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Local Plan

Air Quality Modelling Report (AQ3)

Coventry City Council

12th February 2019

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Document history

Revision	Purpose description	Origin-ated	Checked	Reviewed	Author-ised	Date
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1. Introduction

This deliverable (AQ3) reports the results of the air quality modelling used to inform Coventry City Council's Local Air Quality Plan.

The Air Quality Modelling Methodology Report (AQ2) outlines the methodology for and inputs to the air quality modelling.

The Analytical Assurance Statement provides an overall assessment of the uncertainty associated with the modelling and the results of sensitivity and uncertainty tests undertaken relating to air quality (emissions and dispersion) modelling.

2. Model Verification

Outputs from the base year (2017) air quality model have been compared to the results of nitrogen dioxide (NO_2) diffusion tube and continuous monitoring adjacent to modelled roads, and a model adjustment factor derived, in accordance with the methodology described within LAQM.TG16. The locations of these monitoring sites are shown in Figure A-1.

The following steps were undertaken:

- f-NO_2 values were estimated at each monitoring site using the ratio of modelled Road-NO_2 to Road-NO_x in the 2017 base year;
- background NO_2 concentrations for 2017 were estimated from Defra background maps (for a 2015 reference year), with the "in-square" contribution from Motorways and A-roads removed using Defra's Sector Removal Tool (v 6.0), to avoid double counting;
- modelled total NO_2 was estimated at each monitoring site by entering the modelled Road-NOx concentration, f-NO_2 and background NO_2 concentration at each monitoring site into Defra's NOx to NO_2 calculator (v6.1);
- modelled and measured total annual mean NO_2 concentrations were compared, which indicated that the model tended to under predict measured NO_2 concentrations, with some areas underpredicting more than others e.g. adjacent to Holyhead Road;
- "monitored Road-NOx" was estimated at each monitoring site by entering the measured annual mean NO_2 concentration, modelled f-NO_2 and mapped background NO_2 concentration at each monitoring site into the "NO_2 to NOx" tool within Defra's NOx to NO_2 calculator (v6.1);
- Three alternative model adjustment approaches were considered to improve model performance (as described within the Analytical Assurance Statement). The approach subsequently chosen resulted in the best model performance (in terms of correlation coefficient, RMSE and fractional bias), the most sites being within ±10% of measured concentrations (31 out of 50) and the least number of sites being more than ±25% of measured values (2 out of 50). For the chosen approach, five model adjustment factors were derived for the model domain, with one 'global' factor for the majority of the overall model domain and four factors for isolated transport corridors in different parts of the city. These model adjustment areas were termed "Coventry-wide", "Holyhead Road", "M6", "Spon End" and "Stoney Stanton" respectively;
  - the "Coventry-wide" factor of 2.15 was derived based on linear regression of "monitored Road-NOx" vs. "modelled Road-NOx" at 37 monitoring sites across Coventry. This factor was applied to 38 monitoring sites, with diffusion tube RR3 excluded from the derivation of the factor as the model substantially overestimated NO_2 concentrations at this location;
  - the "Holyhead Road" factor of 2.80 was derived based on a linear regression of "monitored Road-NOx" vs. "modelled Road-NOx" at four monitoring locations on the southern side of Holyhead Road (HR1, HR1c. HR4 and HR6). The model adjustment approach applied for Holyhead Road was specifically discussed and agreed with JAQU due to the elevated concentrations observed in this area;
  - the "M6" factor of 1.45 was derived based on the average of "monitored Road-NOx" vs "modelled Road-NOx" at two monitoring locations adjacent to the M6 (Grange2 and Grange3);
  - the "Spon End" factor of 1.18 was derived based on the average of "monitored Road-NOx" vs "modelled Road-NOx" at two monitoring locations adjacent to Spon End to the south west of the inner ring road (SE1 and SE3);
  - the "Stoney Stanton" factor of 2.81 was derived based on a linear regression of "monitored Road-NOx" vs. "modelled Road-NOx" at four monitoring locations adjacent to the Stoney Stanton Corridor to the north of the inner ring road (SS1, SS2, SS3 and SS5);
- "adjusted modelled NO_2" concentrations were derived by factoring "modelled Road-NOx" concentrations by the relevant model adjustment factor and entering the "adjusted Road-NOx" concentration, f-NO_2 and background NO_2 concentration at each monitoring site into Defra's NOx to NO_2 calculator (v6.1).

The results of the model verification process are summarised in Appendix B. Sensitivity tests around model verification are reported in the Analytical Assurance Statement (AAS).

In summary, post-adjustment 96% of modelled concentrations are within 25% of monitored concentrations. The root mean square error (RMSE) is well below the threshold value of 25% of the AQS objective (i.e. 10 µg/m^3) and close to the ideal of being within 10% of the AQS objective (i.e. 4 µg/m^3). The fractional bias (FB) indicates that the model tends to very slightly under predict.

On that basis the model is deemed to perform acceptably for the use it is intended.

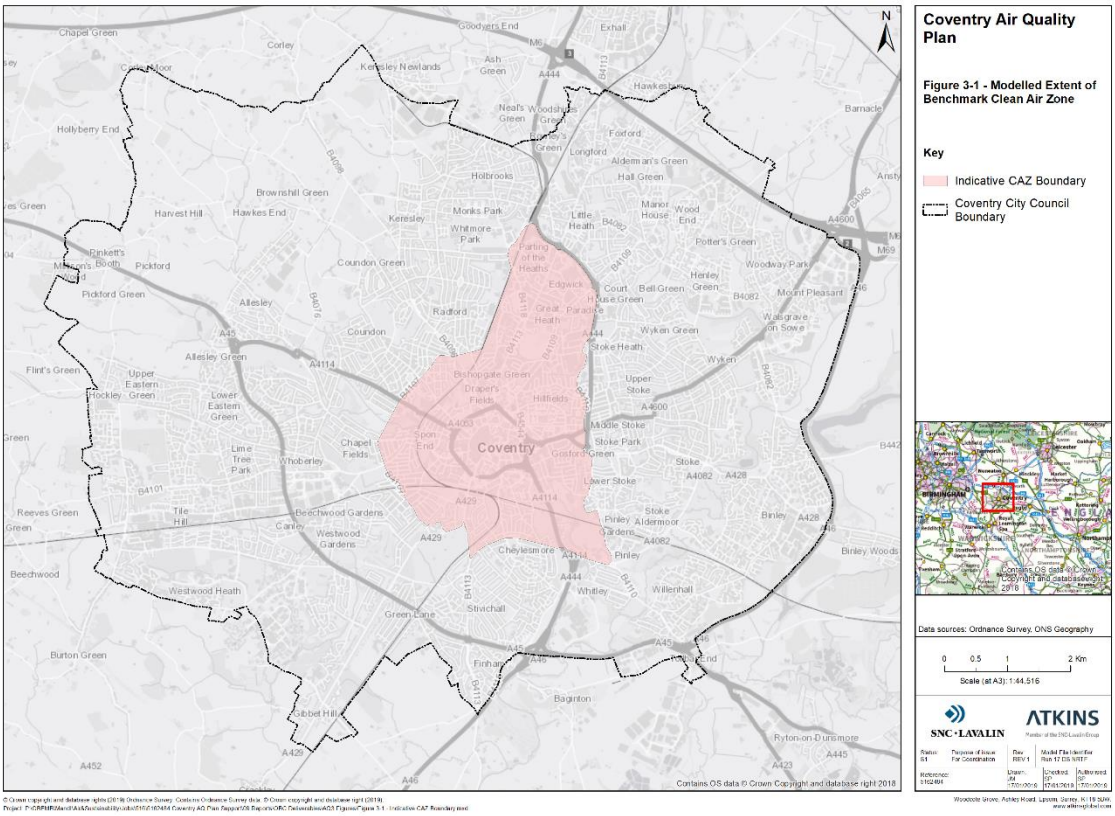
3. Proposed Measures

3.1. Benchmark Clean Air Zone

The benchmark Clean Air Zone (CAZ) considered consists of Class D CAZ (i.e. affecting buses, coaches, taxis, private hire vehicles, LGVs, HGVs and private cars) with a daily toll of £12.50 for Cars and LGVs and £100 for HGVs and coaches to enter the zone. The extent of the benchmark CAZ is presented in Figure 3-1 below.

A range of upgrade responses to the charge have been considered, as discussed in AQ2 and presented within the Analytical Assurance Statement, ranging from 'no upgrade' to the upgrade responses proposed by JAQU.

Figure 3-1 – Modelled Extent of Benchmark Clean Air Zone



3.2. DS12A

Option DS12A consists of the following package of measures:

- City wide traffic signal technology upgrade and additional Variable Message Systems (VMS);
- Taxi licence changes to improve fleet emissions;
- Support for taxi drivers to encourage upgrade of vehicles;
- Bus retrofit to minimum Euro 6, with some waiting facilities improved on key routes;
- Travel planning package city wide (schools, workplaces, communities);
- High quality cycle infrastructure along 4 routes;
- Capacity improvements at Spon End;
- Redesign of Ring Road J7;
- Closure of Coundon Road level crossing;
- Removal of signals at Holyhead Road/Barras Lane;
- HGV ban on Holyhead Road between railway line and J8;

- Peak time restrictions on Holyhead Road (inbound AM, outbound PM).

4. Modelling Results

4.1. Modelled Receptors

The locations of modelled receptors relative to each PCM link are shown in Figure A-2 to Figure A-34. These receptors have been selected to represent the maximum annual mean roadside NO_2 concentrations adjacent to each PCM link at locations which meet the requirements of the Air Quality Directive (Annex III: A, B, and C), and specifically at which there is public access for the duration of relevant air quality criteria.

A number of additional worst-case receptors were modelled adjacent to non-PCM links for those roads with the potential to be affected by displaced traffic as a result of each option. These 'secondary' receptors were positioned in the same way as the discrete receptors modelled to represent PCM links. The locations of these receptors are shown in Figure A-35.

A grid of receptors across Coventry at 100m x 100m resolution and associated points adjacent to the modelled road network (using the ADMS-Roads intelligent gridding function) were also modelled to assess wider air quality impacts, including the effect of each option on population-weighted mean NO_2 concentrations, as suggested in the JAQU Evidence Guidance.

4.2. Summary of Results

4.2.1. Do-Minimum Scenario

4.2.1.1. PCM Compliance

The results of the air quality modelling for the Do-Minimum scenario are summarised in Table 1 and shown in Figure A-36, which indicate that, in the absence of any action, compliance with the annual mean NO_2 EU limit value is not projected to be achieved until 2029 for one link (Holyhead Road - Census ID 7647).

The EU Limit Value is also modelled to be exceeded in 2021 adjacent to the following road links:

- 7103 (A4082 London Road), with compliance projected to be achieved in 2023;
- 7631 (northeast section of A4053 Ring Road), with compliance projected to be achieved in 2026;
- 26497 (Sky Blue Way), with compliance projected to be achieved in 2024;
- 27132 (A4114 London Road), with compliance projected to be achieved in 2023;
- 27693 (northwest section of A4053 Ring Road), with compliance projected to be achieved in 2022;
- 37169 (Binley Road), with compliance projected to be achieved in 2023;
- 37731 (southwest section of A4053 Ring Road), with compliance projected to be achieved in 2027;
- 37748 (southeast section of A4053 Ring Road), with compliance projected to be achieved in 2022;
- 47156 (A429 Kenilworth Road), with compliance projected to be achieved in 2022;
- 47690 (northwest section of A4053 Ring Road), with compliance projected to be achieved in 2023; and
- 58401 (A4600 Walsgrave Road), with compliance projected to be achieved in 2022.

On this basis, measures are required to address non-compliance in the compliance assessment year of 2021.

Table 1 - Air Quality Modelling Results – Do-Minimum Scenario

Census ID	Modelled Roadside Annual Mean NO_2 Concentration (µg/m^3)													
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
7103	**50.72**	**48.97**	**47.17**	**45.25**	**43.33**	**41.40**	39.53	37.69	35.87	34.07	32.30	30.55	28.83	27.14
7631	**56.40**	**54.68**	**52.91**	**50.99**	**49.11**	**46.88**	**44.74**	**42.65**	**40.57**	38.60	36.65	34.75	32.90	31.08
7647	**69.54**	**66.89**	**64.03**	**60.88**	**57.61**	**55.08**	**52.61**	**50.17**	**47.73**	**45.35**	**42.98**	**40.63**	38.29	35.97
26497	**54.66**	**52.85**	**50.96**	**48.90**	**46.83**	**44.61**	**42.46**	40.35	38.25	36.23	34.22	32.26	30.33	28.43
27132	**49.97**	**48.56**	**47.12**	**45.59**	**44.10**	**42.16**	40.30	38.47	36.67	34.91	33.19	31.50	29.86	28.25
27693	**49.97**	**48.04**	**46.05**	**43.93**	**41.84**	40.00	38.25	36.54	34.86	33.27	31.72	30.21	28.75	27.34
37169	**50.20**	**48.21**	**46.15**	**43.94**	**41.69**	39.85	38.09	36.37	34.66	32.98	31.33	29.71	28.13	26.58
37731	**54.42**	**53.46**	**52.50**	**51.46**	**50.63**	**48.55**	**46.55**	**44.60**	**42.66**	**40.82**	39.01	37.24	35.51	33.82
37748	**49.91**	**47.86**	**45.77**	**43.54**	**41.50**	39.81	38.20	36.63	35.08	33.62	32.19	30.80	29.46	28.15
47156	**48.32**	**46.81**	**45.25**	**43.57**	**42.07**	40.46	38.93	37.44	35.96	34.57	33.20	31.87	30.57	29.32
47690	**50.43**	**48.53**	**46.55**	**44.40**	**42.28**	**40.51**	38.80	37.11	35.44	33.85	32.27	30.73	29.22	27.74
58401	**48.04**	**46.76**	**45.45**	**43.99**	**42.57**	40.44	38.39	36.37	34.37	32.44	30.53	28.65	26.82	25.01

Note: Values in **bold** denote exceedances of annual mean NO_2 EU limit value

4.2.1.2. Wider Impacts

The local modelling results at secondary (i.e. non-PCM) receptors indicates that the EU Limit Value has the potential to be exceeded at 28 of the 401 modelled receptors (7.0%) in 2021. These exceedance locations are presented in Figure A-37, but are generally limited to:

- a small number of locations within the A4053 Inner Ring Road and close to Ring Road interchanges;
- a stretch of Stoney Stanton to the north of the A4053 Inner Ring Road; and
- isolated locations adjacent to the Strategic Road Network, including A-roads (A45 and A46) and motorways (M6 and M69).

A contour map of modelled Do-Minimum 2021 NO_2 concentrations in Coventry is presented in Figure A-38. It shows that the highest concentrations occur in close proximity to the modelled road network, with higher concentrations noted adjacent to the:

- A4053 Inner Ring Road;
- Blue Sky Way;
- A444;
- A45;
- A46; and
- M6.

There is an elevated background concentration (between 24 to 26 µg/m³) towards the city centre, but generally, background concentrations are relatively low across the city (less than 22 µg/m³).

4.2.2. Benchmark CAZ D Scenario

4.2.2.1. PCM Compliance

The results of the air quality modelling for the Benchmark CAZ D scenario are summarised in Table 4, which indicate that, in this scenario, compliance with the annual mean NO_2 EU limit value is projected to be achieved between 2023 and 2026 for one link (Holyhead Road - Census ID 7647), depending upon the modelled upgrade response (see AQ2) – hence the range of results reported.

The EU Limit Value is also modelled to be exceeded in 2021 adjacent to the following road links:

- 7103 (A4082 London Road), with compliance projected to be achieved between 2022 and 2023, depending upon the modelled upgrade response;
- 7631 (northeast section of A4053 Ring Road), with compliance projected to be achieved between 2021 and 2023, depending upon the modelled upgrade response;
- 37731 (southwest section of A4053 Ring Road), with compliance projected to be achieved between 2021 and 2023, depending upon the modelled upgrade response.

Table 2 - Air Quality Modelling Results – Benchmark CAZ D Scenario

Census ID	Modelled Roadside Annual Mean NO_2 Concentration (µg/m^3)									
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
6490	31.68 - 30.92	30.16 - 29.48	28.71 - 28.11	27.29 - 26.77	25.88 - 25.44	24.54 - 24.18	23.21 - 22.94	21.92 - 21.72	20.66 - 20.54	19.42 - 19.39
6491	30.51 - 29.87	29.22 - 28.65	27.99 - 27.48	26.79 - 26.35	25.60 - 25.22	24.44 - 24.14	23.31 - 23.07	22.21 - 22.03	21.14 - 21.03	20.09 - 20.05
7103	**43.16 - 41.76**	**41.09** - 39.84	39.08 - 37.96	37.08 - 36.10	35.09 - 34.26	33.12 - 32.44	31.16 - 30.63	29.23 - 28.84	27.31 - 27.07	25.40 - 25.32
7118	31.80 - 30.90	30.18 - 29.38	28.63 - 27.92	27.10 - 26.48	25.59 - 25.06	24.12 - 23.69	22.67 - 22.33	21.25 - 21.01	19.86 - 19.72	18.49 - 18.45
7122	34.31 - 32.62	32.60 - 31.08	30.94 - 29.59	29.29 - 28.12	27.65 - 26.66	26.06 - 25.24	24.48 - 23.83	22.92 - 22.45	21.38 - 21.08	19.86 - 19.74
7631	**42.64** - 38.38	**40.89** - 37.06	39.23 - 35.83	37.59 - 34.63	35.97 - 33.45	34.44 - 32.36	32.94 - 31.29	31.47 - 30.27	30.05 - 29.29	28.66 - 28.35
7647	**47.96 - 42.43**	**46.14 - 41.16**	**44.37** - 39.95	**42.62** - 38.75	**40.87** - 37.57	39.18 - 36.46	37.50 - 35.37	35.85 - 34.31	34.21 - 33.27	32.59 - 32.27
16446	39.53 - 38.73	37.40 - 36.68	35.30 - 34.67	33.22 - 32.67	31.13 - 30.67	29.08 - 28.70	27.03 - 26.72	24.98 - 24.76	22.94 - 22.80	20.91 - 20.85
16467	30.09 - 29.20	28.69 - 27.90	27.35 - 26.66	26.05 - 25.44	24.75 - 24.25	23.53 - 23.12	22.33 - 22.01	21.15 - 20.93	20.01 - 19.88	18.90 - 18.86
17075	28.43 - 27.30	27.05 - 26.03	25.73 - 24.83	24.43 - 23.66	23.15 - 22.50	21.92 - 21.39	20.71 - 20.30	19.53 - 19.25	18.38 - 18.22	17.26 - 17.22
17595	34.01 - 31.56	32.79 - 30.59	31.63 - 29.69	30.50 - 28.81	29.38 - 27.95	28.35 - 27.18	27.33 - 26.42	26.35 - 25.70	25.41 - 25.01	24.50 - 24.36
18006	28.66 - 28.12	27.28 - 26.80	25.96 - 25.54	24.66 - 24.30	23.38 - 23.08	22.15 - 21.90	20.93 - 20.73	19.74 - 19.60	18.58 - 18.50	17.45 - 17.42
26497	39.25 - 35.60	37.61 - 34.33	36.05 - 33.14	34.51 - 31.98	32.99 - 30.84	31.55 - 29.78	30.12 - 28.74	28.73 - 27.74	27.38 - 26.78	26.06 - 25.86

Census ID	Modelled Roadside Annual Mean NO_2 Concentration (µg/m^3)									
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
27132	37.45 - 34.17	36.02 - 33.07	34.65 - 32.05	33.32 - 31.05	32.00 - 30.07	30.72 - 29.13	29.46 - 28.21	28.24 - 27.33	27.05 - 26.48	25.89 - 25.67
27151	26.11 - 24.91	24.94 - 23.87	23.84 - 22.89	22.76 - 21.94	21.70 – 21.00	20.69 - 20.12	19.71 - 19.26	18.75 - 18.43	17.83 - 17.63	16.93 - 16.86
27693	36.92 - 33.79	35.43 - 32.62	34.03 - 31.54	32.67 - 30.50	31.32 - 29.48	30.06 - 28.56	28.84 - 27.66	27.65 - 26.80	26.51 - 25.99	25.41 - 25.23
27708	31.27 - 29.78	29.70 - 28.36	28.18 - 26.99	26.68 - 25.65	25.19 - 24.31	23.74 - 23.02	22.31 - 21.74	20.89 - 20.48	19.50 - 19.25	18.13 - 18.04
36482	39.73 - 39.34	37.81 - 37.46	35.94 - 35.62	34.08 - 33.81	32.22 - 31.99	30.39 - 30.21	28.57 - 28.43	26.76 - 26.66	24.98 - 24.92	23.20 - 23.19
36504	35.52 - 34.68	33.79 - 33.05	32.14 - 31.49	30.51 - 29.94	28.89 - 28.42	27.34 - 26.95	25.80 - 25.51	24.30 - 24.09	22.82 - 22.70	21.37 - 21.33
37169	38.54 - 36.28	36.84 - 34.81	35.20 - 33.40	33.59 - 32.02	31.98 - 30.65	30.41 - 29.32	28.86 – 28.00	27.34 - 26.72	25.84 - 25.48	24.38 - 24.26
37731	**42.81** - 39.14	**41.35** - 38.07	39.98 - 37.07	38.63 - 36.11	37.30 - 35.15	36.05 - 34.29	34.83 - 33.45	33.64 - 32.64	32.49 - 31.87	31.38 - 31.14
37748	36.37 - 33.57	35.07 - 32.56	33.84 - 31.62	32.65 - 30.73	31.47 - 29.84	30.38 - 29.05	29.32 - 28.28	28.29 - 27.54	27.30 - 26.85	26.35 - 26.19
38796	40.01 - 38.53	37.98 - 36.65	36.02 - 34.83	34.08 - 33.05	32.15 - 31.27	30.27 - 29.55	28.41 - 27.85	26.57 - 26.17	24.76 - 24.53	22.97 - 22.91
47156	35.34 - 32.76	34.25 - 31.93	33.23 - 31.19	32.26 - 30.48	31.29 - 29.78	30.42 - 29.18	29.58 - 28.61	28.77 - 28.07	28.00 - 27.57	27.27 - 27.11
47690	36.50 - 33.22	35.02 - 32.07	33.59 - 30.98	32.18 - 29.92	30.79 - 28.87	29.47 - 27.89	28.16 - 26.94	26.88 - 26.02	25.63 - 25.13	24.41 - 24.27
56791	21.98 - 21.36	21.00 - 20.44	20.05 - 19.56	19.13 - 18.71	18.22 - 17.86	17.34 - 17.05	16.47 - 16.25	15.63 - 15.47	14.80 - 14.71	14.00 - 13.97

Census ID	Modelled Roadside Annual Mean NO_2 Concentration (µg/m^3)									
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
58401	37.55 - 34.93	35.78 - 33.43	34.08 - 32.02	32.42 - 30.63	30.77 - 29.27	29.20 - 27.97	27.65 - 26.70	26.14 - 25.47	24.66 - 24.28	23.23 - 23.12
70238	36.05 - 33.60	34.52 - 32.32	33.04 - 31.10	31.60 - 29.91	30.17 - 28.73	28.77 - 27.59	27.39 - 26.47	26.04 - 25.39	24.73 - 24.34	23.45 - 23.33
74638	28.30 - 26.69	27.19 - 25.74	26.16 - 24.89	25.18 - 24.08	24.22 - 23.29	23.36 - 22.60	22.54 - 21.94	21.75 - 21.33	21.02 - 20.77	20.33 - 20.25
74639	30.18 - 28.52	29.15 - 27.67	28.21 - 26.91	27.31 - 26.18	26.42 - 25.47	25.63 - 24.86	24.86 - 24.26	24.14 - 23.71	23.45 - 23.20	22.81 - 22.73
74640	33.98 - 31.61	32.78 - 30.66	31.66 - 29.79	30.58 - 28.96	29.51 - 28.13	28.54 - 27.41	27.58 - 26.70	26.67 - 26.04	25.79 - 25.41	24.95 - 24.82
81233	35.54 - 35.28	33.69 - 33.47	31.91 - 31.71	30.15 - 29.97	28.40 - 28.25	26.69 - 26.57	24.99 - 24.89	23.31 - 23.24	21.66 - 21.62	20.04 - 20.03
99218	38.28 - 36.77	36.43 - 35.09	34.67 - 33.48	32.94 - 31.91	31.22 - 30.35	29.58 - 28.86	27.96 - 27.41	26.38 - 25.98	24.84 - 24.61	23.34 - 23.27

Note: Values in **bold** denote exceedances of annual mean NO_2 EU limit value

4.2.2.2. Secondary Receptors

The local modelling of secondary receptors indicates that between 5 and 11 of the 401 modelled receptors (1.2% to 2.7%) are modelled to be in exceedance of the EU limit value in 2021. This is an improvement relative to the Do-Minimum scenario of between 23 to 17 exceedances. The impacts of the benchmark CAZ D at modelled secondary receptors have been described in accordance with guidance published by Environmental Protection UK (EPUK) and the Institute of Air Quality Management (IAQM)[1], as shown in Figure A-39 to Figure A-41 and summarised in Table 3.

Table 3 - Summary of Impacts at Secondary Receptors in 2021 for benchmark CAZ D

Impact	CAZ D (No Upgrade)	CAZ D (West Midlands Upgrade)	CAZ D (JAQU Upgrade)
Substantial Decrease	30	31	31
Moderate Decrease	105	124	140
Slight Decrease	70	73	70
Negligible	181	165	155
Slight Increase	11	6	4
Moderate Increase	3	2	1
Substantial Increase	1	0	0

The results in Table 3 indicate that the benchmark CAZ D has the potential to result in increases in annual mean NO_2 concentrations at between 5 and 15 secondary receptors (depending on the upgrade scenario). These receptors are primarily located around the boundary of the CAZ as vehicles re-route to avoid entering the CAZ boundary. Significant benefits are modelled within the CAZ boundary, particularly within the A4053 Inner Ring Road and on Stoney Stanton. Overall, the impact of the benchmark CAZ D at secondary receptors is generally positive or negligible.

The difference in the benchmark CAZ D (West Midlands Upgrade) and Do-Minimum 2021 NO_2 concentration contours is shown in Figure A-42. This illustrates the geographical distribution of the impacts of the benchmark CAZ D, with key routes around the CAZ boundary showing an increase in NO_2 concentrations (lightest blue). However, many routes into the city show a decrease in NO_2 concentrations (darkest blue). Figure A-43 shows the difference in the 2021 mean NO_2 concentration by Lower Super Output Area (LSOA) between the benchmark CAZ D (West Midlands Upgrade) scenario and the Do-Minimum scenario. Within the CAZ boundary, the majority of LSOAs are modelled to experience a large reduction in mean NO_2 concentration with smaller reductions elsewhere beyond the boundary. There are only two LSOAs that are modelled to experience an increase in NO_2 concentrations as a result of the scheme, however these increases are negligible (between 0.0 and 0.5 µg/m³). Differences around the outskirts of the city are relatively negligible compared to the improvements within the CAZ boundary.

4.2.3. DS12A Scenario

4.2.3.1. PCM Compliance

The results of the air quality modelling for the DS12A scenario are summarised in Table 4, which indicate that, in this scenario, compliance with the annual mean NO_2 EU limit value is not projected to be achieved until 2025 for two links (Holyhead Road - Census ID 7647 and southwest section of A4053 Ring Road – Census ID 37731).

The EU Limit Value is also modelled to be exceeded in 2021 adjacent to the following road links:

- 7103 (A4082 London Road), with compliance projected to be achieved in 2022;
- 7631 (northeast section of A4053 Ring Road), with compliance projected to be achieved in 2024;

[1] Environmental Protection UK and Institute of Air Quality Management, 'Land-Use Planning & Development Control: Planning for Air Quality', January 2017.

- 26497 (Sky Blue Way), with compliance projected to be achieved in 2023; and,
- 27132 (A4114 London Road), with compliance projected to be achieved in 2022.

Further work has been undertaken to identify interventions for two links below, to bring forward the compliance date. This has been estimated using existing traffic flow information due to time constraints, but demonstrates that these two links can be bought into compliance in 2024 as detailed below.

- opening of the bus gate at Warwick Road to improve concentrations at receptor 33731 i.e. returning that link to two-way and open to all traffic, which is thought will reduce traffic on the Ring Road adjacent to this receptor (traffic currently has to join the ring road at J7 as there is no direct entry to J6); and
- partially closing Holyhead Road for short-term periods (outside of peak hours) directed by real-time air quality monitoring. Indicative results of this intervention have already been estimated by assuming Holyhead Road is closed in one direction in those hours when air quality concentrations are greater than the 95th percentile of hourly means. This indicative modelling suggested the level of improvement was enough to achieve compliance in 2024. However, this was done by factoring the existing air quality outputs, which do not account for the wider traffic impacts of this intervention, which would be needed to support the final OBC submission.

At the time of submission, this work is currently underway and the outputs of the traffic model will be processed into air quality model inputs and run in the model to provide evidence that compliance can be met by 2024 on both links. The OBC is based on achieving compliance in 2024 due to the above detail.

Table 4 - Air Quality Modelling Results – DS12A Scenario

Census ID	Modelled Roadside Annual Mean NO_2 Concentration (µg/m^3)									
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
6490	31.13	29.68	28.30	26.95	25.61	24.34	23.09	21.87	20.68	19.53
6491	29.24	28.09	27.00	25.94	24.89	23.88	22.89	21.93	21.01	20.11
7103	**40.61**	38.80	37.05	35.32	33.60	31.91	30.23	28.58	26.95	25.34
7118	30.90	29.38	27.93	26.49	25.08	23.71	22.37	21.05	19.77	18.51
7122	33.55	31.92	30.33	28.76	27.21	25.70	24.20	22.72	21.27	19.84
7631	**45.55**	**43.48**	**41.51**	39.56	37.63	35.79	33.98	32.21	30.47	28.78
7647	**48.22**	**46.10**	**44.06**	**42.05**	40.06	38.16	36.29	34.46	32.67	30.91
16446	37.27	35.37	33.52	31.67	29.83	28.03	26.24	24.45	22.69	20.93
16467	29.73	28.37	27.09	25.82	24.58	23.40	22.25	21.13	20.04	18.98
17075	28.28	26.92	25.63	24.36	23.11	21.91	20.73	19.58	18.47	17.38
17595	36.13	34.69	33.32	31.98	30.65	29.40	28.18	27.00	25.85	24.73
18006	27.41	26.16	24.97	23.80	22.65	21.55	20.46	19.40	18.37	17.37
26497	**43.39**	**41.33**	39.36	37.41	35.48	33.62	31.78	29.98	28.21	26.47
27132	**40.55**	38.79	37.10	35.45	33.81	32.21	30.63	29.09	27.59	26.12
27151	25.36	24.27	23.25	22.26	21.29	20.37	19.47	18.61	17.78	16.98
27693	39.17	37.45	35.82	34.23	32.65	31.18	29.73	28.32	26.97	25.65
27708	30.20	28.71	27.28	25.87	24.48	23.14	21.81	20.51	19.24	17.99
36482	36.94	35.33	33.76	32.22	30.69	29.20	27.72	26.26	24.83	23.43
36504	34.74	33.11	31.54	30.00	28.47	27.01	25.57	24.16	22.77	21.42
37169	37.94	36.29	34.71	33.16	31.63	30.13	28.65	27.20	25.79	24.41
37731	**47.43**	**45.47**	**43.58**	**41.73**	39.89	38.13	36.38	34.67	33.00	31.35

Census ID	Modelled Roadside Annual Mean NO_2 Concentration (µg/m^3)									
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
37748	38.85	37.29	35.81	34.36	32.92	31.57	30.24	28.95	27.70	26.48
38796	36.74	35.06	33.45	31.87	30.31	28.80	27.31	25.85	24.43	23.04
47156	38.55	37.10	35.72	34.39	33.06	31.83	30.62	29.45	28.33	27.23
47690	37.86	36.30	34.80	33.34	31.89	30.52	29.18	27.87	26.61	25.37
56791	21.21	20.32	19.47	18.64	17.82	17.03	16.26	15.51	14.78	14.06
58401	39.13	37.20	35.35	33.54	31.75	30.03	28.33	26.68	25.06	23.48
70238	36.70	35.10	33.57	32.07	30.58	29.12	27.69	26.29	24.93	23.60
74638	29.27	28.05	26.93	25.84	24.78	23.82	22.90	22.01	21.18	20.39
74639	31.28	30.14	29.09	28.07	27.08	26.18	25.30	24.47	23.68	22.93
74640	36.17	34.75	33.42	32.12	30.83	29.63	28.46	27.32	26.23	25.17
81233	32.56	31.03	29.57	28.13	26.71	25.33	23.97	22.63	21.33	20.06
99218	36.70	35.04	33.46	31.91	30.38	28.93	27.50	26.12	24.77	23.46

Note: Values in **bold** denote exceedances of annual mean NO_2 EU limit value

4.2.3.2. Wider Impacts

The local modelling of secondary receptors in the DS12A scenario shows 10 of the 401 receptors (2.5%) are modelled to be in exceedance of the EU limit value in 2021. This is an improvement relative to the Do-Minimum scenario of 18 exceedances. Potential impacts have been described in accordance with IAQM impact descriptors and presented in Figure A-44 and Table 5.

Table 5 - Impact Summary at Secondary Receptors for DS12A in 2021

Impact	DS12A
Substantial Decrease	22
Moderate Decrease	99
Slight Decrease	83
Negligible	197
Slight Increase	0
Moderate Increase	0
Substantial Increase	0

These results show the impact of the DS12A scenario is either negligible or beneficial at all modelled secondary receptors. Relative to the benchmark CAZ D scenarios there is a reduction in both adverse and beneficial impacts and an increase in the number of negligible impacts.

The difference in the DS12A and Do-Minimum 2021 NO_2 concentration contour plots is shown in Figure A-45. The impact of some of the proposed measures within DS12A is clear with large decreases shown on Holyhead road (darkest blue) and some increases on routes to the north west of Holyhead Road showing the redistribution of traffic as a result of access restrictions on Holyhead Road. Generally, roads show a decrease in concentrations, which is associated with travel planning and cycling measures proposed as part of DS12A reducing traffic flows across Coventry.

Figure A-46 shows the difference in the 2021 mean NO_2 concentration by LSOA between the DS12A scenario and the Do-Minimum scenario. There is a decrease in mean NO_2 concentrations across Coventry in DS12A, with the greatest decreases modelled to occur in LSOAs in the centre of the City and around radial routes leading to the Inner Ring Road (most notably, Holyhead Road). Relative to the CAZ D Benchmark, the reductions are not as great in the city centre, however there is a wider decrease in concentrations across Coventry, particularly to the east of the city.

4.2.4. Conclusions

4.2.4.1. PCM Compliance

- In the Do Minimum scenario, the annual mean NO_2 EU limit value is modelled to be exceeded adjacent to 12 roads links in 2021, with compliance not projected to be achieved until 2029 adjacent to one of these links (Holyhead Road);
- In the benchmark CAZ D scenario, the annual mean NO_2 EU limit value is modelled to be exceeded adjacent to four links in 2021, with compliance projected to be achieved between 2023 and 2026 adjacent to Holyhead Road, depending upon the modelled upgrade response; and
- In the DS12A scenario, compliance with the annual mean NO_2 EU limit value is modelled to be exceeded adjacent to six roads links in 2021, with compliance not projected to be achieved until 2025 adjacent to Holyhead Road and the southwest section of the A4053 Ring Road.

4.2.4.2. Wider Impacts

- The annual mean NO_2 EU limit value in 2021 is modelled to be exceeded at 28 secondary receptor locations;
- In the benchmark CAZ D scenario, the annual mean NO_2 EU limit value in 2021 is modelled to be exceeded at between 5 to 11 secondary receptor locations, representing an improvement relative to the Do Minimum scenario. Beneficial impacts are modelled to occur at between 205 and 241 secondary receptors and adverse impacts at between 5 and 15 secondary receptors.

- In the DS12A scenario, the annual mean NO_2 EU limit value in 2021 is modelled to be exceeded at 10 secondary receptors, representing an improvement relative to the Do Minimum scenario. Beneficial impacts are modelled to occur at 204 secondary receptors, with impacts at all remaining modelled secondary receptors being negligible.
- Population-weighted analysis shows the overall impact of each scenario on the population of Coventry. Table 6 shows the population-weighted mean NO_2 concentrations for LSOAs within Coventry City Council's administrative boundary. This shows that the impact of both the benchmark CAZ D and DS12A scenarios is beneficial relative to the Do-Minimum in both 2021 and 2030.

Table 6 – Population-weighted Mean NO_2 Concentrations (µg/m³) within Coventry

Year	Do-Minimum	CAZ D (No Upgrade)	CAZ D (West Midlands Upgrade)	CAZ D (JAQU Upgrade)	DS12A
2021	21.02	TBC	20.03	19.84	20.23
2031	14.78	TBC	TBC	TBC	14.30

Appendices

Appendix A. Figures

Figure A-1 – Local Air Quality Monitoring Sites

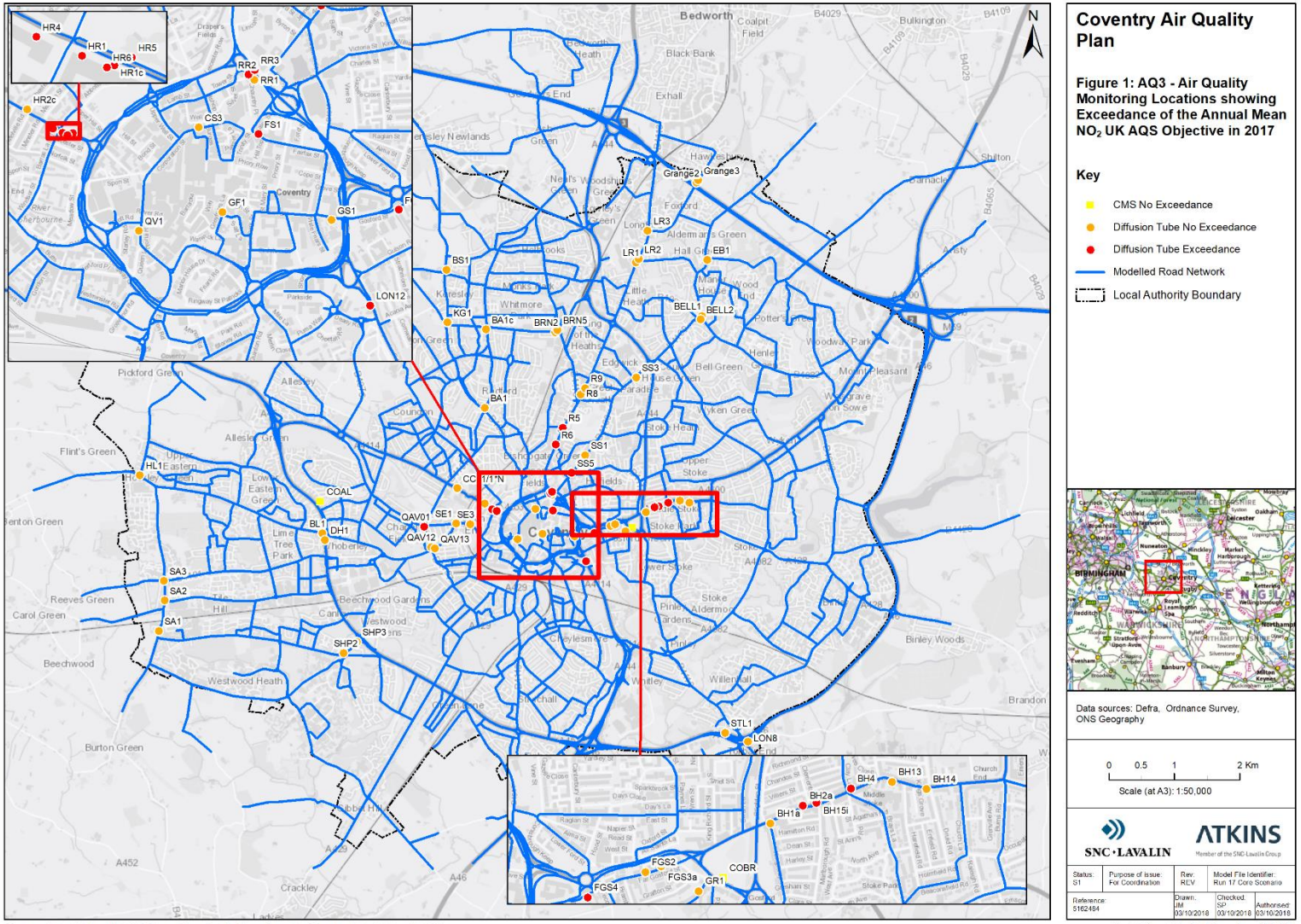


Figure A-2 – Modelled Receptor Adjacent to PCM Link with Census ID 6490

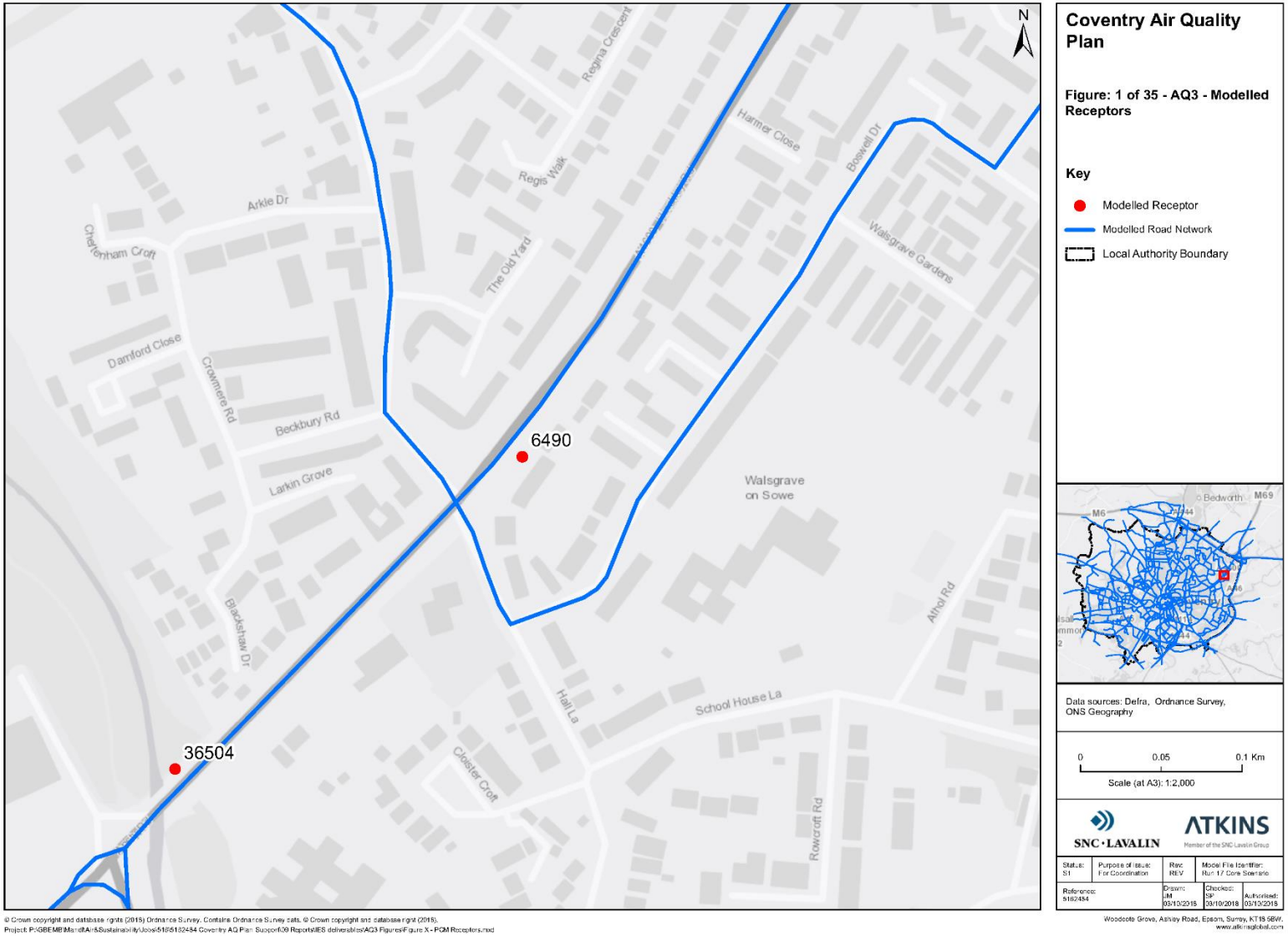


Figure A-3 – Modelled Receptor Adjacent to PCM Link with Census ID 6491

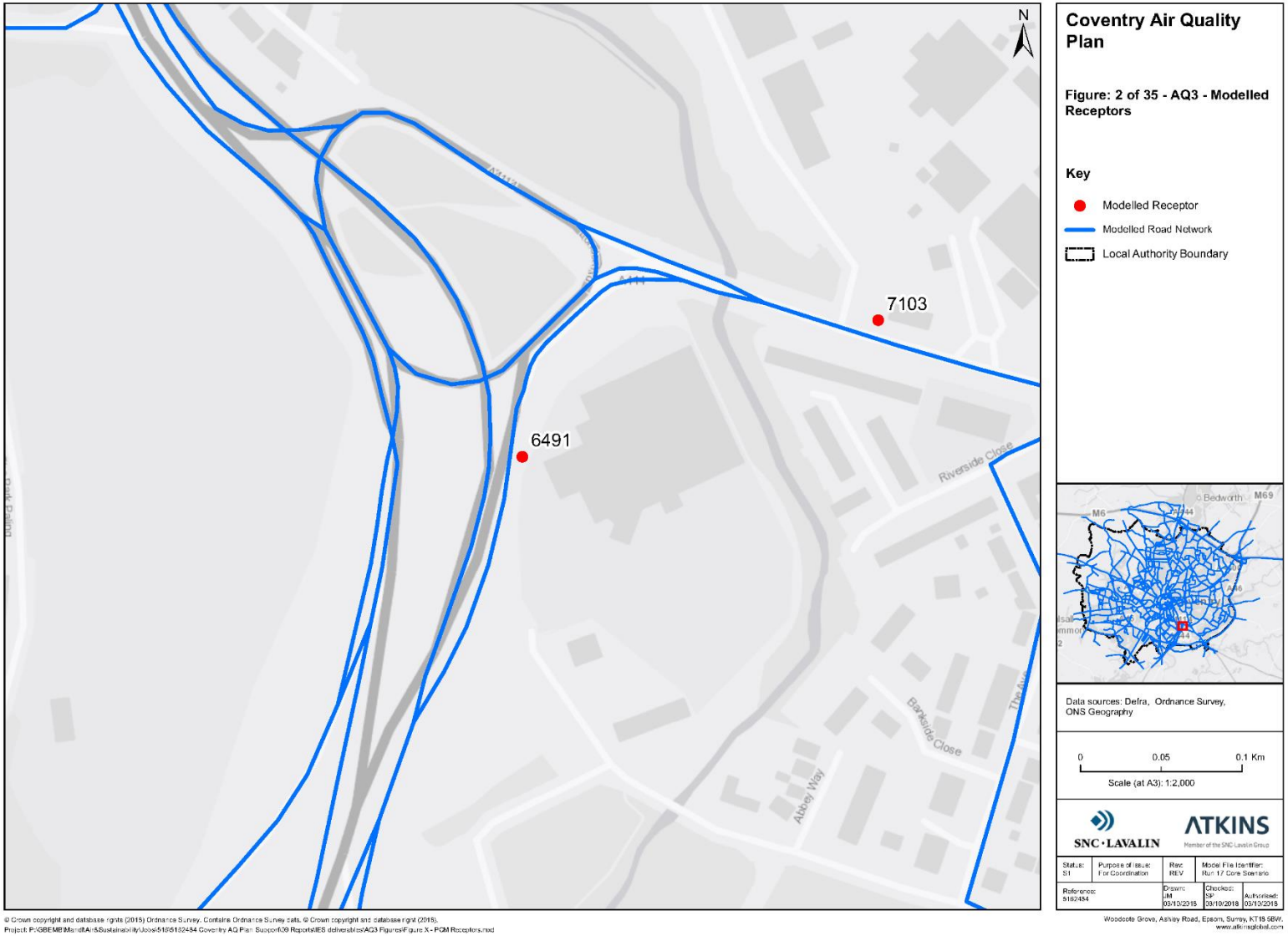


Figure A-4 – Modelled Receptor Adjacent to PCM Link with Census ID 7103

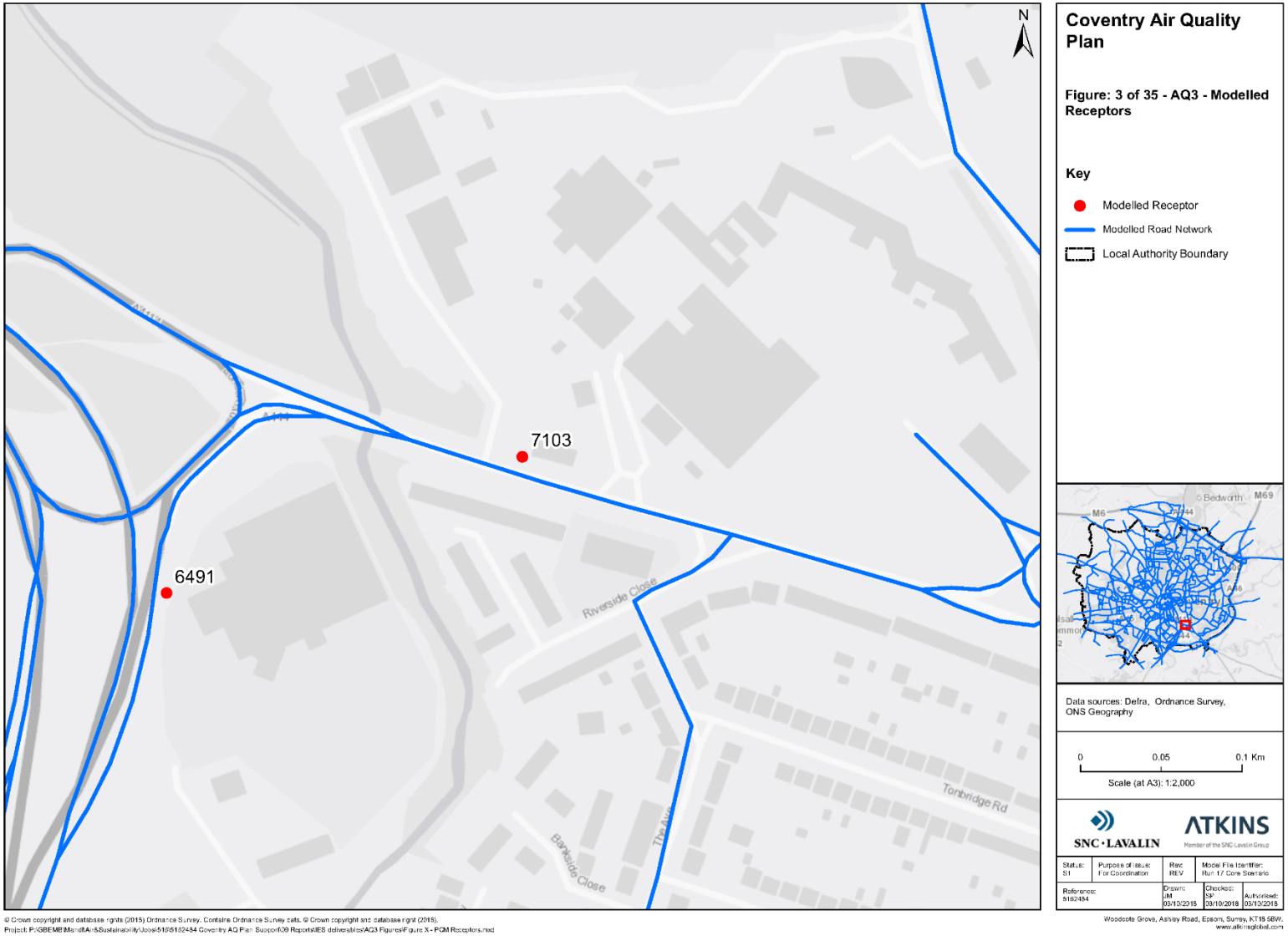


Figure A-5 – Modelled Receptor Adjacent to PCM Link with Census ID 7118

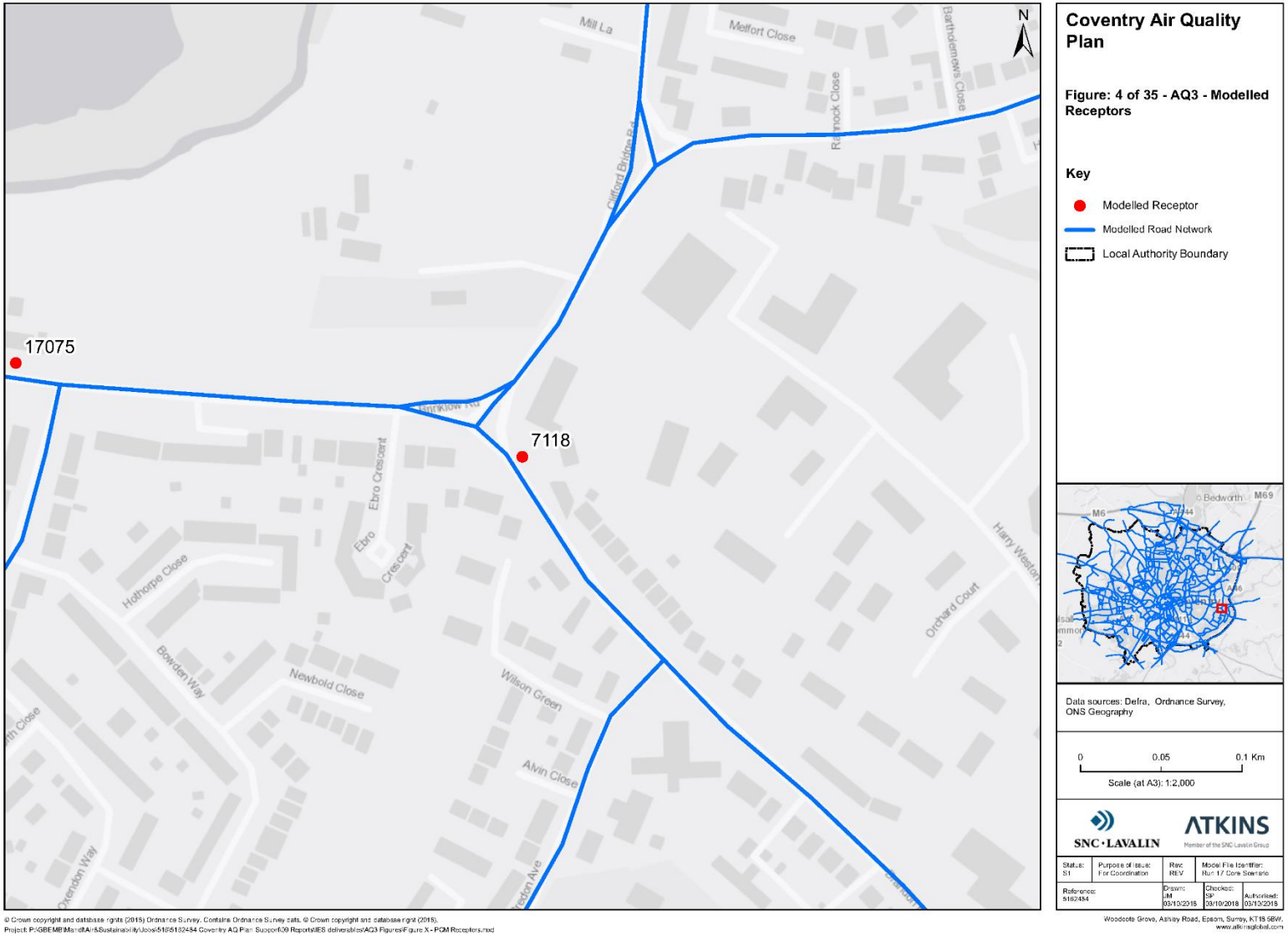


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Figure A-6 – Modelled Receptor Adjacent to PCM Link with Census ID 7122

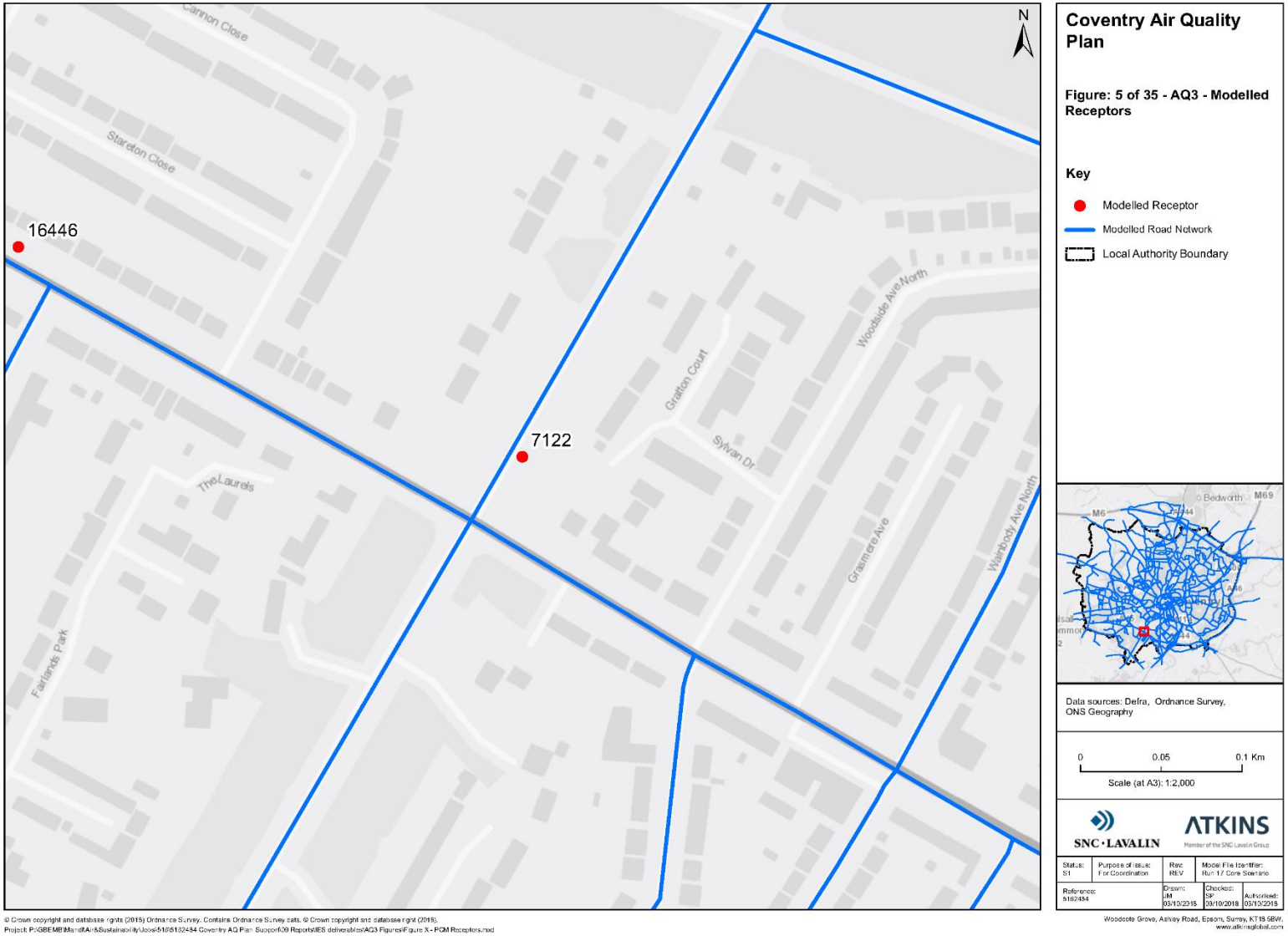

Figure A-7 – Modelled Receptor Adjacent to PCM Link with Census ID 7631

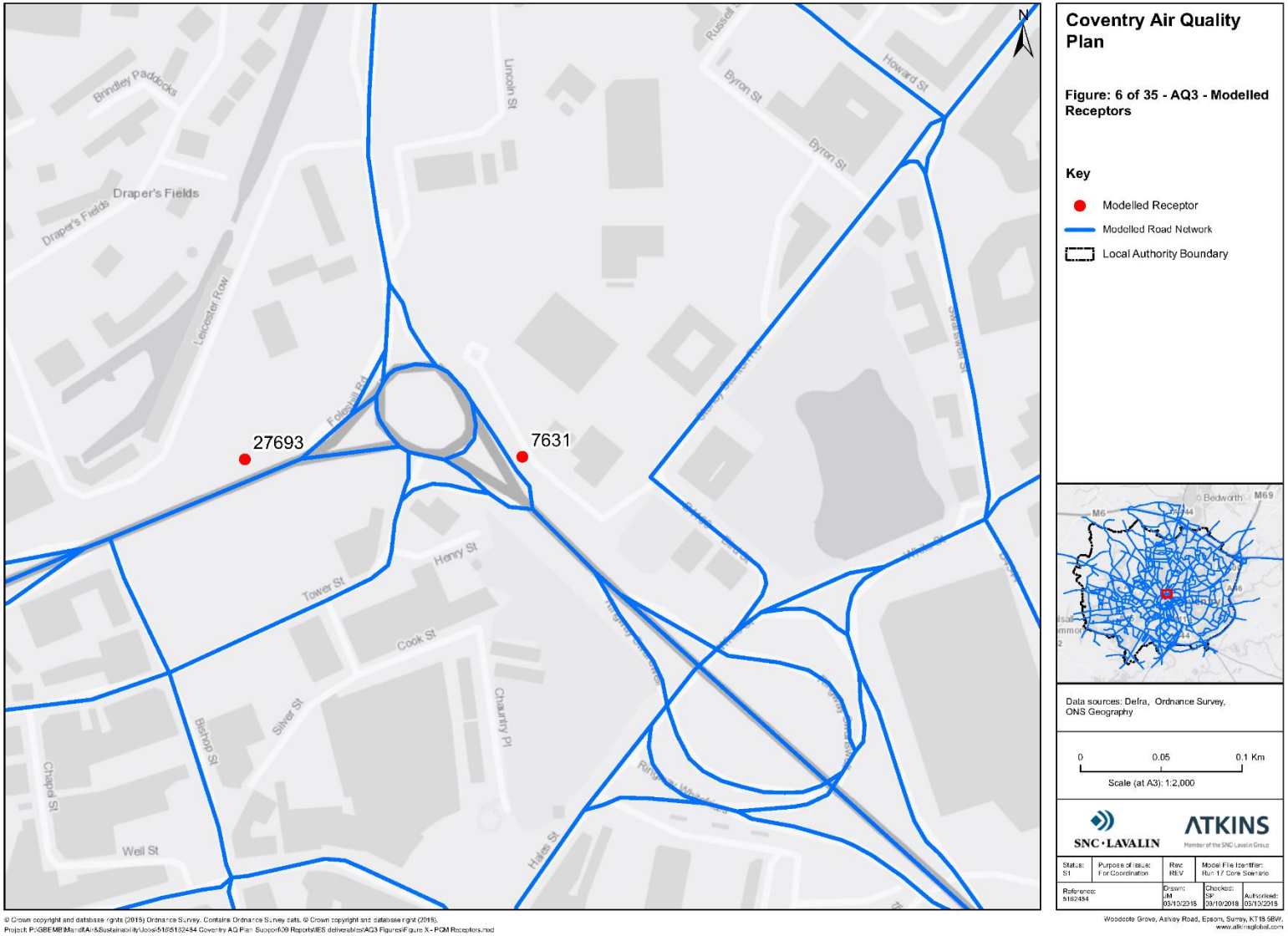

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Figure A-8 – Modelled Receptor Adjacent to PCM Link with Census ID 7647

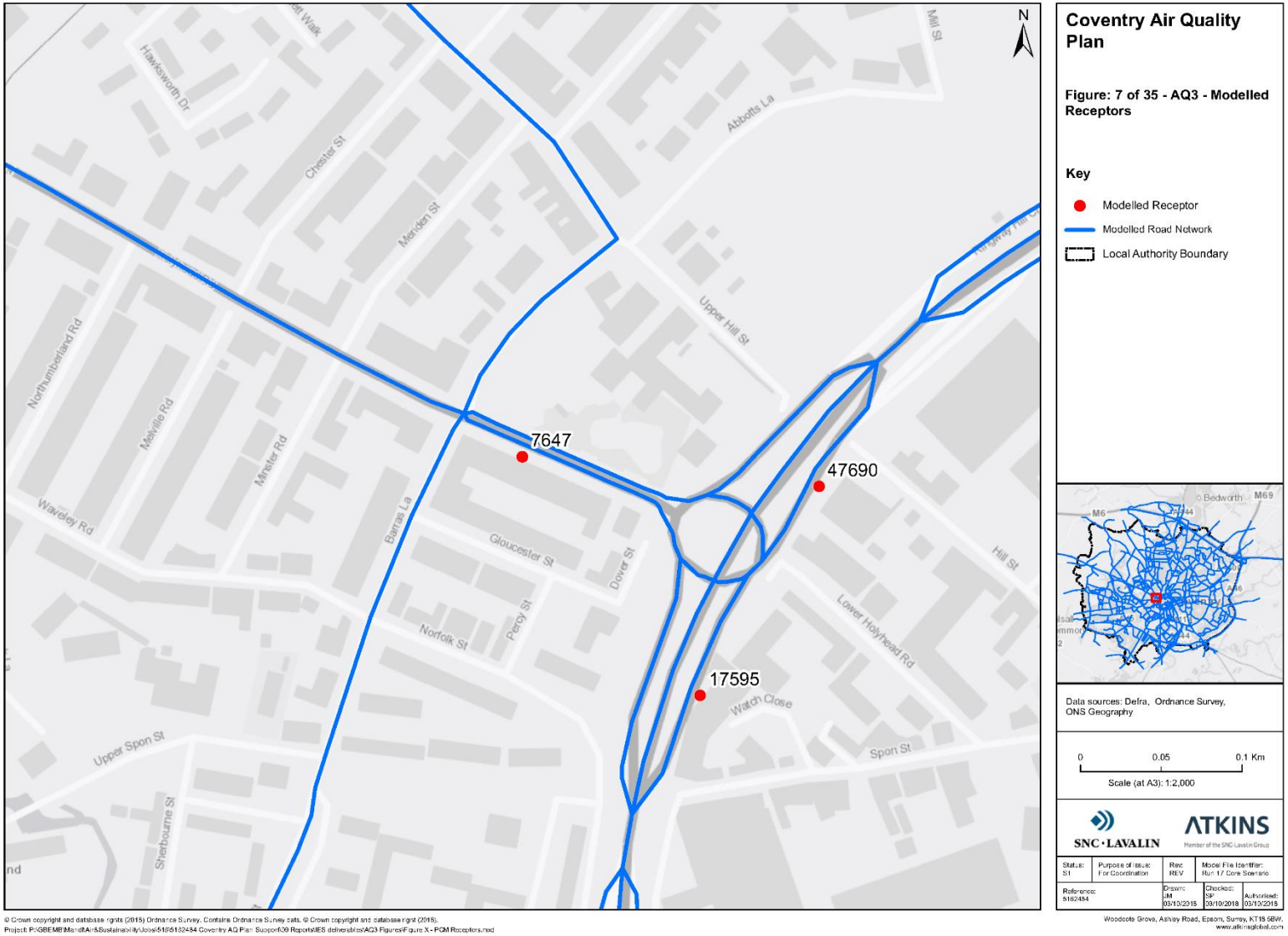

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Figure A-9 – Modelled Receptor Adjacent to PCM Link with Census ID 16446

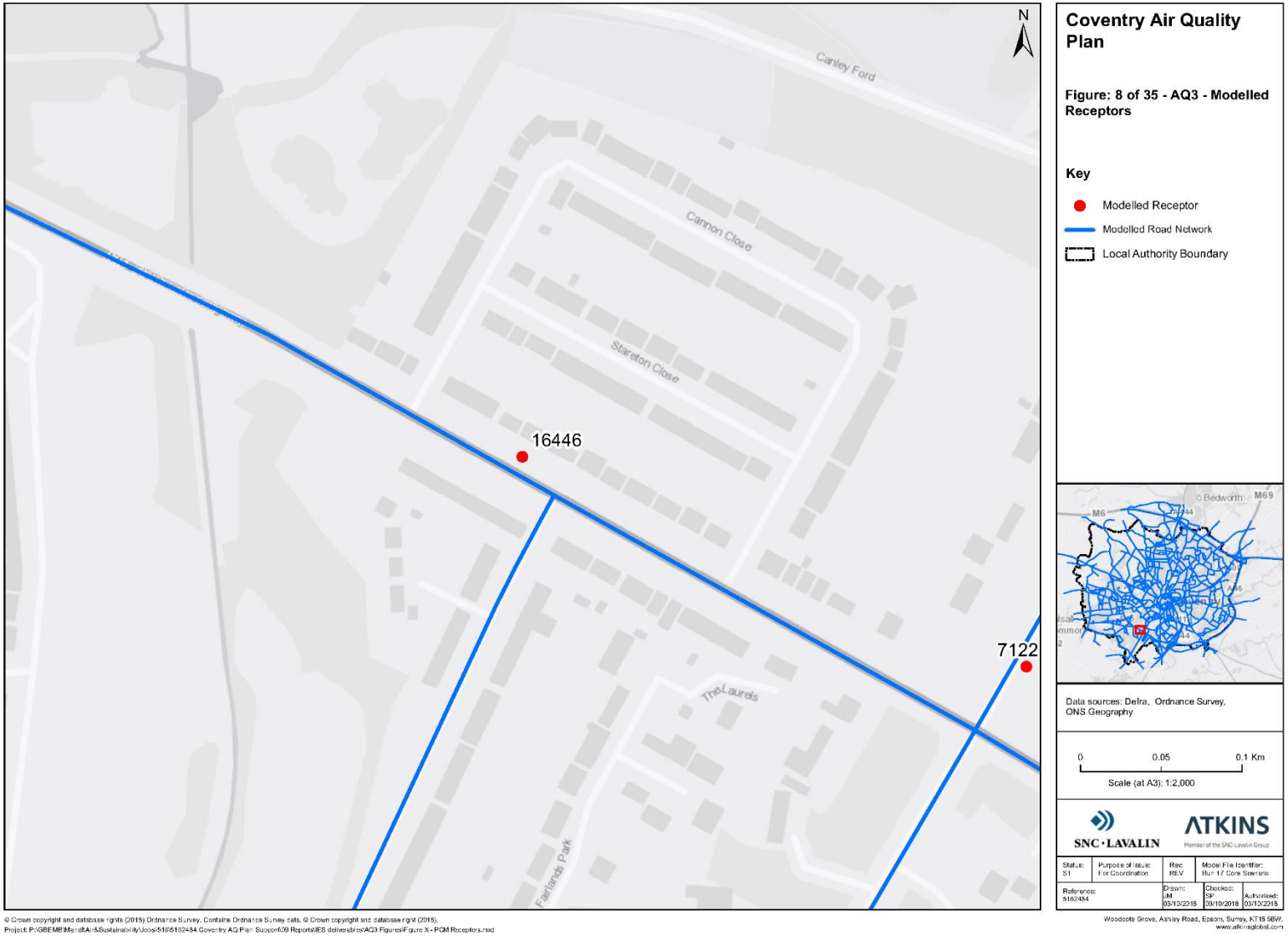

Figure A-10 – Modelled Receptor Adjacent to PCM Link with Census ID 16467

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Figure A-11 – Modelled Receptor Adjacent to PCM Link with Census ID 17075

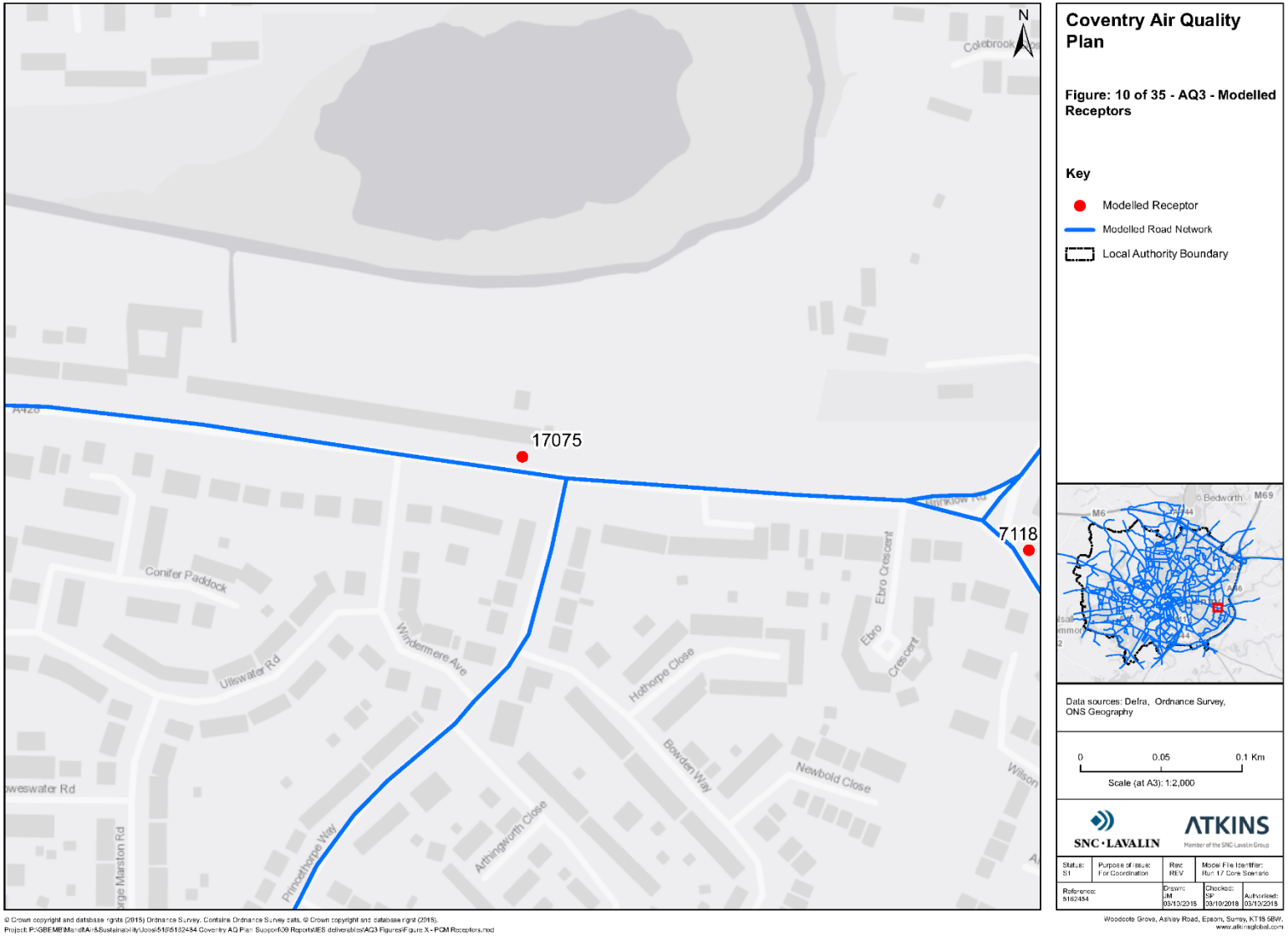

Figure A-12 – Modelled Receptor Adjacent to PCM Link with Census ID 17595

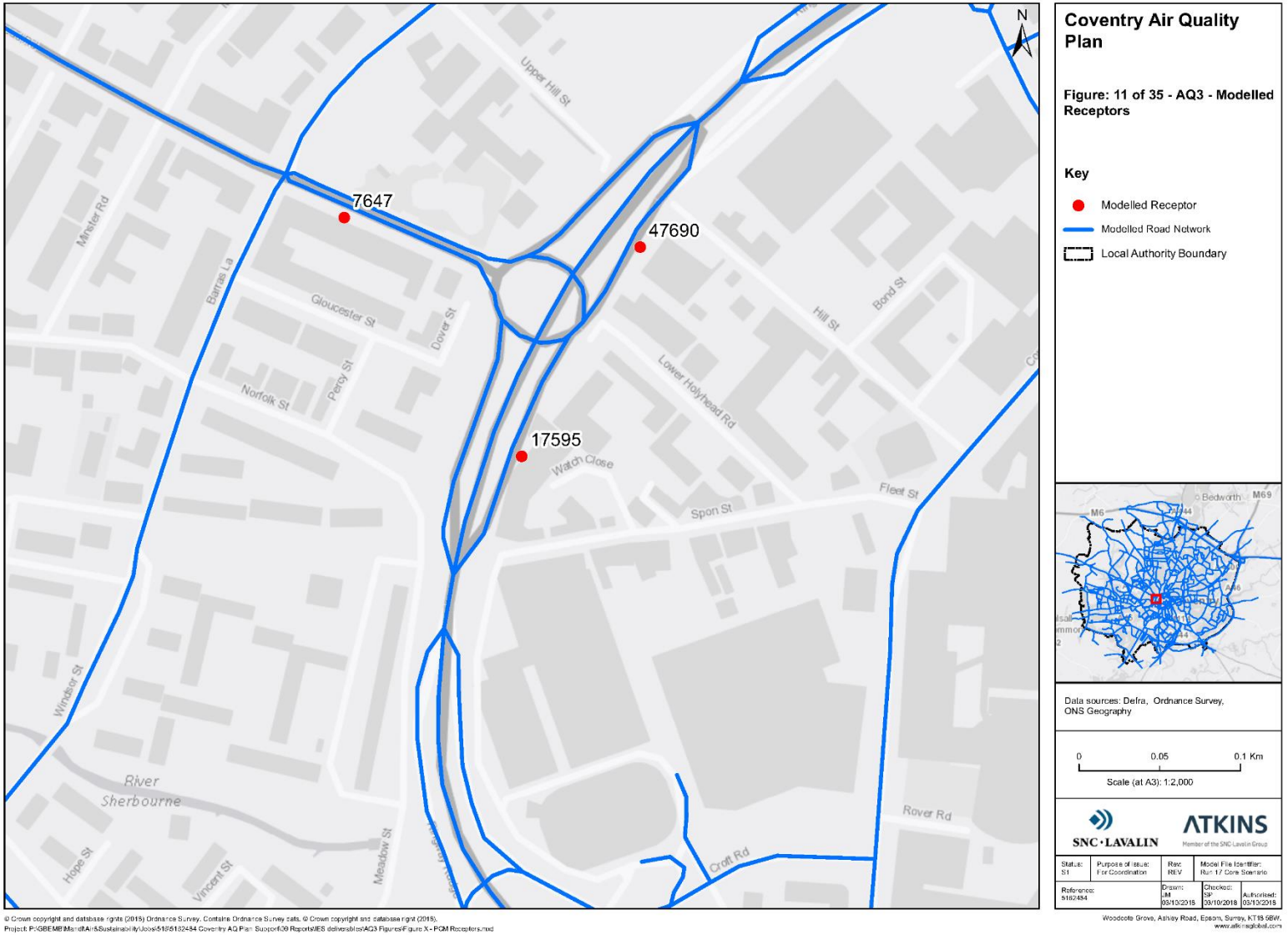

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Figure A-13 – Modelled Receptor Adjacent to PCM Link with Census ID 18006

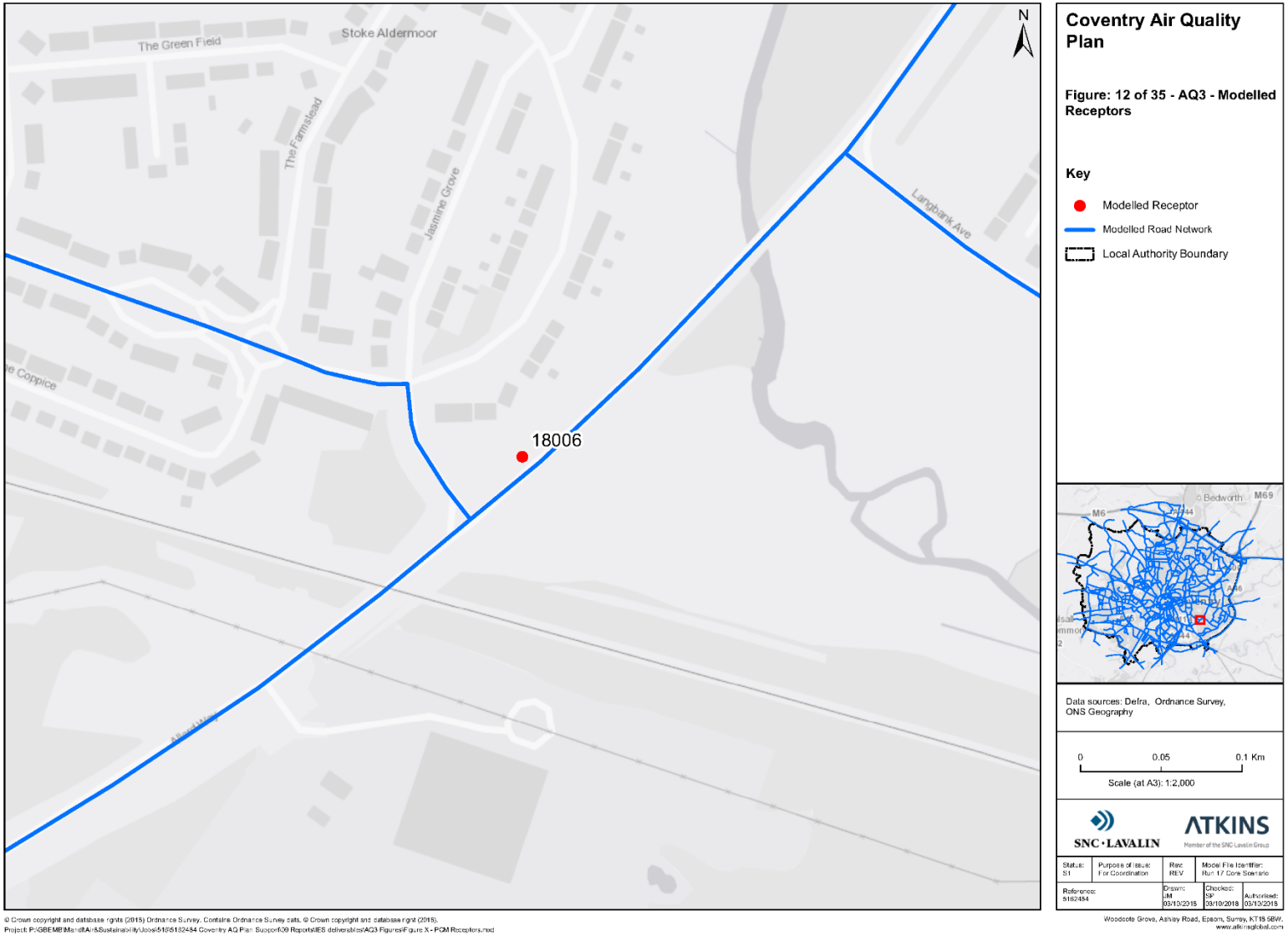

Figure A-14 – Modelled Receptor Adjacent to PCM Link with Census ID 26497

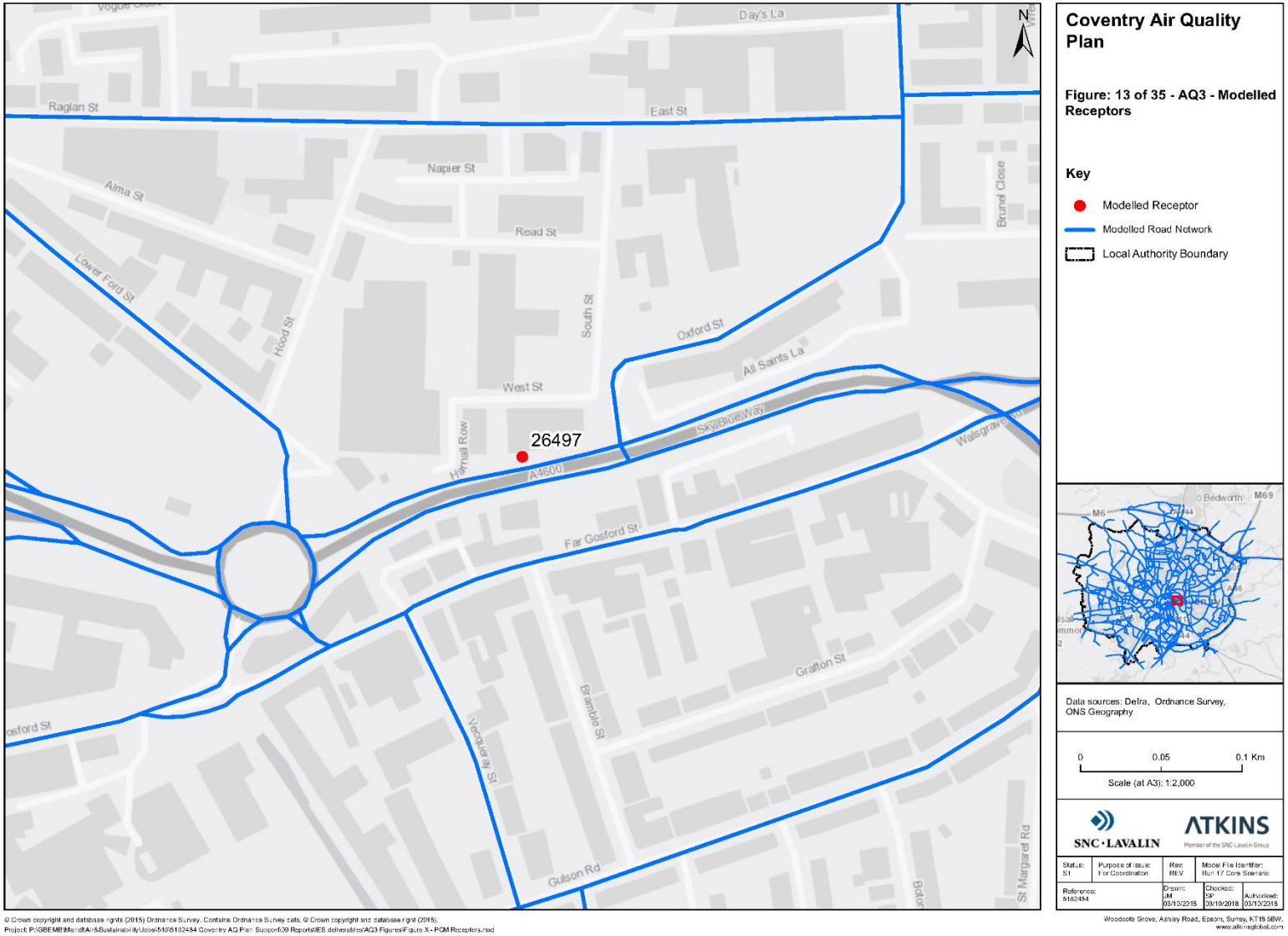

Figure A-15 – Modelled Receptor Adjacent to PCM Link with Census ID 27132

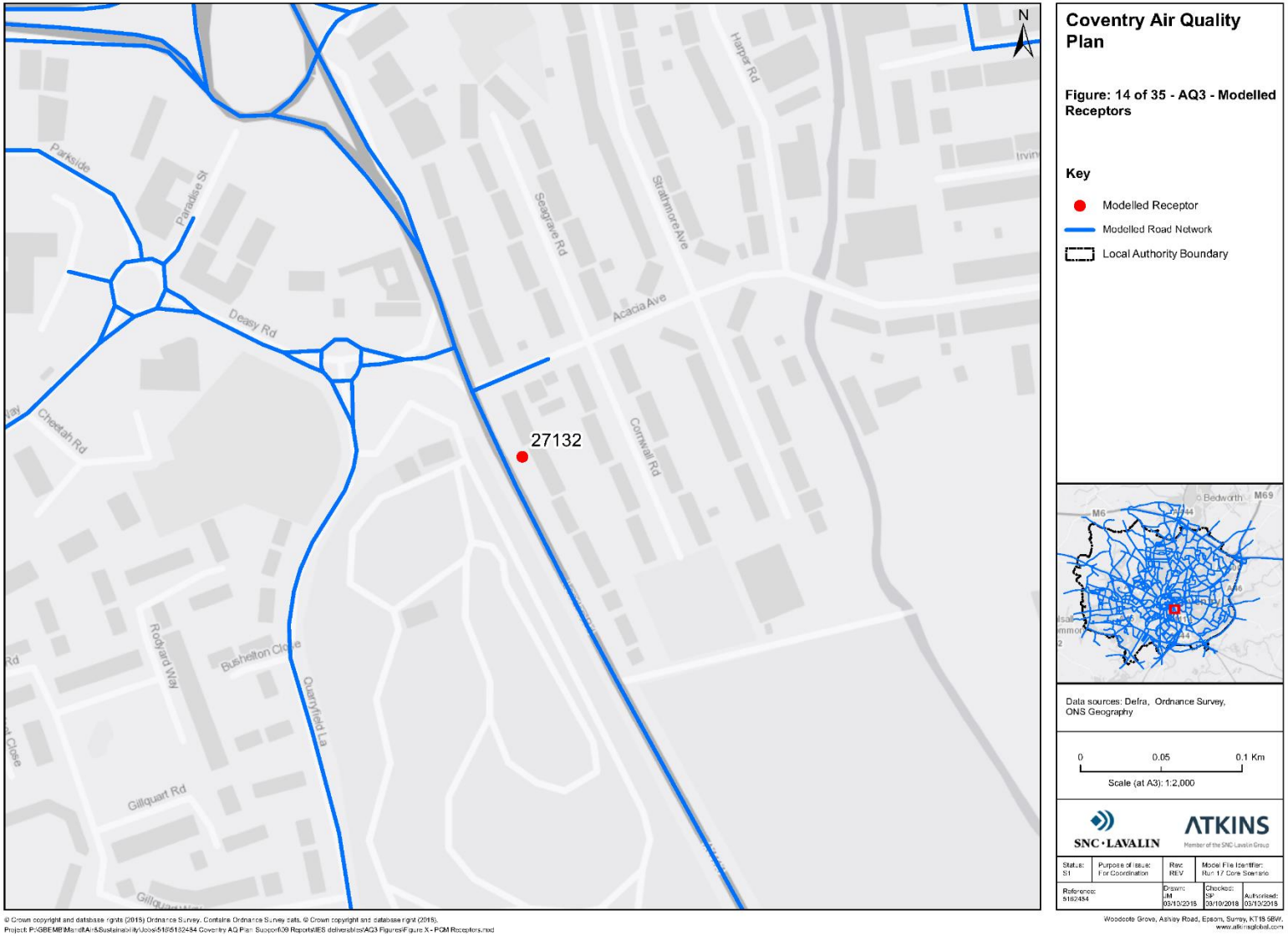

Figure A-16 – Modelled Receptor Adjacent to PCM Link with Census ID 27151

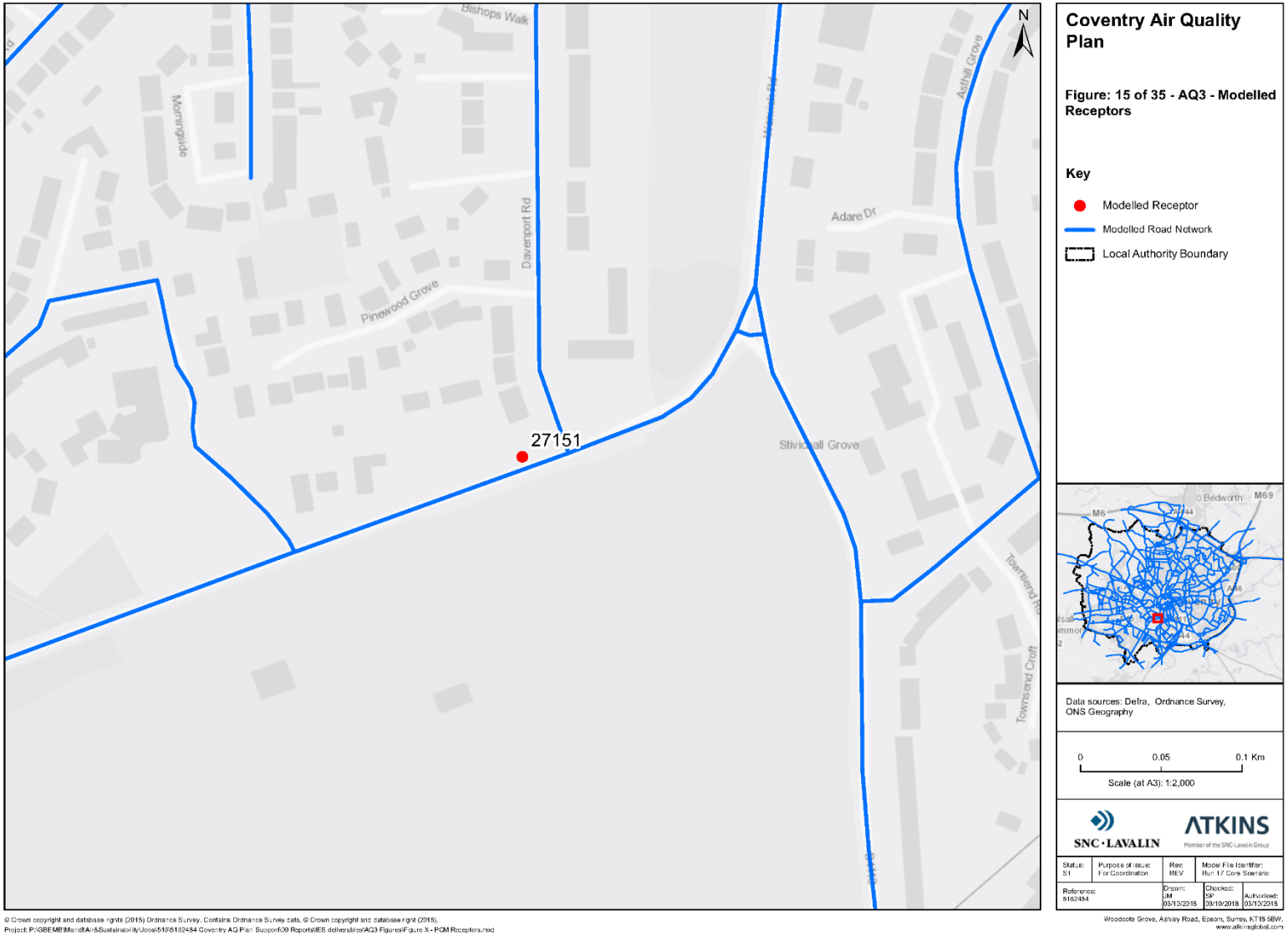

Figure A-17 – Modelled Receptor Adjacent to PCM Link with Census ID 27693

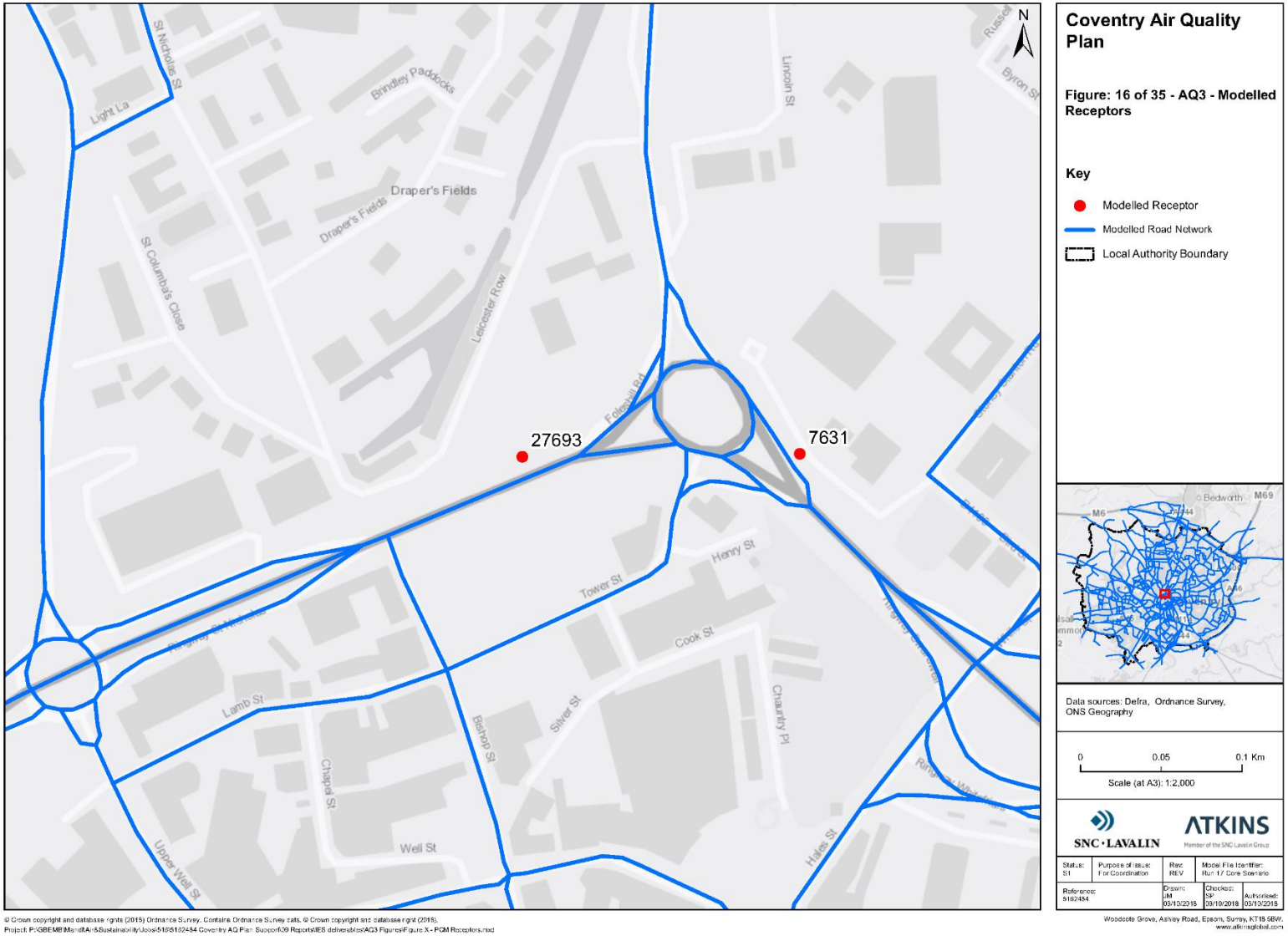

Figure A-18 – Modelled Receptor Adjacent to PCM Link with Census ID 27708

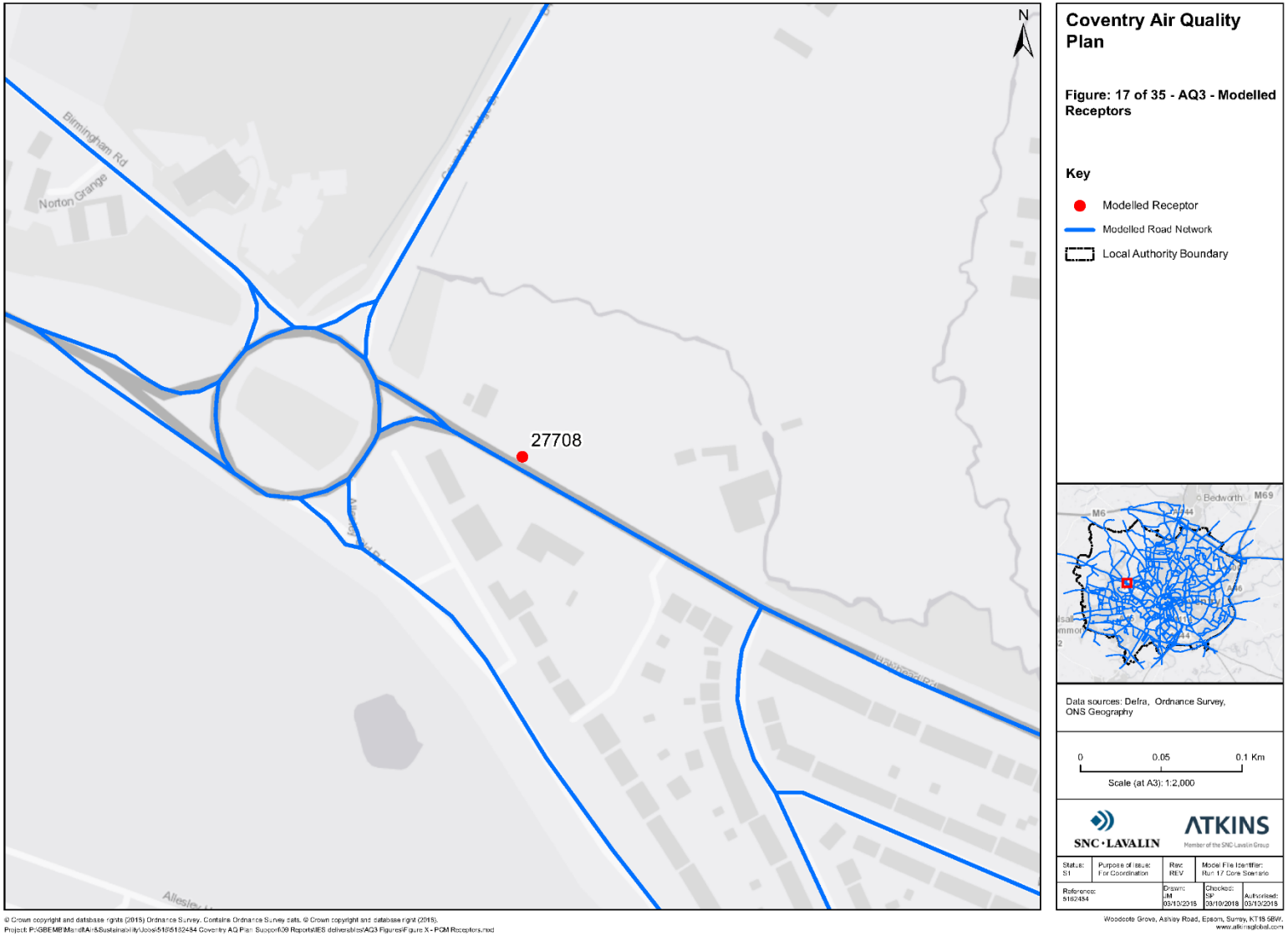

Figure A-19 – Modelled Receptor Adjacent to PCM Link with Census ID 36482

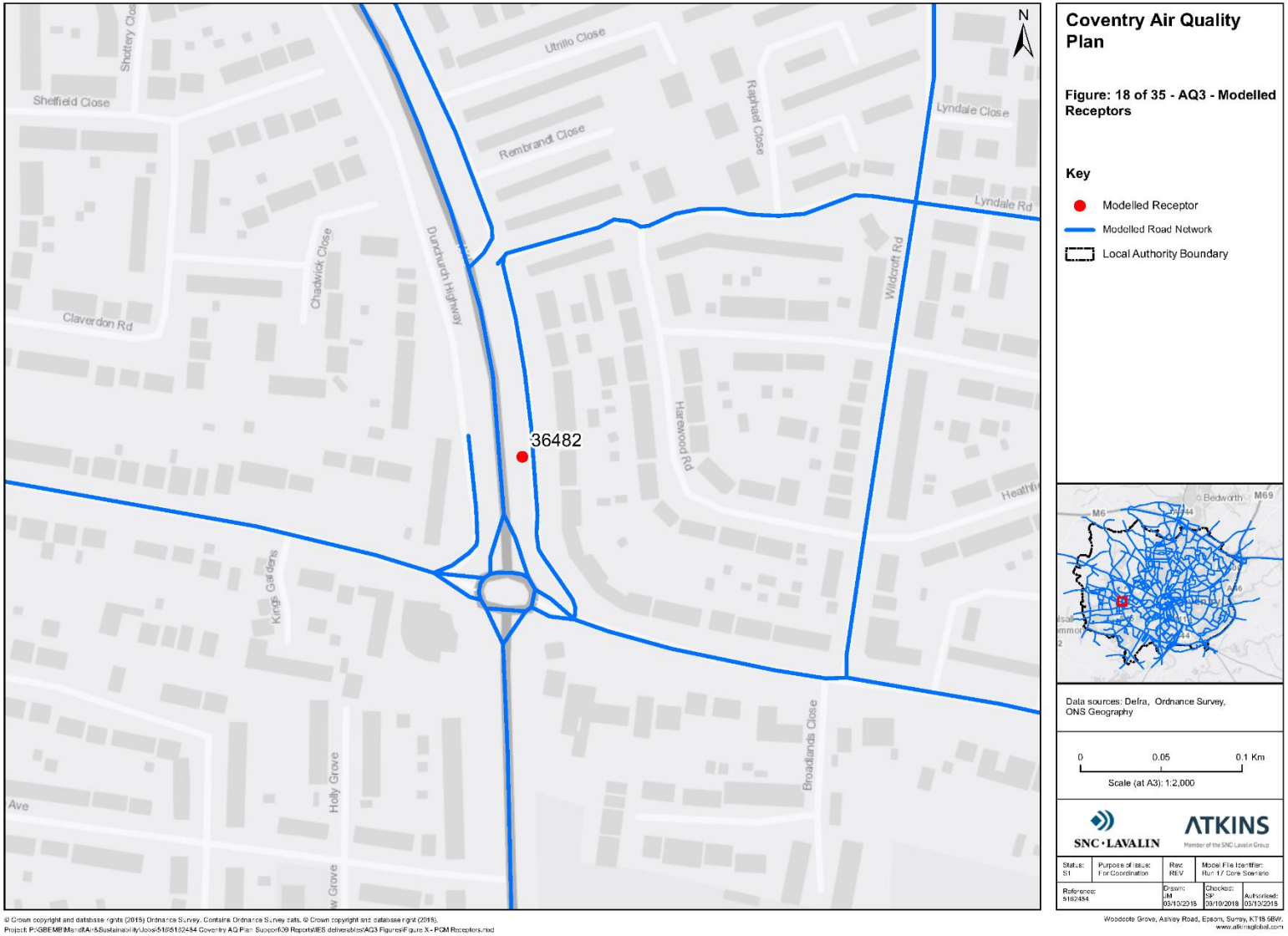

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Figure A-20 – Modelled Receptor Adjacent to PCM Link with Census ID 36504

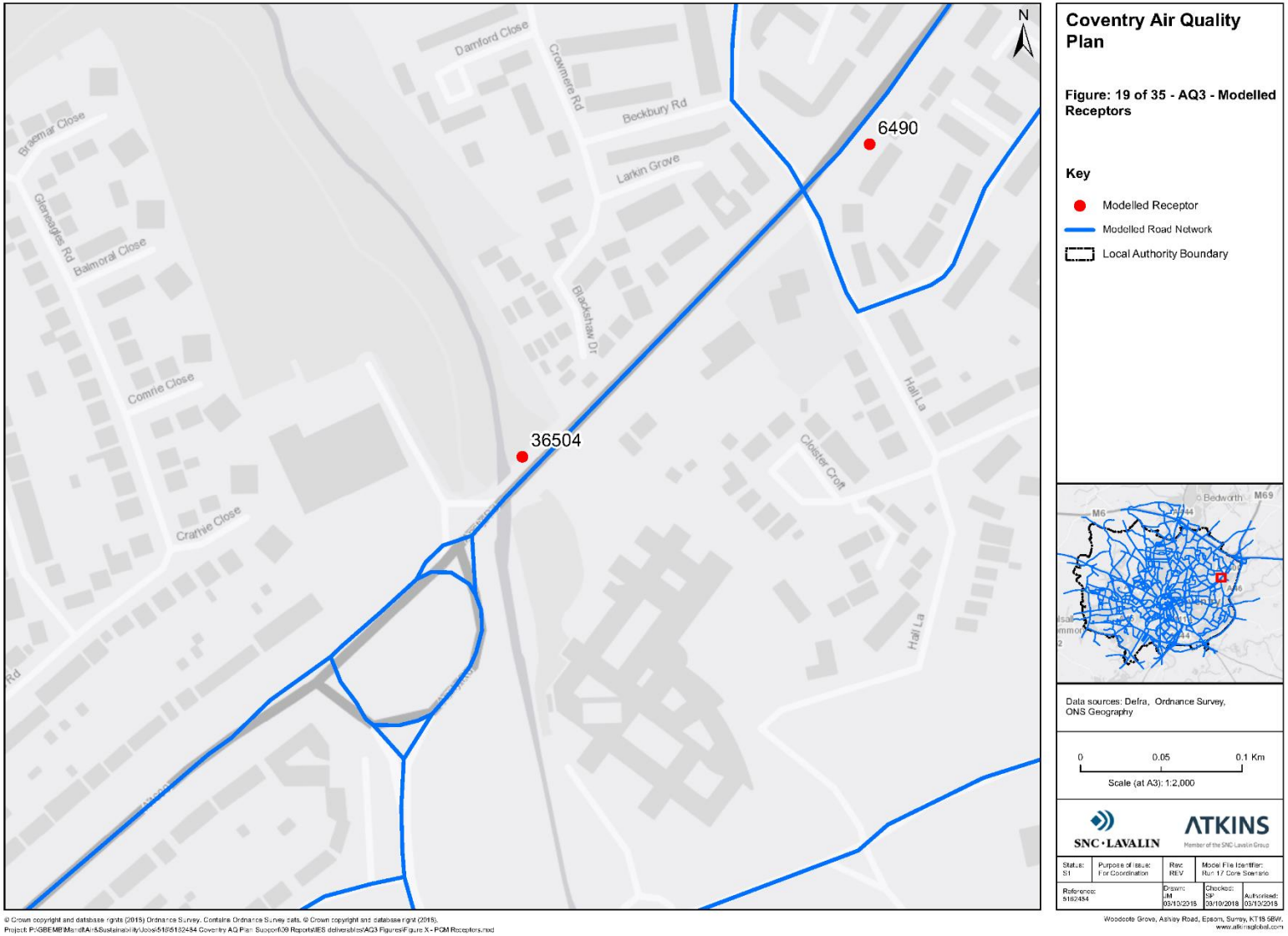

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Figure A-21 – Modelled Receptor Adjacent to PCM Link with Census ID 37169

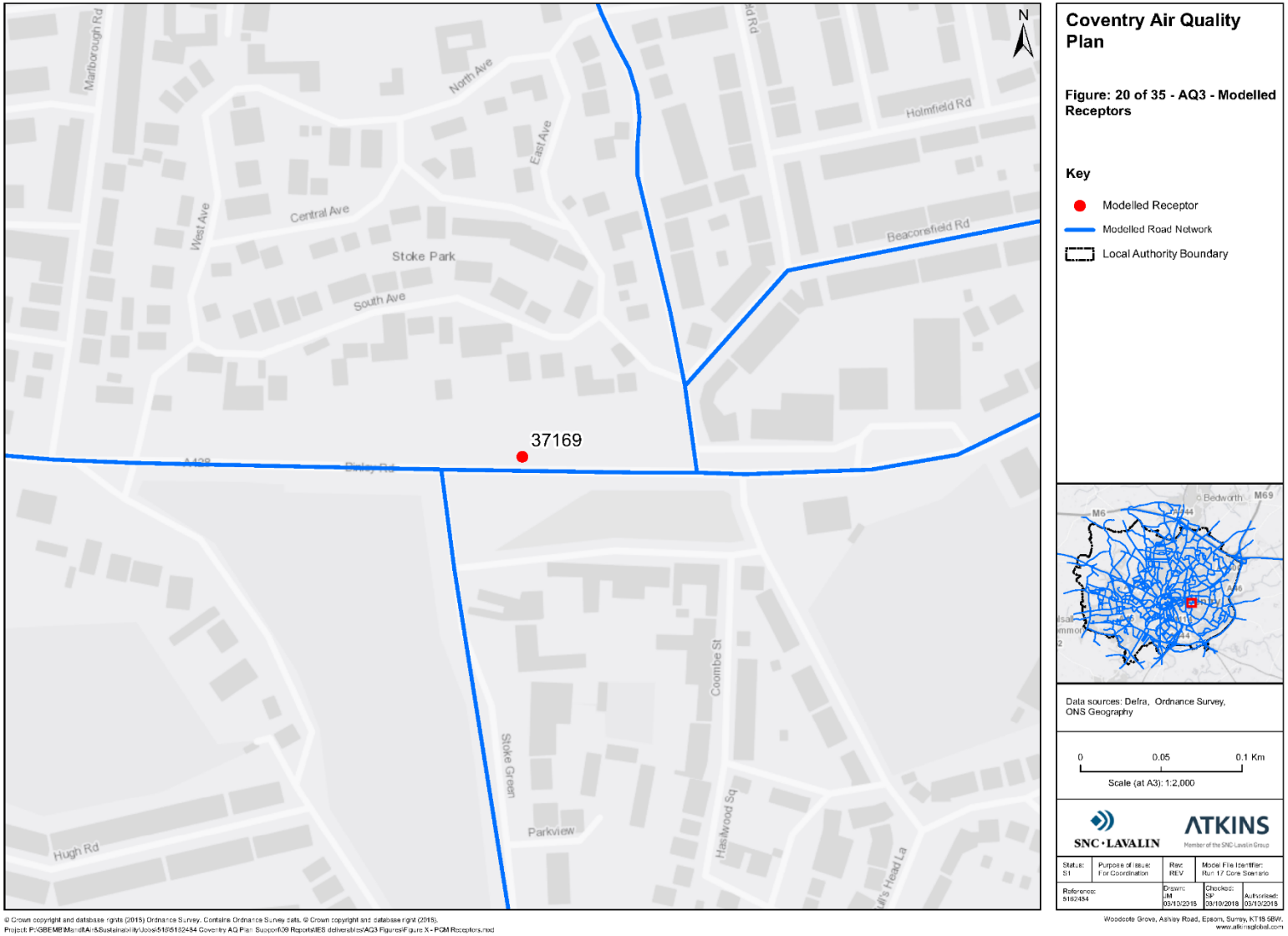

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Figure A-22 – Modelled Receptor Adjacent to PCM Link with Census ID 37731

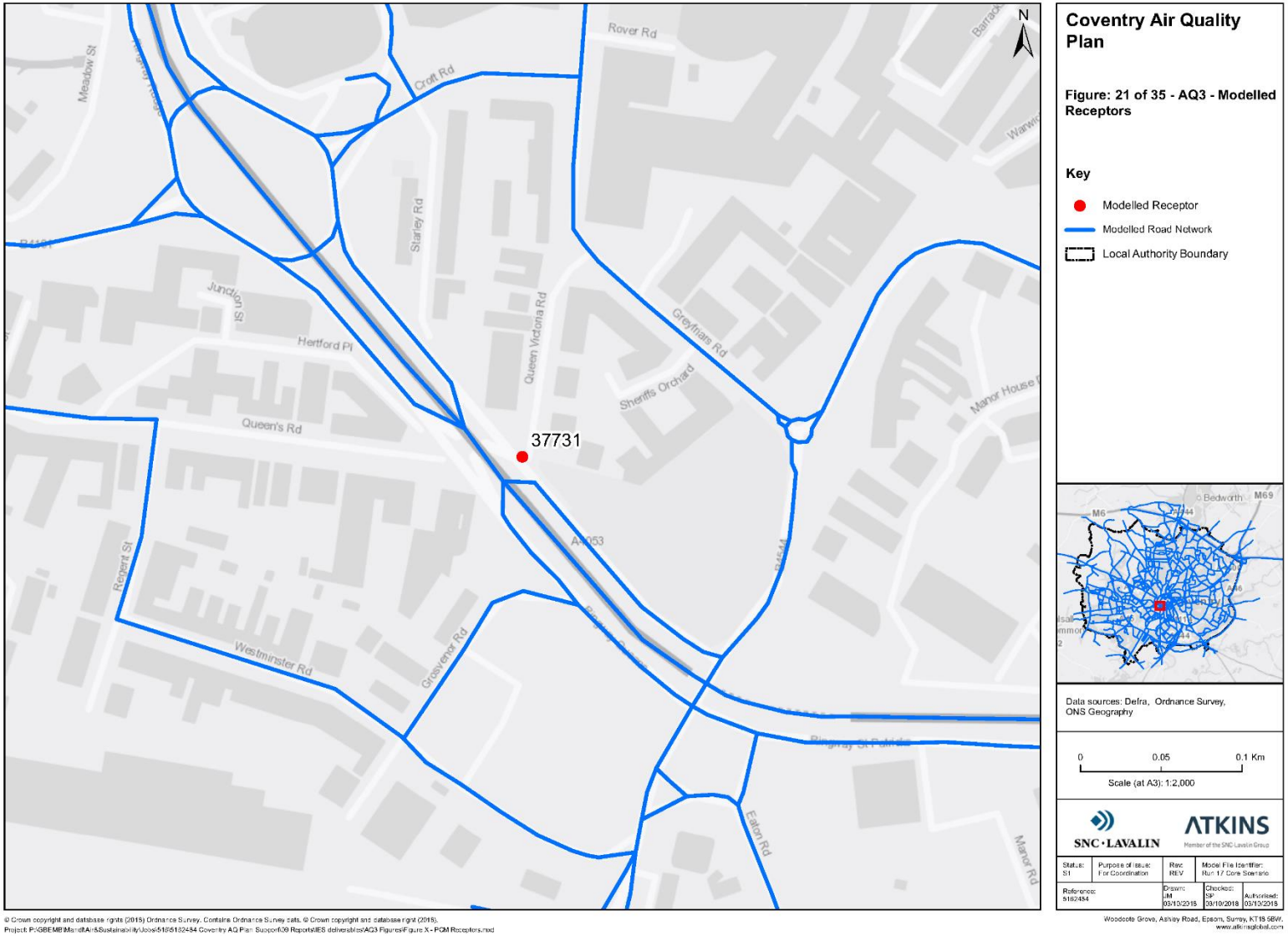

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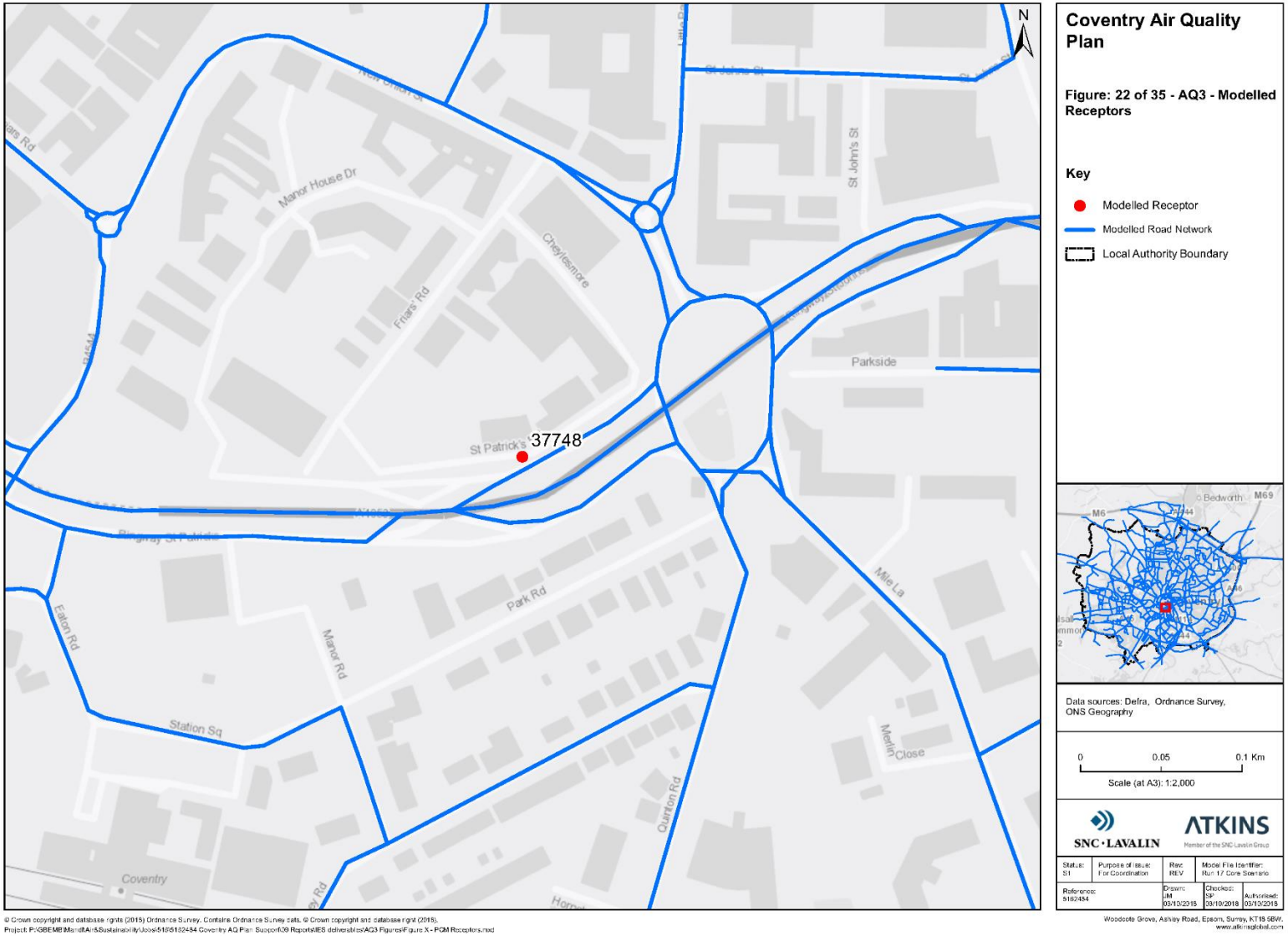
Figure A-23 – Modelled Receptor Adjacent to PCM Link with Census ID 37748



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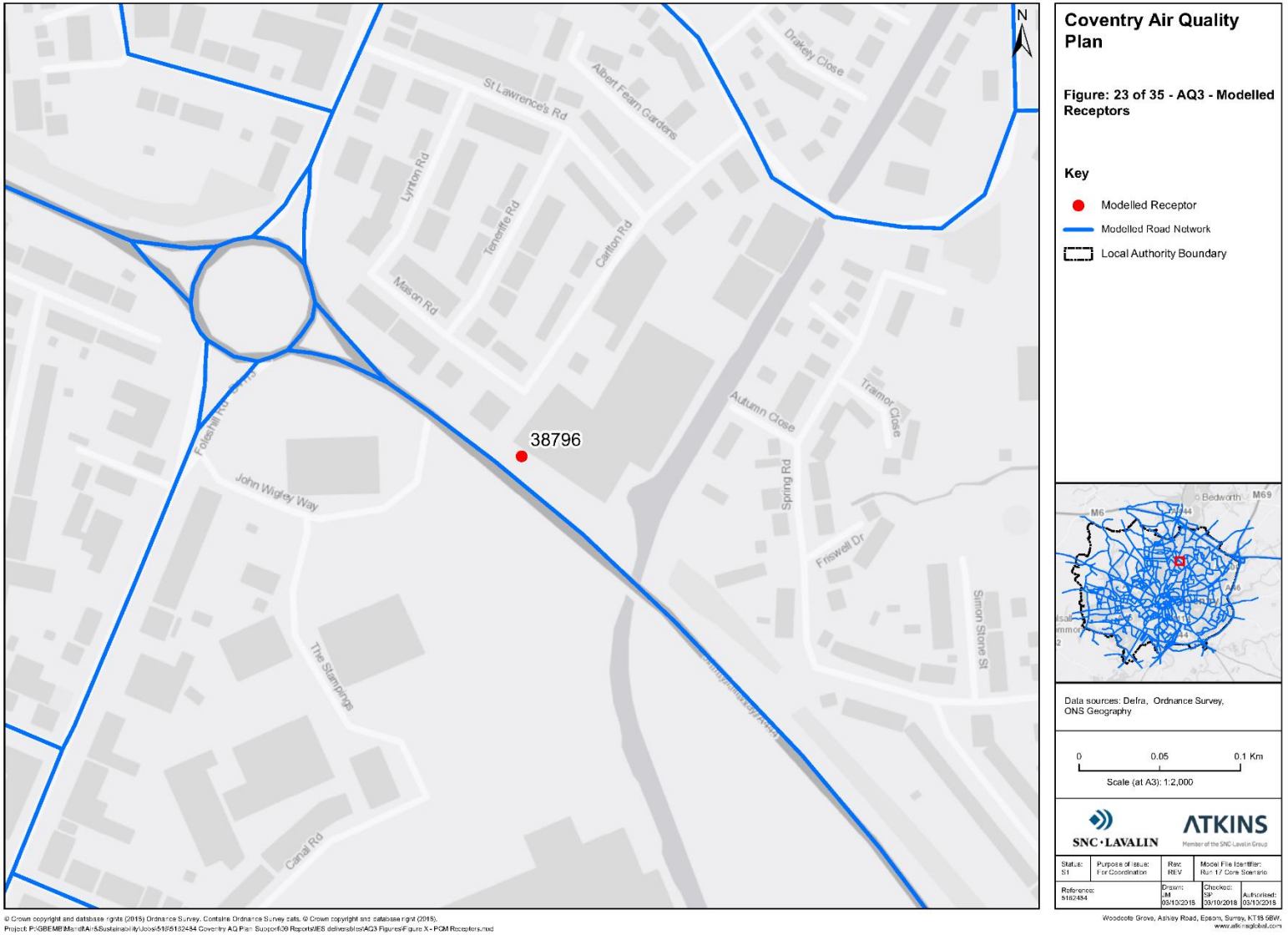

Figure A-25 – Modelled Receptor Adjacent to PCM Link with Census ID 47156

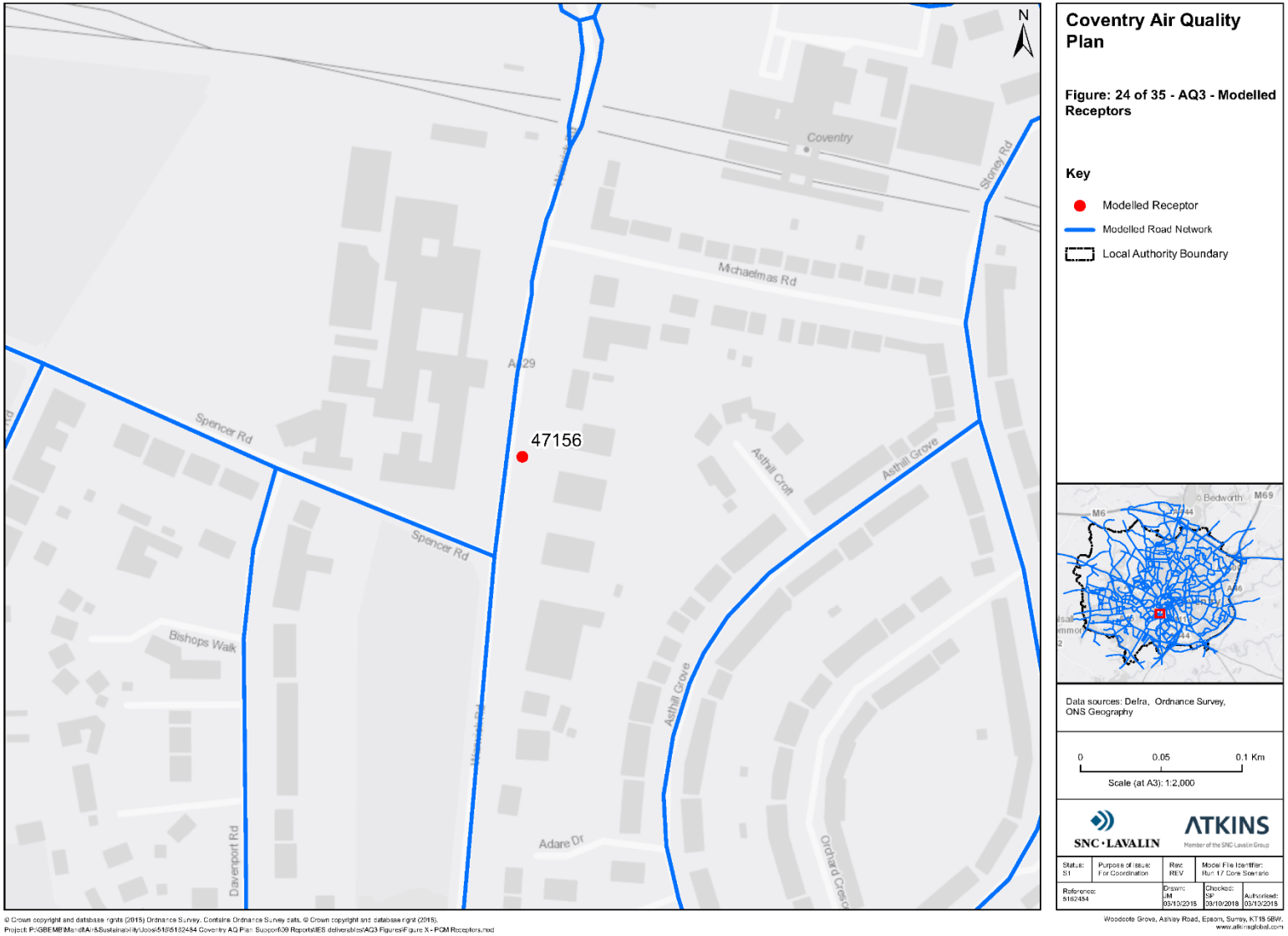

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Figure A-26 – Modelled Receptor Adjacent to PCM Link with Census ID 47690

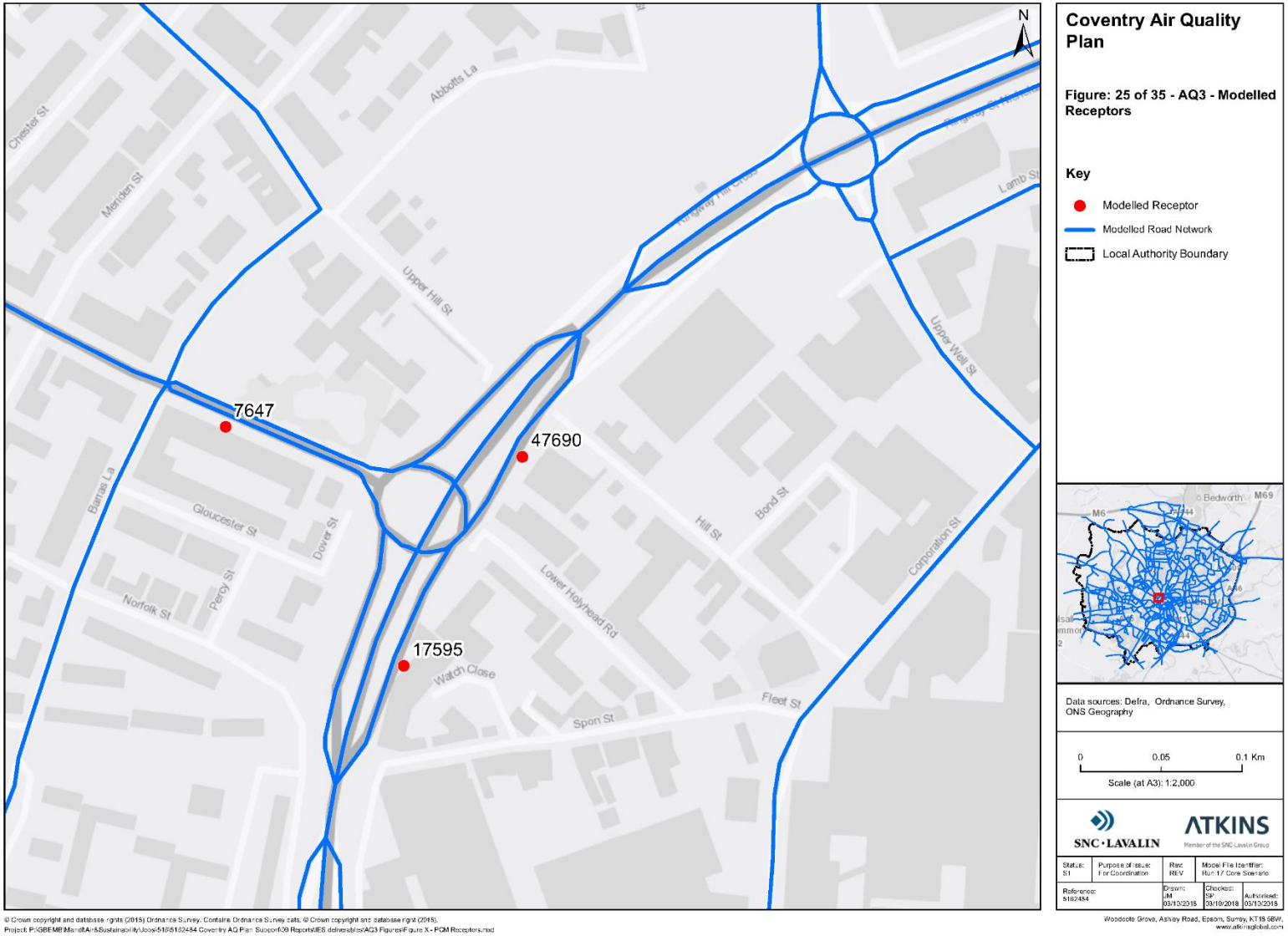

Figure A-27 – Modelled Receptor Adjacent to PCM Link with Census ID 56791

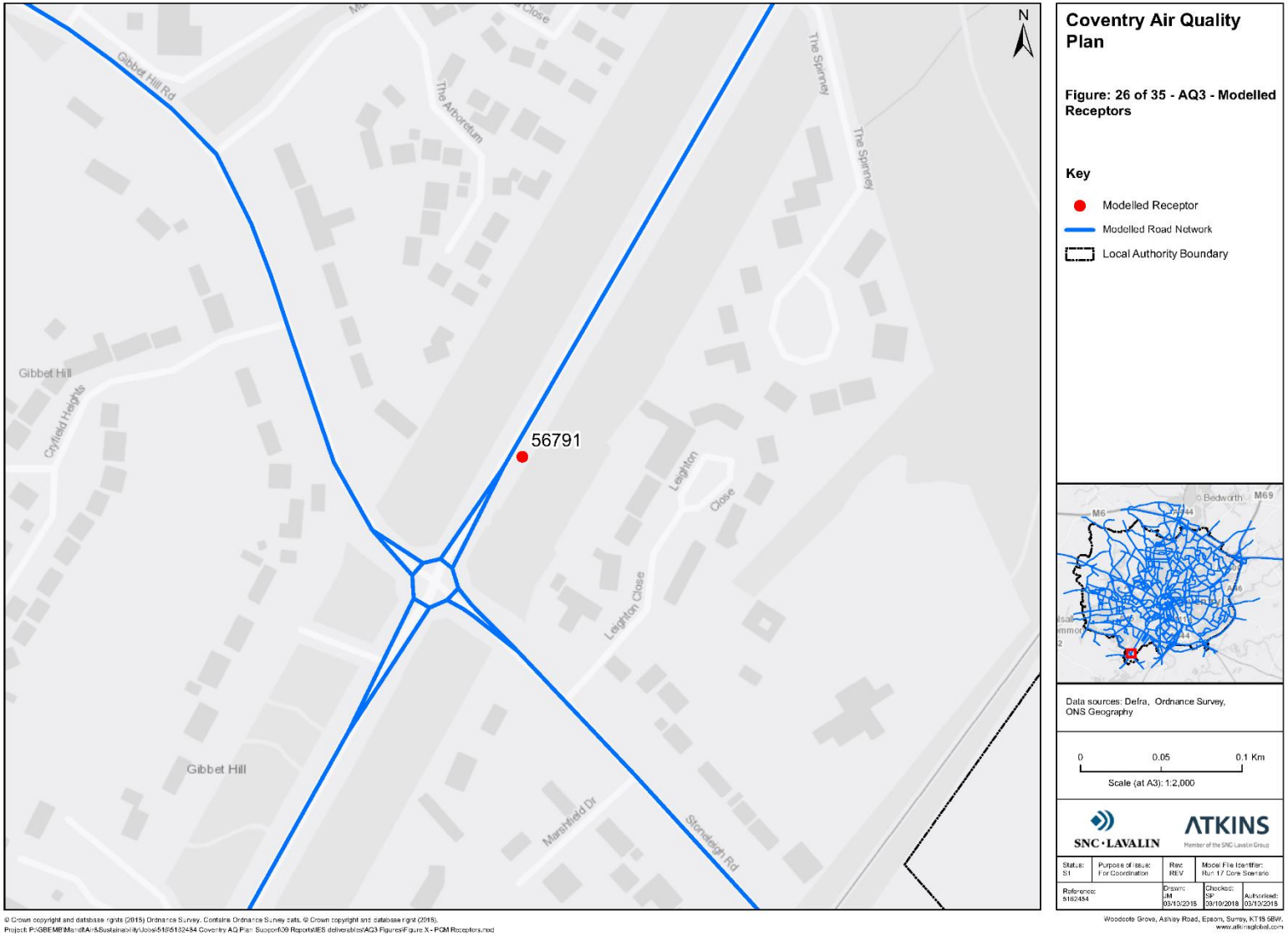

Figure A-28 – Modelled Receptor Adjacent to PCM Link with Census ID 58401

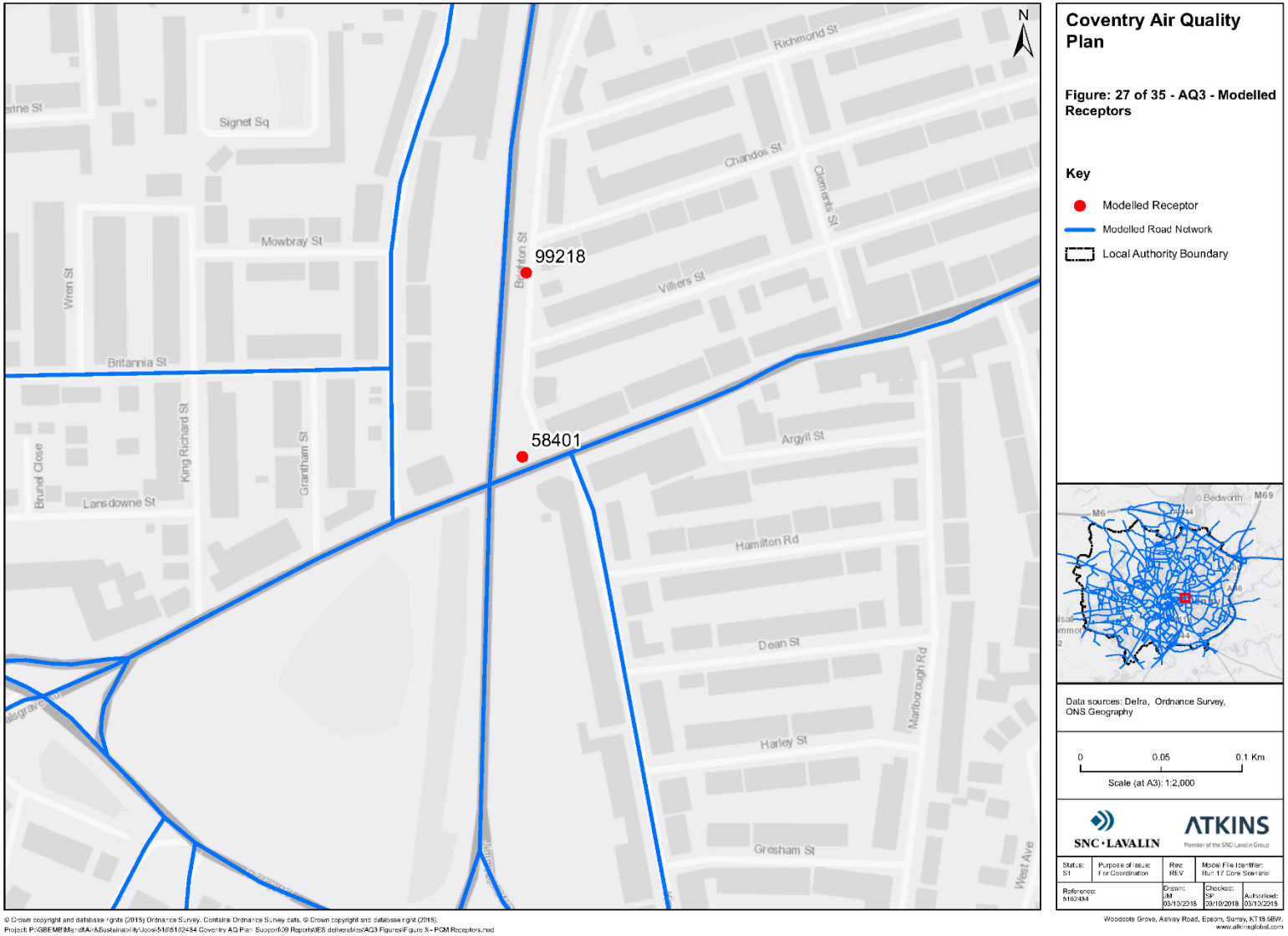

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Figure A-29 – Modelled Receptor Adjacent to PCM Link with Census ID 70238

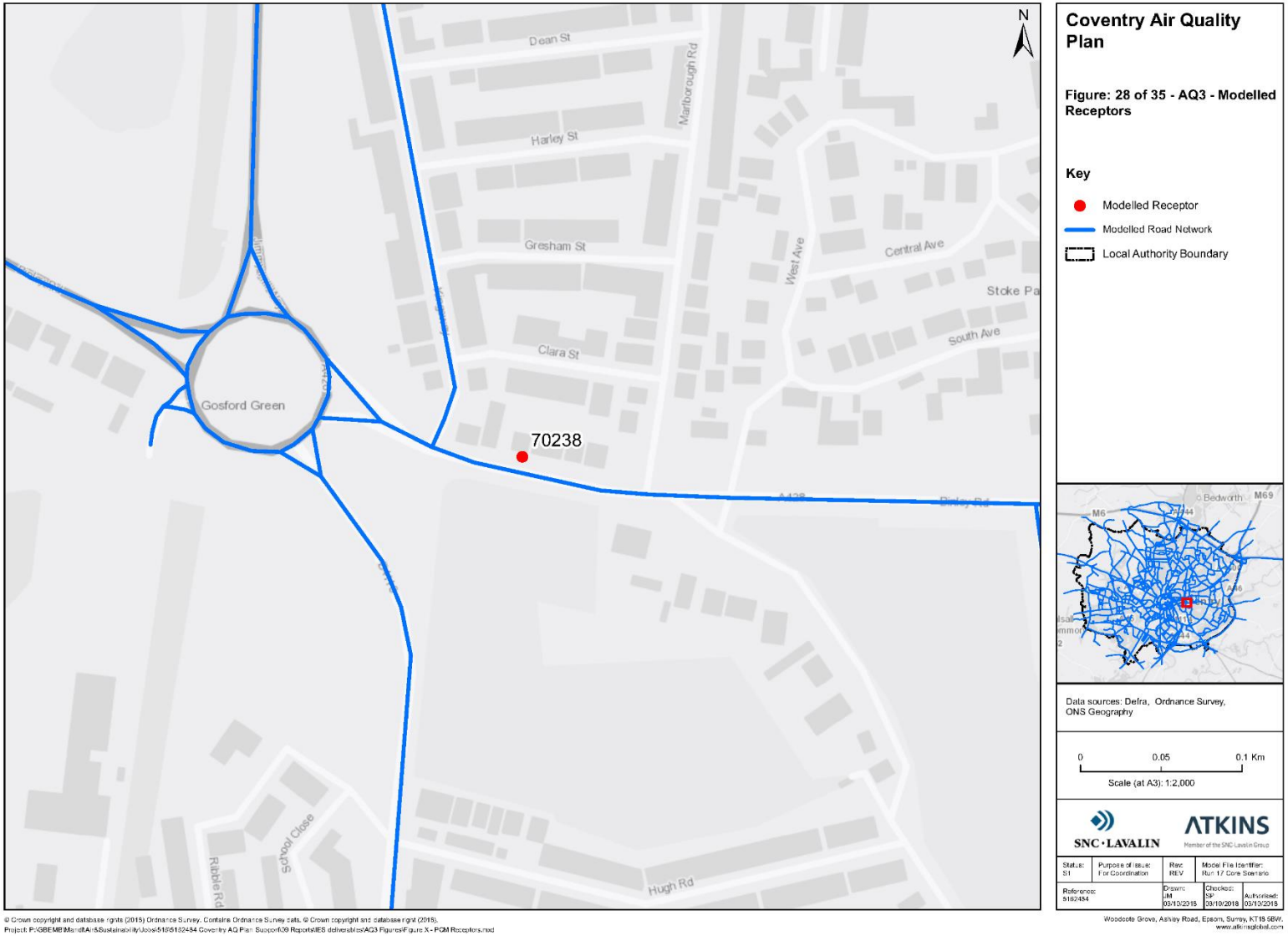

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Figure A-30 – Modelled Receptor Adjacent to PCM Link with Census ID 74638

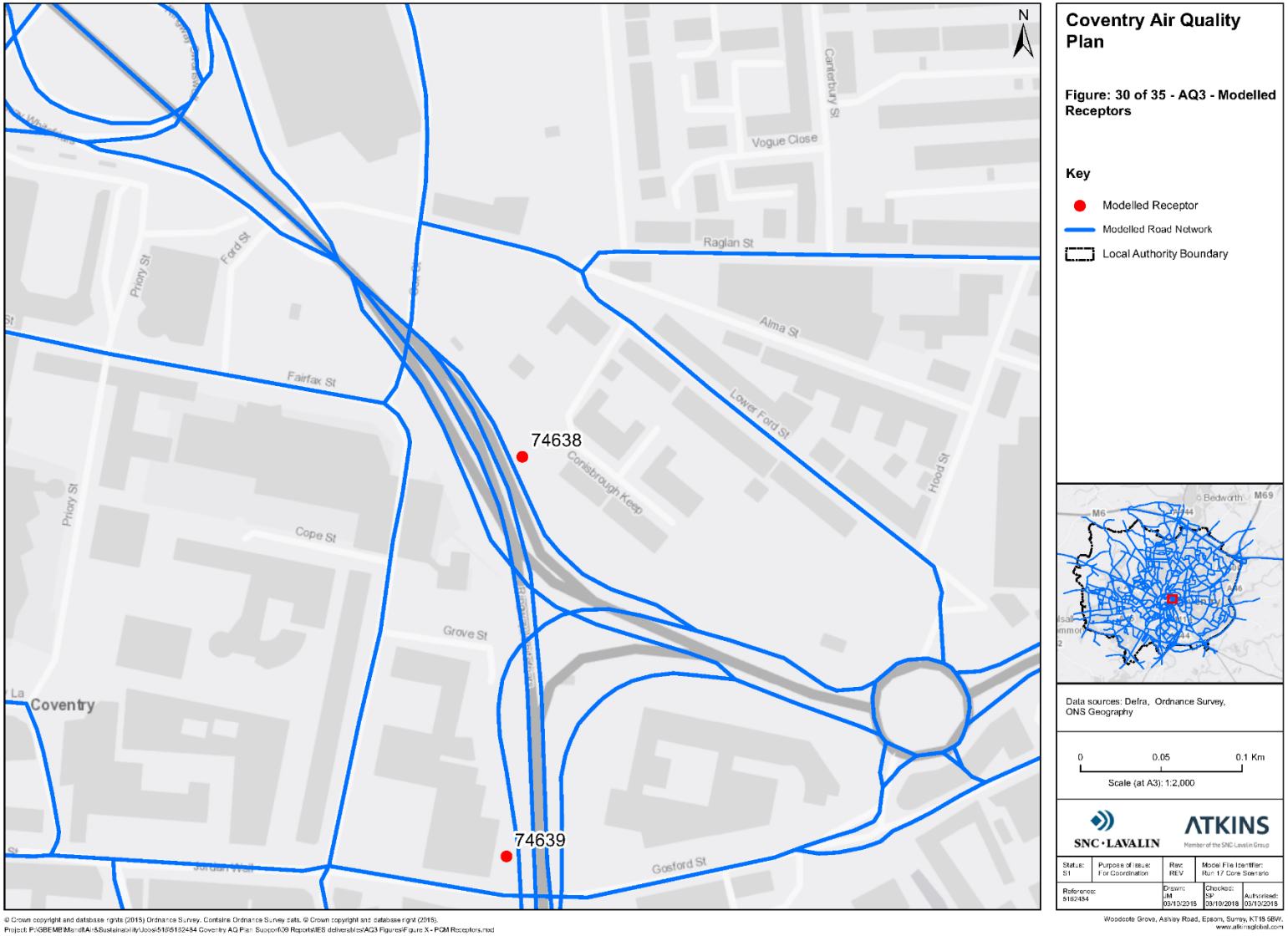

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Figure A-31 – Modelled Receptor Adjacent to PCM Link with Census ID 74639

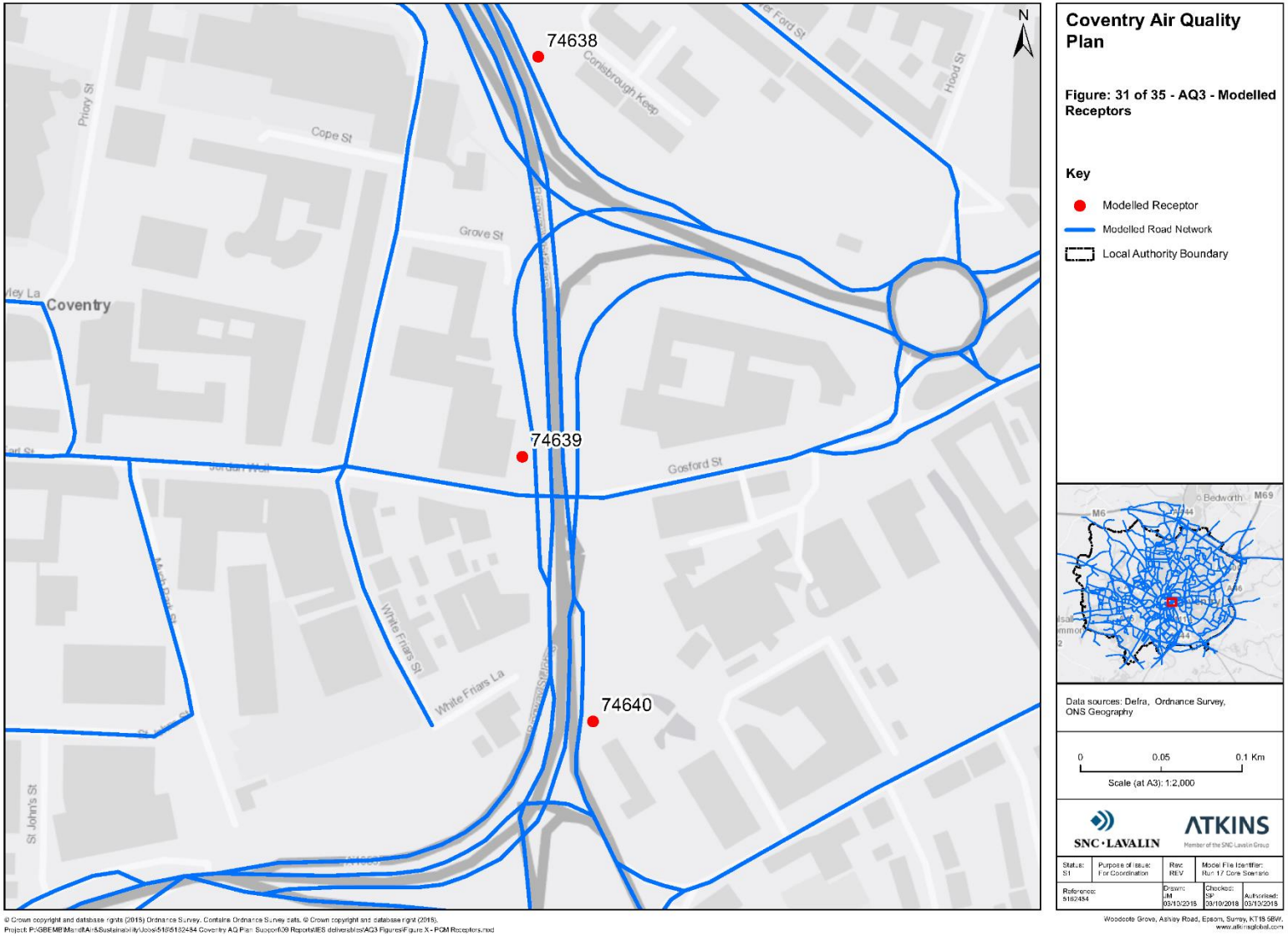

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Figure A-32 – Modelled Receptor Adjacent to PCM Link with Census ID 74640

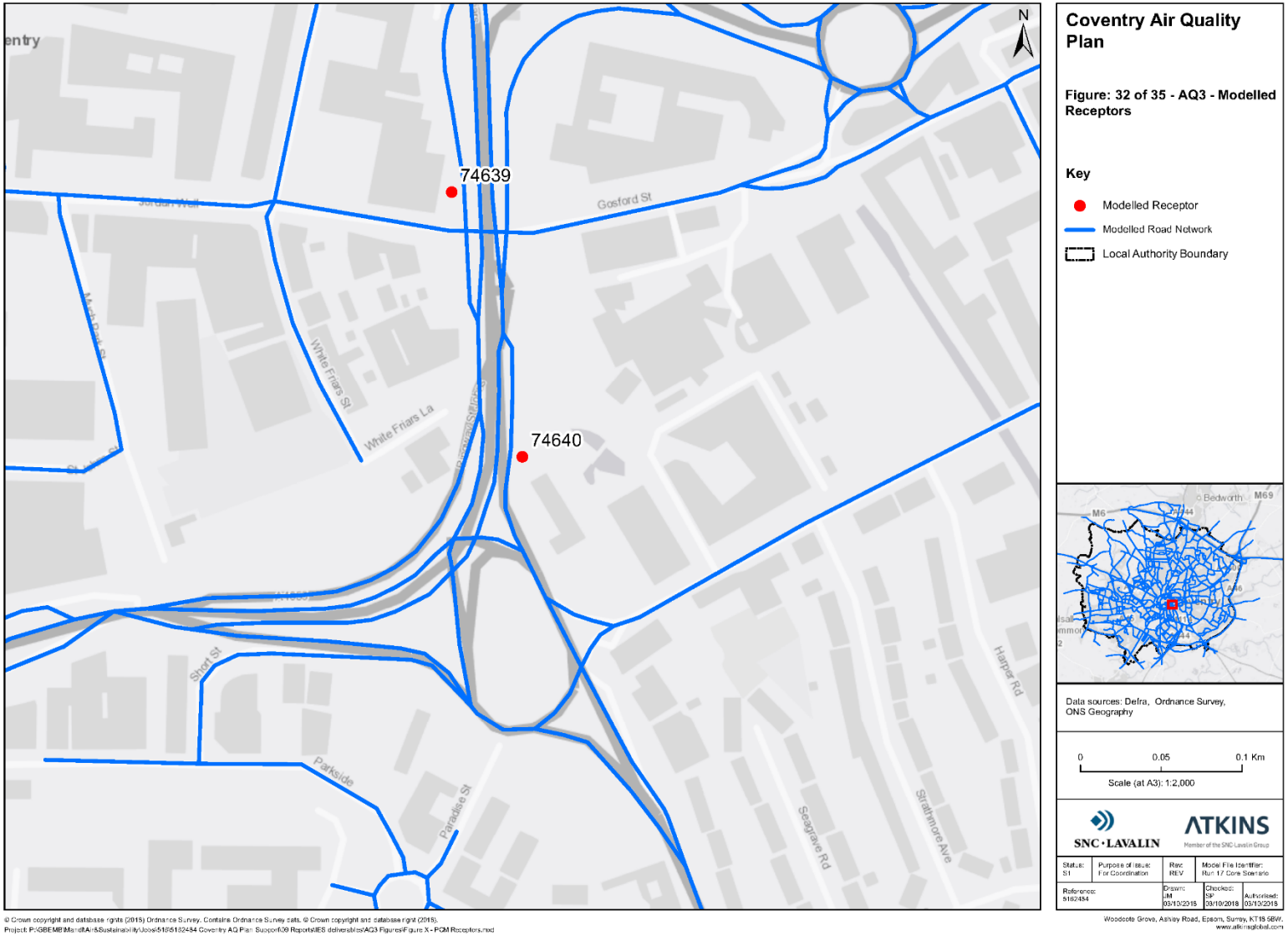

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Figure A-33 – Modelled Receptor Adjacent to PCM Link with Census ID 81233

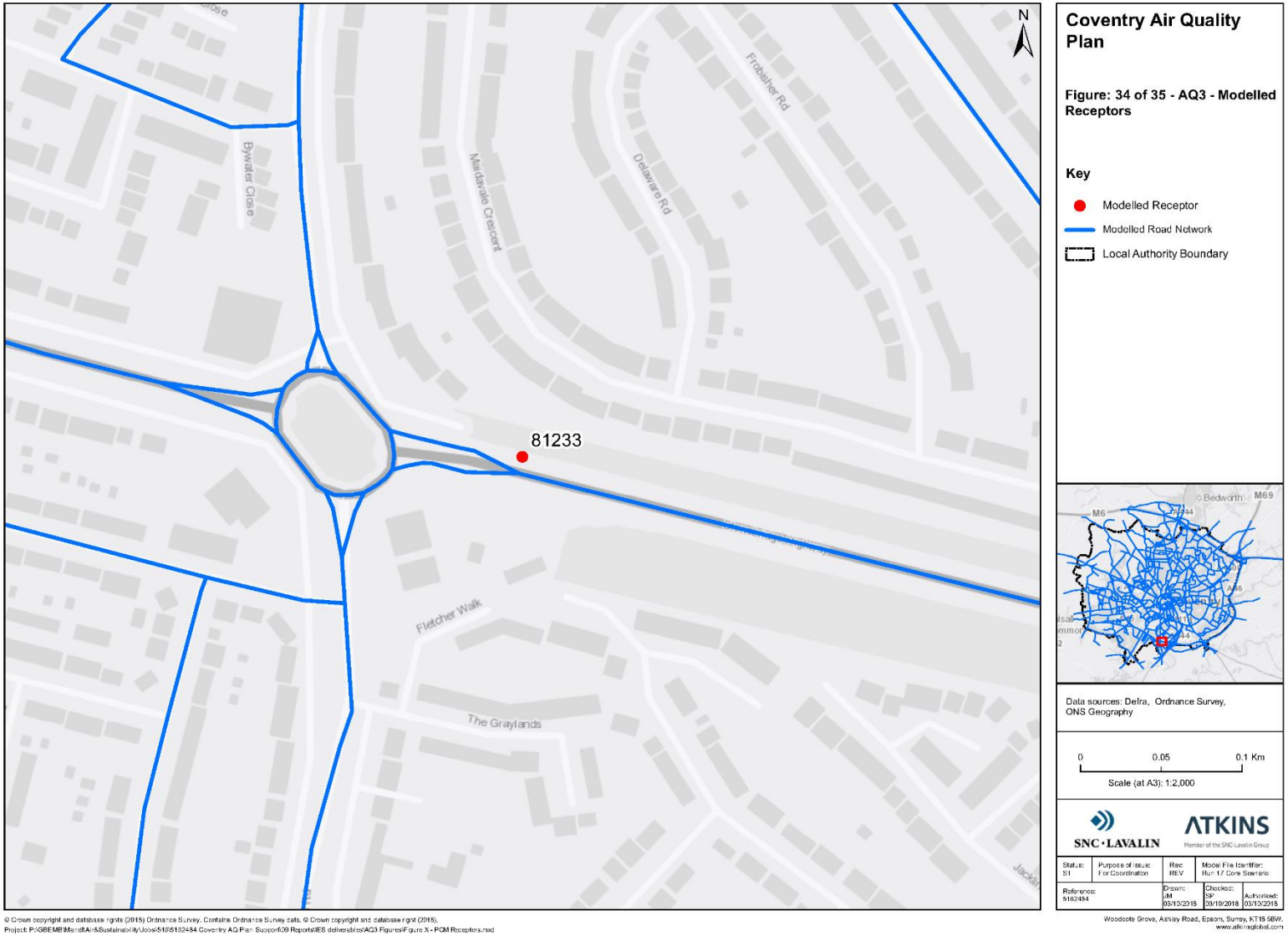

Figure A-34 – Modelled Receptor Adjacent to PCM Link with Census ID 99218

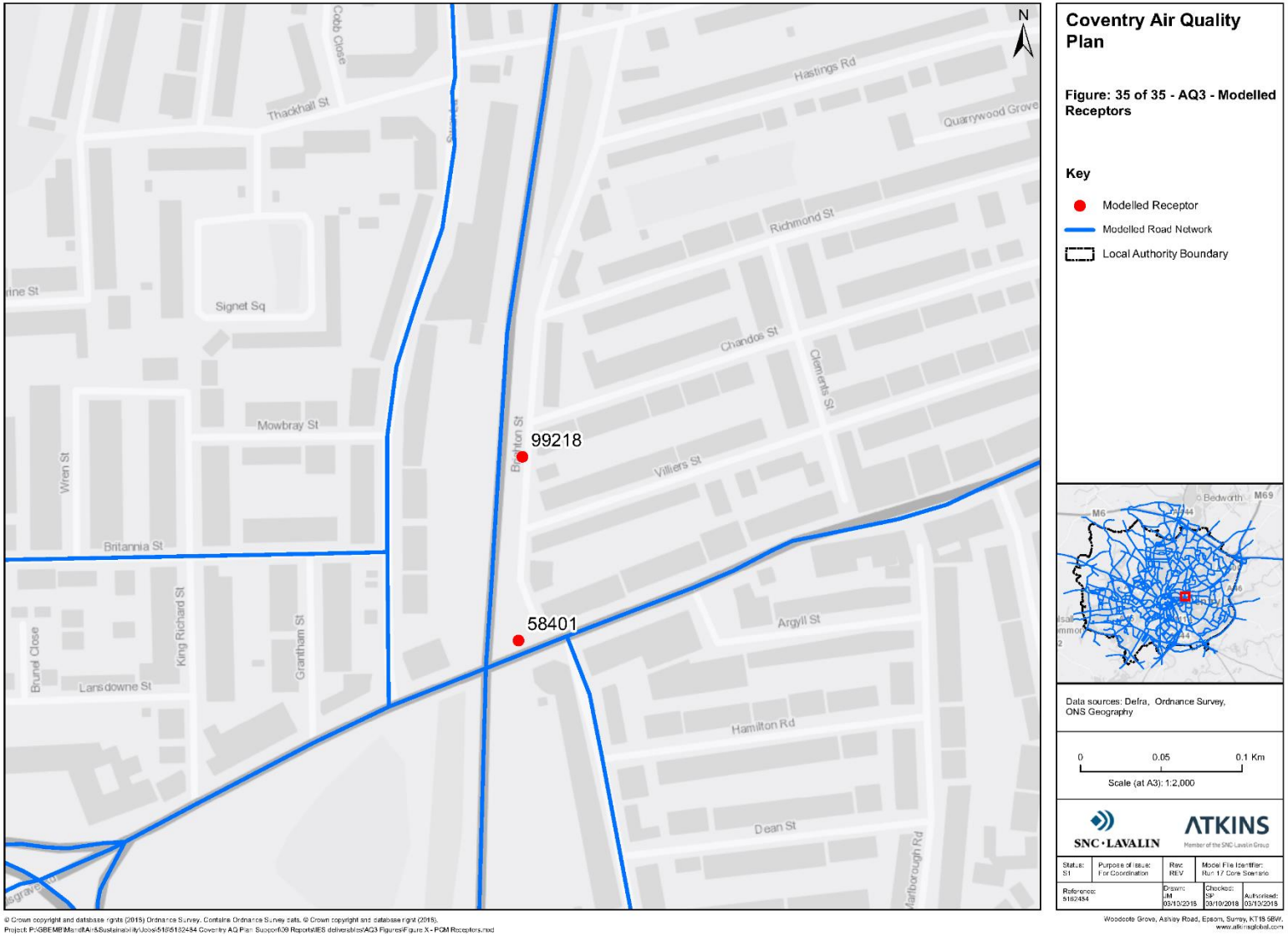

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Figure A-35 – Modelled Secondary Receptors adjacent to Potential Displacement Routes

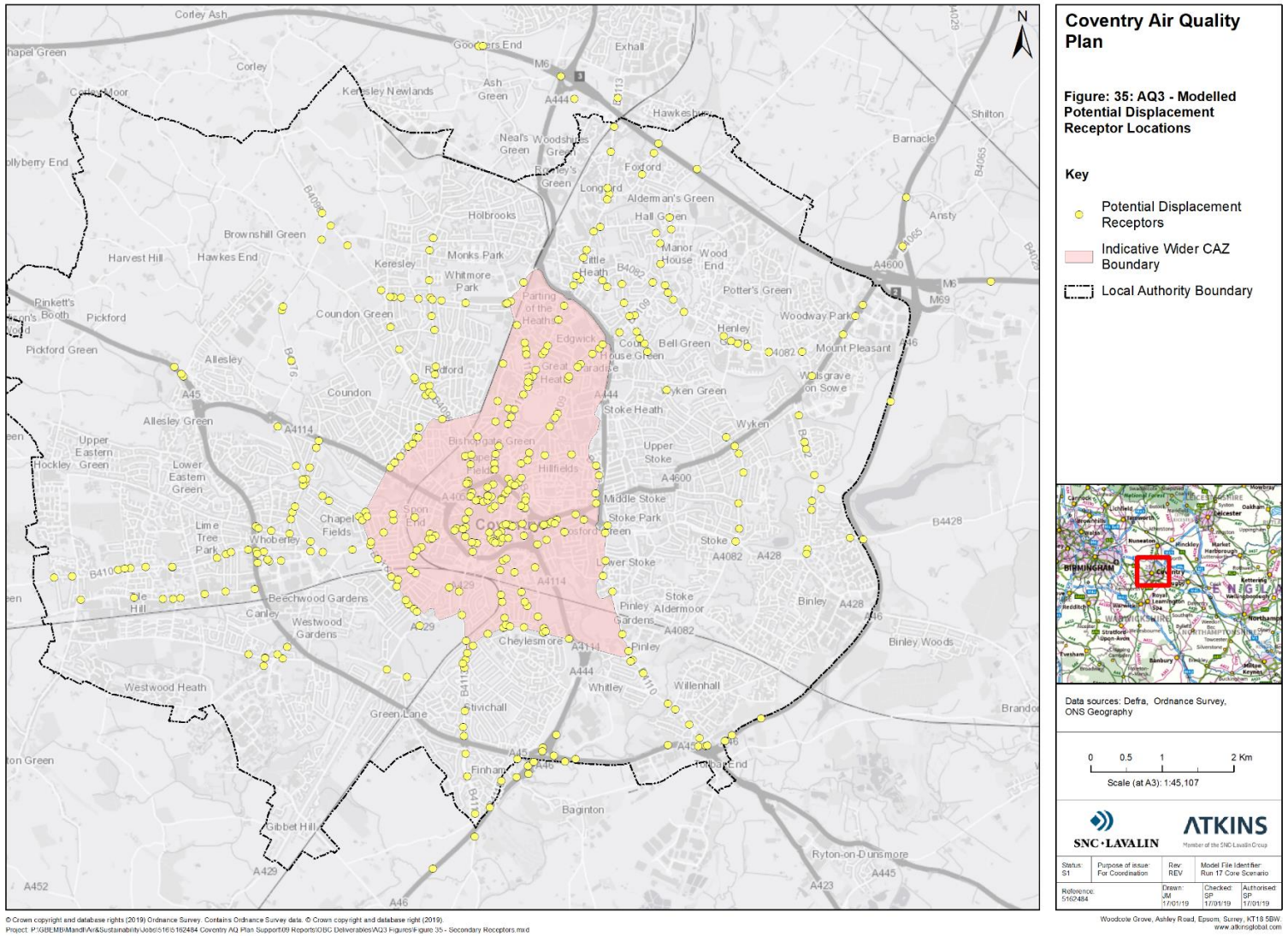

Figure A-36 – Local Modelled NO_2 Concentrations (µg/m³) Mapped to the Defra PCM Network 2021 – Do-Minimum

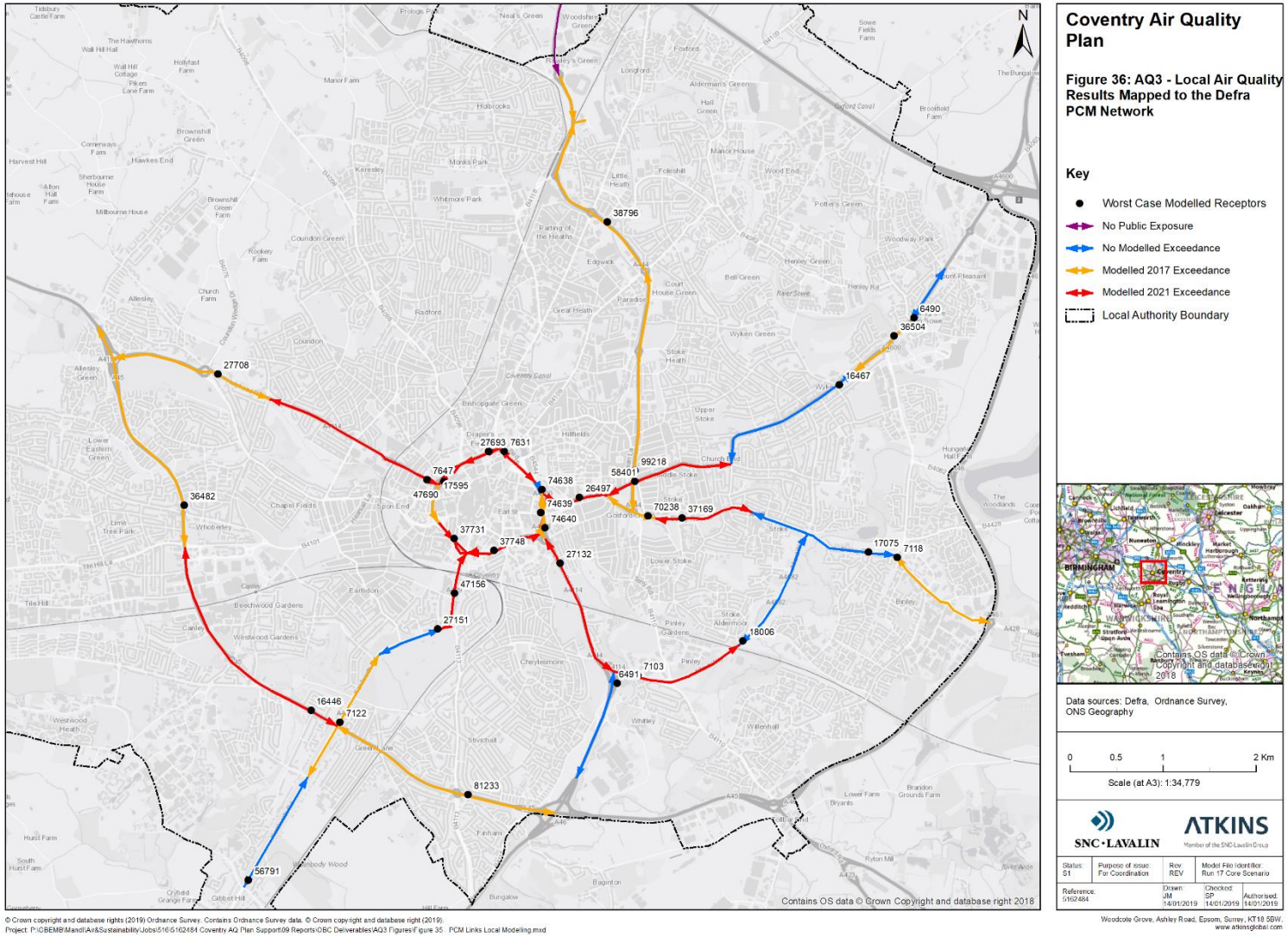

Figure A-37 – Local Modelled NO_2 Concentrations (µg/m³) at Secondary Receptors in 2021 – Do-Minimum

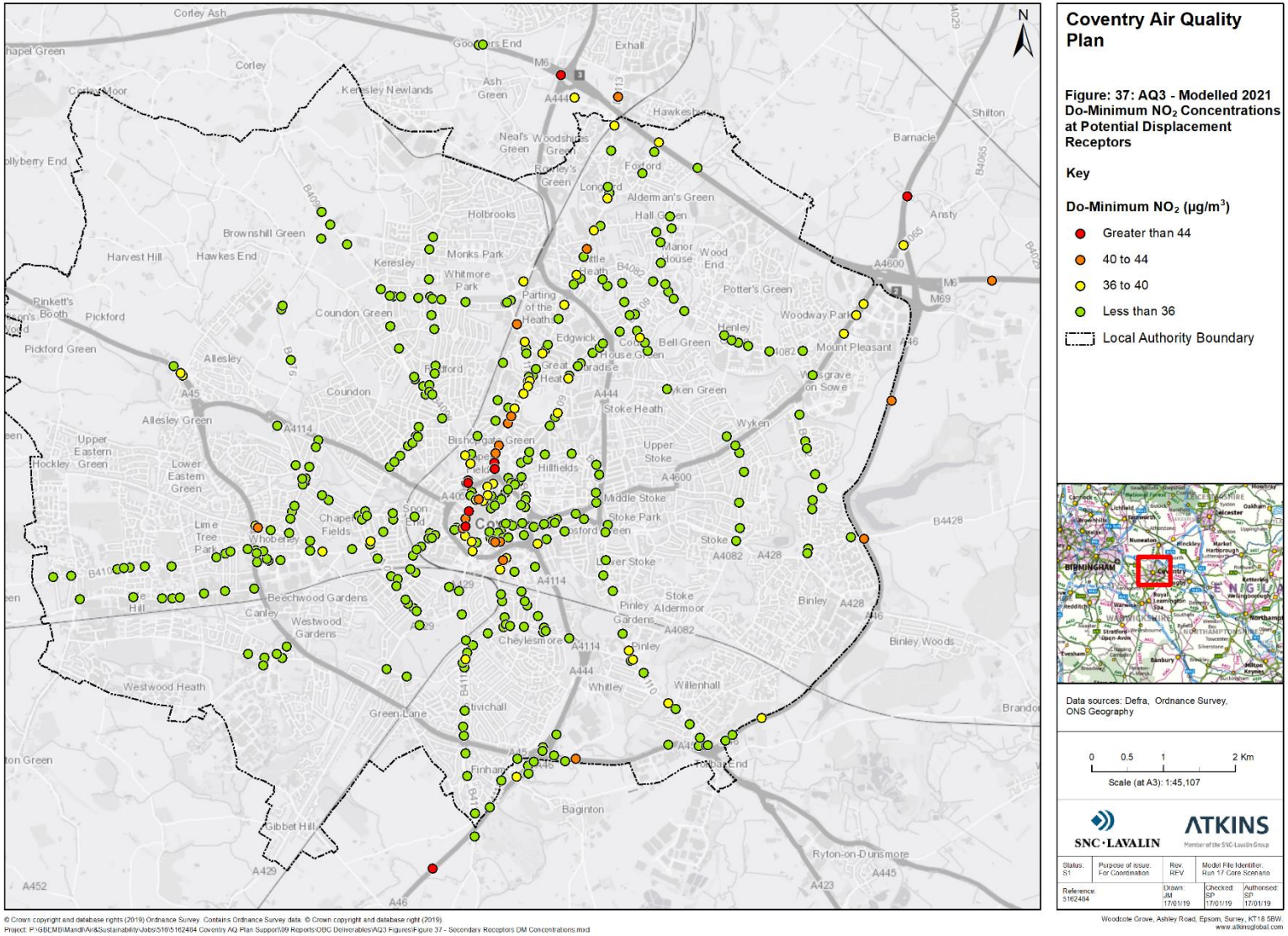

Figure A-38 –Modelled NO_2 Concentrations (µg/m³) Contour 2021 – Do-Minimum

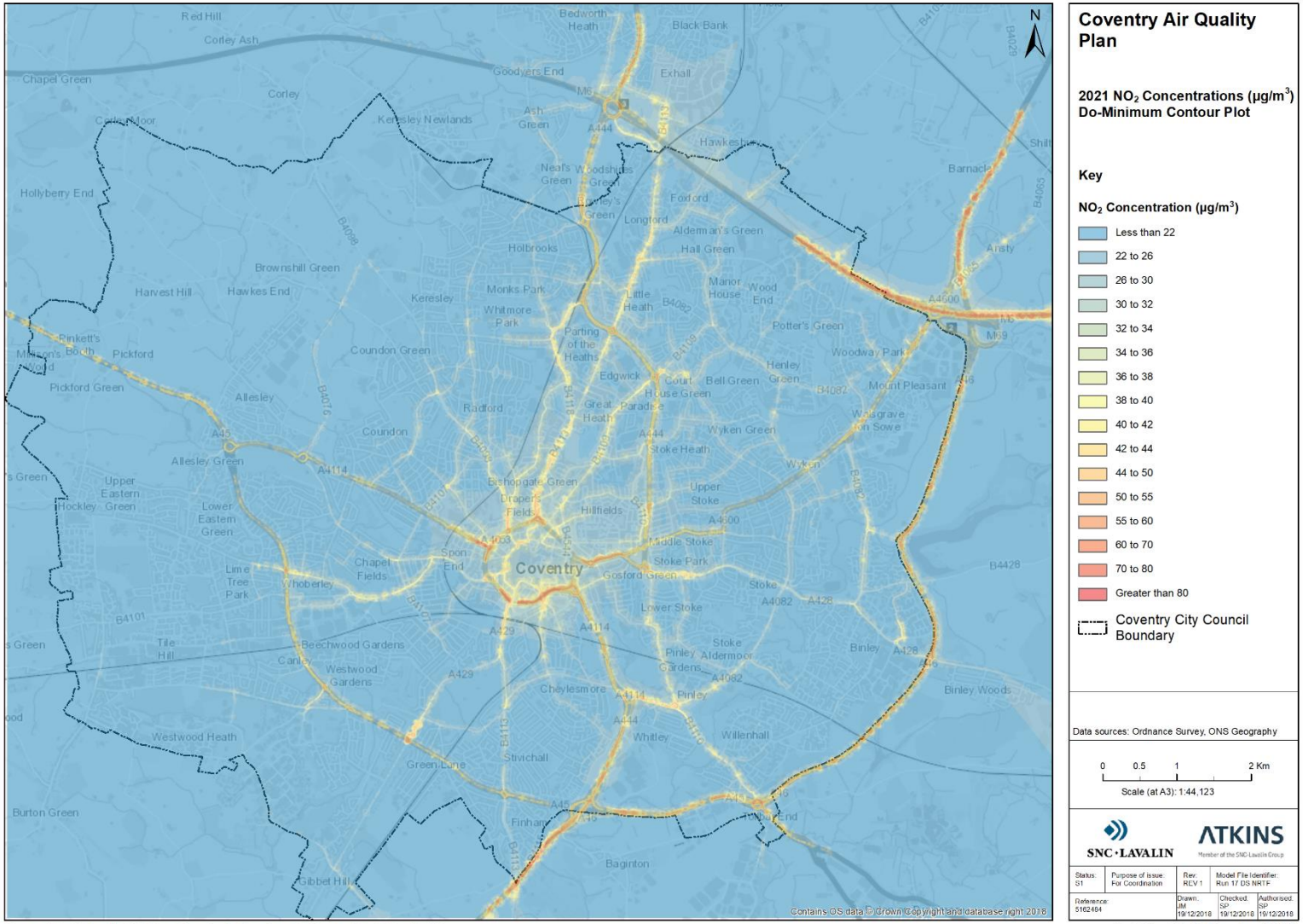

Figure A-39 –Impact at Modelled Secondary Receptors 2021 – CAZ D (No Upgrade)

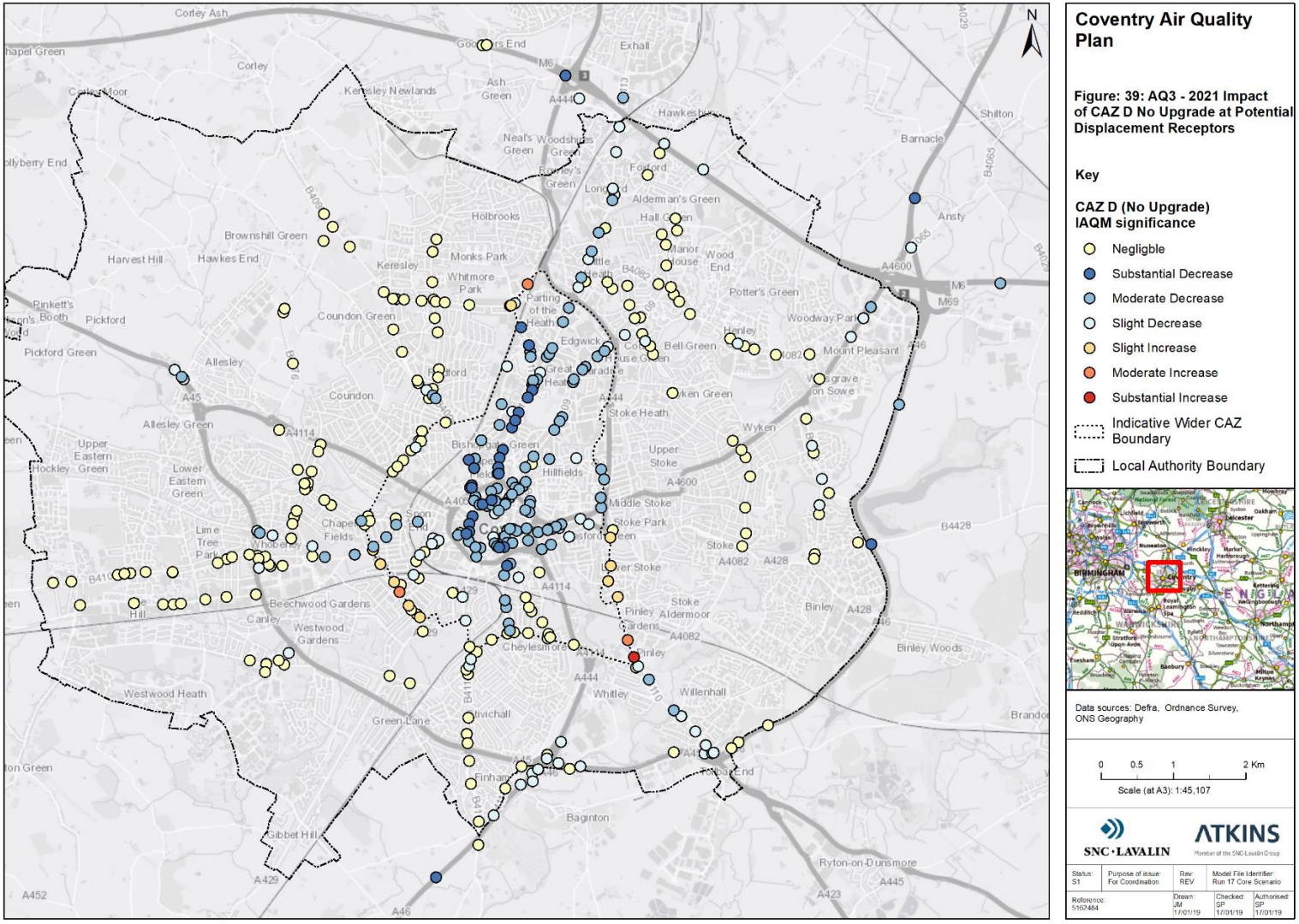

Figure A-40 –Impact at Modelled Secondary Receptors 2021 – CAZ D (West Midlands Upgrade)

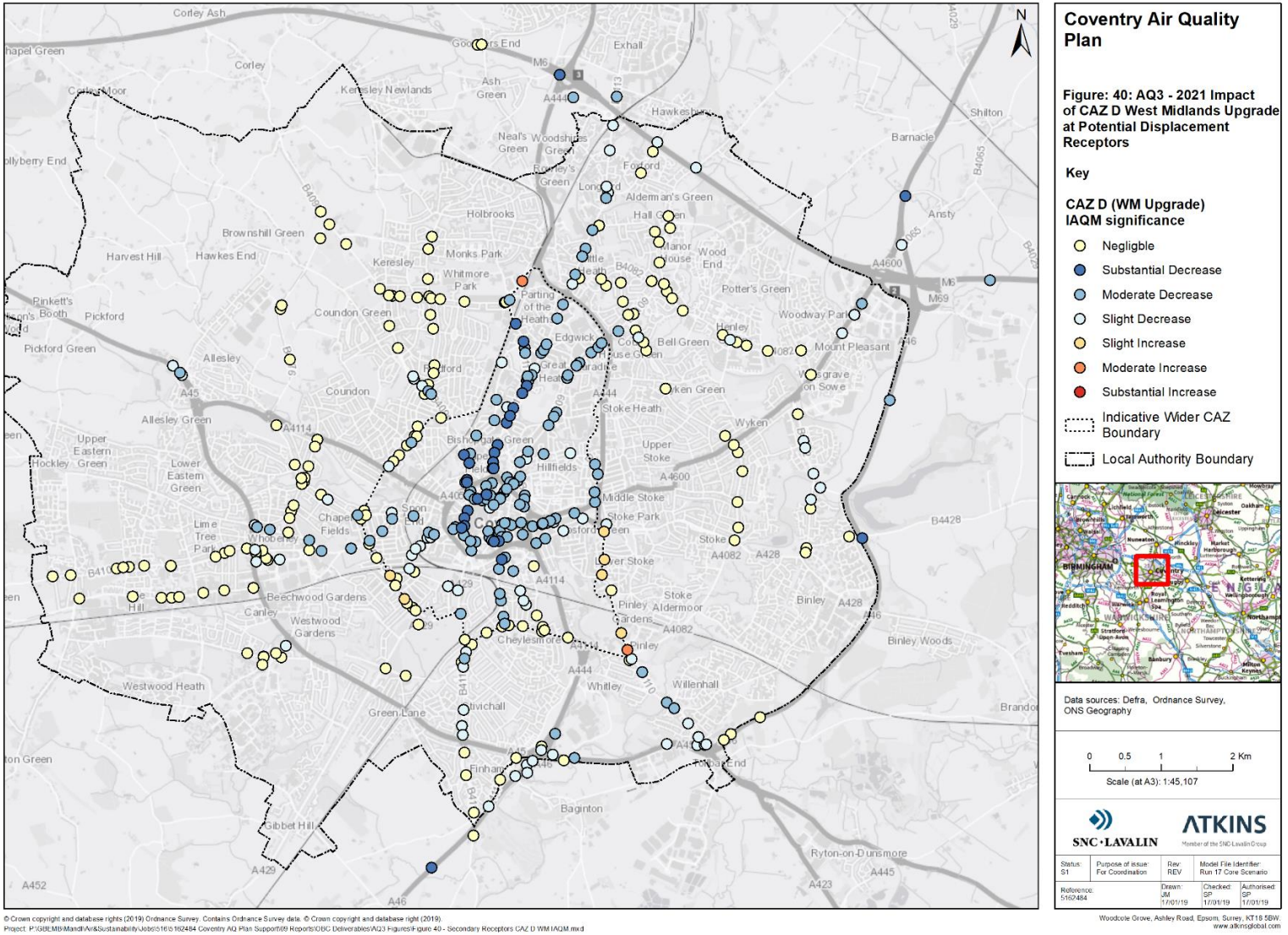

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Figure A-41 –Impacts at Modelled Secondary Receptors in 2021 – CAZ D (JAQU Upgrade)

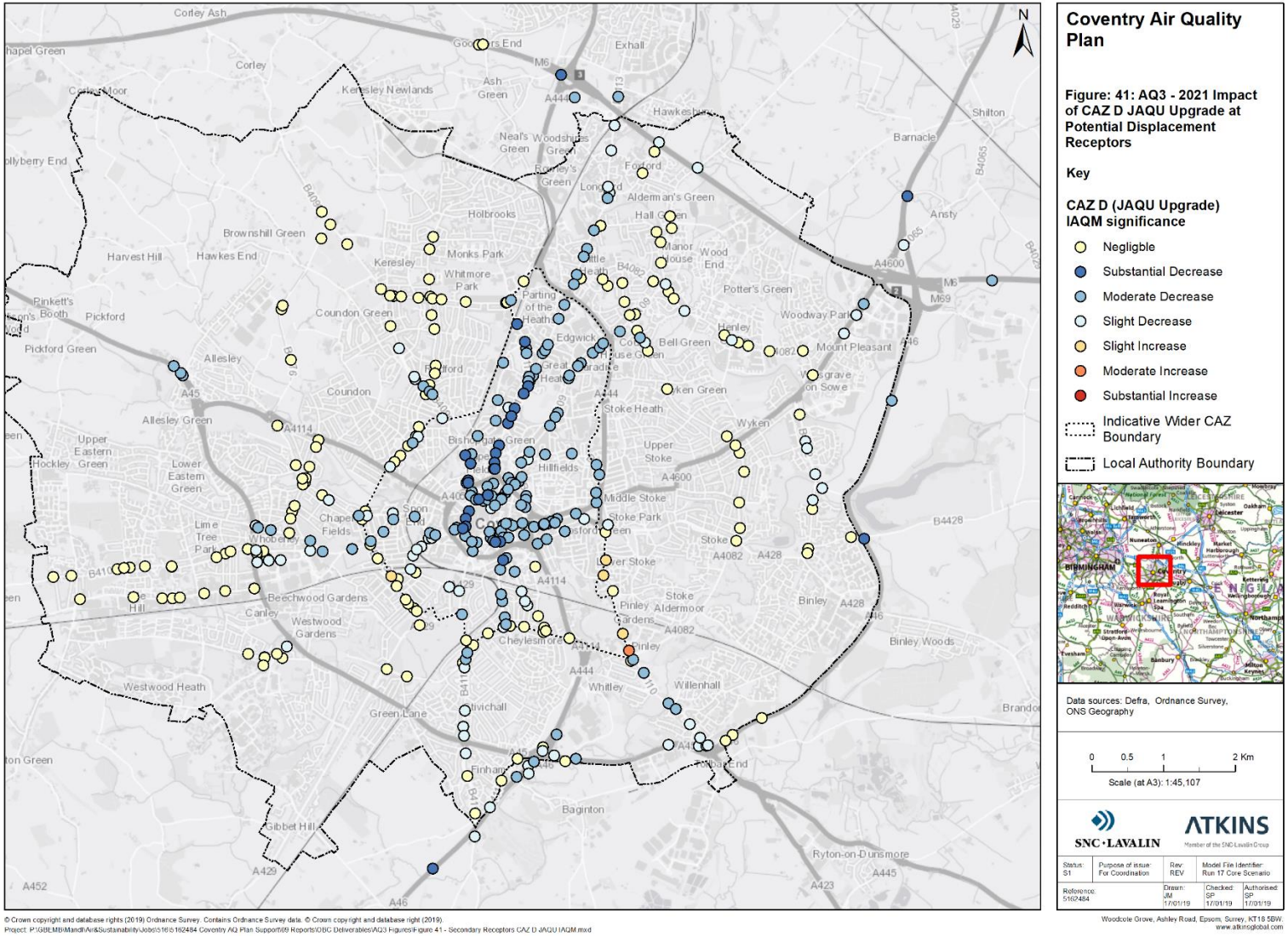

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Figure A-42 – Difference in NO_2 Concentration (µg/m³) between 2021 CAZ D (West Midlands Upgrade) and Do-Minimum

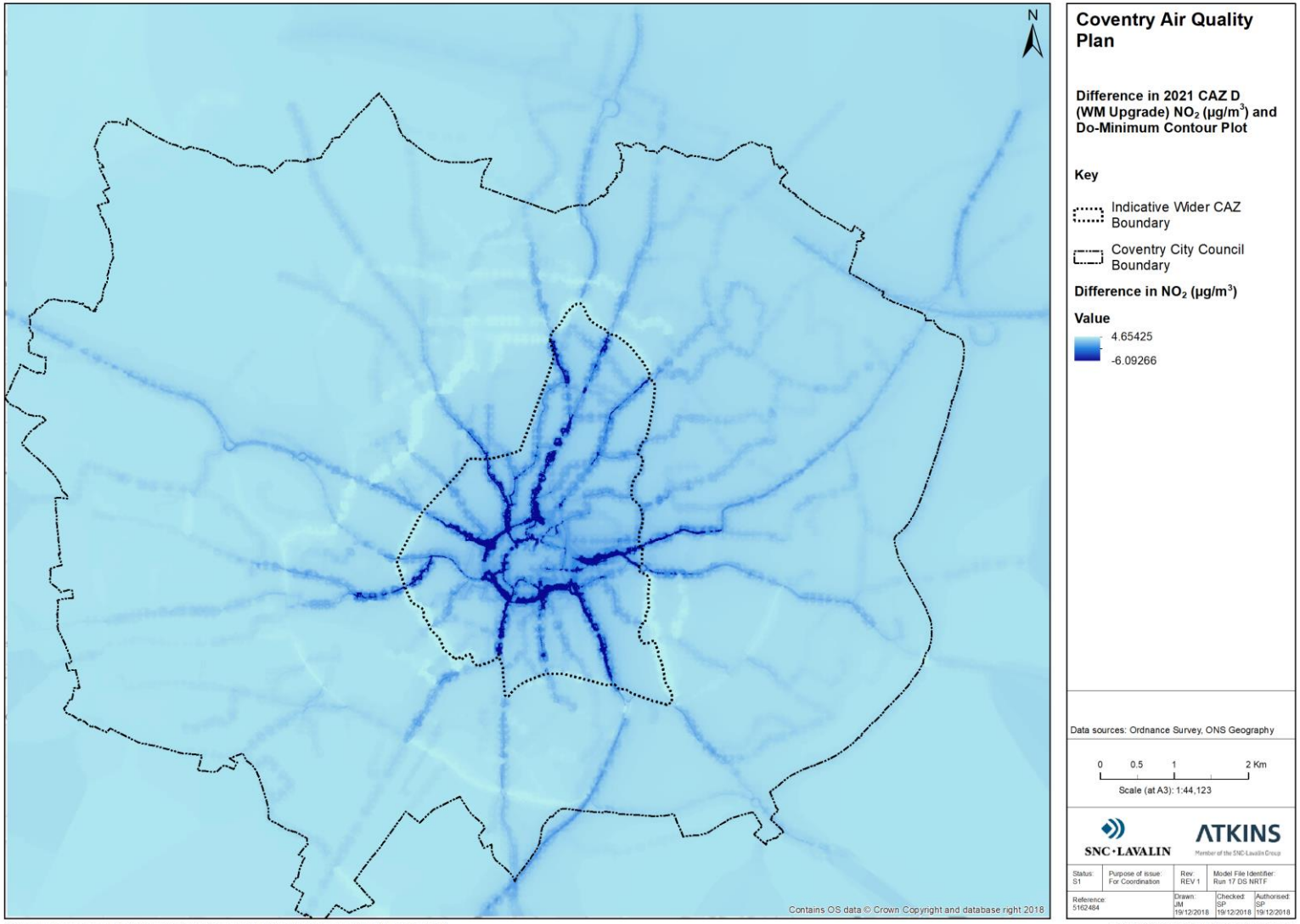

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Figure A-43 – Difference in LSOA Weighted (Area) NO_2 Concentration (µg/m³) between 2021 CAZ D (West Midlands Upgrade) and Do-Minimum

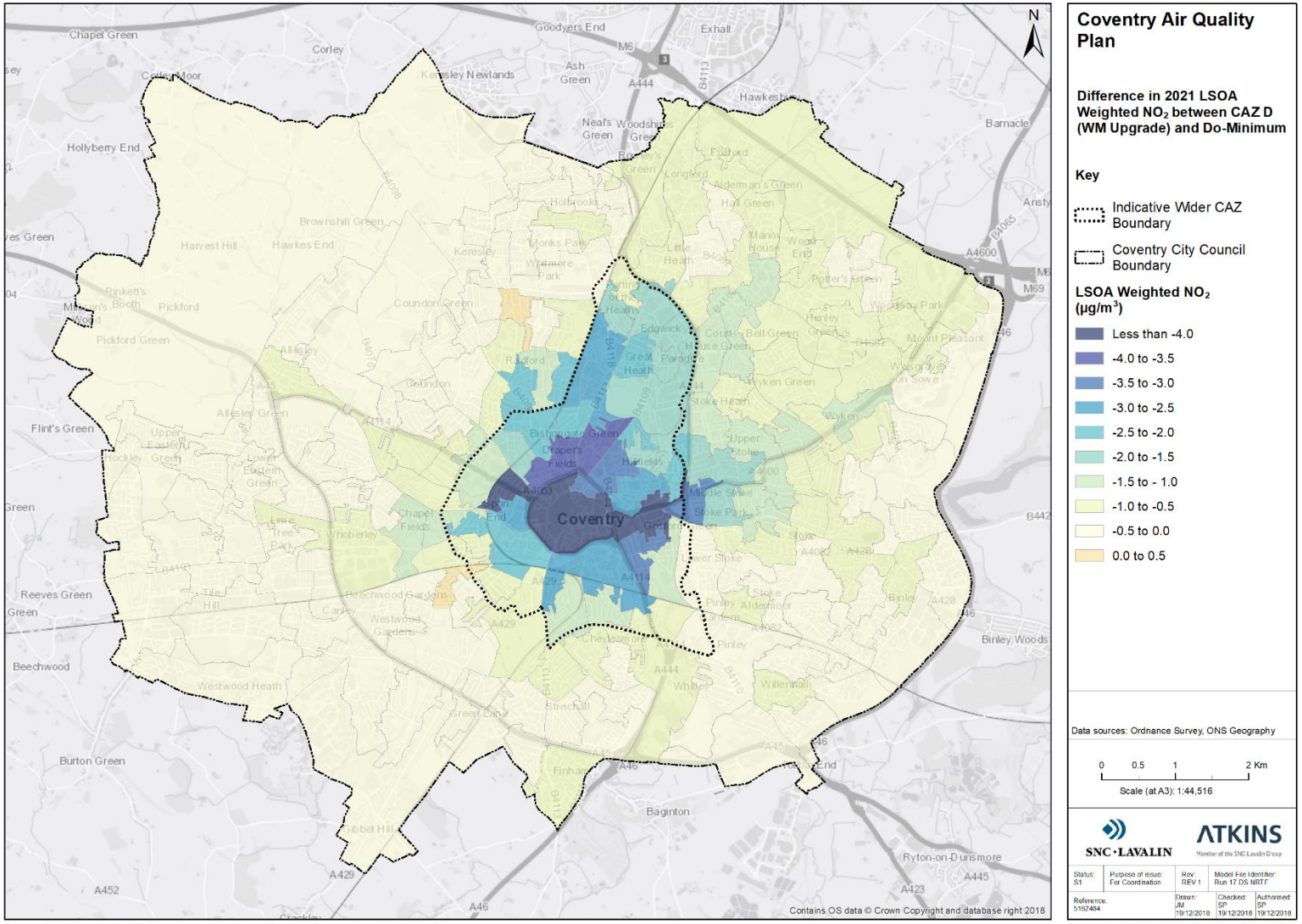

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Figure A-44 –Impact at Modelled Secondary Receptors 2021 – DS12A

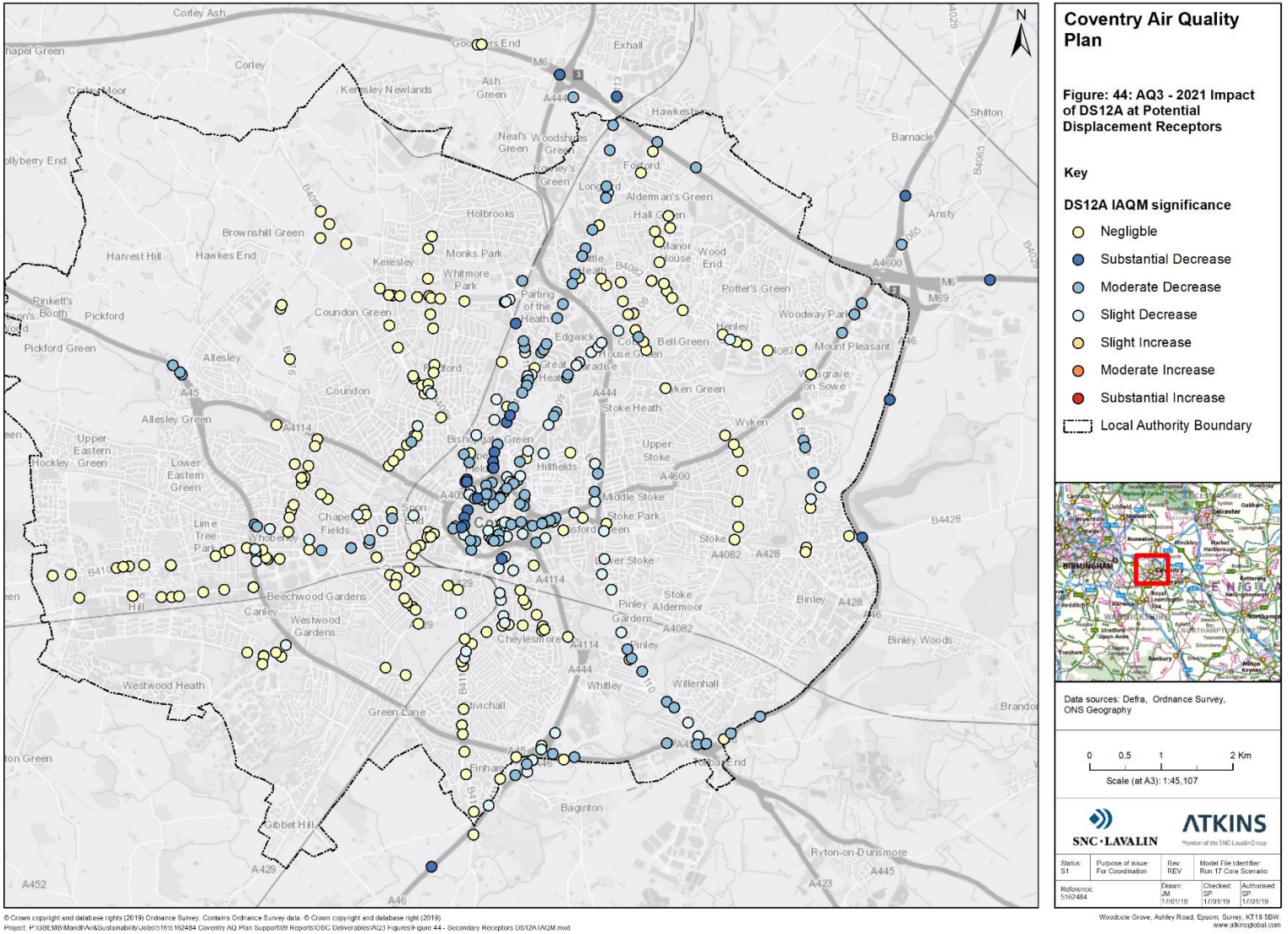


Figure A-45 – Difference in NO_2 Concentration (µg/m³) between 2021 DS12A and Do-Minimum

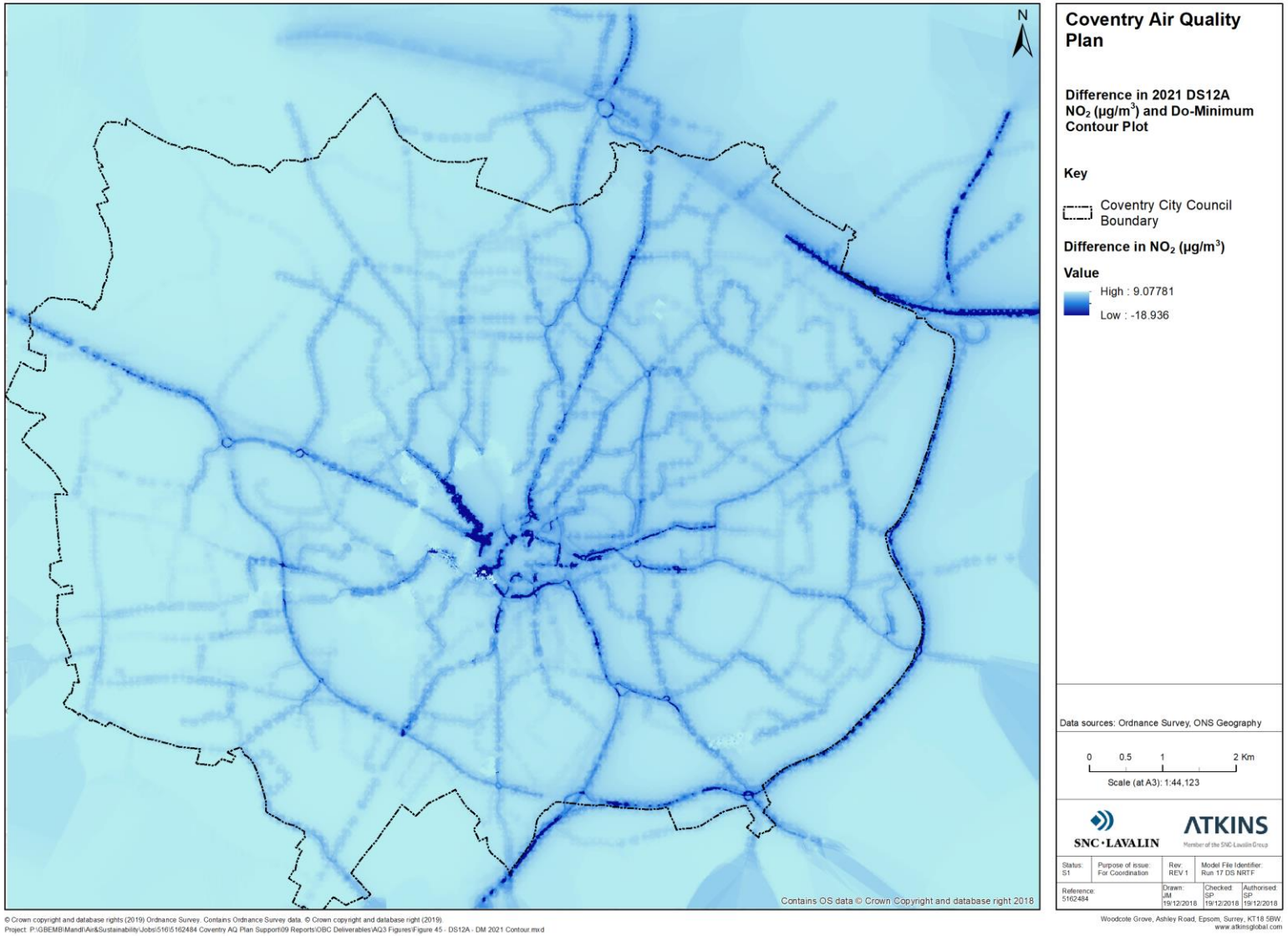
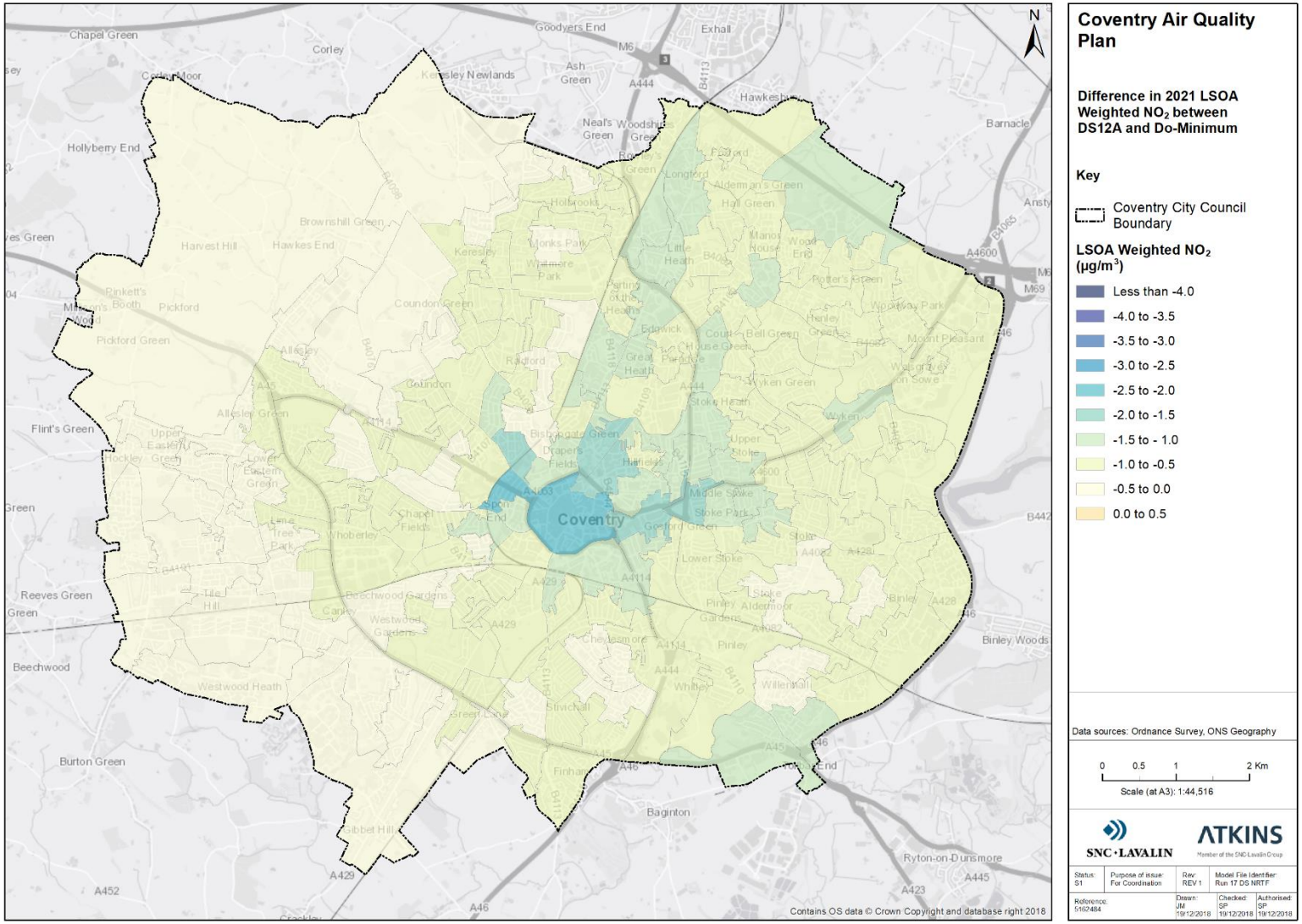


Figure A-46 – Difference in LSOA Weighted (Area) NO_2 Concentration (µg/m³) between 2021 DS12A and Do-Minimum



Appendix B. Model Verification Results

It is good practice to compare modelled estimates of pollutant concentrations with real-world monitoring to assess the model's performance for a base year and to inform the interpretation of model results for future years. Verification of the 2017 base year scenario has been undertaken by comparison of modelled concentrations against those derived from monitoring at fifty monitoring sites located in the study area.

A total of 15 monitoring sites for which data were available were not used in the model verification process for the following reasons:

- HR2c – this monitoring site is located on the façade of a property adjacent to Holyhead Road, but further away from the inner ring road and the diffusion tubes used to derive the "Holyhead Road" adjustment factor. The monitored NO_2 concentrations at this site are significantly lower than those measured elsewhere on Holyhead Road and as a result the model overpredicts rather than under predicts at this location without adjustment;
- LON8, STL1 and BL1 – the geometry of the road network in the 2017 base model (which is based on a 2013 model) does not correspond with the geometry of the real-work road network when the 2017 annual mean was recorded due to recent changes to the local road network at these locations (not reflected in CASM);
- GF1 – an adjacent road link is not included in the CASM traffic model;
- CS3, FGS4, KG1, EB1, SA1, SA2, SA3, HL1 and BS1 – only three months of monitoring data are available for these sites. Whilst these data have been annualised so as to be representative of a 2017 annual mean, it is considered that insufficient confidence can be placed in the results obtained at these sites; and
- QAV01 – this diffusion tube is located on a traffic light pole (<1m from the kerbside) at a junction between the B4106 and B4107. Such a location is difficult to replicate in the air quality model being within the model turbulence zone and as such the model performs poorly at this location. As this site is not representative of pollutant concentrations at 4m from the roadside where the EU Limit Value is assessed, this diffusion tube has been omitted from the verification process.

An air quality model can be considered to perform reasonably well where modelled concentrations are within 25% of monitored concentrations at 95% of sites, in accordance with DEFRA's Technical Guidance LAQM.TG(16). The root mean square error (RMSE) is acceptable if it is well below 25% of the AQS objective at 10 µg/m^3 (a requirement), and is ideal if below 10% of the AQS objective i.e. an RMSE of 4 µg/m^3.

Step 1

Firstly, unadjusted modelled estimates of total annual mean NO_2 concentrations have been compared against monitored annual mean concentrations as shown in Table B-1. These results indicate that the model tended to underestimate compared to monitored concentrations, by up to 47%. Unadjusted model statistics are shown in Table B-2. The RMSE is over 25% of the AQS objective, whilst the Fractional Bias (FB) is well above the ideal value of 0, indicating that the model tends to under estimate. The correlation coefficient suggests the model is not reflecting the measured position well.

Table B-1 – Comparison of Modelled and Measured NO_2 Concentrations (µg/m^3), Unadjusted

Site Name	Background Annual Mean NO_2 (µg/m^3)	Monitored Annual Mean Total NO_2 (µg/m^3)	Unadjusted Modelled Annual Mean Total NO_2 (µg/m^3)	Unadjusted Modelled NO_2 Minus Monitored NO_2 (µg/m^3)	% Difference (unadjusted modelled NO_2 - monitored NO_2) / monitored NO_2 * 100
BA1	18.7	33.8	26.3	-7.5	-22%
BA1c	15.0	25.2	18.8	-6.3	-25%
BELL1	17.7	38.2	25.6	-12.6	-33%
BELL2	17.7	35.2	22.1	-13.1	-37%
BH13	18.6	34.1	24.5	-9.6	-28%
BH14	18.6	37.5	25.1	-12.4	-33%
BH15i	18.6	**40.9**	29.4	-11.4	-28%
BH1a	20.7	37.6	31.2	-6.4	-17%
BH2a	18.6	**43.5**	30.3	-13.2	-30%
BH4	18.6	**45.3**	30.2	-15.1	-33%
BRN2	20.3	36.0	24.1	-11.9	-33%
BRN5	20.3	32.6	26.7	-5.9	-18%
CC01/1*N	22.1	36.8	31.3	-5.5	-15%
COAL (CMS)	16.0	21.9	19.0	-2.9	-13%
COBR (CMS)	19.6	33.4	27.8	-5.6	-17%
DH1	18.3	29.9	24.2	-5.7	-19%
FGS2	20.7	32.7	28.5	-4.2	-13%
FGS3a	20.7	33.8	27.2	-6.6	-19%
FS1	22.8	**45.9**	32.9	-13.0	-28%
GR1	19.6	33.5	24.1	-9.3	-28%
GS1	24.1	35.3	31.6	-3.7	-11%
LON12	19.6	**48.8**	30.7	-18.1	-37%
LR1	17.1	37.8	28.0	-9.8	-26%
LR2	17.1	37.2	31.4	-5.8	-16%
LR3	17.6	38.7	25.0	-13.7	-35%
QAV12	17.9	31.1	25.6	-5.5	-18%
QAV13	17.9	37.3	27.4	-9.9	-27%
QV1	24.1	38.7	34.3	-4.3	-11%
R5	21.5	**40.1**	32.8	-7.3	-18%
R6	21.5	**50.7**	34.1	-16.6	-33%
R8	20.3	37.3	26.2	-11.1	-30%
R9	19.6	36.9	26.9	-10.0	-27%

Site Name	Background Annual Mean NO_2 (µg/m^3)	Monitored Annual Mean Total NO_2 (µg/m^3)	Unadjusted Modelled Annual Mean Total NO_2 (µg/m^3)	Unadjusted Modelled NO_2 Minus Monitored NO_2 (µg/m^3)	% Difference (unadjusted modelled NO_2 - monitored NO_2) / monitored NO_2 * 100
RR1	22.8	38.2	29.7	-8.5	-22%
RR2	22.8	**40.3**	30.8	-9.5	-23%
SHP2	16.8	28.6	22.7	-5.9	-21%
SHP3	16.8	34.0	24.7	-9.3	-27%
HR5	22.1	**67.3**	**47.8**	-19.5	-29%
HR1	22.1	**52.8**	**41.1**	-11.7	-22%
HR1c	22.1	**79.2**	**42.0**	-37.3	-47%
HR4	22.1	**49.7**	35.8	-13.8	-28%
HR6	22.1	**68.8**	39.5	-29.3	-43%
Grange2	18.1	36.5	31.4	-5.1	-14%
Grange3	18.1	34.4	29.6	-4.8	-14%
RR3	22.8	**46.7**	**41.5**	-5.2	-11%
SE1	22.1	35.4	33.3	-2.0	-6%
SE3	22.1	36.6	34.7	-1.9	-5%
SS1	19.9	34.3	24.8	-9.4	-28%
SS2	22.8	31.3	27.9	-3.3	-11%
SS3	19.6	36.1	26.2	-9.9	-28%
SS5	22.8	**45.8**	30.5	-15.3	-33%

Table B-2 – Model Statistics Pre-Adjustment

RMSE [i]	FB [ii]	r [iii]
11.79	0.29	0.825

Notes:

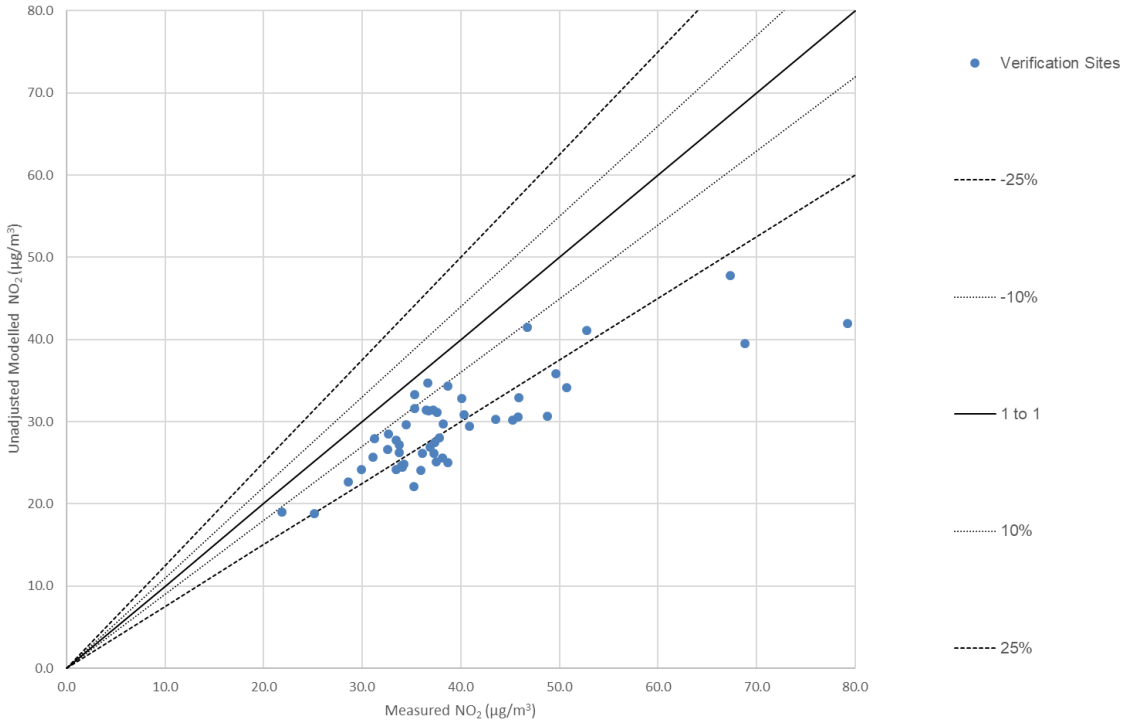
[i] Root Mean Square Error: RMSE is used to define the average error or uncertainty of the model (units = µg/m^3). In the case of modelled annual mean NO_2 a value of less than 10 is acceptable and less than 4 is the ideal

[ii] Fractional Bias: FB is used to identify if the model shows a systematic tendency to over or under estimate. Ideal value is 0

[iii] Correlation coefficient: r is used to measure the linear relationship between modelled and observed data. Ideal value is 1

A comparison of measured and modelled (unadjusted) annual mean NO_2 concentrations is shown below in Figure B-1.

Figure B-1 – Measured NO_2 vs Modelled (Unadjusted) NO_2



Step 2

The model itself does not provide annual mean NO_2, this is determined using DEFRA LAQM.TG(16) methods. The second comparison is thus of directly modelled estimates of road contributed annual mean NOx with the road NOx component derived from monitoring data, as presented in Table B-3. This analysis requires the estimation of the monitored road NOx component from the measured total annual mean NO_2 concentration. This was undertaken using DEFRA's NOx to NO_2 calculator (version 6.1).

Table B-3 – Comparison of Modelled and Measured NO_x Concentrations (µg/m³), Unadjusted

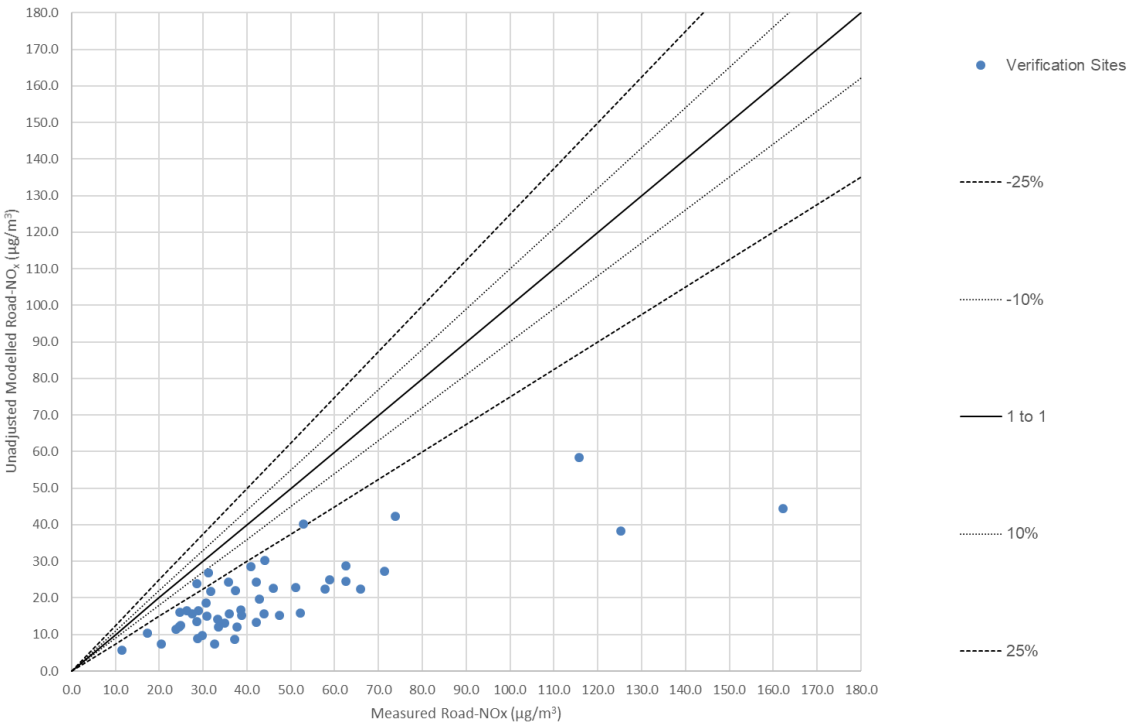
Site Name	Modelled Annual Mean Road NO_x (µg/m³)	Monitored Annual Mean Road NO_x (µg/m³)	Modelled Road NO_x Minus Monitored Road NO_x (µg/m³)	Monitored Road NO_x / Modelled NO_x	% Difference (modelled Road NO_x - monitored Road NO_x) / monitored Road NO_x * 100
BA1	14.9	30.9	-15.9	2.07	-52%
BA1c	7.4	20.4	-13.0	2.77	-64%
BELL1	15.7	43.9	-28.2	2.79	-64%
BELL2	8.7	37.3	-28.6	4.28	-77%
BH13	11.9	33.6	-21.6	2.81	-64%
BH14	13.4	42.2	-28.7	3.15	-68%
BH15i	22.9	51.2	-28.3	2.23	-55%
BH1a	22.1	37.3	-15.2	1.69	-41%
BH2a	25.0	58.9	-33.9	2.36	-58%

Site Name	Modelled Annual Mean Road NO_x ($\mu g/m^3$)	Monitored Annual Mean Road NO_x ($\mu g/m^3$)	Modelled Road NO_x Minus Monitored Road NO_x ($\mu g/m^3$)	Monitored Road NO_x / Modelled NO_x	% Difference (modelled Road NO_x - monitored Road NO_x) / monitored Road NO_x * 100
BH4	24.5	62.5	-38.0	2.55	-61%
BRN2	7.4	32.6	-25.2	4.40	-77%
BRN5	12.5	24.9	-12.4	2.00	-50%
CC01/1*N	18.7	30.7	-12.1	1.65	-39%
COAL	5.8	11.5	-5.8	2.00	-50%
COBR	16.5	28.9	-12.4	1.75	-43%
DH1	12.0	24.5	-12.5	2.05	-51%
FGS2	16.5	26.3	-9.8	1.59	-37%
FGS3a	13.5	28.5	-15.0	2.11	-53%
FS1	22.5	57.7	-35.3	2.57	-61%
GR1	8.9	28.8	-19.9	3.24	-69%
GS1	16.1	24.7	-8.6	1.54	-35%
LON12	22.5	65.9	-43.4	2.93	-66%
LR1	22.7	46.1	-23.3	2.03	-51%
LR2	30.3	44.1	-13.9	1.46	-31%
LR3	15.3	47.5	-32.2	3.11	-68%
QAV12	15.6	27.5	-11.9	1.76	-43%
QAV13	19.6	42.8	-23.1	2.18	-54%
QV1	21.7	31.8	-10.1	1.46	-32%
R5	24.3	42.1	-17.8	1.73	-42%
R6	27.3	71.4	-44.1	2.61	-62%
R8	12.1	37.7	-25.6	3.12	-68%
R9	15.2	38.8	-23.6	2.55	-61%
RR1	14.2	33.4	-19.2	2.35	-57%
RR2	16.7	38.5	-21.9	2.31	-57%
SHP2	11.4	23.7	-12.3	2.07	-52%
SHP3	15.6	36.0	-20.4	2.31	-57%
HR5	58.5	115.8	-57.3	1.98	-50%
HR1	42.2	73.9	-31.7	1.75	-43%
HR1c	44.4	162.2	-117.7	3.65	-73%
HR4	28.7	62.5	-33.8	2.18	-54%
HR6	38.3	125.2	-86.9	3.27	-69%
Grange2	28.5	40.9	-12.5	1.44	-30%

Site Name	Modelled Annual Mean Road NO_x ($\mu g/m^3$)	Monitored Annual Mean Road NO_x ($\mu g/m^3$)	Modelled Road NO_x Minus Monitored Road NO_x ($\mu g/m^3$)	Monitored Road NO_x / Modelled NO_x	% Difference (modelled Road NO_x - monitored Road NO_x) / monitored Road NO_x * 100
Grange3	24.3	35.8	-11.4	1.47	-32%
RR3	40.1	52.9	-12.7	1.32	-24%
SE1	23.8	28.6	-4.7	1.20	-17%
SE3	26.9	31.2	-4.4	1.16	-14%
SS1	9.7	29.8	-20.1	3.07	-67%
SS2	10.3	17.3	-7.0	1.68	-41%
SS3	13.1	35.0	-21.8	2.66	-62%
SS5	15.9	52.2	-36.3	3.28	-69%

A comparison of measured and modelled (unadjusted) annual mean Road-NO_x concentrations is shown below in Figure B-2.

Figure B-2 – Measured Road-NO_x vs Modelled (Unadjusted) Road-NO_x



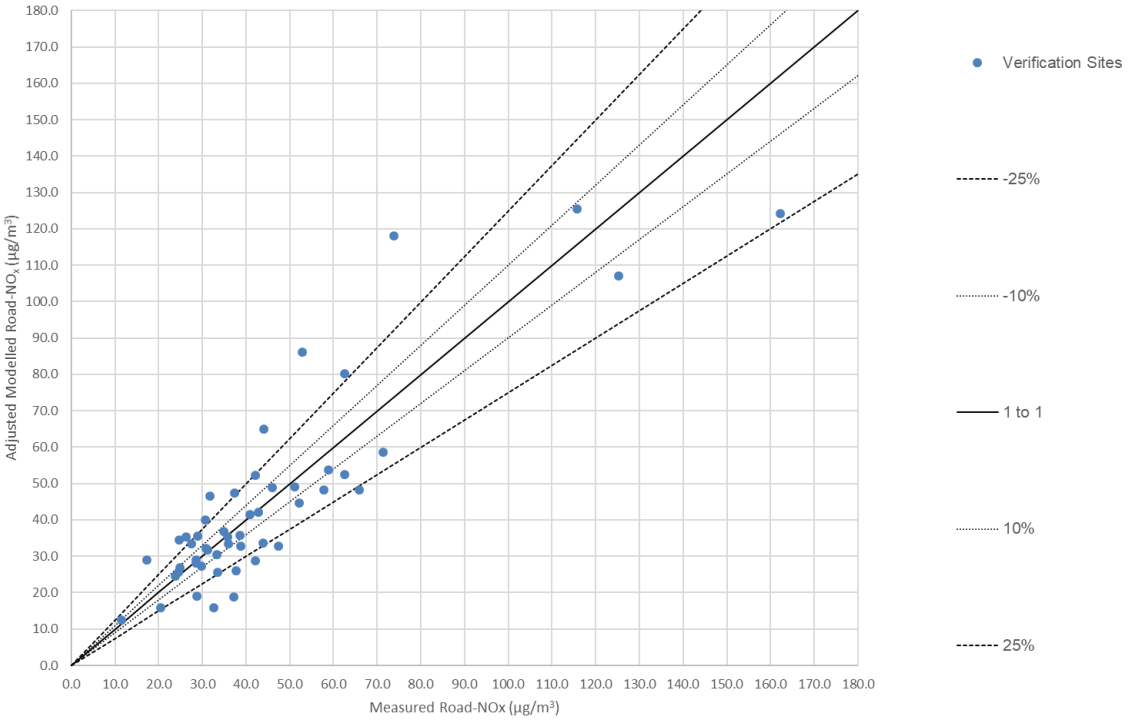
The results from the comparisons above have been used to derive the following model adjustment factors:

- the “Holyhead Road” factor of 2.80 was derived based on a linear regression of “monitored Road-NOx” vs. “modelled Road-NOx” at four monitoring locations on the southern side of Holyhead Road (HR1, HR1c. HR4 and HR6);

- the “M6” factor of 1.45 was derived based on the average of “monitored Road-NOx” vs “modelled Road-NOx” at two monitoring locations located on local roads below the adjacent elevated M6 (Grange2 and Grange3);
- the “Spon End” factor of 1.18 was derived based on the average of “monitored Road-NOx” vs “modelled Road-NOx” at two monitoring locations adjacent to Spon End to the south west of the inner ring road (SE1 and SE3);
- the “Stoney Stanton” factor of 2.81 was derived based on a linear regression of “monitored Road-NOx” vs. “modelled Road-NOx” at four monitoring locations adjacent to the Stoney Stanton Corridor to the north of the inner ring road (SS1, SS2, SS3 and SS5);
- the “Coventry-wide” factor of 2.15 was derived based on linear regression of “monitored Road-NOx” vs. “modelled Road-NOx” at the remaining 37 monitoring sites. Diffusion tube RR3 was excluded from the derivation of the factor as the model substantially overestimated NO_2 concentrations at this location.

A comparison of measured and modelled (adjusted) annual mean Road-NO_x concentrations is shown below in Figure B-3.

Figure B-3 – Measured Road-NO_x vs Modelled (Adjusted) Road-NO_x



Step 3

A comparison of the post-adjustment modelled estimates of total annual mean NO_2 with monitored concentrations is presented in Table B-4. The model statistics post-adjustment are presented in Table B-5. The majority of modelled concentrations (96%) are within 25% of monitored concentrations at monitoring sites, and therefore in line with the recommended value given in DEFRA’s Technical Guidance LAQM.TG(16). The overall RMSE is much improved, being well below the threshold value of 25% of the AQS objective (i.e. 10 µg/m³) and close to the ideal of being within 10% of the AQS objective (i.e. 4 µg/m³) and is therefore considered acceptable. The FB is much improved and quite small, although still slightly above the ideal value (0), indicating that the model tends to very slightly under predict.

Table B-4 – Comparison of Modelled and Measured NO_2 Concentrations (µg/m^3), Adjusted

Site Name	Background Annual Mean NO_2 (µg/m^3)	Monitored Annual Mean Total NO_2 (µg/m^3)	Adjusted Modelled Annual Mean Total NO_2 (µg/m^3)	Adjusted Modelled NO_2 Minus Monitored NO_2 (µg/m^3)	% Difference (adjusted modelled NO_2 - monitored NO_2) / monitored NO_2 * 100
BA1	18.7	33.8	34.3	0.5	2%
BA1c	15.0	25.2	23.0	-2.2	-9%
BELL1	17.7	38.2	33.8	-4.3	-11%
BELL2	17.7	35.2	26.9	-8.3	-24%
BH13	18.6	34.1	30.7	-3.4	-10%
BH14	18.6	37.5	32.0	-5.5	-15%
BH15i	18.6	**40.9**	**40.1**	-0.8	-2%
BH1a	20.7	37.6	**41.5**	3.9	11%
BH2a	18.6	**43.5**	**41.6**	-1.9	-4%
BH4	18.6	**45.3**	**41.6**	-3.7	-8%
BRN2	20.3	36.0	28.3	-7.7	-21%
BRN5	20.3	32.6	33.4	0.9	3%
CC01/1*N	22.1	36.8	**40.8**	4.0	11%
COAL	16.0	21.9	22.3	0.4	2%
COBR	19.6	33.4	36.3	2.9	9%
DH1	18.3	29.9	30.5	0.5	2%
FGS2	20.7	32.7	36.3	3.6	11%
FGS3a	20.7	33.8	34.0	0.2	1%
FS1	22.8	**45.9**	**42.6**	-3.3	-7%
GR1	19.6	33.5	29.0	-4.4	-13%
GS1	24.1	35.3	39.3	4.0	11%
LON12	19.6	**48.8**	**41.9**	-6.9	-14%
LR1	17.1	37.8	38.8	1.0	3%
LR2	17.1	37.2	**45.0**	7.9	21%
LR3	17.6	38.7	32.8	-5.9	-15%
QAV12	17.9	31.1	33.8	2.6	9%
QAV13	17.9	37.3	37.1	-0.2	-1%
QV1	24.1	38.7	44.6	5.9	15%
R5	21.5	**40.1**	**43.9**	3.8	9%
R6	21.5	**50.7**	**46.3**	-4.4	-9%
R8	20.3	37.3	32.4	-4.9	-13%
R9	19.6	36.9	34.4	-2.5	-7%

Site Name	Background Annual Mean NO_2 (µg/m^3)	Monitored Annual Mean Total NO_2 (µg/m^3)	Adjusted Modelled Annual Mean Total NO_2 (µg/m^3)	Adjusted Modelled NO_2 Minus Monitored NO_2 (µg/m^3)	% Difference (adjusted modelled NO_2 - monitored NO_2) / monitored NO_2 * 100
RR1	22.8	38.2	37.0	-1.2	-3%
RR2	22.8	**40.3**	39.1	-1.1	-3%
SHP2	16.8	28.6	29.0	0.4	1%
SHP3	16.8	34.0	32.9	-1.1	-3%
HR5	22.1	**67.3**	**70.3**	3.0	4%
HR1	22.1	**52.8**	**66.7**	14.0	26%
HR1c	22.1	**79.2**	**68.5**	-10.7	-13%
HR4	22.1	**49.7**	**56.1**	6.5	13%
HR6	22.1	**68.8**	**63.4**	-5.4	-8%
Grange2	18.1	36.5	36.7	0.2	0%
Grange3	18.1	34.4	34.3	-0.2	-1%
RR3	22.8	**46.7**	**59.2**	12.4	27%
SE1	22.1	35.4	35.2	-0.2	-1%
SE3	22.1	36.6	36.8	0.2	1%
SS1	19.9	34.3	33.1	-1.1	-3%
SS2	22.8	31.3	36.5	5.2	17%
SS3	19.6	36.1	36.9	0.8	2%
SS5	22.8	**45.8**	**42.9**	-2.9	-6%

Table B-5 – Model Statistics Post-Adjustment

RMSE [i]	FB [ii]	r [iii]
4.80	<0.01	0.896

Notes:

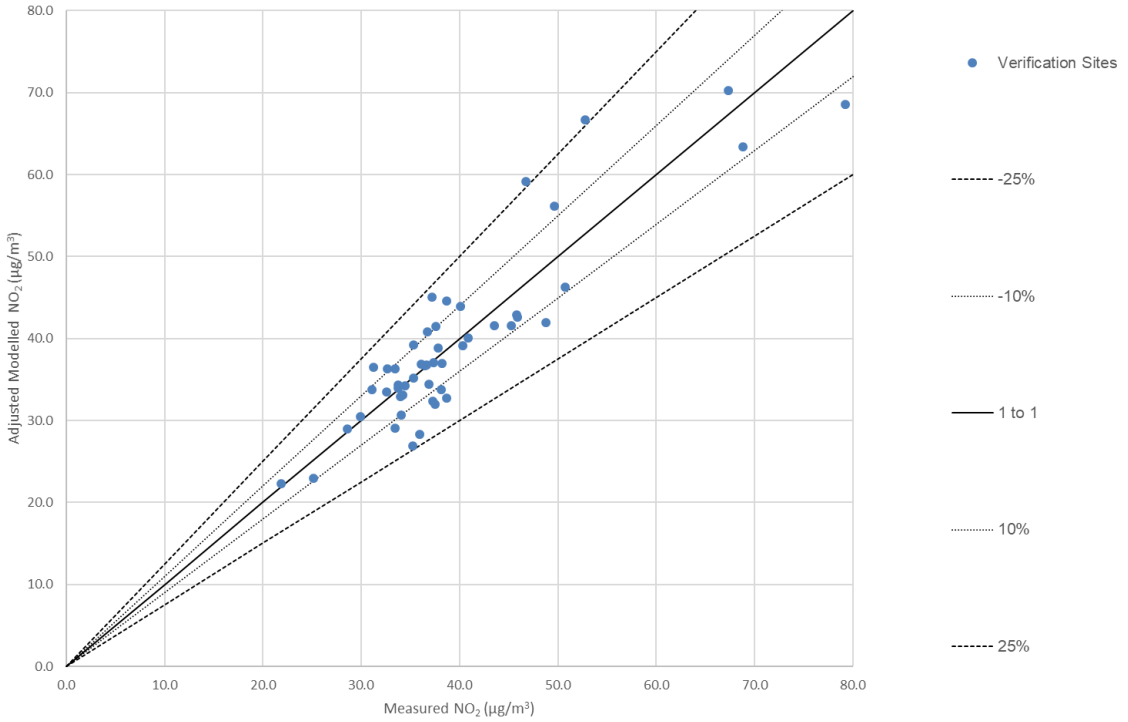
[i] Root Mean Square Error: RMSE is used to define the average error or uncertainty of the model (units = µg/m^3). In the case of modelled annual mean NO_2 a value of less than 10 is acceptable and less than 4 is the ideal

[ii] Fractional Bias: FB is used to identify if the model shows a systematic tendency to over or under estimate. Ideal value is 0

[iii] Correlation coefficient: r is used to measure the linear relationship between modelled and observed data. Ideal value is 1

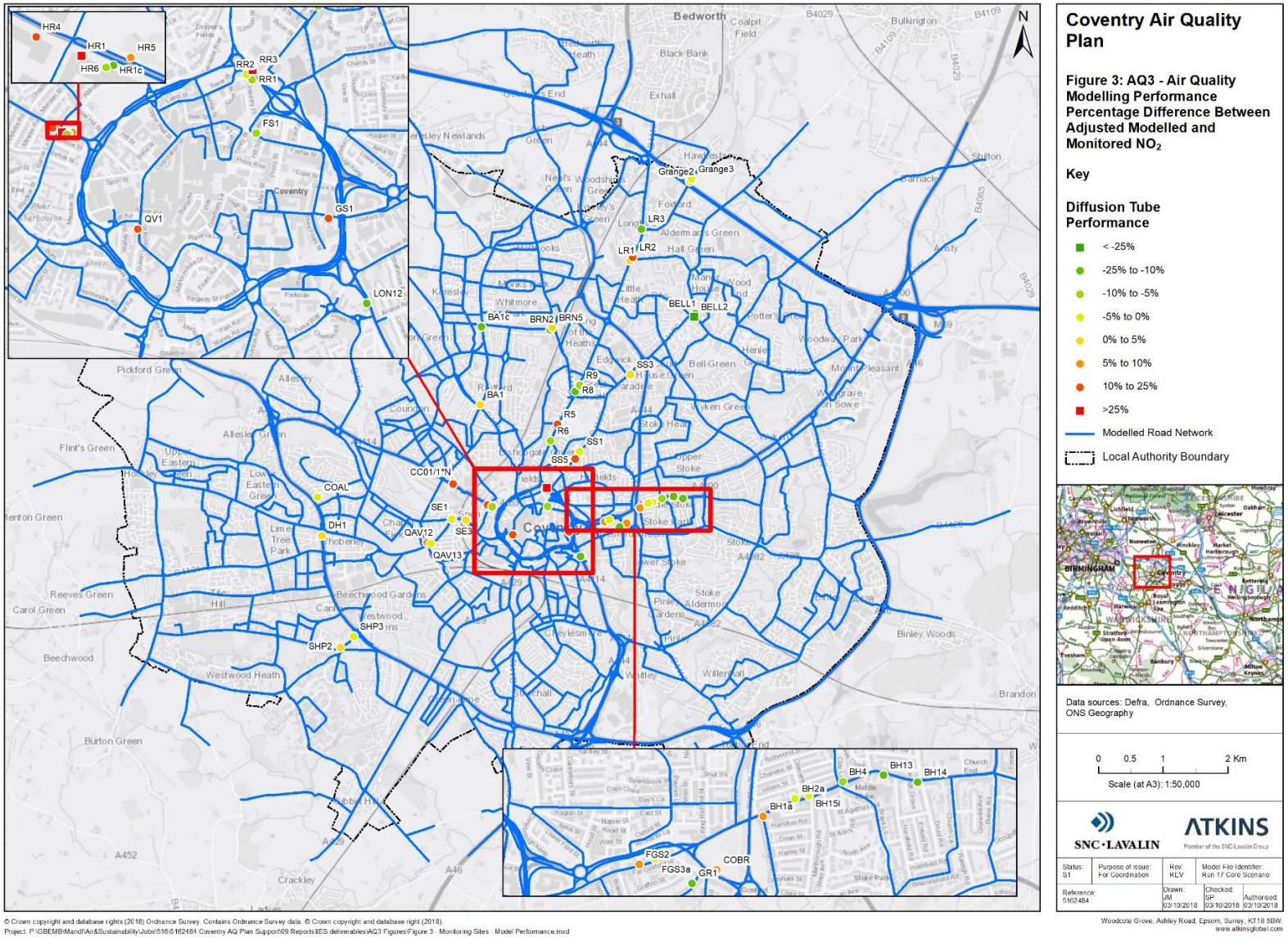
A comparison of measured and modelled (adjusted) annual mean NO_2 concentrations is shown below in Figure B-4.

Figure B-4 – Measured NO_2 vs Modelled (Adjusted) NO_2



The spatial variation in model performance between adjusted modelled NO_2 and monitored NO_2 is presented in Figure B-5.

Figure B-5 – Local Air Quality Model Performance



END