Appendix A14.1 – Air Quality (AWPR Northern Leg)

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14.1 Air Quality Monitoring Data and Methods

14.1.1 This section of the Appendix details the methods used to measure existing air pollution levels both for this current study and by the two Local Councils. The data cover an area greater than any of the subdivisions into which the ES has been structured. This is because all of these data are relevant in defining existing air quality across the area as a whole and thus within each of the scheme sections. All of the measurements used were the most recent data available at the time that this assessment was initially carried out.

14.1.2 Ambient concentrations of nitrogen dioxide were measured for 12 months at 17 monitoring sites using passive diffusion tubes. The locations were chosen to give the best possible indication of existing conditions both along the route of the proposed scheme and near to busy roads in Aberdeen. In terms of fulfilling this latter goal, the sites were chosen to supplement those at which Aberdeen City Council have monitored. Because rural background concentrations of nitrogen dioxide are more spatially uniform than concentrations in urban areas, it was not necessary to have a high density of monitors along the proposed route corridor in order to characterize existing levels. The monitors were supplied and analysed by Aberdeen City Council Laboratory of the Public Analyst. Measurements began in early June 2005 and tubes were replaced monthly until the end of May 2006. For the purposes of this assessment, this monitoring period has been taken to be equivalent to the 2005 calendar year (i.e. the results are assumed to represent 2005 without any adjustment). In addition to these 17 sites, a set of triplicate tubes was exposed alongside the UK Government's automatic monitor in Aberdeen Centre.

14.1.3 Defra and the DAs' Technical Guidance for air quality Review and Assessment (LAQM TG(03)) explains that nitrogen dioxide diffusion tubes may have a significant laboratory-related bias, but that this can be corrected by adjusting the results based on a co-location with an automatic monitor. Table 1 sets out the results from the co-located tubes, together with a measure of tube precision which is used by Defra and the DAs (Defra and the DAs 2006a). Overall, these tubes are shown to have good precision, with only two out of the twelve months giving triplicate values with a coefficient of variation greater than 20%. Table 2 sets out the annual mean of the triplicate tubes described in Table 1, alongside the mean of the automatic monitor. Data capture from the automatic monitor was "good" for each month according to the criteria used by Defra and the DAs (2006a). Table 2 also shows the adjustment factor which must be applied to all raw annual mean measured diffusion tube data in order to correct for laboratory bias.

14.1.4 Table 3 sets out the measured annual mean concentrations at each of the 17 diffusion tube sites run as part of this study. All of these data have been adjusted using the factor from Table 2. The data are also shown in Figure A14.1 (refer to main ES Figures). Specific residential addresses where the tubes were housed have not been presented for reasons of privacy. Most of these tubes were exposed either on the roadside façades of residential properties or in locations that are representative of residential exposure. A small number are marginally closer to the road than the nearest property. At one of the sites, the measured concentration was less than the limit of detection during many of the months and the annual mean is thus presented as $< 5\ \mu g/m^3$. This site represents a residential property north of the A93 between Miltimber and Bieldside. The property in question is in a very rural location - set more than 200m from the main road. In contrast, an exceedence of the Government's air quality objective was measured on the front of a residential property near to the junction of the A96 (Auchmill Road) and North Anderson Drive. Concentrations near to, but below, the annual mean objective were measured near to the A956 north of the City Centre (site 8); adjacent to the A956 south of the City Centre (site 16); adjacent to the A90, south of the Bridge of Dee (site 15); and at the junction of the A93 and Bailieswells Road at Bieldside. Concentrations well below the objective were measured both within and outwith the City, but the smallest concentrations were all measured outwith the City.

Table 1 - Raw Diffusion Tube Concentrations at the Aberdeen Centre AURN Site, Measured Between June 2005 and May 2006

	Tube 1 µg/m^3 NO_2	Tube 2 µg/m^3 NO_2	Tube 3 µg/m^3 NO_2	Triplicate Mean µg/m^3 NO_2	Coefficient of Variation	95% Confidence Level of mean	Tubes Precision Check
Month 1	19	21	23	21	10	5	Good
Month 2	16	17	19	17	9	4	Good
Month 3	15	17	18	17	9	4	Good
Month 4	29	19	28	25	22	14	Poor
Month 5	32	na	29	31	7	19	Good
Month 6	44	42	70	52	30	39	Poor
Month 7	37	38	37	37	2	1	Good
Month 8	36	40	46	41	12	13	Good
Month 9	41	42	40	41	2	2	Good
Month 10	21	21	20	21	3	1	Good
Month 11	24	19	22	22	12	6	Good
Month 12	17	19	19	18	6	3	Good
Whole Survey				**29**			**Good**

Table 2 - Calculation of Bias Adjustment Factor from the Aberdeen Centre AURN Co-location Study - June 2005 to May 2006

Annual Mean from Triplicate Diffusion Tubes (µg/m^3 NO_2)	Annual Mean from Co-located Automatic Monitor (µg/m^3 NO_2)	Adjustment Factor
29	26	0.92[a]

[a]Based on un-rounded numbers

14.1.5 Air quality measurements have also been made by the UK Government and by both Local Councils. As is mentioned above, the UK Government's Automatic Urban and Rural Network (AURN) of air quality monitoring sites includes a monitor at Aberdeen Centre (Errol Place) which measures concentrations of nitrogen dioxide; NOx (the sum of nitrogen dioxide and nitric oxide) and PM_{10}. Aberdeen City Council also measure both nitrogen dioxide and PM_{10} at three additional automatic monitoring sites: Union Street; Market Street; and Anderson Drive. At the time of writing, Aberdeen City Council were not confident in the reliability of their more recent automatic monitoring data and thus agreed that this assessment should use the results from the most recent year of reliable data; which was 2003. The year 2003 is known to be a worst-case year for air pollution nationally (Laxen and Marner, 2004) and so this approach is robust. Because the Anderson Drive monitor was not operational during 2003, only data from Union Street and Market Street have been used. The three automatic monitors that have provided data for this assessment are shown in Figure A14.2 (refer to main ES Figures). The results are set out in Table 4. The 2003 data have been adjusted to predict concentrations in 2005 using factors published by Defra and the DAs (2006a). The annual mean nitrogen dioxide concentration presented for Aberdeen Centre AURN differs from that in Table 3 because here the averaging period is a calendar year.

Table 3 – Annual Mean Measured Nitrogen Dioxide Concentrations at Seventeen Diffusion Tube Sites (June 2005 - May 2006) (µg/m^3). Objective Exceedences are Highlighted in Bold.

Site	X_COORD	Y_COORD	Data Capture (Months)	Annual Mean Nitrogen Dioxide Concentration
1	387430	814574	12	10
2	386618	811287	12	16
3	389514	809624	12	18
4	391292	809136	8[a]	**44**
5	393114	808389	12	22
6	395561	814247	12	26
7	396339	817320	12	14
8	394340	807368	12	34
9	392936	806225	10[a]	27
10	386006	806161	12	15
11	387230	803572	12	11
12	388164	802421	12	31
13	386030	801614	12	9
14	387193	802347	12	<5
15	393054	803447	12	30
16	394703	802999	12	32
17	392650	798079	12	22
Objective				**40**

[a] Due to vandalism, these monitors did not achieve a full 12-months of data capture. Of the eight months of measurements at Site 4, seven gave measurements greater than 40 µg/m^3.

14.1.6 The AURN site is in an urban background location and the relatively low measured concentrations reflect this. The other two automatic monitors are roadside sites within the City Council's Air Quality Management Area and it is thus unsurprising that the annual mean nitrogen dioxide objectives were exceeded during 2005. The annual mean PM_{10} concentration measured at the roadside site on Union Street is smaller than the concurrent concentration measured at the urban background AURN site which might indicate local non-road sources affecting the AURN data.

14.1.7 Aberdeen City Council has also measured nitrogen dioxide concentrations at numerous sites using passive diffusion tubes. This monitoring continued throughout 2004 but not during 2005. These tubes were supplied and analysed by Aberdeen City Council Laboratory of the Public Analyst. As is explained above, data from passive diffusion tubes should be adjusted based on co-location with an automatic monitor. Aberdeen City Council did not co-locate diffusion tubes with any of their automatic monitors during 2004. The most recent co-location studies that they ran ended in 2003. These gave adjustment factors of: 0.97 (Union Street - based on 5 exposure periods); 0.95 (Market Street - based on 6 exposure periods); 0.93 (AURN station - based on 9 tube exposure periods). Previous years gave 12 full exposure periods and gave much higher factors. Guidance from Defra and the DAs (2006a, 2006b) is that bias adjustment factors can change from one year to the next. It is important to note that Aberdeen City Council's diffusion tubes were prepared and analysed in the same way as those used specifically for this study. It is also important to note the close similarity between the factors from 2003 provided by Aberdeen City

Council and the factor for 2005/2006 presented in Table 2. It is considered that the best approach is to adjust Aberdeen City Council's diffusion tube data using the factor from Table 2. Table 5 sets out the 2004 annual mean measurements both before and after adjustment. The Table also shows the projected value for 2005, calculated using the factors published by Defra and the DAs (2006a).

Table 4 – Measured and Projected Nitrogen Dioxide and PM_{10} Concentrations at Three Automatic Monitoring Stations. Data for 2003 are shown as this is the most recent year of reliable measurements provided by Aberdeen City Council.

Site	Annual Mean Nitrogen Dioxide Concentration ($\mu g/m^3$)		Annual Mean NOx Concentration ($\mu g/m^3$ - as NO^2)		Annual Mean PM_{10} Concentration ($\mu g/m^3$)		Number of Exceedences of 50 $\mu g/m^3$ as a 24-hour PM_{10} Concentration	
	2003	2005	2003	2005	2003	2005	2003	2005
Aberdeen Centre AURN	31	24	53	41	22	19	14	4
Market Street	56	48[a]	144	135[a]	na	-	na	-
Union Street	50	44[a]	135	127[a]	20	19[a]	17	2[b]

[a] Adjusted using the future-year projection factors published by Defra and the DAs (2006a).
[b] Estimated based on the relationship with the annual mean as set out in Defra and the DAs (2003).

14.1.8 Most of the diffusion tube measurements (adjusted to 2005) are also presented in Figure A14.3 (refer to main ES Figures). Aberdeen City Council were unable to supply accurate grid references for their diffusion tube monitors. They did, however, supply descriptions of each location. A visit was thus made to each monitoring site in order to ascertain its precise position (grid references accurate to <1m are required in order to verify the dispersion model). While this approach allowed the locations of most of the monitors to be accurately identified; some monitors could not be found and thus sufficiently accurate coordinates could not be assigned. These are highlighted in Table 5 and are not shown in Figure A14.3 (refer to main ES Figures).

Table 5 – Annual Mean Nitrogen Dioxide Concentrations Measured using Diffusion Tubes Operated by Aberdeen City Council. Data for 2004 are shown as this is the most recent year of reliable measurements provided by Aberdeen City Council (µg/m^3). Objective Exceedences are Highlighted in Bold.

Site Name	Site No	Site Type	2004 Unadjusted	2004 Adjusted for Bias[a]	2005[b]
Bucksburn Primary Sch, Inverurie Rd	2	roadside	36	33	32
885 Gt Northern Road	3	roadside	51	47	**46**
549 North Anderson Dr	4	roadside	38	35	34
38 Ellon Road	5	roadside	40	37	36
St Marys Church King St	6	na[c]	47	43	na[c]
86 Victoria Road Torry	8	roadside	41	38	37
Wellington Rd/ Kerloch Pl	9	roadside	48	44	**43**
107 Anderson Drive	10	roadside	55	51	**49**
481 Gt Western Rd (RSMcColl)	11	roadside	36	33	32
Lang Stracht/ Westray Rd	12	roadside	23	21	21
31 Market St	14	roadside	53	49	**47**
184/192 Market St	15	roadside	77	71	**69**
105 King Street	16	roadside	73	67	**65**
40 Union St	17	roadside	62	57	**55**
Music Hall Union St	18	roadside	53	49	**47**
Dyce Primary, Gordon Terr	20	background	15	14	14
Collie Sports Centre, Scotstown Rd	21	na[c]	17	16	na[c]
Northfield swimming pool, Kettleshill Cres	23	background	19	17	17
Day Nursery ARI	24	na[c]	20	18	na[c]
St Nicholas Square	28	na[c]	51	47	na[c]
Guild St/ Market Street	34	roadside	57	52	**51**
43/45 Union St (Poundstretcher)	35	roadside	56	51	**50**
14 Holburn St (Polo Club)	36	roadside	58	53	**52**
468 Union St (Shish Mahal)	37	roadside	60	55	**54**
215 King Street (Safeways)	38	roadside	42	39	38
26 King Street	39	roadside	49	45	**44**
104 King St (Gala Bingo)	40	roadside	52	48	**46**
Gt Northern Road	41	na[c]	42	39	na[c]
40 Auchmill Road	42	roadside	46	42	**41**
21 Holburn St (Kings Fabrics)	43	roadside	53	49	**47**
147 Holburn Street	44	roadside	37	34	33
82 Holburn St (Malt Mill)	45	roadside	52	48	**46**
61 Holburn Street	46	roadside	47	43	**42**
469 Union Street	47	roadside	65	60	**58**

Site Name	Site No	Site Type	2004 Unadjusted	2004 Adjusted for Bias[a]	2005[b]
209 Union St (British Airways)	48	na[c]	56	51	na[c]
249 Holburn Street	49	roadside	42	39	38
Objective	**-**	**-**	**-**	**-**	**40**

[a] Using a factor of 0.92

[b] Predicted using the factors published by Defra and the DAs (2006a)

[c] It was not possible to ascertain the precise location (i.e. to within 1m) of this monitor. As this information is needed in order to verify the dispersion model; the site has not been included further.

14.1.9 Aberdeen City Council's diffusion tube results show that very many exceedences of the annual mean nitrogen dioxide objective were expected during 2005 (based on monitoring carried out during 2004). Exceedences were expected both within and outwith the Council's Air Quality Management Area. All of the objective exceedences are next to heavily-trafficked roads. Away from busy roads, measured concentrations are well below the objectives.

14.1.10 Nitrogen dioxide concentrations have also been measured by Aberdeenshire Council during 2005 using passive diffusion tubes. Aberdeenshire Council do not run their own co-location study and thus rely on data from Aberdeen City Council in order to adjust their data for bias. Thus, it is considered most appropriate to use the bias adjustment factor set out in Table 2 to adjust the Aberdeenshire Council diffusion tube data. These results are set out in Table 6 and in Figure A14.4 (refer to main ES Figures). All of the annual mean measurements are well below the level of the objective; even at those sites which are close to busy roads through the towns.

Table 6 – Annual Mean Nitrogen Dioxide Concentrations Measured using Diffusion Tubes Operated by Aberdeenshire Council (ug/m^3).

site name	Raw Measured 2005 Annual Mean	2005 Annual Mean Adjusted for Bias
Inverurie 1	29	26
Inverurie 2	11	10
Inverurie 3	12	11
Inverurie 4	11	10
Mintlaw 1	16	15
Peterhead 1	25	23
Peterhead 2	26	23
Peterhead 3	23	21
Peterhead 4	22	21
Stonehaven 1	22	21
Stonehaven 2	11	10
Stonehaven 3	10	9
Westhill 1	12	11
Westhill 2	16	15
Objective	**40**	**40**

14.2 Adjustment of Background Concentrations

14.2.1 Every run of the detailed dispersion model has explicitly included every link in the traffic model that is within 10km of the proposed scheme. Non-road sources have been accounted for by augmenting the explicitly-modelled concentrations with estimated background concentrations, which are published for each 1km x 1km square of the UK by Defra and the DAs (2006a). The revised versions of these maps, published in late January 2006, were used. These background concentrations include all principal emission sources, including road traffic and it would clearly be inappropriate to include road transport sources twice. In order to remove this potential double counting the following approach has been adopted for both NOx and PM_{10}:

1) The background concentration maps and also the background emissions maps covering the entire study area were obtained from Defra and the DAs (2006a and 2007c). Both of these maps refer to a base year of 2004.

2) Each map presents data averaged across a 1 km x 1 km grid. For each 1 km grid of the concentration map, the respective square, and eight adjoining squares from the emissions map were identified.

3) For each aggregated set of nine squares from the emissions map, the proportion of road emissions to total emissions was calculated.

4) The minimum background concentration (excluding blanks) in any grid square within 50km of the proposed scheme was identified and subtracted from the background concentration in each other grid square. This represents the "rural" contribution, which is assumed to be constant across the region.

5) The remaining background concentration in each grid square was reduced by the proportion identified in (3) above.

6) The rural contribution identified in (4) above was added back on to each adjusted background concentration.

7) This procedure is summarised in Equation A14.1. Where C_{adj} is the adjusted background concentration in any given grid square; C_{raw} is the raw mapped background concentration in that square; C_{rur} is the minimum background concentration in any square; E_{road} is the combined emissions from roads in the 3km x 3km square surrounding the C_{raw} square; and E_{tot} is the combined total emissions from this 3km x 3km square.

$$\text{Equation A14.1: } C_{adj} = (C_{raw} - C_{rur}) \times (E_{road} / E_{tot}) + C_{rur}$$

14.2.2 It is not appropriate (or possible) to apply this adjustment to nitrogen dioxide concentrations. Instead, the adjustment has focused on NOx concentrations. Background nitrogen dioxide concentrations have been derived from the background NOx concentrations using the same relationship that is used in producing the background concentration maps (as described in Stedman et al., 2005a with revisions set out in Stedman et al., 2005b and advised by Stedman pers comm.). This is summarized below.

If NOx > 17.19 $\mu g/m^3$:

[NO2] = (0.093[NOx] + B).f(NOx)

Where B is the oxidant concentration (taken to be 35.0 in 2005 and 36.1 in 2010) and the equation used for f(NOx) characterises those locations not directly influenced by roads:

$f(NOx) = (1.015 \times 10\text{-}1) + (1.367 \times 10\text{-}2\ [NOx]) - (6.127 \times 10\text{-}5\ [NOx]^2) - (4.464 \times 10\text{-}8\ [NOx]^3)$

If NOx < =17.19 $\mu g/m^3$:

$[NO2] = [NOx] \times 0.7835$

14.2.3 Background concentrations in 2011 were then calculated from the predicted 2010 background data using factors published by Defra and the DAs (2006a).

14.3 Dispersion Model Input Data

14.3.1 As is noted in the main text of the ES, meteorological data came from Dyce Airport. Traffic data came from MVA. MVA supplied both peak-hour and Annual Average Daily Traffic flow (AADT) data. The dispersion model uses peak-hour flows but it was thought inappropriate to use the peak-hour traffic data directly. This is because a separate diurnal profile was not available for each road on the network. Since only long-term (24-hour or more) average pollutant concentrations are of concern to this assessment, the total flow of vehicles during a day is more relevant than the peak-hour flow. The average diurnal profile in traffic flow was taken as the average of eight long-term traffic counts conducted in Aberdeen. This, together with the modelled AADT flows was used to calculate a pseudo-peak flow. The dispersion model subsequently uses the pseudo-peak flow to calculate the total daily flow which, following this method, must always equal the AADT.

14.3.2 The data provided by MVA include buses in the AADT figures but not in the percentage Heavy Duty Vehicle (HGV) data. This assessment has assumed that emissions from buses are equal to emissions from HGVs. Thus, percentage HGV data have been recalculated incorporating modelled bus flows supplied by MVA.

Horizontal Road Alignments

14.3.3 The horizontal position of each road in the traffic model and within 10km of the proposed scheme has been provided by MVA. The road alignment describes continuous curves as a series of straight sections. In order to achieve reasonable model run times, the network has been generalized to a tolerance of 1m (this means that as many vertices as possible have been removed from the road alignment without causing any section of road to move by 1m or more). Roads which would not move as a result of the proposed scheme have been given exactly the same alignment with and without the proposed road in place.

Vertical Road Alignments

14.3.4 Some sections of both the existing and proposed road network are either elevated or depressed. The assessment has thus explicitly included the most significant bridges / cuttings etc. These have been identified based on: first-hand observation; aerial photographs; contour maps; and other maps. For the proposed scheme itself, the most significant elevations and cuttings have been assigned based on information provided by the engineering team. Junction heights have not been included and so junctions are assumed not to be elevated. This will tend to over-predict the air quality impacts of elevated junctions and thus provide a worst-case approach.

Vehicle Speeds

14.3.5 MVA supplied 2 different annual average speeds, one with and one without junction delay. Air pollution emissions tend to be greatest near to junctions, where vehicles are speeding up and slowing down. It is thus desirable to assign different speeds along some sections of the same road; one speed near to junctions and another on open roads. The procedure outlined below has been applied to all speeds used in the dispersion modelling of local air pollutants. For the calculation of total emissions and greenhouse gases, the with junction delay speeds from MVA have been used.

14.3.6 An analysis of maps and aerial photographs, as well as reliance on first-hand observation, was used to identify which sections of road would be likely to be slowed by their proximity to a junction. As a general rule, the section of each road within 50m of a junction was separated from the dataset. The road network was thus assigned into "slow" and "fast" sections.

14.3.7 Any specific link from the traffic model that has not been assigned a "slow" section at all is assumed to have an annual average speed equal to the modelled speed with junction delay.

14.3.8 For those links from the traffic model that are split into slow and "fast" sections, the "fast" section is assumed to have an annual average speed equal to the modelled speed without junction delay.

14.3.9 The annual average speed within each "slow" section has been calculated thus:

1) The length of each link was subdivided into the section within a "slow" length, and the section within a "fast" length.

2) The time for a vehicle to pass the total length of the link at the with junction delay speed was calculated (T_{total}).

3) The length of time for a vehicle to pass through the "fast" section of road at the without junction delay speed was also calculated (T_{fast}).

4) T_{total} - T_{fast} gives the total time remaining for a vehicle to cross the slow section ($T_{remaining}$).

5) The speed for the "slow" section is thus calculated by dividing the "slow" link length by $T_{remaining}$.

14.3.10 Thus, the average speed along the whole length of each link remains equal to the with junction delay speed provided by MVA, all that is added is a variation in speed along that length.

14.3.11 In order to provide the best possible estimate of speed-specific emissions, a final step has been to adjust all calculated speeds that are less than 5kph up to 5kph (below which the emission factors become unrealistic).

14.3.12 Speeds around roundabouts have been estimated by MVA (at 20kph) and these have not been adjusted.

Emission Factors

14.3.13 Emissions have been predicted using the emission factors that are set out in the DMRB v11.3. Aberdeen City Council have, in their own assessments (ACC, 2005), included

different assumptions about vehicle fleet composition than the national average data that are included in the DMRB. This detail is not expected to have a significant effect on the conclusions of this assessment and the methodology used here is considered to be robust.

14.4 Model Verification – Nitrogen Dioxide

14.4.1 The algorithms on which the AAQuIRE dispersion model is based have undergone extensive international validation. This validation has not, however, been performed for this specific geographical area and these specific input data. It is thus important to verify the model results by comparing them with local measurements. By adjusting the model to agree closely with the measured data, uncertainties can be minimised.

14.4.2 Most nitrogen dioxide (NO_2) is produced in the atmosphere by reaction of NOx with ozone. It is therefore most appropriate to verify the model in terms of primary pollutant emissions. The model has been run to predict annual mean concentrations of NOx during 2005 at the three automatic monitoring sites described above.

14.4.3 The raw model outputs of road-NOx (i.e. the component of total NOx coming from road traffic) have been compared with the measured road-NOx, the latter derived by subtracting the estimated background NOx concentrations from the total measured NOx. The result of this comparison is shown in Figure A14.5. The data appear to underestimate NOx emissions from local roads. This effect is very common with the AAQuIRE model and can be corrected for. Figure A14.5 also shows the ordinary least squares regression best fit line, forced through zero, and its mathematical relationship. In order to account for the initial under-prediction of NOx concentrations, **all raw NOx outputs have been multiplied by 5.568** (i.e. 1/0.1796).

14.4.4 Next, the model was run to predict NOx concentrations at each of the diffusion tube sites described in Tables 14.1.2 and 14.1.4. The diffusion tube sites operated by Aberdeenshire Council have not been used to verify the model because baseline flows on roads remote from Aberdeen are known with less certainty than those on roads within Aberdeen. All of the predicted NOx concentrations were adjusted as described above, before the predicted background NOx concentration was added. Road-NO_2 concentrations (i.e. the component of total NO_2 coming from road traffic) were calculated following the relationship for post-2003 data outwith London as set out in Laxen et al. (2007), as advised by Defra and the DAs (2007a and 2007b):

$$\text{road-NO}_2 = -0.0719 \times \text{LN total-NOx} + 0.62483 \times \text{road-NOx}$$

14.4.5 Total-NO_2 concentrations were then derived by summing the road-NO_2 with the predicted background NO_2 at each monitoring site. Figure A14.6 shows how these predicted NO_2 concentrations compare with the relevant measured data. The fit is improved, but the model still appears to under-predict total NO_2 concentrations. As above, Figure A14.6 also shows the ordinary least squares regression best fit line, forced through zero, and its mathematical relationship. In order to account for the initial under-prediction of total NO_2 concentrations, **all predicted total NO_2 concentrations have been multiplied by 1.1016** (i.e. 1/0.9078).

14.4.6 Figure A14.7 sets out the measured versus predicted total NO_2 concentrations following this second adjustment. There is still some scatter but no bias and the fit is reasonably good. It is also worth noting that those data that are known with most certainty - i.e. the automatic measurements and the diffusion tube measurements made as part of this current study tend to be over-predicted by the model. Most data that the model has under-predicted are diffusion tube data from 2004 which have been adjusted using national factors. The modelled versus measured annual mean nitrogen dioxide concentrations are also set out in Table 7.

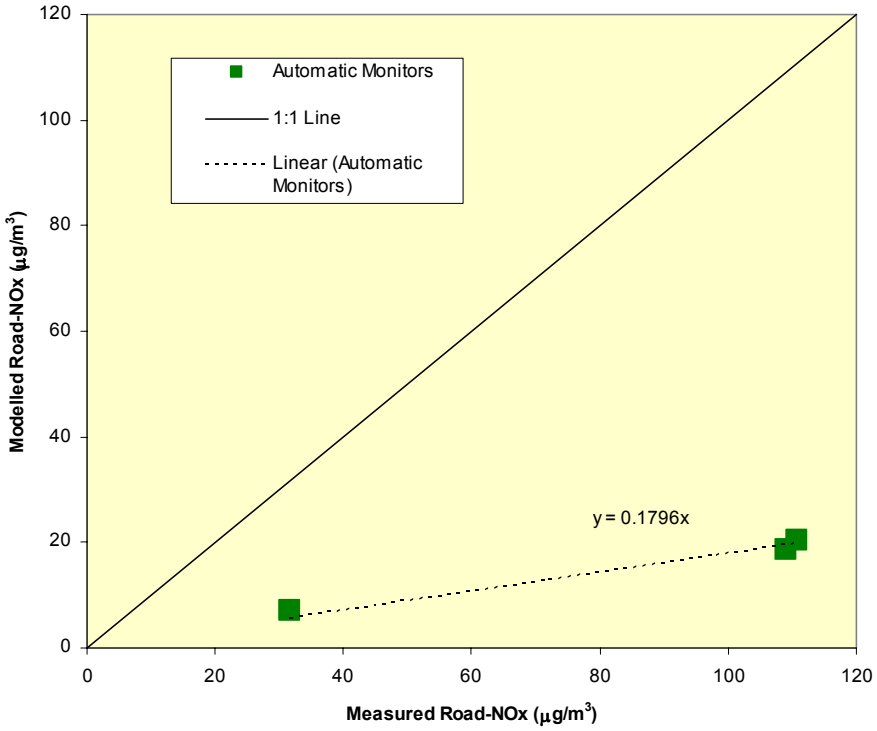

Figure A14.6 Comparison of Modelled vs Measured Annual Mean Road-NOx Concentrations at the Three Automatic Monitoring Sites in 2005.

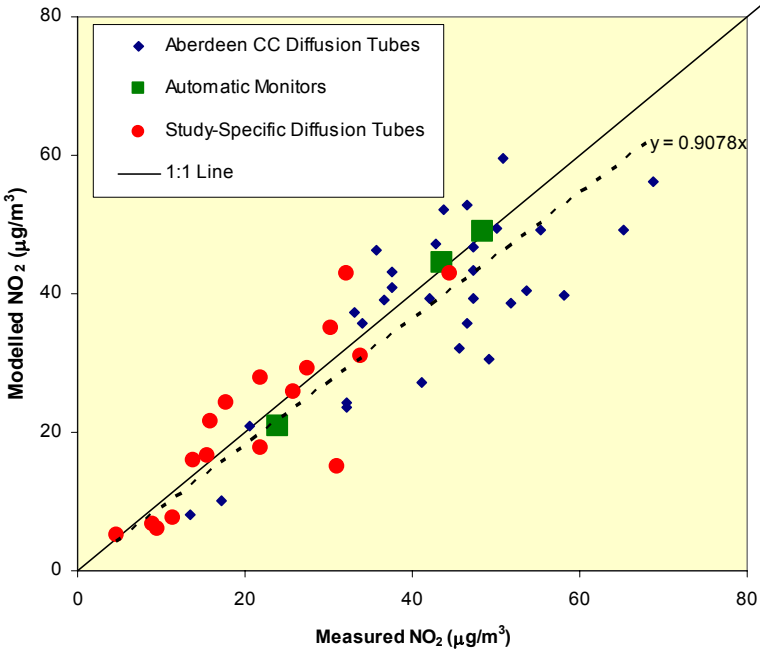

Figure A14.6 Comparison of Modelled vs Measured Annual Mean Nitrogen Dioxide Concentrations in 2005.

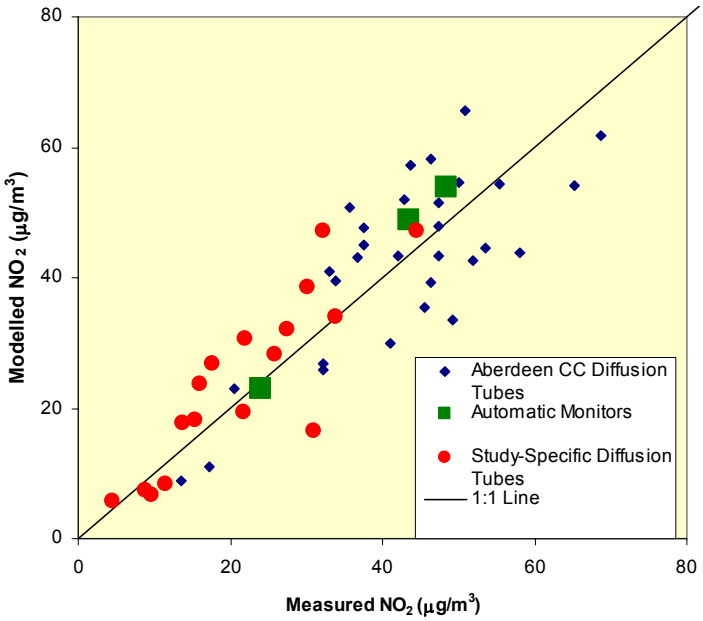

Figure A14.7 Comparison of Modelled vs Measured Annual Mean Nitrogen Dioxide Concentrations in 2005 Following a Secondary Model Adjustment

Table 7 – Comparison of Modelled vs Measured Annual Mean Nitrogen Dioxide Concentrations in 2005 (µg/m^3).

Data Source	Site Code	Measured	Predicted
Automatic Monitors	AURN	24	23
Automatic Monitors	Union St	44	49
Automatic Monitors	Market St	48	54
Study-Specific Diffusion Tube	1	10	7
Study-Specific Diffusion Tube	2	16	24
Study-Specific Diffusion Tube	3	18	27
Study-Specific Diffusion Tube	4	44	47
Study-Specific Diffusion Tube	5	22	19
Study-Specific Diffusion Tube	6	26	28
Study-Specific Diffusion Tube	7	14	18
Study-Specific Diffusion Tube	8	34	34
Study-Specific Diffusion Tube	9	27	32
Study-Specific Diffusion Tube	10	15	18
Study-Specific Diffusion Tube	11	11	8
Study-Specific Diffusion Tube	12	31	17
Study-Specific Diffusion Tube	13	9	7
Study-Specific Diffusion Tube	14	5	6
Study-Specific Diffusion Tube	15	30	39
Study-Specific Diffusion Tube	16	32	47
Study-Specific Diffusion Tube	17	22	31
Aberdeen CC Diffusion Tube	2	32	27
Aberdeen CC Diffusion Tube	3	46	35
Aberdeen CC Diffusion Tube	4	34	39
Aberdeen CC Diffusion Tube	10	49	34
Aberdeen CC Diffusion Tube	11	32	26
Aberdeen CC Diffusion Tube	12	21	23
Aberdeen CC Diffusion Tube	23	17	11
Aberdeen CC Diffusion Tube	42	41	30
Aberdeen CC Diffusion Tube	14	47	51
Aberdeen CC Diffusion Tube	17	55	54
Aberdeen CC Diffusion Tube	39	44	57
Aberdeen CC Diffusion Tube	40	46	58
Aberdeen CC Diffusion Tube	16	65	54
Aberdeen CC Diffusion Tube	38	38	45
Aberdeen CC Diffusion Tube	18	47	43
Aberdeen CC Diffusion Tube	37	54	44
Aberdeen CC Diffusion Tube	47	58	44
Aberdeen CC Diffusion Tube	36	52	43
Aberdeen CC Diffusion Tube	43	47	48
Aberdeen CC Diffusion Tube	45	46	39
Aberdeen CC Diffusion Tube	44	33	41
Aberdeen CC Diffusion Tube	5	36	51
Aberdeen CC Diffusion Tube	8	37	43
Aberdeen CC Diffusion Tube	9	43	52
Aberdeen CC Diffusion Tube	15	69	62
Aberdeen CC Diffusion Tube	20	14	9
Aberdeen CC Diffusion Tube	34	51	66
Aberdeen CC Diffusion Tube	35	50	55
Aberdeen CC Diffusion Tube	46	42	43
Aberdeen CC Diffusion Tube	49	38	48

14.5 Model Verification – PM_{10}

14.5.1 As with nitrogen dioxide, the AAQuIRE dispersion model has undergone extensive validation regarding its ability to accurately predict ambient PM_{10} concentrations. This validation has not, however, been performed for this specific geographical area and these specific input data. It is thus important to verify the model results by comparing them with local measurements. By adjusting the model to agree closely with the measured data, any uncertainties inherent in the model can be minimised.

14.5.2 The model was initially run to predict road-PM_{10} concentrations (i.e. the component of total PM_{10} coming from road traffic) at both of the automatic monitoring sites for which data are available. Figure A14.8 compares the measured versus modelled road-PM_{10} concentrations. Also shown is the ordinary least squares regression best fit line, forced through zero, and its mathematical relationship. The model clearly under-predicts road-PM_{10} concentrations. In order to account for this, **all raw PM_{10} outputs have been multiplied by 5.066 (i.e. 1/0.1974)**. The close similarity of this factor to the NOx adjustment factor described above inspires confidence in the results.

14.5.3 Following this adjustment, the total PM_{10} concentration at each of the monitoring sites was predicted by summing the adjusted modelled road-PM_{10} concentration with the predicted background PM_{10} concentration. Figure A14.9 and Table 8 show the result of this comparison. The fit is not perfect, but this is likely to be because both sites measured very similar concentrations. The adjusted model appears to perform reasonably well.

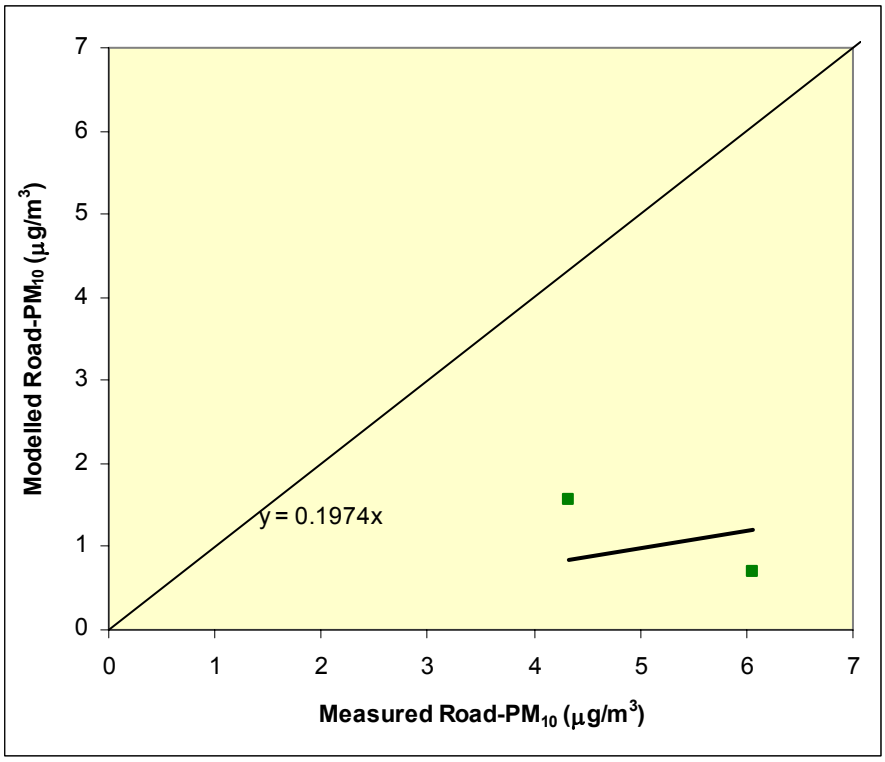

Figure A14.8 Comparison of Modelled vs Measured Annual Mean Road-PM_{10} Concentrations in 2005 at Two Automatic Monitoring Stations.

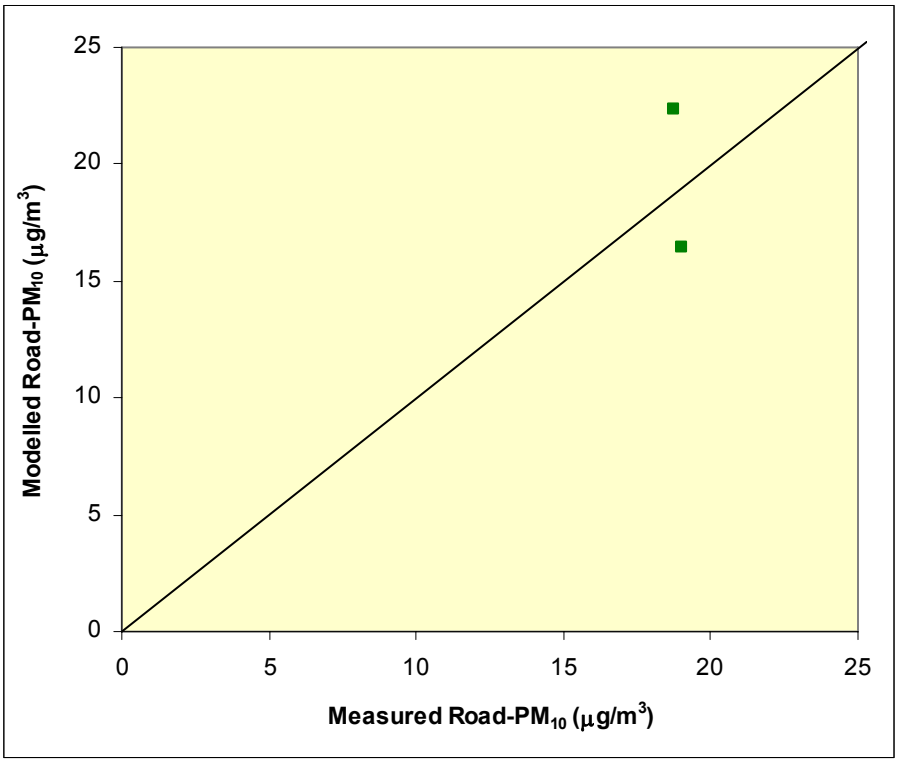

Figure A14.9 Comparison of Adjusted-Modelled vs Measured Annual Mean Total PM_{10} Concentrations in 2005 at Two Automatic Monitoring Stations.

Table 8 – Comparison of Adjusted-Modelled vs Measured Annual Mean PM_{10} Concentrations in 2005 at Two Automatic Monitoring Stations (µg/m^3).

Site	Measured	Predicted
AURN	19	16
Union St	19	22

14.5.4 Since there is no reliable way to predict the diurnal variation in background PM_{10} concentrations in Scotland, the number of exceedences of 50 µg/m^3 as a 24-hour mean PM_{10} concentration has been calculated from the adjusted-modelled total annual mean concentration following the relationship advised by Defra and the DAs (2003b):

$$A = -18.5 + 0.00145\ B^3 + 206/B$$

where A is the number of exceedences of 50 µg/m^3 as a 24-hour mean PM_{10} concentration and B is the annual mean PM_{10} concentration. The relationship is only applied to annual mean concentrations greater than 16.5 µg/m^3, below this concentration, the number of 24-hour exceedences is assumed to be zero.

14.6 NOx Concentrations at Organic Farms

14.6.1 As has been explained in Chapter 14, there is no requirement in the DMRB to assess impacts of air quality on farming activities. Furthermore, there is no reason for air quality impacts to contravene the organic status of any farmland (See Chapter 7: Land Use). It is, however, recognised that land-owners might be concerned about the potential for traffic-related air pollution to affect farmland. Since there is no set methodology for assessing the potential for such impacts, a pragmatic approach has been taken of treating all organic farmland within the Northern Leg corridor as if it were a SSSI, SAC, SPA or Ramsar site. This provides a working method for assessing air quality impacts on particularly sensitive vegetation. It is, however, recognised that the pollutants that might be relevant to a SSSI might be different from those that are relevant for organic farming. The effects of nitrogen enrichment to farmland have thus not been assessed; since they are not considered to be relevant in this context. The assessment focuses on NOx concentrations. NOx is generally used as the key indicator of traffic pollution, and thus assessing NOx impacts provides a clear indication of traffic pollution levels in general.

14.6.2 NOx concentrations for the base year (2005) and the year of opening, both with and without the proposed scheme, were calculated using unadjusted background concentration maps (Defra and the DAs 2006a) and using the DMRB Screening Model which is recommended in IAN 61/05. For the purposes of the IAN 61/05 method, the DMRB model is sufficiently robust, and it is not necessary to use the AAQuIRE model. The method set out in IAN 61/05 is to assess points along a transect at increasing distances from the centre of each road that might affect each site. Results are thus presented for each road and each site separately. Concentrations are predicted at the edge of each site that is closest to each road, and then along a 50m transect of increasing distances from the centre of the road. In addition, where any predicted concentrations exceed the critical level, an additional distance has been added to the transect, reflecting the shortest distance at which the critical level would not be exceeded.

14.6.3 There are farms with organic farming areas within the Northern Leg corridor. These are the campus of the Scottish Agricultural College and Walton Farm. NOx concentrations are presented in Table 9, and show that the proposed scheme would cause increased NOx concentrations near to some roads, and reduced NOx concentrations near to others. The critical level is likely to have been exceeded during 2005 adjacent to the A96 and to Dyce Drive. The results show that the critical level will not be exceeded by 2011 with or without the proposed scheme. Traffic pollution levels are thus expected to remain relatively low, even very close to roads. Away from roads (i.e. >100m from the centreline), concentrations will remain exceptionally low in a national context.

Table 9 – Predicted NOx Concentrations at Organic Farmland within the Northern Leg Corridor

Site	Road	Distance from Road Centre (m)	Annual Mean NOx (µg/m^3)		
			2005	2011 Without Scheme	2011 With Scheme
Scottish Agricultural College	existing road running south of A96 at Chapel of Stoneywood	3	9	8	5
		50	7	6	5
		100	7	5	5
		150	6	5	5
		200	6	5	5
	AWPR	30	9	7	23
		50	9	7	17
		100	9	7	10
		150	9	7	8
		200	9	7	7
	A96	15	**34**	27	25
		21	30	24	23
		50	19	15	14
		100	12	9	9
		150	10	8	8
		200	9	7	7
	Dyce Drive	10	**36**	22	22
		22	30	18	18
		50	21	14	14
		100	15	11	11
		150	13	10	10
		200	12	10	10
	AWPR to A96 link road at Craibstone	17	9	7	21
		50	9	7	13
		100	9	7	9
		150	9	7	7
		200	9	7	7
	road from Craibstone junction to Dyce	18	12	21	20
		50	12	15	14
		100	12	11	11
		150	12	10	10
		200	12	10	10
Walton Farm	AWPR	20	8	6	22
		50	8	6	14
		100	8	6	8
		150	8	6	7
		200	8	6	7
	A96	15	**33**	24	26
		20	30	22	24
		50	18	14	14
		100	11	8	9
		150	9	7	7
		200	8	7	7

Site	Road	Distance from Road Centre (m)	Annual Mean NOx (µg/m^3)		
			2005	2011 Without Scheme	2011 With Scheme
	road from Craibstone junction to Dyce	18	12	23	22
		50	12	16	15
		100	12	11	11
		150	12	10	10
		200	12	10	10
	Dyce Drive	18	25	22	20
		50	18	15	14
		100	14	11	11
		150	13	10	10
		200	12	10	10
	road from A96 at Chapel of Stoneywood to Dyce Drive	6	16	6	6
		50	10	6	6
		100	9	6	6
		150	8	6	6
		200	8	6	6
Critical Level			**30**	**30**	**30**