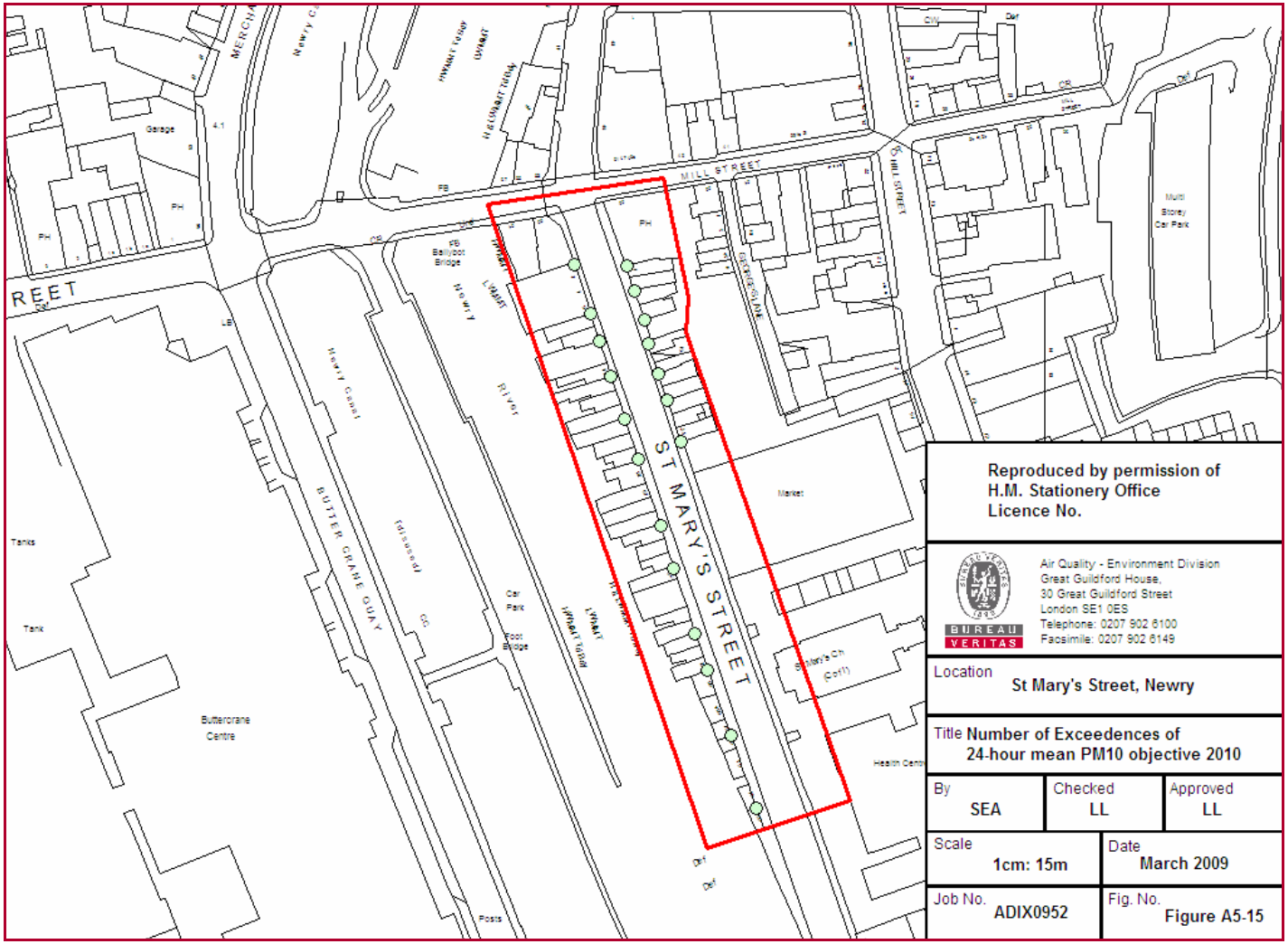


Figure A5-15 – St Mary's Street AQMA 2010



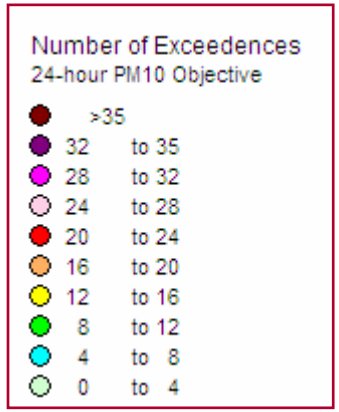


Figure A5-16 – Patrick Street AQMA 2007

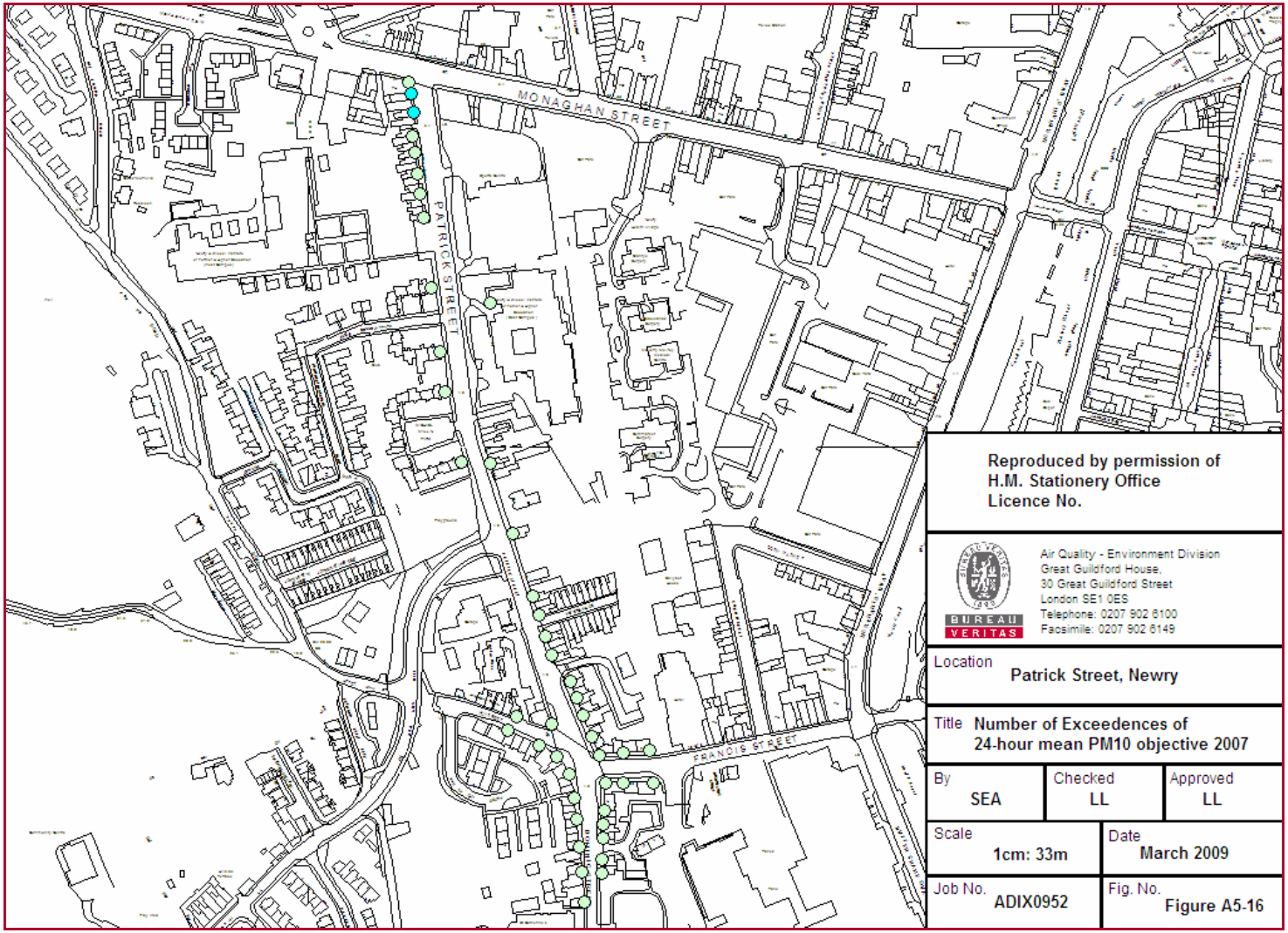


Figure A5-17 – Patrick Street AQMA 2008

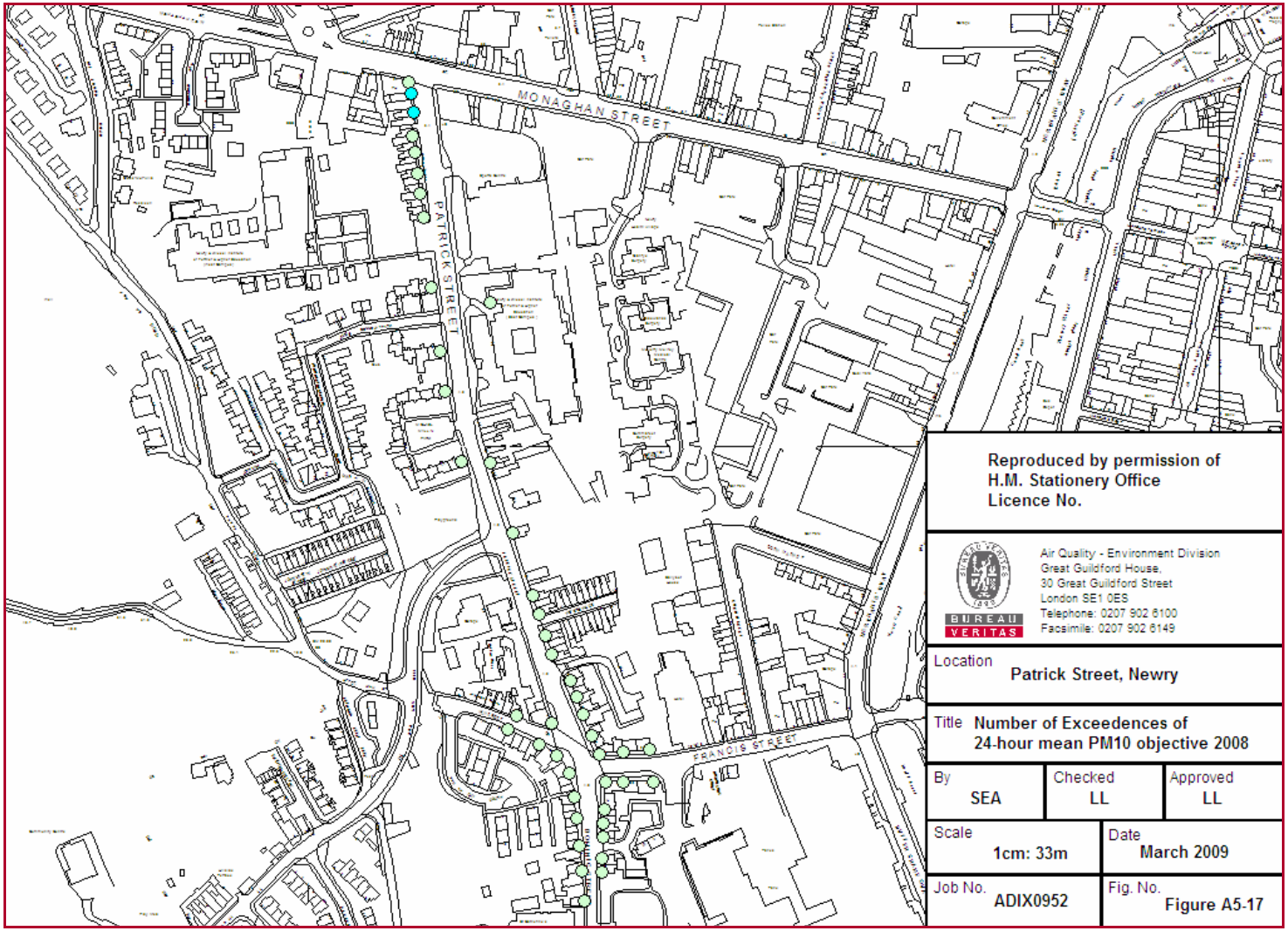


Figure A5-18 – Patrick Street AQMA 2010

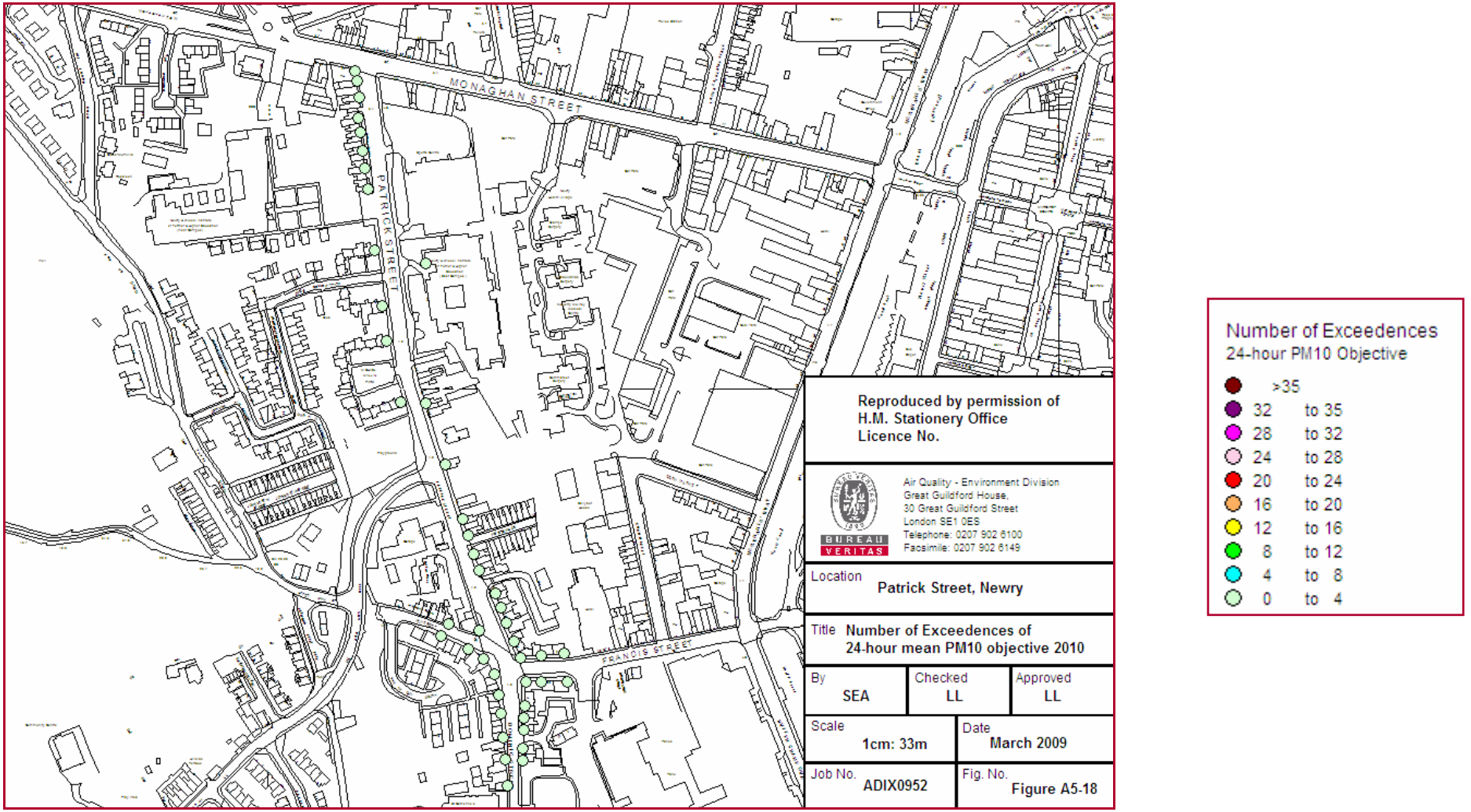
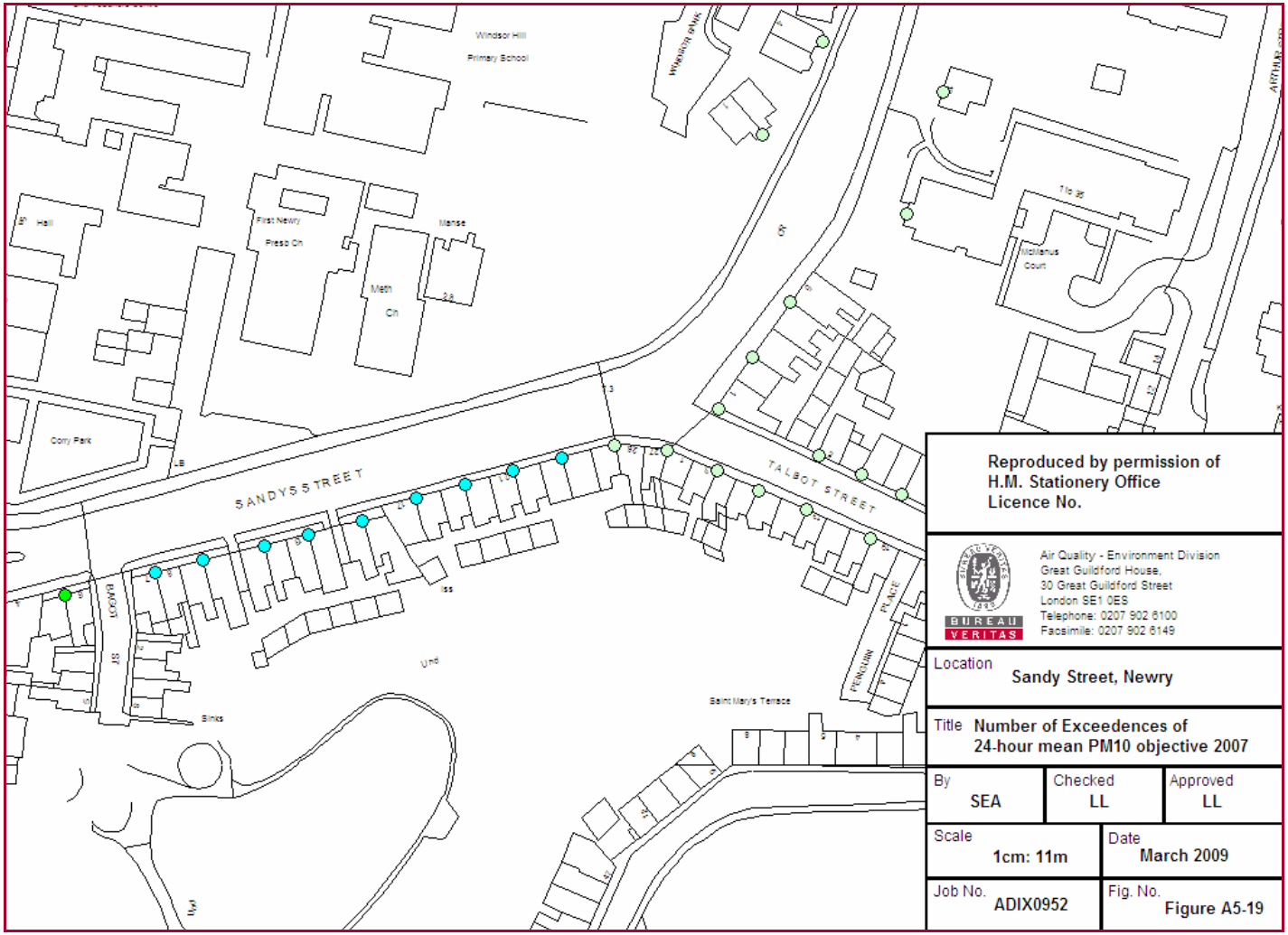


Figure A5-19 – Sandy Street AQMA 2007



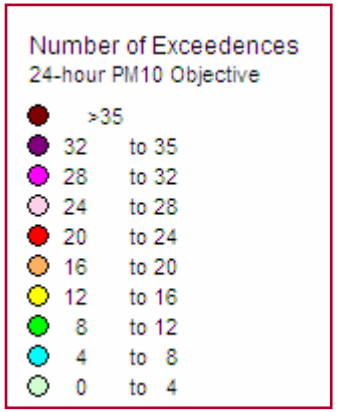
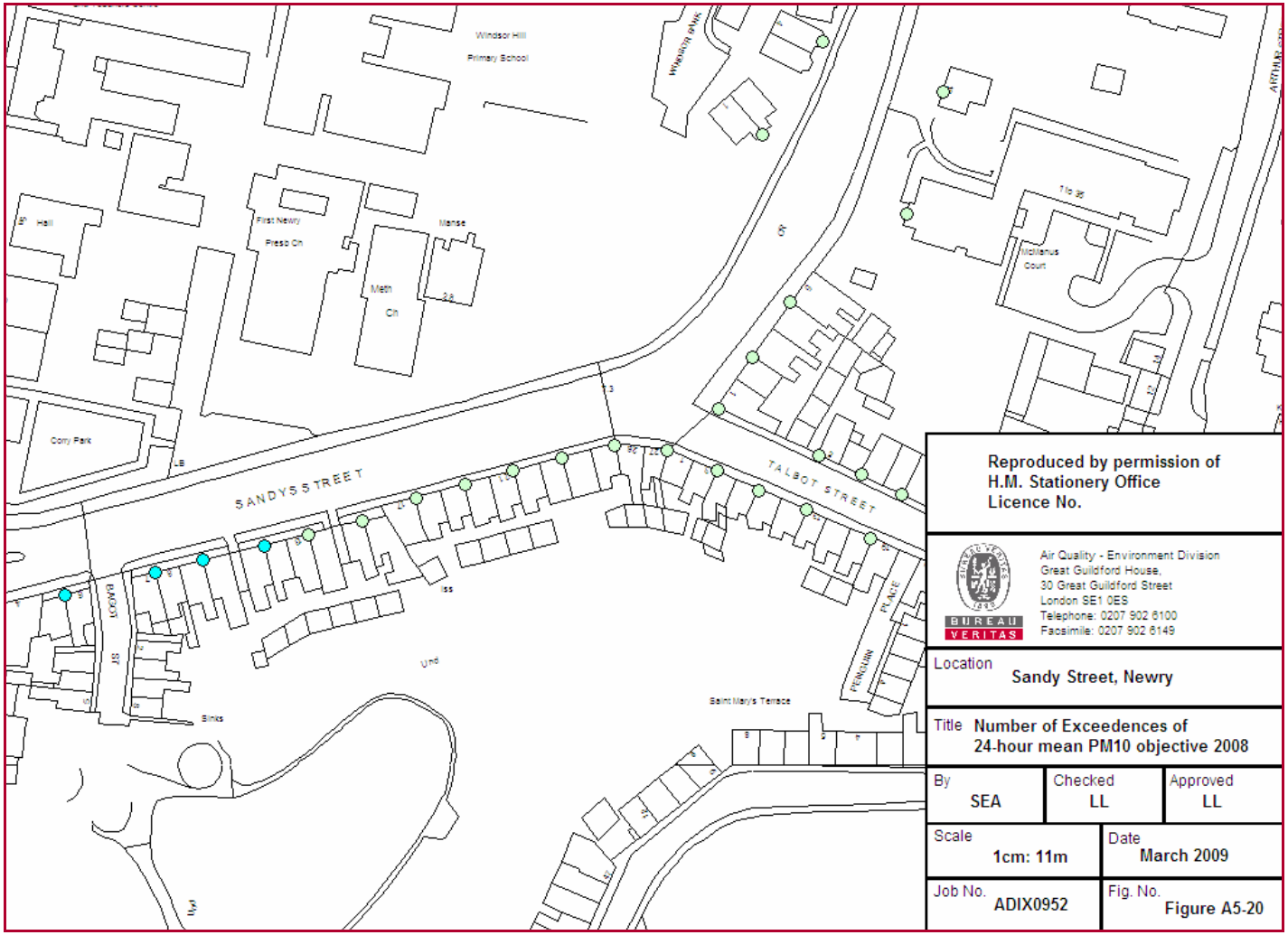


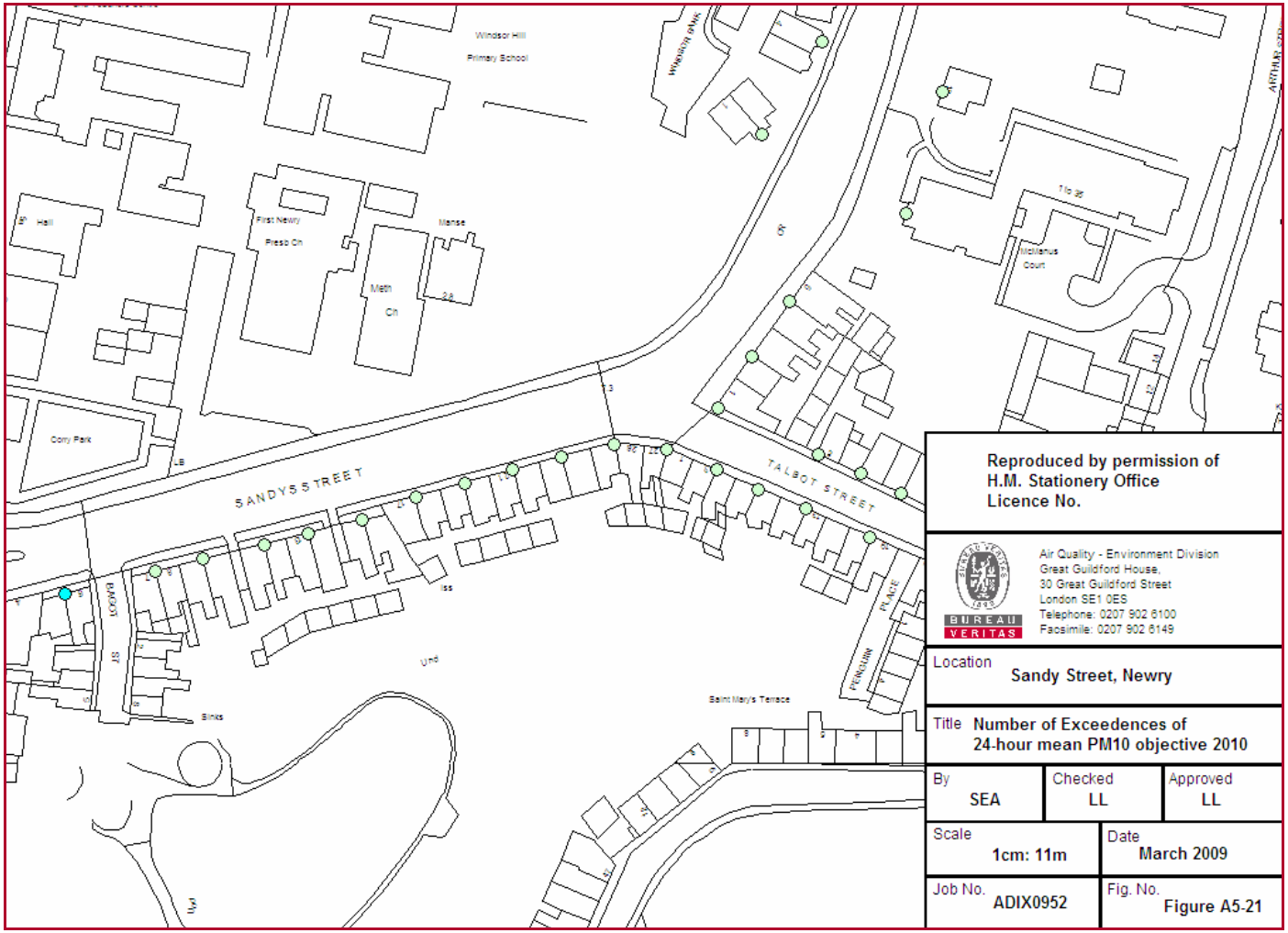
Figure A5-20 – Sandy Street AQMA 2008

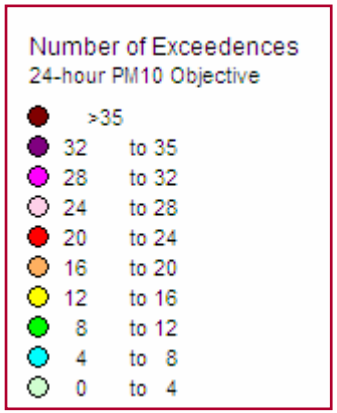


Number of Exceedences
24-hour PM10 Objective

- >35
- 32 to 35
- 28 to 32
- 24 to 28
- 20 to 24
- 16 to 20
- 12 to 16
- 8 to 12
- 4 to 8
- 0 to 4

Figure A5-21 – Sandy Street AQMA 2010





Appendix 6 – Modelled Contour Results

Figure A6-1 – Canal Street AQMA 2007

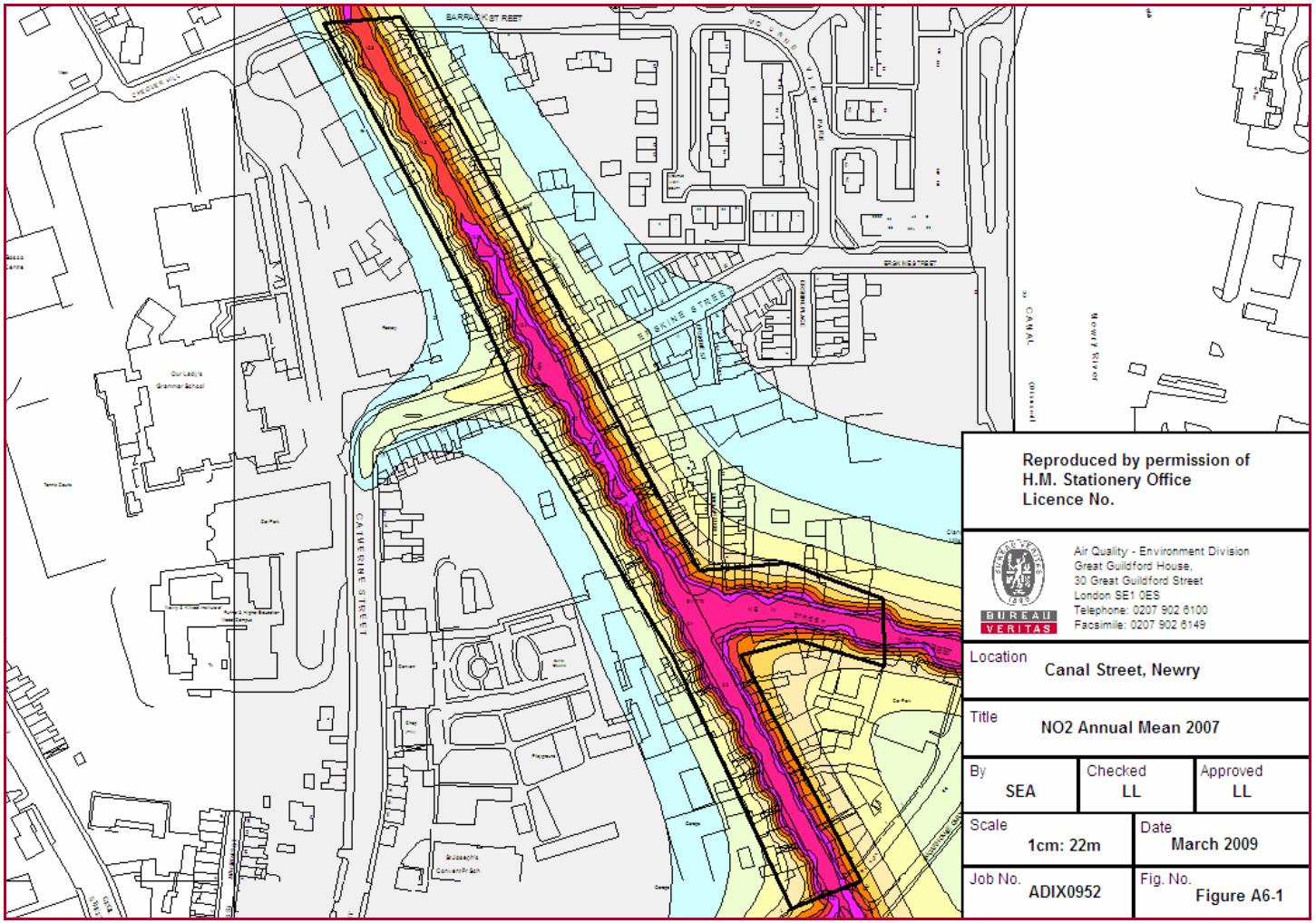


Figure A6-2 – Water Street AQMA 2007

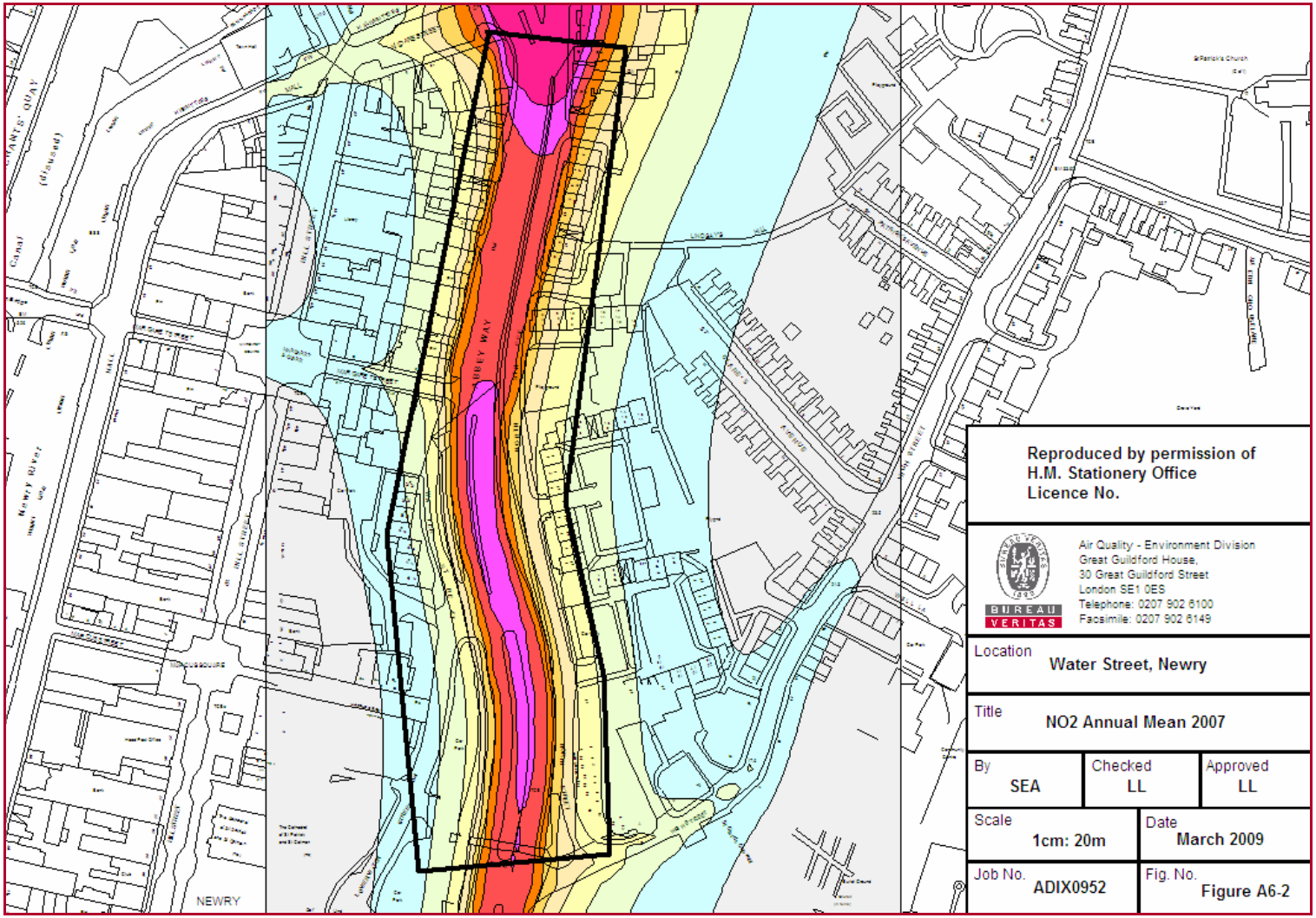


Figure A6-3 – Kilmorey Street AQMA 2007