PORT OF
TILBURY
LONDON

PLANNING ACT 2008
INFRASTRUCTURE PLANNING
(APPLICATIONS: PRESCRIBED FORMS AND PROCEDURE) REGULATIONS 2009
REGULATION 5 (2) (a)

PROPOSED PORT TERMINAL AT FORMER TILBURY POWER STATION

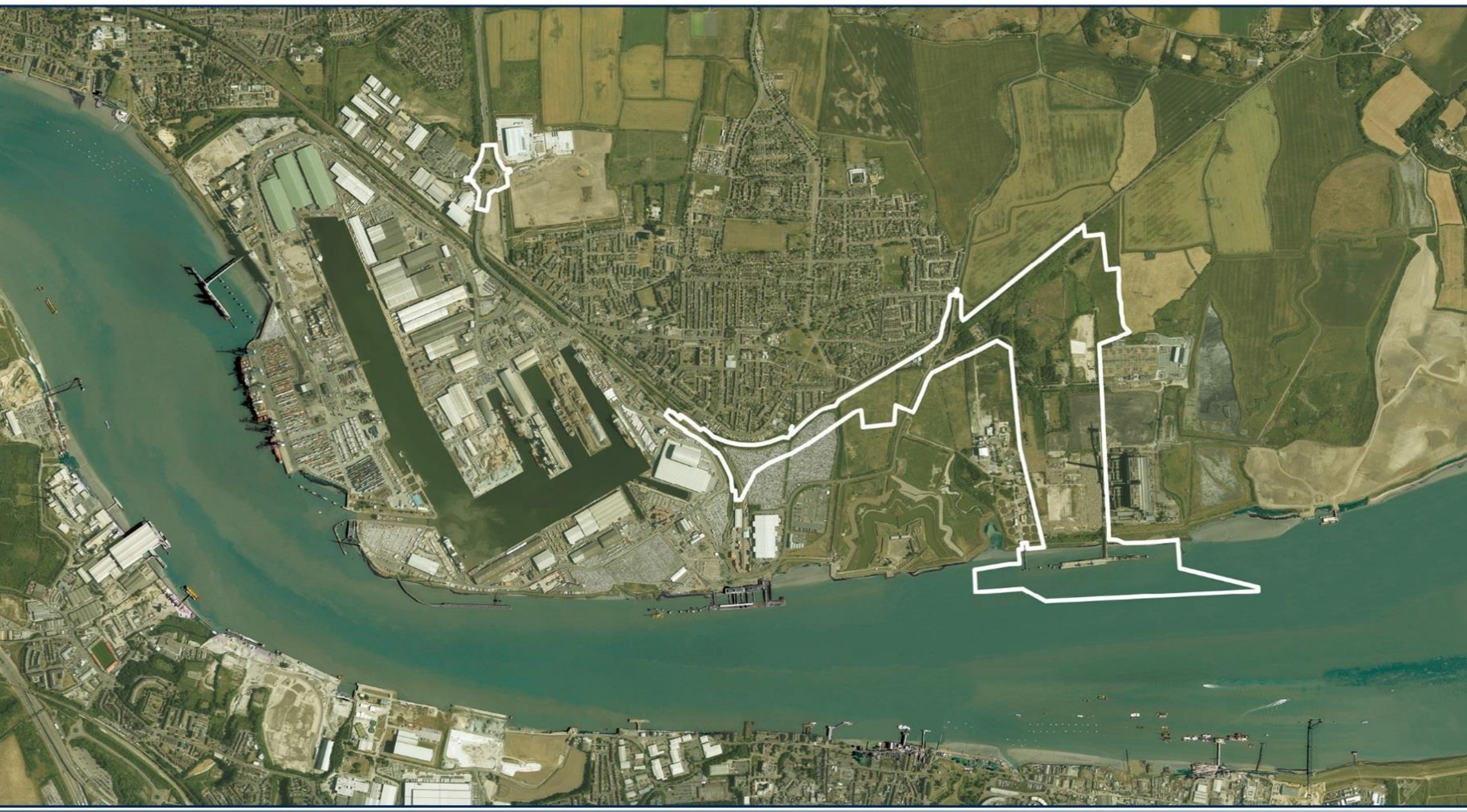
TILBURY2

TR030003

VOLUME 6 PART B

ES APPENDICES 18.A – 18.E

DOCUMENT REFS: 6.2 18.A – 18.E



TILBURY2

18 AIR QUALITY – APPENDIX

18.A AIR QUALITY ASSESSMENT METHODOLOGY

18.A.1 Construction Dust

IAQM Construction Dust Guidance (2014, version 1.1) presents a framework for a risk-based approach to the assessment of dust emissions from construction sites and proposes a number of industry standard good practice control measures that are considered to be “highly recommended” or “desirable” for the various site risk categories. The approach is deliberately conservative. The assessment of dust emissions during construction is considered in the context of the overall scale and nature of the development and the potential sensitivity of receptors.

The matrices in Table 18.1 to Table 18.3 provide a method of assigning the level of risk for each activity. This should be used to determine the level of mitigation that must be applied. For those cases where the risk category is ‘negligible’ no mitigation measures beyond those required by legislation will be required.

Table 18.1 Risk of Dust Impacts – Demolition

Sensitivity of Area	Dust Emission Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Medium Risk
Medium	High Risk	Medium Risk	Low Risk
Low	Medium Risk	Low Risk	Negligible

Table 18.2 Risk of Dust Impacts – Earthworks and Construction

Sensitivity of Area	Dust Emission Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Medium Risk	Low Risk
Low	Low Risk	Low Risk	Negligible

Table 18.3 Risk of Dust Impacts - Trackout

Sensitivity of Area	Dust Emission Magnitude		
	Large	Medium	Small
High	High Risk	Medium Risk	Low Risk

Medium	Medium Risk	Low Risk	Negligible
Low	Low Risk	Low Risk	Negligible

18.A.2 Operational Dust

IAQM Minerals Planning Guidance (2016, version 1.1) presents a framework for a risk-based approach to the assessment of dust emissions from minerals sites and proposes a number of industry standard good practice control measures that are considered to be appropriate for the various site risk categories. The approach is deliberately conservative. The assessment of dust emissions during operation is considered in the context of the overall scale and nature of the development and the potential sensitivity of receptors.

Having determined the residual dust source emission magnitude, the potential for impacts on sensitive receptors is based upon:

- the likely magnitude of dust emissions (after control measures are incorporated);
- the likely meteorological characteristics at the site;
- the dispersion and dilution afforded by the pathway to the receptors, considering distance, orientation, local terrain and features, and other relevant factors;
- the sensitivity of the receptors to disamenity, health and/or ecology effects; and
- any likely cumulative interactions.

The matrices in Tables 18.4 to 18.8 below provide an example from the IAQM guidance for a method of assigning the likely magnitude of dust risk, which can then be used to determine the level of mitigation that must be applied.

Table 18.4 Wind frequency

Category	Criteria
Infrequent	Frequency of winds >5 m/s from the direction of the dust source less than 5%
Moderately frequent	Frequency of winds >5 m/s from the direction of the dust source between 5 and 12%
Frequent	Frequency of winds >5 m/s from the direction of the dust source between 12 and 20%
Very frequent	Frequency of winds >5 m/s from the direction of the dust source greater than 20%

Table 18.5 Receptor distance

Category	Criteria
Distant	Receptor is between 200 m and 400 m from the dust source
Intermediate	Receptor is between 100 m and 200 m from the dust source

Close	Receptor is less than 100 m from the dust source

Table 18.6 Pathway Effectiveness

		Frequency of potentially dust winds			
		Infrequent	**Moderately frequent**	**Frequent**	**Very frequent**
Receptor Distance Category	Close	Ineffective	Moderately Effective	Highly Effective	Highly Effective
	Intermediate	Ineffective	Moderately Effective	Moderately Effective	Highly Effective
	Distant	Ineffective	Ineffective	Moderately Effective	Moderately Effective

Table 18.7 Estimation of Dust Impact Risk

		Residual Source Emissions		
		Small	**Medium**	**Large**
Pathway Effectiveness	Highly effective pathway	Low Risk	Medium Risk	High Risk
	Moderately effective pathway	Negligible Risk	Low Risk	Medium Risk
	Ineffective pathway	Negligible Risk	Negligible Risk	Low Risk

Table 18.8 IAQM Descriptors for Magnitude of Dust Effects

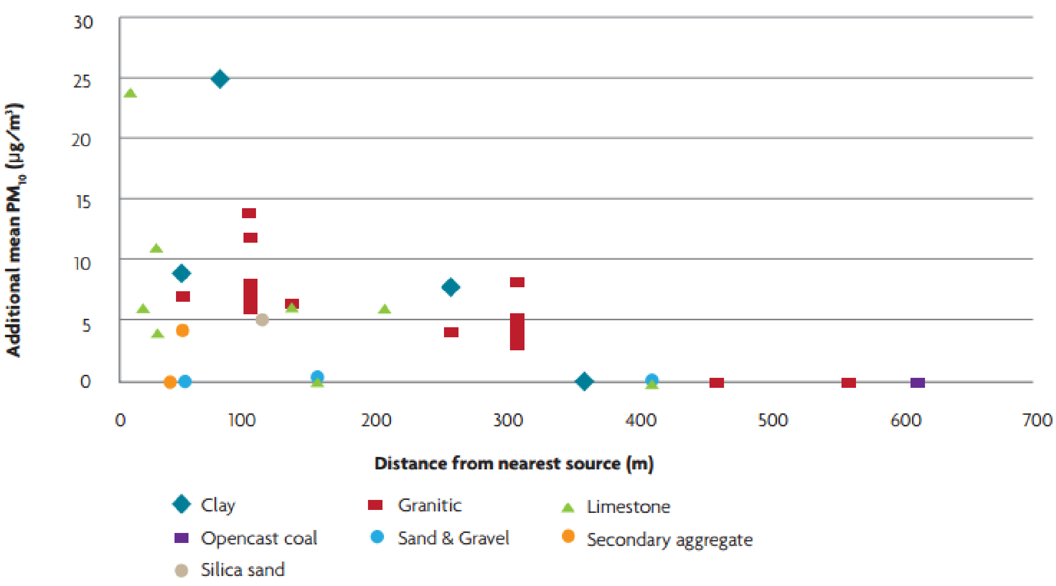
		Receptor Sensitivity		
		Low	**Medium**	**High**
Dust Impact Risk	High Risk	Slight Adverse Effect	Moderate Adverse Effect	Substantial Adverse Effect
	Medium Risk	Negligible Effect	Slight Adverse Effect	Moderate Adverse Effect
	Low Risk	Negligible Effect	Negligible Risk	Slight Adverse Effect
	Negligible Risk	Negligible Effect	Negligible Effect	Negligible Effect

Table 18 Error! No text of specified style in document.**.9 Operational Dust Wind Frequency for Gravesend (2014-2016)**

Blowing From	Blowing Towards	Direction, deg	0- 2 m/s	2 - 5 m/s	5 - 8 m/s	>8 m/s	% >5 m/s	IAQM Category
N	S	0	1.38	5.09	1.16	0.04	1.20	Infrequent
NE	SW	45	1.16	3.89	1.57	0.06	1.63	Infrequent
E	W	90	1.79	7.83	2.73	0.1	2.83	Infrequent
SE	NW	135	1.46	4.08	0.63	0.03	0.66	Infrequent
S	N	180	2.5	8.07	3.7	0.7	4.40	Infrequent
SW	**NE**	225	1.95	11.99	8.41	2.5	**10.91**	**Moderately frequent**
W	**E**	270	1.58	9.07	6.17	1.91	**8.08**	**Moderately frequent**
NW	SE	315	1.05	4.73	1.28	0.13	1.41	Infrequent

Extract from IAQM guidance illustrating fall off in PM_{10} incremental concentration with distance from source

Table A2-6
Mineral Site PM_{10} Increment as a Function of Distance from Quarry Operations by Mineral Type



18.A.3 Odour

IAQM Odour Planning Guidance (2014) presents a framework for a risk-based approach to the assessment of odour for planning purposes. The potential for effects of odour on sensitive receptors is based upon Table 18.10 which describes:

- Source odour potential;
- Pathway effectiveness;
- Receptor sensitivity.

The matrices in Tables 18.11 to 18.14 which follow provide a method of assigning the likely odour effect at sensitive receptors. Professional judgement needs to be applied to conclude the significance of the odour effect on, or from, the development as a whole, taking into account the possibly different magnitudes of effects that occur at different receptors.

Table 18.10 IAQM suggested descriptors for magnitudes of odour effects

Source Odour Potential	Pathway Effectiveness	Receptor
Factors affecting the source odour potential include: - the magnitude of the odour release (taking into account odour-control measures); - how inherently odourous compounds are; and - the unpleasantness of the odour.	Factors affecting the odour flux to the receptors are: - distance from source to receptor; - the frequency (%) of winds from source to receptor (or, qualitatively, the direction of receptors from source with respect to prevailing wind); - the effectiveness of any mitigation/control in reducing flux to the receptor; - the effectiveness of dispersion/dilution in reducing the odour flux to the receptor; - topography and terrain	For the sensitivity of people to odour, IAQM recommends that the air quality practitioner uses professional judgement to identify where on the spectrum between high and low sensitivity a receptor lies, taking into account the following general principals:
Large Source Odour Potential	**Highly Effective Pathway for Odour Flux to Receptor**	**High Sensitivity Receptor**
<u>Magnitude</u> – Larger Permitted processes of odorous nature or large Sewage Treatment Works (STWs); materials usage hundreds of thousands of tonnes/m^3 per year; area sources of thousands of m^2. Very odorous compounds, with very low Odour Detection Thresholds (ODTs). <u>Unpleasantness</u> – processes classed as “Most offensive”; or (where known) compounds/odours having unpleasant (-2 to very unpleasant hedonic score. <u>Mitigation/control</u> – open air operation with no containment, reliance solely on good	Distance – receptor is adjacent to the source/site; distance well below any official set-back distances*. Direction – high frequency (%) of winds from source to receptor (or, qualitatively, receptors downwind of source with respect to prevailing wind). Effectiveness of dispersion/dilution – open processes with low-level releases, e.g. lagoons, uncovered effluent treatment plant, landfilling of putrescible wastes.	Surrounding land where: - users can reasonably expect enjoyment of a high level of amenity; and - the people would reasonably be expected to be present here continuously, or at least regularly for extended periods, as part of the normal pattern of use of the land. Examples may include residential dwellings, hospitals, schools/education and tourist/cultural.

management techniques and best practice.		
Medium Source Odour Potential	**Moderately Effective Pathway for Odour Flux to Receptor**	**Medium Sensitivity Receptor**
Magnitude – smaller Permitted processes or small STWs; materials usage thousands of tonnes/m^3 per year; area sources of hundreds of m^2. The compounds involved are moderately odorous. Unpleasantness – processes classes as "Moderately offensive"; or (where known) odours having neutral (0) to unpleasant (-2) hedonic score. Mitigation/control – some mitigation measures in place, but significant residual odour remains.	Distance – receptor is local to the source. Where mitigation relies on dispersion/dilution – releases are elevated, but compromised by building effects.	Surrounding land where: - users would expect to enjoy a reasonable level of amenity, but wouldn't reasonably expect to enjoy the same level of amenity as in their home; or - people wouldn't reasonably be expected to be present here continuously or regularly for extended periods as part of the normal pattern of use of the land. Examples may include places of work, commercial/retail premises and playing/recreation fields.
Small Source Odour Potential	**Ineffective Pathway for Odour Flux to Receptor**	**Low Sensitivity Receptor**
Magnitude – falls below Part B threshold; material usage hundreds of tonnes/m^3 per year; area sources of tens m^2. The compounds involved are only mildly odorous, having relatively high ODTs where known. Unpleasantness – processes classes as "Less offensive", or (where known) compounds/odours having neutral (0) to very pleasant (+4) hedonic score. Mitigation/control – effective, tangible mitigation measures in place leading to little or no residual odour.	Distance – receptor is remote from the source; distance exceeds any official setback distances. Direction – low frequency (%) of winds from source to receptor (or, qualitatively, receptors upwind of source with respect to prevailing wind). Where mitigation relies on dispersion/dilution – releases are from high level (e.g. stacks, or roof vents >3m above ridge height) and are not compromised by surrounding buildings.	Surrounding land where: - the enjoyment of amenity would not reasonably be expected; or - there is transient exposure, where the people would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land. Examples may include industrial, farms, footpaths and roads.
*Minimum "setback" distances may be defined for some odorous activities.		

Table 18.11 IAQM suggested descriptors for magnitudes of odour effects

	Receptor Sensitivity			
		Low	**Medium**	**High**
Odour Exposure (Impact)	Very Large	Moderate adverse	Substantial adverse	Substantial adverse
	Large	Slight adverse	Moderate adverse	Substantial adverse
	Medium	Negligible	Slight adverse	Moderate adverse
	Small	Negligible	Negligible	Slight adverse
	Negligible	Negligible	Negligible	Negligible

Table 18.12 Risk of odour exposure (impact) at the specific receptor location

		Source Odour Potential		
		Small	**Medium**	**Large**
Pathway Effectiveness	Highly effective	Low Risk	Medium Risk	High Risk
	Moderately effective	Negligible Risk	Low Risk	Medium Risk
	Ineffective	Negligible Risk	Negligible Risk	Low Risk

Table 18.13 Likely magnitude of odour effect at the specific receptor location

Risk of Odour Exposure	Receptor Sensitivity		
	Low	**Medium**	**High**
High Risk	Slight adverse	Moderate adverse	Substantial adverse
Medium Risk	Negligible	Slight adverse	Moderate adverse
Low Risk	Negligible	Negligible	Slight adverse
Negligible Risk	Negligible	Negligible	Negligible

Table 18.14 Matrix to assess the odour effect at individual receptors

		Receptor Sensitivity		
		Low	**Medium**	**High**
Overall Odour Exposure	Very Large	Substantial adverse	Substantial adverse	Substantial adverse
	Large	Moderate adverse	Moderate adverse	Substantial adverse
	Medium	Slight adverse	Slight adverse	Moderate adverse
	Small	Negligible	Negligible	Slight adverse

18.B BASELINE AIR QUALITY

18.B.1 Continuous monitoring data

There are four continuous monitoring stations (CMS) currently operating within the borough of Thurrock. The results from the last six years (2011 to 2016 inclusive) are shown in the following tables for nitrogen dioxide, particulate matter (PM_{10} and $PM_{2.5}$) and sulphur dioxide. These data have been used to inform the main assessment.

Data for these CMS for the years 2011 to 2015 were taken from Thurrock Council's 2016 LAQM Annual Status Report. Data for 2016 were obtained from the London Air Quality Network[1].

[1] https://www.londonair.org.uk/LondonAir/Default.aspx

Table 18.15 Descriptions of CMS in Thurrock

CMS	Location	Grid Reference	Type	Distance to relevant exposure (m)	In AQMA	Distance from ARN
TK1	Thurrock Grays AURN	561066, 177894	Urban background	38	No	1.9 km south
TK8	Purfleet London Road	556698, 177937	Roadside	3	Yes	0.8 km west
TK3	Stanford le Hope	569358, 182736	Roadside	3	No	1.2 km east
TK4	Tilbury Calcutta Road	563900, 176282	Roadside	6	Yes	0.01 km south

Table 18.16 Annual mean concentrations of NO_2 measured by CMS in Thurrock

CMS	Location	2011	2012	2013	2014	2015	2016
TK1	Thurrock Grays AURN	28.2	28.7	27.5	26.5	25.4	28.0
TK8	Purfleet London Road	**62.3 (4)**	**62.7 (7)**	**62.8 (4)**	**61.0 (5)**	**55.5 (0)**	**55.0 (1)**
TK3	Stanford le Hope	33.9	32.8	30.0	25.1	22.9	27.0
TK4	Tilbury Calcutta Road	38.6	39.3	34.6	32.8	30.0	33.0

AQS Objective:
40 µg/m^3 as an annual mean; exceedances are highlighted in **bold**.

200 µg/m^3 as an hourly mean, not to be exceeded more than 18 times per year (no. of exceedences shown in brackets)

Table 18.17 Annual mean concentrations of PM_{10} and $PM_{2.5}$ measured by CMS in Thurrock

CMS	Location		2011	2012	2013	2014	2015	2016
TK1	Thurrock Grays AURN		24.9	17.7	19.2	19.3	17.1	17.0
TK8	Purfleet London Road		27.7	23.9	27.4	26.8	24.9	25.0
TK3	Stanford le Hope	PM_{10}	23.4	22.6	24.3	19.8	17.1	20.0
		$PM_{2.5}$	17.9	15.3	14.1	14.2	10.1	10.1
AQS Objective: 40 µg/m^3 as an annual mean for PM_{10} 25 µg/m^3 as an annual mean for $PM_{2.5}$								

Table 18.18 Number of exceedences of daily mean standard for PM_{10} measured by CMS in Thurrock

CMS	Location	2011	2012	2013	2014	2015	2016
TK1	Thurrock Grays AURN	25	10	4	11	2	4
TK8	Purfleet London Road	18	14	16	9	2	9
TK3	Stanford le Hope	24	14	21	22	22	4
AQS Objective: 50 µg/m^3 as a 24 hour mean, not to be exceeded more than 35 times a year							

Table 18.19 Number of exceedences of short term air quality standards* for SO_2 measured by CMS in Thurrock

CMS	Location	2011	2012	2013	2014	2015	2016
TK1	Thurrock Grays AURN	0	0	0	0	0	0
TK4	Tilbury Calcutta Road	0	0	0	0	0	0
AQS Objective: 125 µg/m^3 as a 24 hour mean, not to be exceeded more than 3 times a year 266 µg/m^3 as a 15 minute mean, not to be exceeded more than 35 times a year 350 µg/m^3 as a 1 hour mean, not to be exceeded more than 24 times a year							

Table 18.20 Annual mean concentrations of NO_2 measured by CMS in Havering

CMS	Location	2011	2012	2013	2014	2015	2016
HV1	Rainham	*	n/a	30	35	32	34
HV3	Romford	*	*	33	*	35	**44**

n/a CMS not operational,
* insufficient data capture (<75%) so value not reported.
Exceedances of the annual mean NO_2 UK AQS objective are highlighted in **bold.**
Data taken from the Havering LAQM Annual Status Report 2016.

Table 18.21 Annual mean concentrations of particulate matter measured by CMS in Havering

CMS	Location	PM Fraction	2011	2012	2013	2014	2015	2016
HV1	Rainham	PM_{10}	*	n/a	*	19	18	19
		$PM_{2.5}$	n/a	n/a	n/a	12	11	*
HV3	Romford	PM_{10}	25	23	24	26	24	21

n/a CMS not operational,
* insufficient data capture (<75%) so value not reported

Table 18.22 Annual mean concentrations of NO_2 measured by CMS in Gravesham

CMS	Location	2011	2012	2013	2014	2015	2016
ZG2	Gravesham A2 Roadside	34	35.2	31.4	30.9	30	29.6
ZG3	Gravesham Industrial Background	26	27	31.1	24.4	23.4	24.1

Table 18.23 Annual mean concentrations of PM_{10} measured by CMS in Gravesham

CMS	Location	2012	2013	2014	2015	2016
ZG2	Gravesham A2 Roadside	18	20	18	18	19
ZG3	Gravesham Industrial Background	20	20	19	20	18
Data taken from the Gravesham LAQM Annual Status Report 2017						

18.B.2 Diffusion Tube Monitoring

Annual mean nitrogen dioxide concentrations measured by Thurrock Council by diffusion tube, for those sites within and surrounding the air quality study area, are tabulated for the period 2011 to 2016 in Table 18.24.

Results from the site-specific nitrogen dioxide diffusion tube monitoring survey undertaken by Atkins on behalf of the applicant are provided in Table 18.25.

Table 18.24 Annual mean NO_2 diffusion tube monitoring results ($\mu g/m^3$) within and surrounding the air quality study area

Site ID	Site Name	Site Type	OS Grid Reference	Within 200 m of ARN links	2011	2012	2013	2014	2015	2016
LRAR	London Road Arterial Road	Roadside	555301, 179438	No	**50.3**	**57.2**	**58.3**	**58.5**	**52.2**	**62.5**
PRS	Purfleet Rail Station	Roadside	555389, 178145	No	31.9	35.7	35.3	34.7	33.5	35.0
WC	Watts Crescent	Roadside	556314, 178765	No	38.7	**40.5**	**43.4**	**40.7**	38.6	**50.2**
JC	Jarrah Cottages	Roadside	556701, 177937	No	**47.0**	**52.5**	**58.8**	**56.8**	**53.4**	**48.6**
STON	Stonehouse Lane	Roadside	557132, 177970	No	**40.5**	**42.5**	**41.4**	**-**	**-**	**-**
IBIS	Ibis Hotel	Urban Background	557570, 177789	Yes	**46.0**	**45.8**	**46.3**	**49.1**	**52.7**	**49.1**
GDSO	Gatehope Drive	Urban background	557595, 181060	Yes	29.5	30.3	28.5	28.6	27.8	28.9
LT	Lakeside Tesco Roundabout	Roadside	557981, 178700	No	**52.3**	**53.7**	**62.0**	**50.1**	**52.4**	**53.7**
KCNO	Kemps Cottage	Urban background	558148, 183532	Yes	32.6	34.2	35.2	34.3	34.2	32.8
WT	London Road W Thurrock	Roadside	558483, 177678	No	38.8	**43.9**	**40.1**	38.7	38.7	**41.1**
HR	Howard Road	Roadside	559118, 179462	No	29.2	30.9	31.4	31.0	30.2	31.5
NAS2	A1306	Roadside	559720, 179630	Yes	**53.0**	**53.9**	**51.7**	**50.0**	**50.6**	**56.0**
LRSS	London Road South Stifford	Roadside	559785, 177910	No	**43.1**	**49.3**	**44.8**	**40.6**	**40.5**	39.6
LRG	London Road Grays	Roadside	560624, 177811	No	37.5	38.7	39.7	37.7	37.6	38.9
NAS4	Wingfield Grays	Urban background	560772, 178434	No	21.5	21.8	20.9	-	-	-
ER	Elizabeth Road	Roadside	560954, 179535	No	**47.0**	**53.5**	**56.7**	**52.7**	**52.9**	**51.8**
PS	Poison Store AURN Site	Urban background	561066, 177894	No	26.0	27.1	27.7	26.2	24.9	25.7
HL	Hogg Lane	Roadside	561108, 178922	No	29.9	33.9	33.3	35.1	31.3	33.9
NAS1	Queensgate Centre Grays	Roadside	561469, 178063	No	34.2	33.1	35.0	32.9	30.1	33.5
CR	Cromwell Road Grays	Industrial	561572, 178154	No	30.8	36.1	32.0	33.0	32.7	32.6
SRG	Stanley Road Grays	Roadside	561685, 177833	No	28.0	31.1	33.1	30.5	27.9	30.9
NAS3	Chestnut Avenue Grays	Urban background	561830, 179878	No	22.5	23.7	22.7	21.7	21.1	22.0
WES	William Edwards School	Roadside	561958, 180967	Yes	28.4	31.8	31.4	30.3	29.9	31.8
B	Bulphan	Rural background	563855, 184772	No	18.4	20.6	18.4	17.5	16.3	17.2

Site ID	Site Name	Site Type	OS Grid Reference	Within 200 m of ARN links	2011	2012	2013	2014	2015	2016
TL	Calcutta Road Tilbury	Roadside	563867, 176293	Yes	35.7	**40.5**	37.1	35.2	32.0	35.7
PKSL	Park Road	Roadside	567781, 182400	Yes	30.7	33.3	31.0	28.6	28.0	29.0
SL	Stanford Library	Urban background	568501, 182459	No	26.3	25.9	27.3	25.6	24.9	27.0
M	Manorway Monitoring Station	Roadside	569357, 182737	No	32.7	34.4	32.7	25.4	25.7	27.0
FRC	Francisco Close (Chafford Hundred)	Industrial	559136, 179084	No	29.5	32.6	34.3	33.7	31.9	33.2
SLHRS	Stanford-le-Hope Railway Station	Roadside	568162, 182296	No	30.2	28.1	29.5	-	-	-
ETRS	East Tilbury Rail Station	Roadside	567655, 179003	No	27.8	31.5	28.4	-	-	-
TILA	Dock Road (Tilbury)	Roadside	563498, 176483	Yes	**32.3**	**43.2**	**40.3**	39.8	37.8	**40.8**
TILB	Broadway Intersection (Tilbury)	Roadside	563645, 176348	Yes	**40.4**	**42.6**	**42.0**	39.3	38.0	39.7
TILC	St Andrews Road (Tilbury)	Roadside	563600, 176321	Yes	38.6	**43.8**	**40.4**	37.4	34.1	39.0
TILD	Calcutta Road East (Tilbury)	Roadside	563995, 176291	Yes	33.5	39.1	38.1	33.5	32.6	36.9
TILE	Calcutta Road North (Tilbury)	Roadside	563870, 176305	Yes	33.1	36.9	35.3	35.5	33.1	34.9
TK4_AB	Thurrock 4 (co-located site)	Roadside	563900, 176282	Yes	31.5	36.1	32.8	30.7	30.9	31.5
PBP	Purfleet By-pass	Roadside	556257, 178438	No	**42.0**	**41.1**	**40.7**	38.1	37.0	37.8
PBPA	Purfleet By-pass	Roadside	556221, 178461	No	-	-	-	35.7	32.9	34.7
LYD	Lydden	Urban background	560057, 179873	Yes	-	36.0	34.4	34.1	30.9	30.8
AVSL	Aveley Ship Lane	Roadside	556713, 180167	No	-	**47.0**	**45.2**	**45.4**	**42.3**	**41.0**
AVHS	Aveley High Street	Roadside	556661, 180180	No	-	39.0	39.4	38.5	37.5	37.3
SOAA	South Ockendon Arisdale Avenue	Roadside	558785, 182323	No	-	32.0	33.0	32.7	31.3	30.3
TSR	Tilbury Sydney Road	Urban background	564122, 176152	No	-	33.3	31.9	26.9	28.7	28.1
DR	Devonshire Road	Roadside	560279, 178944	No	-	30.9	29.8	32.9	30.0	30.0
LRARN	London Road Art Road (North)	Roadside	555286, 179501	No	30.5	34.3	33.9	34.7	32.8	32.0

Site ID	Site Name	Site Type	OS Grid Reference	Within 200 m of ARN links	2011	2012	2013	2014	2015	2016
LRARS	London Road Art Road (South)	Roadside	555357, 179362	No	28.6	31.6	30.0	32.6	27.7	31.1
LRARMN	London Road Art Road (Mid-North)	Roadside	555299, 179453	No	-	**44.5**	**44.5**	**43.4**	38.1	**45.6**
LRARMS	London Road Art Road (Mid-South)	Roadside	555329, 179397	No	-	39.4	38.8	39.7	33.9	**43.6**
JRP	Joslin Road Purfleet	Urban background	556395, 178002	No	-	-	-	-	27.3	27.6
MRS	Manor Road School	Urban background	562416, 177650	No	-	-	-	-	-	23.3
MTV	Mary the Virgin Church, Little Thurrock	Urban background	562611, 177773	No	-	-	-	-	-	21.0
Values in bold in exceedance of annual mean AQS objective (40 µg/m^3)										

Table 18.25 Site Specific Diffusion Tube Monitoring Data, Annualisation and Bias Adjustment

ID	Exposure Period	Period Mean (2017), μg/m^3	Data capture (over 6 months), %	Annualisation Factor	Bias Adjustment Factor	Annual Mean (2016), μg/m^3
DT1	Apr, May, Jun, Jul, Aug, Sep	28.4	100	1.26	0.92	32.9
DT2	Apr, Jun, Jul, Aug, Sep	28.3	83	1.28	0.92	33.4
DT3	Apr	32.9	16	-	-	-
DT4	Apr, May, Jun, Jul, Aug, Sep	29.1	100	1.26	0.92	33.7
DT5	Apr, May, Jun, Jul, Aug, Sep	33.3	100	1.26	0.92	38.6
DT6	Apr, May, Jun, Jul, Aug, Sep	30.4	100	1.26	0.92	35.2
DT7	Apr, May, Jun, Jul, Aug, Sep	30.1	100	1.26	0.92	34.9
DT8	Apr, May, Jun, Jul, Aug, Sep	23.0	100	1.26	0.92	26.7
DT9	Apr, May	21.3	33	-	-	-
DT10	Jul, Aug, Sep	22.2	50	1.34	0.92	27.4
DT11	Jul, Aug, Sep	20.0	50	1.34	0.92	24.7

Notes
DT3 and DT9 experienced continued tampering; the locations were moved to DT10 and DT11 respectively.
DT3 and DT9 have not been annualised as they generated fewer than three months of monitoring data

18.B.3 Trend analysis for annual mean nitrogen dioxide

Analysis of trends in annual mean NO_2 has been undertaken using the Finnish Meteorological Institute MAKESENS (v1) spreadsheet using the annual mean times series data for CMS and diffusion tube sites. The analysis examines the trend in the annual mean concentrations. It can also inform the selection of sites with suitably robust data for use in the selection of suitable long-term trend factors where necessary.

The statistical analysis undertaken includes a Sen's Slope[2] estimate of the linear trend, residual concentrations[3] which indicate the variation year on year and the Mann-Kendall test statistic (S) to indicate the significance of any trend. In order to conduct a Mann-Kendall test four or more series of data must be presented for each site. The Mann-Kendall test statistic is expressed as a whole number. For the null hypothesis of a random distribution of the data to be rejected, the S[4] has to be equal to or greater than an absolute value determined from the number of data points (equivalent to a probability of less than 0.1 or 10%).

Table 18.26 summarises the statistical analysis for each monitoring site. Graphs 18.1 to 18.4 show the trends in annual mean NO_2. The vertical axis indicates concentration in µg/m^3. Confidence intervals for data are only plotted where there are ten or more data points. The linear trend is shown as a solid black line and residual concentrations are shown as a solid light blue line.

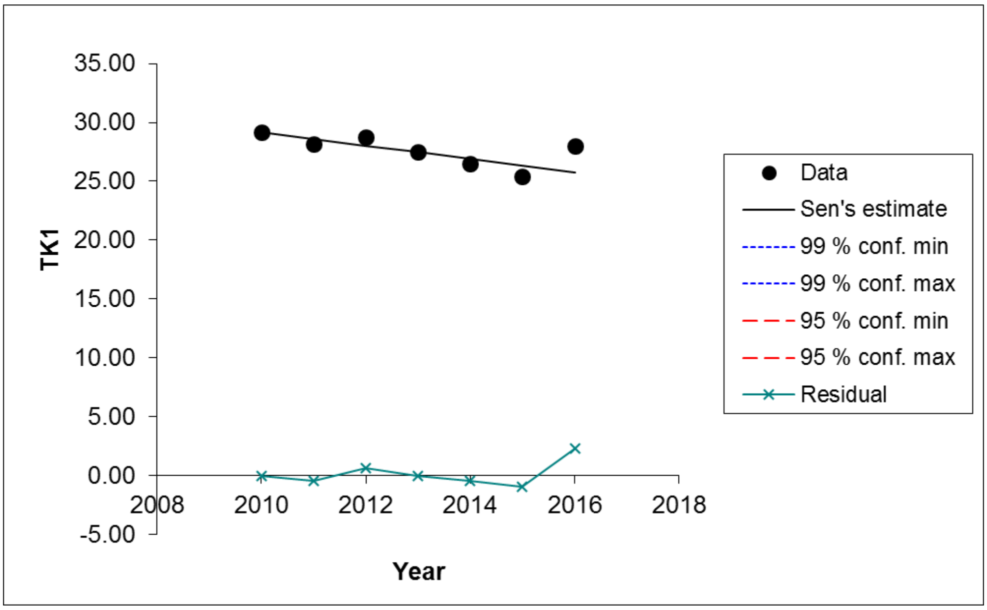
The analysis indicates that there are statistically significant downward trends in annual mean NO_2 concentrations at most monitoring sites. Notably these include the Thurrock urban background (general decrease in NO_2 concentration of 0.58 µg/m^3 per year over the six-year period) and Tilbury, Calcutta Road CMS (general decrease in NO_2 concentration of 1.86 µg/m^3 per year over the six year period):

Table 18.26 Summary of Annual Mean NO_2 Trend Analysis

Site ID	Site Type	No. of Data Points	Required S Value	S Value	Sen's Slope	Significant	Within 200m of ARN links?
TK1	CMS - Urban background	7	11	-13	-0.58	**Yes**	No
TK8	CMS - Roadside	7	11	-15	-1.82	**Yes**	No
TK3	CMS - Roadside	7	11	-17	-2.63	**Yes**	No
TK4	CMS - Roadside	7	11	-15	-1.86	**Yes**	**Yes**

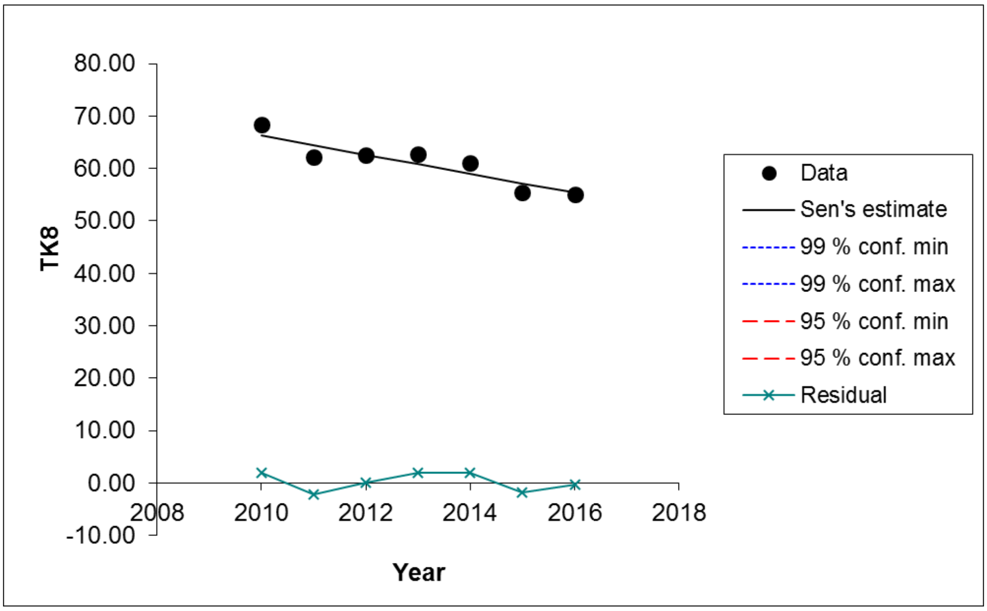
The data available to date (at end of September 2017) indicate that the downward trend in annual mean NO_2 concentrations is continuing.

Graph Error! No text of specified style in document..1 Site TK1 – Mann-Kendall and Sen Estimate of Annual Mean NO_2 Trend



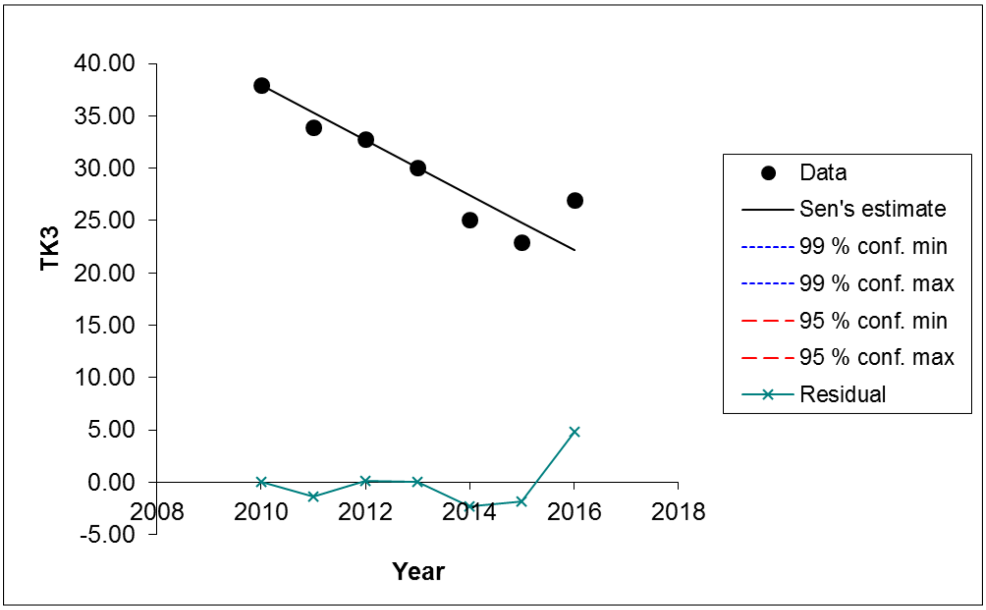
Site TK1 has seven data points. The Sen's slope estimate, illustrated by the solid black line is, -0.58 which suggests that there was a general decrease in NO_2 concentration of 0.58 µg/m^3 per year over the seven year period. The plot of residual concentrations shows that there was little variation year on year with the exception of the period between 2015 and 2016. The Mann-Kendall test statistic (S) is expressed as whole number, for TK1 this is -13. For the null hypothesis of a random distribution of the data to be rejected, where the number of data points is seven, the value of S would have to be equal to or greater than an absolute value of eleven (equivalent to a probability of less than 0.1 or 10%). For seven data points, only S values of eleven or more give a reasonably robust indication of a significant monotonic trend. Consequently, there is evidence of a statistically significant monotonic trend.

Graph Error! No text of specified style in document..2 Site TK8 – Mann-Kendall and Sen Estimate of Annual Mean NO_2 Trend



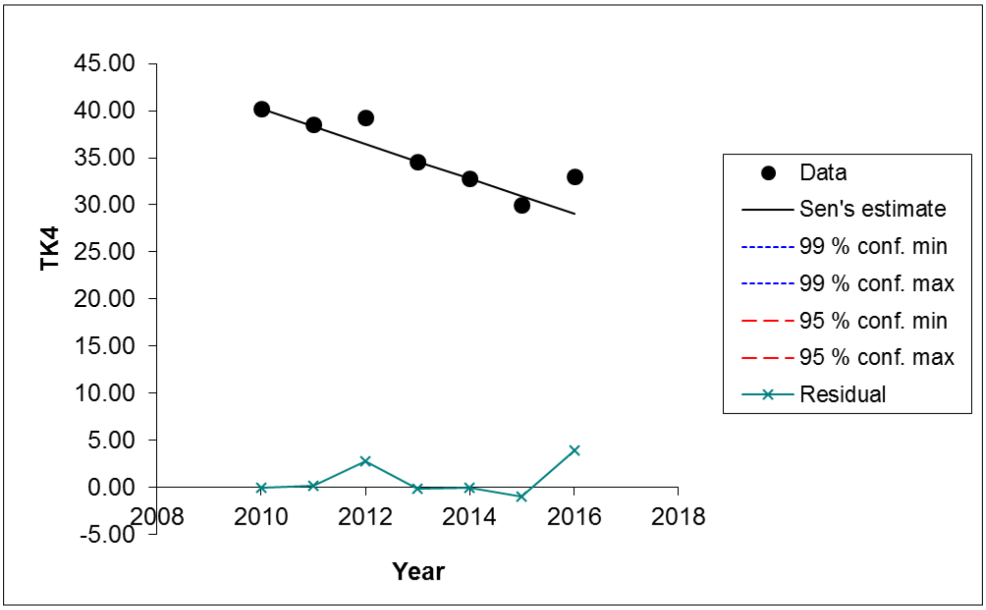
Site TK8 has seven data points. The Sen's slope estimate, illustrated by the solid black line is -1.82 which suggests that there was a general decrease in NO_2 concentration of 1.82 µg/m^3 per year over the seven year period. The plot of residual concentrations shows that there was little variation year on year. The Mann-Kendall test statistic (S) is expressed as whole number, for TK8 this is -15. For the null hypothesis of a random distribution of the data to be rejected, where the number of data points is seven, the value of S would have to be equal to or greater than an absolute value of eleven (equivalent to a probability of less than 0.1 or 10%). For seven data points, only S values of eleven or more give a reasonably robust indication of a significant monotonic trend. Consequently, there is evidence of a statistically significant monotonic trend.

Graph Error! No text of specified style in document..3 Site TK3 – Mann-Kendall and Sen Estimate of Annual Mean NO_2 Trend



Site TK3 has seven data points. The Sen's slope estimate, illustrated by the solid black line is, -2.63 which suggests that there was a general decrease in NO_2 concentration of 2.63 µg/m^3 per year over the seven year period. The plot of residual concentrations shows that there was little variation year on year with the exception of the period between 2013 and 2016. The Mann-Kendall test statistic (S) is expressed as whole number, for TK3 this is -17. For the null hypothesis of a random distribution of the data to be rejected, where the number of data points is seven, the value of S would have to be equal to or greater than an absolute value of eleven (equivalent to a probability of less than 0.1 or 10%). For seven data points, only S values of eleven or more give a reasonably robust indication of a significant monotonic trend. Consequently, there is evidence of a statistically significant monotonic trend.

Graph Error! No text of specified style in document..4 Site TK4 – Mann-Kendall and Sen Estimate of Annual Mean NO_2 Trend



Site TK4 (Tilbury, Calcutta Road) has seven data points. The Sen's slope estimate, illustrated by the solid black line is -1.86 which suggests that there was a general decrease in NO_2 concentration of 1.86 µg/m^3 per year over the seven year period. The plot of residual concentrations shows that there was some variation between 2011 to 2013 and 2015 to 2016.

The Mann-Kendall test statistic (S) is expressed as whole number, for TK4 this is -15. For the null hypothesis of a random distribution of the data to be rejected, where the number of data points is seven, the value of S would have to be equal to or greater than an absolute value of eleven (equivalent to a probability of less than 0.1 or 10%). For seven data points, only S values of eleven or more give a reasonably robust indication of a significant monotonic trend. Consequently, there is evidence of a statistically significant monotonic trend.

18.C DETAILED MODELLING

18.C.1 Traffic data

Two-way traffic data for a 2016 baseline year, 2019 (construction), 2020 Do-minimum (DM) (with committed development but without proposals), and 2020 Do-something (DS) (with committed development and the proposals) were provided by the project traffic consultant.

Data for a total of 25 links were derived from a variety of sources including Webtris, Local Authority automatic traffic counts (ATC) and Department for Transport (DfT) database, and factored accordingly. The data consist of 24 hour Annual Average Daily Traffic (AADT) flows, percentage of heavy goods vehicles (HGV%) and average speed (kph).

The two-way traffic data used for each modelled link in each assessment year and scenario are presented in Table 18.27.

Table 18.27 Traffic Data used in the ADMS Dispersion Model

ID	Name	Base 2016			DM 2020			DS 2020			Construction 2019		
		AADT	HGV%	Speed (kph)	AADT	HGV %	Speed (kph)	AADT	HGV%	Speed (kph)	AADT	%HGV	Speed (kph)
1	A13 East of A1089	85,354	8.9	109	92,248	9.6	109	92,900	10.1	109	182	18.7	109
2	A13 West of A1089	90,417	9.6	102	97,699	10.4	102	99,347	11.7	102	260	38.5	102
3	A13 Westbound Off-Slip	4,707	7.0	113	5,808	7.7	113	6,134	11.3	113	91	18.7	113
4	A13 Westbound On-Slip	6,521	32.6	113	8,483	35.9	113	9,307	40.7	113	130	38.5	113
5	A13 Eastbound Off-Slip	8,010	28.9	113	10,050	32.3	113	10,874	36.7	113	130	38.5	113
6	A13 Eastbound On-Slip	4,862	17.3	113	5,972	16.5	113	6,298	19.6	113	91	18.7	113
7	A1089 North of A126 Slips	25,224	23.8	100	31,491	25.9	100	33,781	30.0	100	440	30.0	100
8	A1089 North of ASDA Rbt	29,076	23.8	98	36,819	24.8	98	39,241	28.3	98	566	23.3	98
9	A1089 St Andrews Rd North of Gate 1	13,447	46.3	64	14,297	46.8	64	16,719	51.9	64	566	23.3	64
10	A1089 Ferry Road - North of Proposed Link Road	5,263	26.4	61	5,827	30.1	61	8,249	45.2	61	566	23.5	61
11	A1089 Ferry Road - South of Proposed Link Road	5,263	26.4	61	5,827	30.1	61	5,020	26.7	61	566	23.5	61
12	Fort Road - South of Site Access	681	17.0	55	1,005	40.8	55				566	23.5	55
13	Fort Road - North of Brennan Road	1,906	13.2	54	2,006	13.2	54	2,006	13.2	54			
14	Site Access	230	6.3	38	518	58.4	38	3,237	70.3	38	661	20.1	38
15	Proposed Link Road							3,610	66.0	61			
16	A13 East of M25 Jct 30	110,537	11.6	80	119,580	12.6	80	121,228	13.7	80	260	38.5	80
17	A13 West of M25 Jct 30	89,481	10.6	90	95,195	10.8	90	95,759	11.3	90	100	34.0	90
18	M25 North of Jct 30	128,855	20.5	102	137,271	20.8	102	137,987	21.2	102	86	53.5	102
19	M25 South of Jct 30	115,324	19.1	88	122,786	19.4	88	123,128	19.6	88	46	47.8	88
20	Dock Road	12,924	0.8	43	14,566	0.7	43	14,566	0.7	43			
21	Calcutta Road	10,118	0.5	43	11,613	0.4	43	11,639	0.4	43	24	-	43
22	A13 East of A126 Interchange to A1012	83,034	12.3	80	90,633	13.7	80	92,281	15.1	80	260	38.5	80

23	Arterial Rd North Stifford from B186 to Long Ln roundabout	29,691	5.8	64	31,250	5.8	64	31,250	5.8	64			
24	A1013 Stanford Rd from Daneholes roundabout to A1014	11,868	6.9	81	12,491	6.9	81	12,491	6.9	81			
25	Fort Road - Between Brennan Road and the Site Access	1,906	13.2	54	2,006	13.2	54	2,105	12.6	54	95	-	54

HGV% = The project transport consultant has confirmed that HDVs include heavy goods vehicles (HGVs), buses and coaches

18.C.2 Vehicle emissions

Pollutant emission rates were calculated for NO_x, PM_{10} and $PM_{2.5}$ using two different tools:

- Air Quality Consultants' Calculator Using Realistic Emissions for Diesels (CURED) V2A for NO_x emissions[5];
- DEFRA Emissions Factor Toolkit (EfT)[2] v7.0 for PM_{10} and $PM_{2.5}$ emissions.

A detailed analysis of emissions from modern diesel vehicles carried out by Air Quality Consultants (AQC, 2016b)[6] showed that, where previous standards had limited on-road success, the 'Euro VI' and 'Euro 6' standards that new vehicles have had to comply with from 2013/16[1] are delivering real on-road improvements. A detailed comparison of the predictions in the DEFRA EFT v7.0 against the results from on-road emissions tests has shown that DEFRA's latest emission estimates still have the potential to under-predict emissions from some vehicles, albeit by less than has historically been the case.

Furthermore, these improvements are expected to increase as the Euro 6 standard is fully implemented. Despite this, AQC's detailed analysis suggested that, in addition to modelling using the EFT v7.0, a sensitivity test using elevated nitrogen oxides emissions from certain diesel vehicles should be carried out. In order to account for this potential under-prediction, the emissions from Euro IV, Euro V, Euro VI, and Euro 6 vehicles can be uplifted using AQC's CURED V2A tool. The adjustments to EFT are set out in Table 18.28. The justifications for these adjustments are given in AQC (2016b).

The CURED V2A tool is therefore an alternative, more conservative approach to estimating NO_x emissions, as it applies adjustments to the emission factors in the DEFRA EFT v7.0 for diesel vehicles, to reflect real world driving conditions. The results from CURED V2A are likely to over-predict emissions from vehicles in the future and thus provide a reasonable worst-case upper-bound to the assessment.

The use of CURED V2A for the Tilbury2 assessment was agreed through consultation with Thurrock Council.

Table 18.28 Summary of Adjustments Made to Defra's EFT (V7.0)

Vehicle Type		Adjustment Applied to Emission Factors
All Petrol Vehicles		No adjustment
Diesel LDVs	Euro 5 and earlier	No adjustment

[5] AQC (2016a) CURED V2A, [Online], Available: http://www.aqconsultants.co.uk/getattachment/Resources/Download-Reports/CURED-V2A.zip.aspx .
[2] All adjustments were applied to the COPERT functions. Fleet compositions etc. were applied following the same methodology as used within the EFT.
[6] AQC (2016b) Emissions of Nitrogen Oxides from Modern Diesel Vehicles, [Online], Available: http://www.aqconsultants.co.uk/getattachment/Resources/Download-Reports/Emissions-of-Nitrogen-Oxides-from-Modern-Diesel-Vehicles-210116.pdf.aspx
[1] Euro VI refers to heavy duty vehicles, while Euro 6 refers to light duty vehicles. The timings for meeting the standards vary with vehicle type and whether the vehicle is a new model or existing model.

	Euro 6	Increased by 78%
Diesel HDVs	Euro III and earlier	No adjustment
	Euro IV and V	Set to equal Euro III values
	Euro VI	Set to equal 20% of Euro III emissions [a]

[a] *Taking account of the speed-emission curves for different Euro classes (see AQC (2016b)).*

The inputs to EfT v7.0 and CURED V2A are the same, and are described below.

The geographic area was set to “England (not London)” as the affected road network lies predominantly outside of the M25 motorway and all within Thurrock.

The year of calculation was the assessment year for each scenario, i.e. 2016 baseline, 2019 construction and 2020 operation.

The traffic format selected was a “Basic Split” which assumes standard fleet composition for the selected road type. Only the percentage of HDVs[7] was specified.

The Road Type defined for each road is set out in Table 18.29 below. The road type was set to match the characteristics of each individual road link modelled. Most modelled links were classed as “Motorway (not London)” as this assumption best represents the type of road (fast flowing dual carriageway) [8] and the higher proportion of HGVs that will be using those roads[9]. In addition, the 2013 vehicle fleet composition projections published by the National Atmospheric Emission Inventory[10] suggest that this option is also more pessimistic in terms of the larger composition of diesel vehicles using the roads. Furthermore, this option best represents the routes used by HGVs travelling to and from the port, as the proportion of articulated lorries is expected to be higher than that of rigid. The roads that are not heavily used by HGVs and/or within an urban area with a population of more than 10,000 are classified as urban. One road (the A1013) was classified as rural due to its more remote location.

Table 18.29 Summary of Road Type used for Emission Calculations

ID	Description	Road Type
1	A13 East of A1089	Motorway (not London)
2	A13 West of A1089	Motorway (not London)
3	A13 Westbound Off-Slip	Urban (not London)
4	A13 Westbound On-Slip	Motorway (not London)
5	A13 Eastbound Off-Slip	Motorway (not London)
6	A13 Eastbound On-Slip	Motorway (not London)

[7] The project transport consultant has confirmed that HDVs include heavy goods vehicles (HGVs), buses and coaches. For the purposes of the traffic surveys, HGVs are classified as vehicles greater than 5.5m. Therefore, this will include heavy goods vehicles, buses and coaches but excludes cars towing trailers/caravans
[8] https://laqm.defra.gov.uk/documents/EFTv7.0-user-guide-v2.0.pdf
[9] The EFT recommends that the M25 should be classified as a “London Motorway”, however a check was made to confirm it is more conservative to classify it simply as “Motorway (not London)”
[10] http://naei.beis.gov.uk/resources/rtp_fleet_projection_Base2013_v3.0_final.xlsx

7	A1089 North of A126 Slips	Motorway (not London)
8	A1089 North of ASDA Rbt	Motorway (not London)
9	A1089 St Andrews Rd North of Gate 1	Motorway (not London)
10	A1089 Ferry Road - North of Proposed Link Road	Motorway (not London)
11	A1089 Ferry Road - South of Proposed Link Road	Motorway (not London)
12	Fort Road - South of Site Access	Urban (not London)
13	Fort Road - North of Brennan Road	Urban (not London)
14	Site Access	Urban (not London)
15	Proposed Link Road	Motorway (not London)
16	A13 East of M25 Jct 30	Motorway (not London)
17	A13 West of M25 Jct 30	Motorway (not London)
18	M25 North of Jct 30	Motorway (not London)
19	M25 South of Jct 30	Motorway (not London)
20	Dock Road	Urban (not London)
21	Calcutta Road	Urban (not London)
22	A13 East of A126 Interchange to A1012	Motorway (not London)
23	Arterial Rd North Stifford from B186 to Long Ln roundabout	Urban (not London)
24	A1013 Stanford Rd from Daneholes roundabout to A1014	Rural (not London)
25	Fort Road - Between Brennan Road and the Site Access	Urban (not London)

The emission rates are not modelled as constant throughout the day. Instead they are factored within ADMS to account for diurnal and weekday variations in traffic flow. Each modelled road link was assigned a unique time-varying profile to factor emissions throughout the day and day of week. This was determined by the project traffic consultants using Automatic Traffic Count (ATC) data for each link for each hour of the day. A profile for weekdays, Saturday and Sunday was produced for each link using the average hourly flow divided by the total flow over the 7-day period.

18.C.3 Rail emissions

The emission rate for the proposed rail link was estimated using the anticipated number of locomotives per day and emission rates for locomotives from the National Atmospheric Emissions Inventory (NAEI). A conservative assumption that all locomotives would be Class 66 has been made. This locomotive class has the highest emission rate of NO_x of all the rail freight locomotives listed on NAEI.

Emission rates assumed per Class 66 locomotive are presented inTable 18.31.

Table 18.30 Assumed NAEI rail freight emission factors per locomotive

Pollutant	Emission Rate (g/km)
NO_x	387.5
PM_{10}	5.1
$PM_{2.5}$*	3.6
***** NAEI does not provide $PM_{2.5}$ emission rates for rail freight locomotives, therefore the fraction of PM_{10} that is $PM_{2.5}$ has been estimated using the EfT for a comparative Euro III Articulated HGV. The fraction of PM_{10} that is $PM_{2.5}$ of a Euro III Articulated HGV operating at 96 kph is 0.71.	

Due to the limited information at this stage on the timing of locomotive movements during the day, a constant emission rate throughout the day has been modelled for the rail link.

18.C.4 Meteorological and Surface Data

Hourly sequential meteorological data for Gravesend meteorological station for the year 2016 was used in the model. The Gravesend meteorological station is located approximately 3.7 kilometres west of the study area. The wind rose for Gravesend meteorological station (presented in Graph 18.5 and Table 18.31below) identified that the dominant wind direction for 2016 was from the south west.

In accordance with DEFRA guidance, data for the year 2016 were used in the model to be consistent with the baseline for traffic and air quality monitoring data. The local monitoring data suggests that 2016 was a poor year for air pollution dispersion thus providing a conservative assessment.

The parameters required by the ADMS model include: date, time, wind direction (angle wind is blowing from), wind speed (at 10 metres above ground level), surface air temperature (degrees Celsius), and cloud cover (oktas – or eighths of sky covered).

Graph Error! No text of specified style in document..5 Wind Rose Diagram for Gravesend (Broadness), 2016

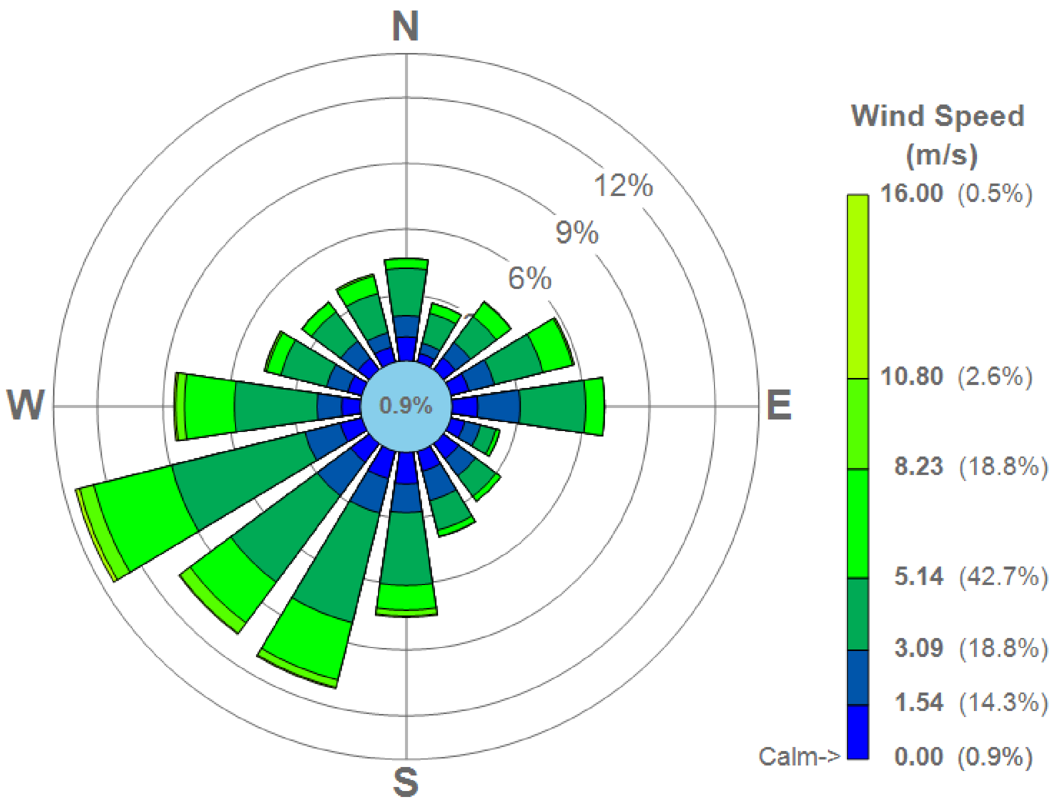


Table 18.31 Relative Frequency Distribution of Wind Speed and Direction, (%)

Direction	Degree	Wind speed (m/s)						
		< 1.54	1.54 - 3.09	3.09 - 5.14	5.14 - 8.23	8.23 - 10.8	> 10.8	Total
N	0.0	1.09	0.97	2.15	0.44	0.00	0.00	4.66
NNE	22.5	0.41	0.48	1.41	0.47	0.00	0.00	2.77
NE	45.0	0.69	0.85	1.47	0.82	0.03	0.00	3.87
ENE	67.5	0.84	1.21	2.28	1.39	0.08	0.00	5.79
E	90.0	1.16	1.92	3.01	0.85	0.01	0.00	6.96
ESE	112.5	0.66	0.73	0.73	0.19	0.00	0.00	2.31
SE	135.0	0.87	0.97	1.16	0.27	0.00	0.00	3.27
SSE	157.5	0.93	1.39	1.39	0.30	0.01	0.01	4.03
S	180.0	1.43	1.30	3.32	1.13	0.27	0.06	7.51
SSW	202.5	1.29	1.62	5.16	2.70	0.35	0.06	11.17
SW	225.0	1.06	1.90	4.92	2.31	0.59	0.05	10.83

WSW	247.5	1.01	1.66	6.27	3.65	0.67	0.19	13.47
W	270.0	0.85	1.13	3.77	2.28	0.40	0.09	8.52
WNW	292.5	0.65	1.00	2.15	0.67	0.10	0.02	4.60
NW	315.0	0.66	0.97	1.66	0.54	0.02	0.00	3.85
NNW	337.5	0.71	0.67	1.84	0.82	0.09	0.00	4.13
Total		14.32	18.76	42.69	18.83	2.64	0.48	97.72
Calms								0.88
Missing								1.40
Total								100.00

The latitude entered to the model was 51.5 degrees. This determines times of sunrise and sunset for each day throughout the year, which in turn affects atmospheric stability calculations.

Surface roughness coefficients for the air quality study area were defined as 0.5 metres (representative of parkland and open suburbia). The surface roughness is important in the approximation of turbulent conditions within the atmospheric boundary layer and thus in the estimation of pollutant concentrations at receptors.

Minimum Monin-Obukhov length (to reasonably limit the occurrence of very stable atmospheric conditions) was defined as 30 metres at both the meteorological site and at the dispersion site (representative of a mixed urban/industrial setting). This parameter limits the occurrence of very stable boundary layer conditions (i.e. when the air is still) to a degree that is appropriate to the general land-use. In general, the potential for very stable conditions is lowest in large urban areas where the 'heat island' effect promoting turbulent motion in the boundary layer is strongest.

18.C.5 Model Receptors

Table 18.32 presents the human health receptors included in the ADMS model and their distance to the nearest modelled road. The locations of these receptors are illustrated in Figure 18.2.

Table 18.32 Human Health Receptors included in the Air Dispersion Model

ID	Description	Local Authority	Distance to road centre (metres)	Grid Reference	
				Easting	Northing
R1	The Thurrock Hotel, Ship Lane, Aveley, Purfleet	Thurrock Borough Council	73.8	557439	179107
R2	54 Gatehope Drive, South Ockendon	Thurrock Borough Council	130.6	557597	181084
R3	Stifford Clays Farmhouse Hotel, Stifford Clays Road, North Sitfford, Orsett, Grays	Thurrock Borough Council	59.8	561350	180920
R4	21 Gammon Field, Long Lane, Grays	Thurrock Borough Council	32.6	563478	180584
R5	6 Baker Street, Orsett, Grays	Thurrock Borough Council	45.9	563560	180866

ID	Description	Local Authority	Distance to road centre (metres)	Grid Reference	
				Easting	Northing
R6	Murrells Cottages, Stanford Road, Orsett, Grays	Thurrock Borough Council	21.2	564894	181056
R7	Heath Farm Cottages, Farm Road, Orsett Grays	Thurrock Borough Council	31.6	563889	179678
R8	42 Salix Road, Grays, Essex	Thurrock Borough Council	88.2	563101	177478
R9	16 Dock Road, Tilbury	Thurrock Borough Council	12.2	563461	176521
R10	8 Nairn Court, Dock Road, Tilbury	Thurrock Borough Council	13.6	563911	176123
R11	8 Dock Road, Tilbury	Thurrock Borough Council	85.5	564314	175875
R12	1 - 4 Hume Close, Tilbury	Thurrock Borough Council	96.0	564434	175856
R13	Ivydene, Sandhurst Road, Tilbury	Thurrock Borough Council	44.7	565181	176256
R14	138 London Road, Tilbury	Thurrock Borough Council	30.0	565039	176156
R15	191 Brennan Road, Tilbury	Thurrock Borough Council	12.8	565339	176504
R16	26 Bown Close, Tilbury	Thurrock Borough Council	75.2	564701	175973
R17	46 Brunel Close, Tilbury	Thurrock Borough Council	61.2	564617	175897
R18	William Edwards School and Sports College, Stifford Clays Road, Grays	Thurrock Borough Council	120.8	562008	180949
R19	St Mary's Roman Catholic Primary School, Calcutta Road, Tilbury	Thurrock Borough Council	10.9	563904	176281
R20	The Barn & Coach House, High Road, North Stifford, Grays	Thurrock Borough Council	195.9	560604	180416
R21	Lydden, Clockhouse Lane, North Stifford, Grays	Thurrock Borough Council	35.6	560035	179870
R22	12 The Caravan Site, Ship Lane, Aveley, Purfleet, South Ockendon	Thurrock Borough Council	200.3	556895	179284
R23	191 Purfleet Road, Aveley, Purfleet, South Ockendon	Thurrock Borough Council	48.9	555379	179902
R24	Kemps Cottage, Dennises Lane, South Ockendon	Thurrock Borough Council	77.8	558144	183519
R25	Talford, Horndon Road, Hordon on the Hill, Stanford-le-Hope	Thurrock Borough Council	32.6	567446	182119
R26	Medina, Dennises Lane, Upminster, South Ockendon	London Borough of Havering	185.3	558009	184058
R27	Treetops School, Buxton Road, Grays, Essex	Thurrock Borough Council	65.7	563778	179720

Table 18.33 presents the ecological receptors included in the ADMS model and their distance to the nearest modelled road. The locations of these receptors are illustrated in Figure 18.2.

Table 18.33 Ecological Receptors included in the Air Dispersion Model

ID	Description	Grid Reference	
		Easting	Northing
E1	0m from Redline Boundary	564841	175914
E2	10m from Redline Boundary	564846	175907
E3	20m from Redline Boundary	564852	175898
E4	30m from Redline Boundary	564858	175890
E5	50m from Redline Boundary	564870	175874
E6	100m from Redline Boundary	564900	175834
E7	150m from Redline Boundary	564929	175793
E8	200m from Redline Boundary	564958	175753
E9	45m from Fort Road Edge	564968	175709
E10	30m from Fort Road Edge	564971	175694
E11	20m from Fort Road Edge	564973	175684
E12	10m from Fort Road Edge	564975	175674
E13	0m in Mitigation Area	565968	176472
E14	10m in Mitigation Area	565975	176479
E15	20m in Mitigation Area	565982	176486
E16	30m in Mitigation Area	565989	176493
E17	50m in Mitigation Area	566003	176507
E18	100m in Mitigation Area	566039	176542
E19	150m in Mitigation Area	566074	176578
E20	200m in Mitigation Area	566109	176613

18.C.6 Estimation of total concentrations

The modelled results are output from the model as road-derived increments to annual mean concentrations of NO_x, PM_{10} and $PM_{2.5}$.

In order to derive total NO_2 concentrations from modelled road concentrations the method described in DEFRA's Technical Guidance LAQM.TG(16) was used. This requires the road-increment to be combined with a background concentration. The unadjusted mapped background in the study area is shown in Table 18.34.

Table 18.34 DEFRA Mapped Background Concentrations - Unadjusted

Grid Reference	2016				2019				2020			
	NO_x	NO_2	PM_{10}	$PM_{2.5}$	NO_x	NO_2	PM_{10}	$PM_{2.5}$	NO_x	NO_2	PM_{10}	$PM_{2.5}$
554500,180500	30.0	20.3	18.3	12.8	24.7	17.2	17.8	12.3	23.0	16.1	17.7	12.2
555500,179500	32.5	21.9	18.7	13.1	26.8	18.5	18.2	12.6	24.9	17.4	18.0	12.5

Grid Reference	2016				2019				2020			
	NO_x	NO_2	PM_{10}	$PM_{2.5}$	NO_x	NO_2	PM_{10}	$PM_{2.5}$	NO_x	NO_2	PM_{10}	$PM_{2.5}$
555500,180500	38.1	24.5	17.8	12.6	33.5	22.0	17.3	12.1	32.0	21.2	17.1	12.0
556500,179500	33.3	22.4	19.8	13.7	27.4	18.9	19.2	13.2	25.4	17.7	19.1	13.0
557500,177500	36.4	24.1	20.8	14.3	29.8	20.3	20.2	13.8	27.6	19.0	20.0	13.6
557500,178500	39.8	25.9	19.8	13.9	32.7	21.9	19.2	13.3	30.3	20.6	19.0	13.1
557500,179500	38.4	25.3	19.5	13.7	30.9	21.0	18.9	13.1	28.4	19.6	18.7	12.9
557500,180500	34.9	23.3	18.6	13.1	28.3	19.5	18.1	12.6	26.1	18.2	17.9	12.4
557500,181500	29.9	20.4	18.4	12.8	24.6	17.2	17.9	12.4	22.8	16.1	17.7	12.2
557500,182500	28.0	19.2	17.9	12.5	23.0	16.2	17.4	12.0	21.4	15.2	17.2	11.9
557500,183500	23.0	16.1	17.4	12.1	19.4	13.9	16.9	11.7	18.2	13.1	16.8	11.6
558500,179500	36.9	24.4	19.3	13.6	30.2	20.6	18.8	13.1	27.9	19.3	18.6	12.9
558500,180500	28.1	19.3	17.7	12.5	23.5	16.5	17.3	12.1	21.9	15.5	17.1	12.0
558500,183500	25.6	17.8	19.1	12.8	21.2	15.0	18.6	12.4	19.7	14.1	18.5	12.3
558500,184500	26.6	18.4	18.5	12.8	21.7	15.3	18.0	12.3	20.1	14.3	17.8	12.2
558500,185500	27.6	19.0	18.5	12.8	22.4	15.8	18.0	12.3	20.6	14.7	17.9	12.2
559500,179500	33.8	22.6	19.3	13.5	27.8	19.2	18.8	13.0	25.9	18.0	18.6	12.9
560500,179500	31.6	21.3	19.1	13.4	26.3	18.2	18.6	12.9	24.5	17.2	18.4	12.7
560500,180500	27.4	18.9	18.1	12.6	22.8	16.1	17.6	12.2	21.3	15.1	17.5	12.0
561500,180500	28.6	19.6	18.5	12.9	23.8	16.7	18.0	12.5	22.1	15.7	17.9	12.3
561500,181500	22.5	15.9	18.5	12.7	19.0	13.7	18.1	12.3	17.9	12.9	18.0	12.1
562500,180500	25.3	17.6	17.4	12.3	21.3	15.1	17.0	11.9	20.0	14.3	16.8	11.7
562500,181500	26.6	18.4	19.3	13.2	22.2	15.7	18.9	12.8	20.7	14.8	18.7	12.6
563500,176500	24.6	17.0	16.5	11.7	21.2	15.0	16.0	11.4	20.1	14.3	15.9	11.2
563500,177500	22.8	16.0	17.9	12.4	19.4	13.8	17.5	12.1	18.2	13.1	17.3	11.9
563500,178500	25.0	17.4	17.8	12.5	21.0	14.9	17.3	12.1	19.7	14.1	17.2	11.9
563500,179500	24.9	17.3	17.4	12.2	20.9	14.8	16.9	11.8	19.6	14.0	16.8	11.7
563500,180500	30.0	20.5	18.8	13.0	24.8	17.4	18.3	12.6	23.1	16.3	18.1	12.4
563500,181500	23.3	16.3	17.1	12.1	19.7	14.1	16.7	11.7	18.5	13.3	16.5	11.5
564500,175500	23.0	16.0	15.4	11.1	20.2	14.3	14.9	10.8	19.2	13.7	14.8	10.6
564500,176500	24.9	17.2	15.8	11.5	21.6	15.2	15.4	11.1	20.5	14.5	15.3	11.0
564500,180500	26.3	18.2	18.0	12.6	22.1	15.6	17.6	12.2	20.7	14.8	17.4	12.0
564500,181500	24.9	17.4	17.1	12.1	21.0	14.9	16.6	11.7	19.8	14.1	16.5	11.5
565500,175500	21.8	15.3	15.0	10.9	19.5	13.8	14.6	10.6	18.7	13.3	14.4	10.4
565500,176500	21.1	14.9	15.8	11.4	18.5	13.3	15.4	11.0	17.7	12.7	15.3	10.9
565500,181500	28.3	19.4	18.7	13.0	23.6	16.6	18.3	12.5	22.0	15.6	18.1	12.4
566500,181500	27.4	18.9	18.1	12.6	23.1	16.3	17.7	12.2	21.6	15.4	17.5	12.0
567500,181500	21.9	15.5	16.4	11.6	18.9	13.5	16.0	11.2	17.8	12.9	15.8	11.1
567500,182500	27.6	19.0	18.3	12.7	23.3	16.4	17.8	12.3	21.8	15.5	17.7	12.2
568500,182500	25.2	17.5	16.8	12.0	21.6	15.3	16.4	11.6	20.4	14.5	16.3	11.5

The suitability of the use of the unadjusted DEFRA background mapped data for nitrogen dioxide was investigated by comparing the 2016 annual mean concentration measured at Thurrock Council's TK1 urban background CMS with the corresponding mapped DEFRA mapped background concentration for that grid square. This comparison, shown below in Table 18.35, indicates that the DEFRA mapped estimate substantially underestimates background concentrations in the local area, and thus an uplift factor of 1.66 was applied to all mapped background concentrations of nitrogen dioxide used in the assessment.

A similar comparison undertaken for annual mean PM_{10} showed good agreement (±10%) between the monitored and mapped concentrations at the TK1 CMS. Therefore mapped background concentrations of PM_{10} (and $PM_{2.5}$) were not adjusted in the same manner as for nitrogen dioxide.

Table 18.35 Comparison of DEFRA mapped background with CMS data

Site ID	CMS X, Y	Grid Square X, Y	Pollutant	2016 Mapped Background	2016 Measured Background	% Difference	Factor
TK1	561066, 177894	561500, 177500	NO_2	16.9	28.0	-40%	1.66
			PM_{10}	16.3	17.0	-4%	-

To avoid double counting of emissions, the background data used in an assessment must not include the influenced of sources explicitly modelled. For this reason, adjustment of mapped data was undertaken; in this case, the component attributable to main modelled roads i.e. motorways and trunk /A-roads (those included in the model) were removed.

As the majority of motorway and trunk / A-roads have been included in the model, the DEFRA mapped concentrations have been adjusted as described above to avoid double counting when processing model results. The following sectors were removed from all grid squares used in the calculation of total concentrations:

- Motorway in square;
- Motorway out square;
- Trunk A-Road in square; and
- Trunk A-Road out square.

In addition, the Primary A-Road in square component was removed from the grid squares which contain model links 23 and 24 (these road links were added to improve model performance using publicly available data obtained from the DfT).

For NO_2, concentrations must then be recalculated using DEFRA's NO_2 Adjustment for NO_x Sector Removal Tool (currently version 5.1, October 2016)[11]. This adjustment is undertaken prior to adjusting the DEFRA mapped concentrations for any underestimation (as described above).

Further analysis of the DEFRA mapped 1 km grid square concentrations showed that there was a steep gradient between adjacent grid squares in some areas of the model. To avoid the possibility that background concentrations may not be accurately reflected at receptors located at the confluence of several grid squares, where broadly urban and rural areas meet, the DEFRA mapped concentrations for

[11] Available at: https://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxNO2calc

those receptors located within 200 m of an adjacent grid square were averaged to obtain a more representative background concentration.

The sector removal and averaging across grid squares was undertaken for NO_2, PM_{10} and $PM_{2.5}$ to obtain a background that is more representative of concentrations in the study area. Additionally, the adjustment factor derived from the background map comparison () was applied to the averaged, sector removed background NO_2 concentration.

The road-traffic components of nitrogen oxides and nitrogen dioxide in the DEFRA background maps have been uplifted to derive future year background concentrations. Details of the approach are provided in the report prepared by AQC (2016c)[12]. The adoption of this approach was agreed in consultation with the Thurrock EHO.

The final, fully adjusted background concentrations used to calculate total concentrations at each receptor in the assessment are presented in Table 18.36.

Total annual mean NO_2 concentrations are calculated from modelled road NO_x (verified and adjusted if necessary) and background NO_2 concentrations, using the latest version of the 'NO_x to NO_2 conversion spreadsheet' (version 5.1) available from the DEFRA UK-AIR website.

The DEFRA NO_x to NO_2 conversion tool requires the local authority to be specified to determine regional oxidant concentrations and a traffic mix to determine the proportion of primary NO_2. The local authority is "Thurrock" and the year set is 2016 (baseline), 2019 (construction) or 2020 (operation).

The traffic mix for each location is set based on the classification of the nearest modelled road:

- Motorway (not London) - All non-urban UK traffic;
- Urban (not London) - All other urban UK traffic; and
- Rural (not London) - All non-urban UK traffic.

Table 18.36 Adjusted DEFRA Mapped Background Concentrations

ID	Grid Reference	No. Grid Squares within 200m	2016				2019				2020			
			NO_x	NO_2	PM_{10}	$PM_{2.5}$	NO_x	NO_2	PM_{10}	$PM_{2.5}$	NO_x	NO_2	PM_{10}	$PM_{2.5}$
GDSO	557595, 181055	2	20.4	14.4	18.2	12.7	18.4	13.2	17.8	12.3	17.7	12.7	17.7	12.2
NAS2	559721, 179626	1	24.1	16.8	19.1	13.3	21.7	15.3	18.7	12.9	20.9	14.8	18.5	12.8
WES	561960, 180962	4	19.9	14.2	18.3	12.6	17.9	12.9	17.9	12.3	17.2	12.4	17.8	12.2
TL	563866, 176290	2	22.4	15.7	16.1	11.6	20.4	14.4	15.7	11.2	19.7	14.0	15.5	11.1
TILA	563501, 176485	1	21.7	15.2	16.4	11.7	19.7	14.0	16.0	11.3	19.0	13.6	15.8	11.2
TILB	563643, 176346	1	21.7	15.2	16.4	11.7	19.7	14.0	16.0	11.3	19.0	13.6	15.8	11.2
TILC	563600, 176325	1	21.7	15.2	16.4	11.7	19.7	14.0	16.0	11.3	19.0	13.6	15.8	11.2

[12] Air Quality Consultants Ltd. (AQC 2016c). Adjusting Background NO_2 Maps for CUREDV2A, [Online], Available at: http://www.aqconsultants.co.uk/getattachment/Resources/Download-Reports/Adjusting-Background-NO2-Maps-for-CURED-September-2016.pdf.aspx.

ID	Grid Reference	No. Grid Squares within 200m	2016				2019				2020			
			NO_x	NO_2	PM_{10}	$PM_{2.5}$	NO_x	NO_2	PM_{10}	$PM_{2.5}$	NO_x	NO_2	PM_{10}	$PM_{2.5}$
TILD	563993, 176295	2	22.4	15.7	16.1	11.6	20.4	14.4	15.7	11.2	19.7	14.0	15.5	11.1
TILE	563870, 176308	2	22.4	15.7	16.1	11.6	20.4	14.4	15.7	11.2	19.7	14.0	15.5	11.1
TK4	563900, 176282	2	22.4	15.7	16.1	11.6	20.4	14.4	15.7	11.2	19.7	14.0	15.5	11.1
TK4_AB	563900, 176282	2	22.4	15.7	16.1	11.6	20.4	14.4	15.7	11.2	19.7	14.0	15.5	11.1
LYD*	560037, 179867	4	21.5	15.8	18.1	12.6	19.3	13.8	17.7	12.3	19.5	13.3	17.6	12.2
TSR	564121, 176156	4	21.3	15.0	15.7	11.3	19.3	13.7	15.3	10.9	18.6	13.3	15.1	10.8
KCNO	558148, 183533	2	18.2	13.0	18.1	12.3	16.3	11.8	17.7	12.0	15.7	11.4	17.6	11.9
IBIS	557570, 177789	1	23.2	16.2	20.4	13.9	20.8	14.7	20.0	13.6	20.0	14.2	19.9	13.5
PKSL*	567781, 182400	1	20.3	18.3	18.1	12.5	18.3	13.2	17.7	12.2	22.8	12.7	17.6	12.1
R1	557439, 179107	2	24.6	17.0	19.3	13.4	22.1	15.5	18.8	13.0	21.2	14.9	18.7	12.9
R2	557597, 181084	2	20.4	14.4	18.2	12.7	18.4	13.2	17.8	12.3	17.7	12.7	17.7	12.2
R3	561350, 180920	2	19.5	13.9	18.4	12.6	17.5	12.6	18.0	12.3	16.8	12.2	17.9	12.2
R4*	563478, 180584	1	20.5	18.1	18.5	12.8	18.5	13.3	18.1	12.4	22.4	12.8	18.0	12.3
R5*	563560, 180866	2	20.2	16.1	17.8	12.4	18.2	13.1	17.4	12.0	19.8	12.6	17.3	11.9
R6*	564894, 181056	4	19.7	16.2	17.4	12.2	17.7	12.8	17.1	11.8	19.8	12.3	16.9	11.7
R7	563889, 179678	2	20.9	14.8	16.8	11.9	18.8	13.5	16.4	11.5	18.1	13.0	16.2	11.4
R8	563101, 177478	2	20.8	14.7	17.0	12.0	18.8	13.4	16.6	11.7	18.1	13.0	16.4	11.6
R9	563461, 176521	1	21.7	15.2	16.4	11.7	19.7	14.0	16.0	11.3	19.0	13.6	15.8	11.2
R10	563911, 176123	4	21.3	15.0	15.7	11.3	19.3	13.7	15.3	10.9	18.6	13.3	15.1	10.8
R11	564314, 175875	2	22.2	15.6	15.6	11.3	20.2	14.3	15.1	10.9	19.5	13.9	15.0	10.8
R12	564434, 175856	2	22.2	15.6	15.6	11.3	20.2	14.3	15.1	10.9	19.5	13.9	15.0	10.8
R13	565181, 176256	2	21.4	15.0	15.8	11.4	19.4	13.8	15.4	11.0	18.8	13.4	15.2	10.9
R14	565039, 176156	4	21.1	14.8	15.5	11.2	19.2	13.7	15.1	10.8	18.6	13.3	14.9	10.7
R15	565339, 176504	1	19.6	13.9	15.8	11.3	17.9	12.8	15.4	11.0	17.3	12.5	15.2	10.9
R16	564701, 175973	2	22.2	15.6	15.6	11.3	20.2	14.3	15.1	10.9	19.5	13.9	15.0	10.8
R17	564617, 175897	2	22.2	15.6	15.6	11.3	20.2	14.3	15.1	10.9	19.5	13.9	15.0	10.8
R18	562008, 180949	4	19.9	14.2	18.3	12.6	17.9	12.9	17.9	12.3	17.2	12.4	17.8	12.2
R19	563904, 176281	2	22.4	15.7	16.1	11.6	20.4	14.4	15.7	11.2	19.7	14.0	15.5	11.1
R20	560604, 180416	1	20.0	14.2	17.9	12.4	18.0	12.9	17.5	12.1	17.3	12.5	17.4	12.0
R21	560035, 179870	4	22.6	15.8	18.1	12.7	20.3	14.4	17.7	12.3	19.5	13.9	17.6	12.2
R22	556895, 179284	2	22.1	15.5	19.2	13.3	19.8	14.1	18.9	13.0	19.0	13.6	18.8	12.8
R23	555379, 179902	2	28.4	19.1	18.0	12.6	25.9	17.7	17.6	12.3	25.0	17.1	17.5	12.1
R24	558144, 183519	2	18.2	13.0	18.1	12.3	16.3	11.8	17.7	12.0	15.7	11.4	17.6	11.9
R25*	567446, 182119	2	19.7	16.6	17.2	12.0	17.8	12.8	16.8	11.7	20.4	12.4	16.7	11.6
R26	558009, 184058	4	18.3	13.1	17.7	12.2	16.5	11.9	17.3	11.8	15.8	11.5	17.2	11.7
R27	563778, 179720	1	21.2	15.0	17.3	12.1	19.0	13.6	16.9	11.8	18.3	13.2	16.7	11.7
DT1	563948, 179146	4	21.2	15.0	16.8	11.9	19.0	13.6	16.4	11.6	18.3	13.1	16.3	11.5
DT2	563979, 179144	4	21.2	15.0	16.8	11.9	19.0	13.6	16.4	11.6	18.3	13.1	16.3	11.5
DT3	564012, 179142	4	21.2	15.0	16.8	11.9	19.0	13.6	16.4	11.6	18.3	13.1	16.3	11.5
DT4	563890, 179670	2	20.9	14.8	16.8	11.9	18.8	13.5	16.4	11.5	18.1	13.0	16.2	11.4
DT5*	560047, 179882	4	21.5	15.8	18.1	12.6	19.3	13.8	17.7	12.3	19.5	13.3	17.6	12.2
DT6*	560040, 179919	4	21.5	15.8	18.1	12.6	19.3	13.8	17.7	12.3	19.5	13.3	17.6	12.2
DT7*	560036, 179950	4	21.5	15.8	18.1	12.6	19.3	13.8	17.7	12.3	19.5	13.3	17.6	12.2

ID	Grid Reference	No. Grid Squares within 200m	2016				2019				2020			
			NO_x	NO_2	PM_{10}	$PM_{2.5}$	NO_x	NO_2	PM_{10}	$PM_{2.5}$	NO_x	NO_2	PM_{10}	$PM_{2.5}$
DT8	565197, 176296	2	21.4	15.0	15.8	11.4	19.4	13.8	15.4	11.0	18.8	13.4	15.2	10.9
DT9	565028, 176159	4	21.1	14.8	15.5	11.2	19.2	13.7	15.1	10.8	18.6	13.3	14.9	10.7
DT10	563860, 179147	3	21.1	14.9	17.1	12.0	19.0	13.6	16.7	11.7	18.2	13.1	16.5	11.6

* Additional Primary A-road in-square sector removed

18.D MODEL VERIFICATION

The comparison of modelled concentrations with local monitored concentrations is a process termed 'verification'. Model verification identifies any discrepancies between modelled and measured concentrations, which can arise for a range of reasons. The following are examples of potential causes of such discrepancies:

- Estimates of background pollutant concentrations;
- Meteorological data uncertainties;
- Traffic data uncertainties;
- Emission factor uncertainties;
- Model input parameters, such as 'roughness length'; and
- Overall limitations of the ability of the dispersion model to model dispersion in a complex urban environment.

The verification process involves a review of the modelled pollutant concentrations against corresponding monitoring data to determine how well the air quality model has performed. Depending on the outcome it may be considered that the model has performed adequately and that there is no need to adjust any of the modelled results.

Alternatively, the model may perform poorly[13] against the monitoring data, as a result there is a need to check all the input data to ensure that it is reasonable and accurately represented in the air quality modelling process. Where all input data, such as traffic data, emissions rates and background concentrations have been checked and considered reasonable, then the modelled results may require adjustment to best align them with the monitoring data. This may be either a single verification adjustment factor to be applied to the modelled concentrations across the study area or a range of different adjustment factors to account for the different situations within the study area.

18.D.1 Residual Uncertainty

Residual uncertainty may remain after systematic error or 'overall model accuracy' has been accounted for in the final predictions. Residual uncertainty may be considered synonymous with the 'residual inaccuracies' of the mode predictions, i/e/ how wide the scatter or residual variability of the predicted values compare with the monitored 'true value', once systematic error has been allowed for. The quantification of final model accuracy provides an estimate of how the final predictions may deviate from the 'true' (monitored) values at the same location over the same period. It must be recognised though that some of the residual uncertainty will be down to uncertainties in the monitored values. This uncertainty is greater for monitoring using diffusion tubes than for automatic monitors.

Suitable local monitoring data for the purpose of verification is available for concentrations of NO_2 at the locations shown in Table 18.39. This monitoring data

[13] The acceptable limits of model verification performance are set out in DEFRA's Local Air Quality Management Technical Guidance (2016) (LAQM.TG(16))

has been used to validate the dispersion model prediction and obtain adjustment factors which can be applied to predictions of pollutant concentrations in the base and future years.

18.D.2 Model Performance

An evaluation of model performance has been undertaken to establish confidence in model results. LAQM.TG(16) identifies a number of statistical procedures that are appropriate to evaluate model performance and assess the uncertainty. The statistical parameters used in this assessment are:

- Root mean square error (RMSE);
- Fractional bias (FB); and
- Correlation coefficient (CC).

A brief explanation of each statistic is provided in Table 18.36; further details can be found in LAQM.TG(16) Box 7.17.

Table 18.37 Statistical Parameters used to estimate model performance

Statistical Parameter	Comments	Ideal Value
CC	Used to measure the linear relationship between predicted and observed data. A value of zero means no relationship and a value of 1 means absolute relationship.	1.00
RMSE	Defines the average error or uncertainty of the model. The units of RMSE are the same as the quantities compared. If the RMSE values are higher than 25% of the objective being assessed, it is recommended that the model inputs and verification should be revisited in order to make improvements. For example, if the model predictions are for the annual mean NO_2 objective of 40 µg/m^3, if an RMSE of 10 µg/m^3 or above is determined for a model it is advised to revisit the model parameters and model verification. Ideally an RMSE will be within 10% of the air quality objective, i.e. ±4 µg/m^3 for the annual mean NO_2 objective.	0.01
FB	Used to identify if the model shows a systematic tendency to over or under predict. FB values vary between +2 and -2 and have an ideal value of zero. Negative values suggest a model over-prediction and positive values suggest a model under-prediction.	0.00

These parameters estimate how the model results agree or diverge from the observations. These calculations have been carried out prior to, and after, adjustment and provide information on the improvement of the model predictions as a result of the application of the verification adjustment factors.

18.D.3 Air Quality Monitoring Data

The verification method following the process detailed in LAQM.TG(16). Both passive and CMS monitoring sites within 200 metres of the ARN were used. The air quality monitoring data collected as part of this assessment (Appendix 18.2) were firstly reviewed to determine the suitability of each of the monitoring locations within the model verification process. The criteria used to determine the suitability of the monitoring sites were:

- Within reasonable proximity (~ 50m) to modelled road links;
- Diffusion tube monitoring data for 2016 with greater than 75% data capture;
- Automatic monitoring data for 2016 with greater than 90% data capture;

Monitoring sites were excluded if major sources that may influence monitored concentrations but could not be included in the ADMS modelling (such as large car parks, industrial stacks etc.). Sites where the location of the monitoring could not be confirmed to a satisfactory standard were also omitted from the verification.

A total of one CMS and fifteen diffusion tube monitoring sites in the air quality study area were considered suitable for use in the verification exercise. From the full network of NO_2 diffusion tubes available, only those representative of selected sensitive receptor locations and with sufficient data capture were included.

Following the detailed analysis of each viable monitoring location, a total of ten diffusion tubes and one automatic monitoring site were taken forward and used in the model verification exercise. Those sites not used in verification are shown Table 18.38

Table 18.38 Diffusion tube sites excluded from model verification

Site ID	X	Y	Reason for exclusion from verification
IBIS	557570	177789	Close to an unmodeled junction off the M25.
NAS2	559721	179625	Excluded in favour of a diffusion tube site located closer to the modelled road link.
WES	561960	180961	Located too far from A13 modelled road link.
TK4_AB	563900	176282	Co-located with the CMS TK4 which is included in verification.
TSR	564121	176156	Determined to be an urban background site too far from modelled road links.

Comparison of Total NO_2

Unadjusted modelled estimates of total annual mean NO_2 concentrations were first compared against measured annual mean NO_2 at each monitoring site. Out of eleven comparisons, eight modelled estimates were within ± 25% of monitored concentrations without adjustment, as shown in Table 18.39. Substantial underestimates of more than -25% were found at sites TILA and TILB whilst overestimates were found at sites PKSL, LYD (more than 25%) KCNO and GDSO. At only one of the sites, KCNO, is the modelled estimate within ±10% of the measurement.

Table 18.39 Comparison of Unadjusted Modelled and Measured NO_2 Concentrations (µg/m^3)

Site ID	Measured NO_2	Modelled Total NO_2	Modelled - Measured	Modelled / Measured	% Difference
TL	35.7	28.3	-7.4	0.8	-21%
TILA	40.8	29.2	-11.6	0.7	-28%
TILB	39.7	28.7	-11.1	0.7	-28%
TILC	39.0	29.9	-9.1	0.8	-23%
TILD	36.9	28.8	-8.0	0.8	-22%
TILE	34.9	28.8	-6.1	0.8	-17%
TK4	33.0	28.3	-4.8	0.9	-14%
PKSL	29.0	34.3	5.3	1.2	18%
LYD	30.8	40.7	10.0	1.3	32%
KCNO	32.8	35.2	2.4	1.1	7%
GDSO	28.9	33.6	4.7	1.2	16%

Comparing unadjusted modelled estimates of NO_2 to measured concentrations, the RMSE is 7.82 µg/m^3, which is within the target value according to DEFRA's Technical Guidance LAQM.TG(16) of not more than 25% of the 40 µg/m^3 objective. An ideal RMSE is within 10% of the objective, which equates to 4 µg/m^3 for annual mean NO_2. The performance of the unadjusted model overall is therefore acceptable but not ideal.

Overall, the unadjusted model tends to underestimate total concentrations of NO_2, as indicated by a fractional bias value of 0.10.

Comparison of Road NO_x

The second round of verification compared modelled estimates of road contributed annual mean NO_x with the road NO_x component derived from monitoring data. This comparison is presented in **Error! Reference source not found.**18.40. Since diffusion tubes only measure NO_2 and do not directly measure NO_x the measured road NO_x component must be estimated. This was performed using the DEFRA NO_2 to NO_x calculator, (version 5.1, June 2016).

The unadjusted modelled road NO_x both underestimates and overestimates measured concentrations by -78% to 191%. This suggests that the model results should be adjusted.

Further examination shows that the data can be divided into distinct groups. In accordance with LAQM.TG(16) such an approach can be used to improve the verification process. Three groups of sites were designated: those within Tilbury, where local NO_2 concentrations are likely to have been derived from the built-up area; and those within the A13 and M25 corridors, where the contribution to background NO_2 concentrations is likely almost solely derived from either A-road or motorway emissions.

Table 18.40 Comparison of Modelled and Measured NO_x Concentrations ($\mu g/m^3$)

Site ID	Measured NO_x	Modelled Total NO_x	Modelled - Measured	Modelled / Measured	% Difference
TL	20.1	4.5	-15.6	0.2	-77.6
TILA	33.2	7.9	-25.3	0.2	-76.1
TILB	30.9	6.8	-24.1	0.2	-78.0
TILC	28.8	9.3	-19.5	0.3	-67.6
TILD	22.7	5.6	-17.1	0.2	-75.3
TILE	18.5	5.6	-12.8	0.3	-69.5
TK4	14.3	4.4	-9.9	0.3	-69.0
PKSL	10.0	21.2	11.2	2.1	111.2
LYD	11.3	33.0	21.6	2.9	190.7
KCNO	22.8	27.9	5.1	1.2	22.5
GDSO	9.9	19.6	9.8	2.0	99.1

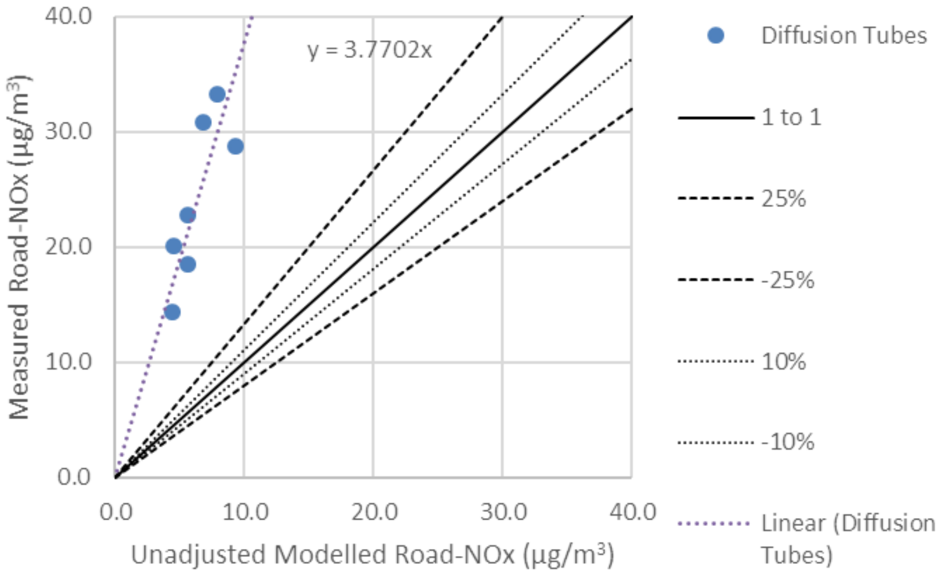
Adjustment factors for modelled road NO_x concentrations were derived by taking the slope of each linear regression line that has been forced through zero, as shown in Graph 18.6 to 18.8. This suggests that the model underestimates significantly within Tilbury, but overestimates within the A13 and M25 corridors. To allow a conservative approach to assessment, no adjustment was made to the A13 and M25 receptors, while the Tilbury modelled road NO_x was multiplied by 3.77.

Graph 18.6 to Graph 18.8 show the comparison each model domain. The model adjustment factors for unadjusted road NO_x derived in this way are:

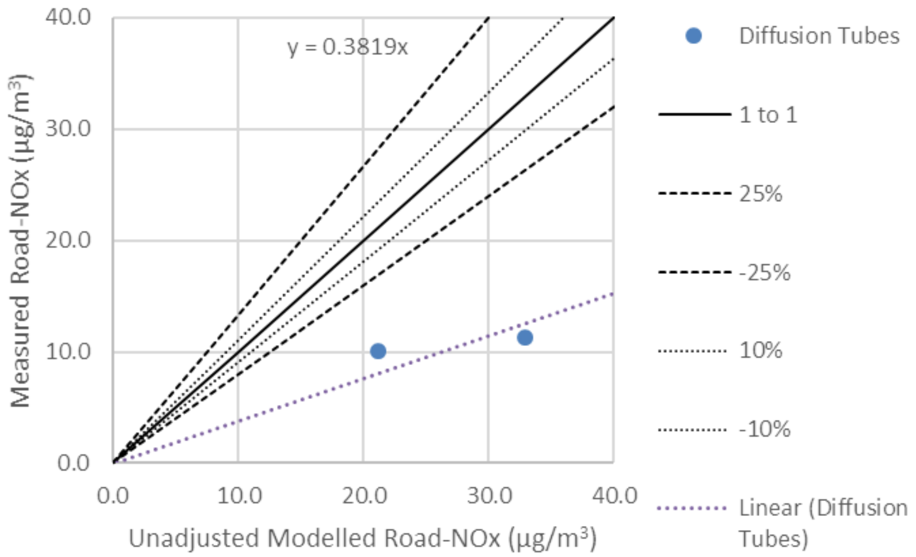
- Tilbury: 3.77
- A13 corridor: 0.38
- M25 corridor: 0.71

This suggests that the model underestimates significantly within Tilbury, but overestimates within the A13 and M25 corridors. To allow a conservative approach to assessment, no adjustment was made to the A13 and M25 receptors, while the Tilbury modelled road NO_x was multiplied by 3.77.

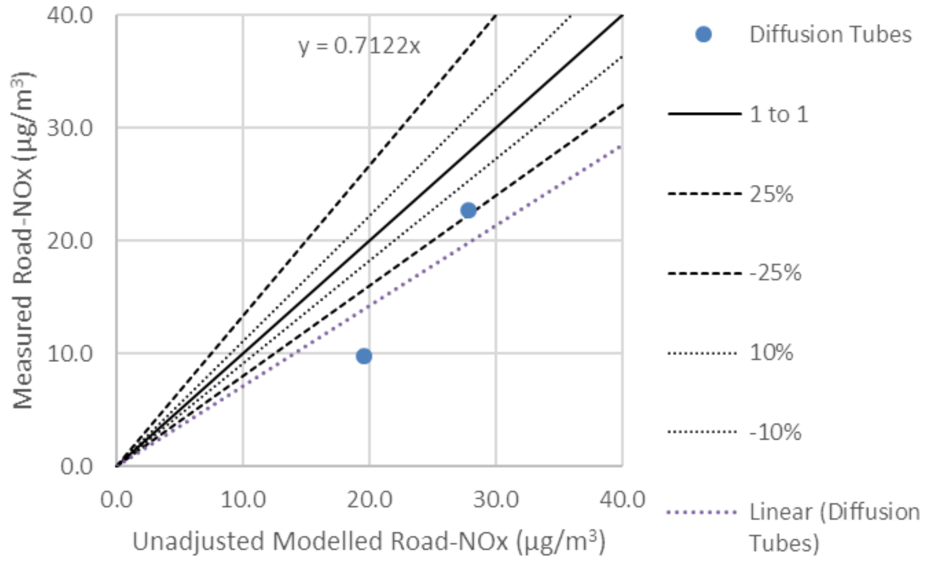
Graph 18.6 Modelled vs. Measured road NO_x before adjustment – Tilbury



Graph 18.7 Modelled vs. Measured road NO_x before adjustment – A13



Graph 18.8 Modelled vs. Measured road NO_x before adjustment – M25



Comparison of adjusted total NO_2

The final comparison of the adjusted modelled estimates of total annual mean NO_2 with measured concentrations is presented in Graph 18.9 and Table 18.41. All modelled estimated concentrations are within ±10% of measured concentrations, this suggests that the model is performing well at all locations in accordance with DEFRA Technical Guidance LAQM.TG(16).

Graph 18.9 Modelled vs. Measured NO_2 road contribution - after adjustment of modelled road NO_x component (Tilbury only)

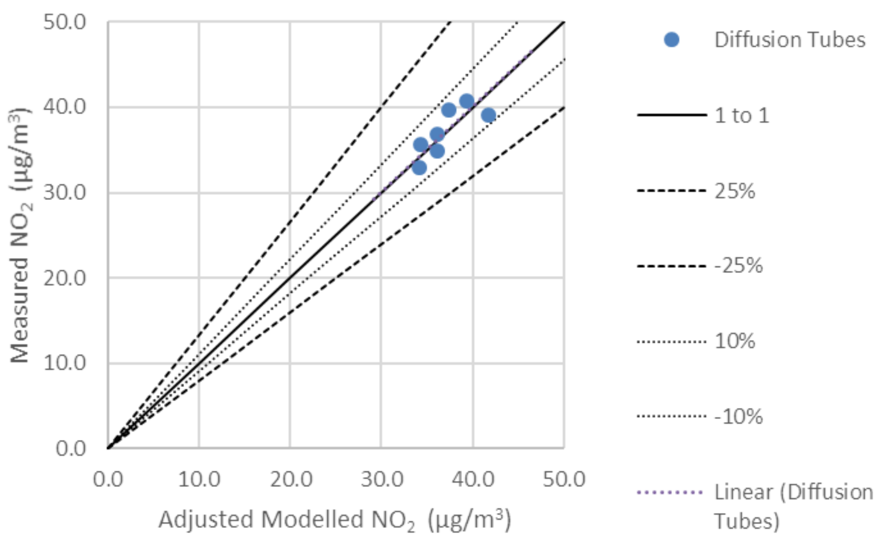


Table 18.41 Comparison of Adjusted Modelled and Measured NO_2 Concentrations ($\mu g/m^3$)

Site	Measured NO_2	Modelled Total NO_2	Modelled - Measured	Modelled / measured	% Difference
TL	35.7	34.3	-1.4	1.0	-4.0
TILA	40.8	39.3	-1.4	1.0	-3.6
TILB	39.7	37.4	-2.3	0.9	-5.8
TILC	39.0	41.8	2.8	1.1	7.1
TILD	36.9	36.1	-0.7	1.0	-2.0
TILE	34.9	36.2	1.3	1.0	3.6
TK4	33.0	34.1	1.1	1.0	3.4
PKSL*	29.0	34.3	5.3	1.2	18.4
LYD*	30.8	40.7	10.0	1.3	32.4
KCNO*	32.8	35.2	2.4	1.1	7.2
GDSO*	28.9	33.6	4.7	1.2	16.2

* Not adjusted, to ensure a conservative approach to assessment

Table 18.42 summarises the statistics prior to and post-road NO_x adjustment for the full verification study area. Adjustment factors were applied to road NO_x contributions for the Tilbury area only, before conversion to total NO_2. The RMSE for adjusted modelled NO_2 concentrations compared to measured NO_2 concentrations is 4.00 $\mu g/m^3$ or 10% of the AQS objective. Adjustment of the Tilbury modelled road NO_x increments has therefore substantially improved overall model performance. The adjusted model has achieved a fractional bias value of -0.06, extremely close to the ideal value of 0.0.

Table 18.42 RMSE and Adjustment Factors used in Air Quality Model verification

Model Domain	No. Sites within ±25% of the Measured Concentration before adjustment	Raw RMSE (Pre-adjustment) (μg/m^3)	Model Adjustment Factor	Adjusted Model RMSE	Fractional Bias (Post-adjustment)	No. Sites within ±25% of the Measured Concentration after Adjustment
Tilbury	5	7.82	3.77	4.00	-0.06	7
Outskirts/A13	1		n/a*			1
Outskirts/M25	2		n/a*			2

* not adjusted

18.E Detailed Model Results

18.E.1 Construction Phase – traffic emissions

Table 18.43 Construction Traffic (CT) Increment (µg/m^3) 2019 and as a percentage of With Scheme (DS) Increment 2020

ID	NO_2			PM_{10}			$PM_{2.5}$		
	CT 2019	DS 2020	% of DS	CT 2019	DS 2020	% of DS	CT 2019	DS 2020	% of DS
R1	0.0	6.3	0.2	0.0	0.7	0.1	0.0	0.4	0.1
R2	0.0	6.5	0.2	0.0	0.7	0.1	0.0	0.4	0.1
R3	0.0	8.0	0.5	0.0	0.8	0.4	0.0	0.5	0.4
R4	0.1	5.7	1.2	0.0	0.6	1.1	0.0	0.4	1.1
R5	0.0	11.2	0.4	0.0	1.0	0.4	0.0	0.7	0.4
R6	0.0	6.4	0.2	0.0	0.6	0.2	0.0	0.4	0.2
R7	0.1	6.4	1.4	0.0	0.7	1.3	0.0	0.4	1.3
R8	0.1	7.3	1.5	0.0	0.2	1.3	0.0	0.1	1.3
R9	0.2	14.0	1.1	0.0	0.7	0.6	0.0	0.4	0.7
R10	0.3	8.5	3.5	0.0	0.3	3.1	0.0	0.2	3.1
R11	0.1	3.5	3.7	0.0	0.1	3.4	0.0	0.1	3.3
R12	0.1	3.1	2.6	0.0	0.1	2.8	0.0	0.1	2.7
R13	0.1	4.2	2.4	0.0	0.1	2.8	0.0	0.1	2.7
R14	0.1	4.8	1.5	0.0	0.1	1.9	0.0	0.1	1.7
R15	0.1	3.0	1.7	0.0	0.1	1.9	0.0	0.1	1.9
R16	0.1	2.8	1.8	0.0	0.1	2.3	0.0	0.1	2.1
R17	0.1	3.2	1.9	0.0	0.1	2.2	0.0	0.1	2.0
R18	0.0	3.4	0.6	0.0	0.3	0.4	0.0	0.2	0.4
R19	0.1	8.4	1.2	0.0	0.4	0.8	0.0	0.2	0.8
R20	0.0	2.8	0.4	0.0	0.3	0.4	0.0	0.2	0.4
R21	0.1	11.7	0.5	0.0	1.4	0.4	0.0	0.9	0.4
R22	0.0	2.2	0.0	0.0	0.2	0.2	0.0	0.1	0.2
R23	0.0	5.7	0.2	0.0	0.6	0.2	0.0	0.4	0.2
R24	0.0	9.5	0.1	0.0	1.0	0.1	0.0	0.6	0.1
R25	0.0	13.3	0.2	0.0	1.2	0.2	0.0	0.8	0.2
R26	0.0	3.5	0.0	0.0	0.3	0.1	0.0	0.2	0.1
R27	0.0	2.7	1.1	0.0	0.3	1.2	0.0	0.2	1.2

18.E.2 Operational Phase – transport emissions

Table 18.44 Annual Mean NO_2 Results (µg/m^3) for Human Health Receptors

ID	Background 2016	Background 2020	2016 Base	2020 DM	2020 DS	2020 Change	Impact magnitude
R1	28.3	24.8	37.5	31.0	31.1	0.1	Negligible
R2	24.0	21.1	33.4	27.6	27.6	0.0	Negligible
R3	23.0	20.2	32.7	27.9	28.3	0.4	Negligible
R4	24.1	21.2	30.6	26.4	26.9	0.5	Negligible
R5	23.9	21.0	37.0	31.9	32.2	0.3	Negligible
R6	23.3	20.5	31.0	26.8	26.9	0.1	Negligible
R7	24.6	21.6	31.9	27.3	28.1	0.8	Negligible
R8	24.3	21.5	32.9	28.1	28.9	0.8	Negligible
R9	25.3	22.5	39.2	34.7	36.6	1.9	Slight
R10	24.8	22.1	30.8	26.2	30.6	4.4	Moderate
R11	25.8	23.0	28.6	24.9	26.6	1.7	Negligible
R12	25.8	23.0	27.8	24.4	26.1	1.7	Negligible
R13	24.9	22.3	26.2	23.4	26.4	3.0	Slight
R14	24.6	22.1	25.8	23.0	26.8	3.8	Slight
R15	23.1	20.7	26.2	23.0	23.6	0.6	Negligible
R16	25.8	23.0	27.1	24.0	25.8	1.8	Negligible
R17	25.8	23.0	27.2	24.1	26.2	2.1	Negligible
R18	23.5	20.6	27.6	23.9	24.1	0.2	Negligible
R19	26.0	23.2	34.1	30.7	31.6	0.9	Slight
R20	23.6	20.7	27.1	23.4	23.5	0.1	Negligible
R21	26.3	23.1	40.9	34.3	34.8	0.5	Negligible
R22	25.8	22.6	28.8	24.8	24.8	0.0	Negligible
R23	31.7	28.4	39.2	34.0	34.1	0.1	Negligible
R24	21.6	19.0	35.3	28.4	28.5	0.1	Negligible
R25	23.3	20.5	38.9	33.7	33.8	0.1	Negligible
R26	21.8	19.1	26.9	22.6	22.6	0.0	Negligible
R27	24.8	21.8	27.9	24.2	24.5	0.3	Negligible

Table 18.45 Annual Mean PM_{10} Results (µg/m^3) for Human Health Receptors

ID	Background 2016	Background 2020	2016 Base	2020 DM	2020 DS	2020 Change	Impact Magnitude
R1	19.3	18.7	20.0	19.4	19.4	0.0	Negligible
R2	18.9	17.7	19.6	18.4	18.4	0.0	Negligible
R3	19.2	17.9	20.0	18.6	18.6	0.0	Negligible
R4	19.2	18.0	19.7	18.5	18.6	0.1	Negligible
R5	18.9	17.3	20.0	18.3	18.3	0.0	Negligible
R6	18.2	16.9	18.9	17.6	17.6	0.0	Negligible
R7	17.3	16.2	17.9	16.8	16.9	0.1	Negligible
R8	17.2	16.4	17.4	16.6	16.7	0.1	Negligible
R9	17.0	15.8	17.6	16.5	16.5	0.0	Negligible
R10	15.8	15.1	15.9	15.3	15.4	0.1	Negligible
R11	15.6	15.0	15.7	15.1	15.1	0.0	Negligible
R12	15.6	15.0	15.6	15.1	15.1	0.0	Negligible
R13	15.8	15.2	15.8	15.3	15.4	0.1	Negligible
R14	15.5	14.9	15.5	14.9	15.1	0.2	Negligible
R15	15.9	15.2	16.0	15.3	15.4	0.1	Negligible
R16	15.6	15.0	15.6	15.0	15.1	0.1	Negligible
R17	15.6	15.0	15.6	15.0	15.1	0.1	Negligible
R18	18.6	17.8	18.9	18.1	18.1	0.0	Negligible
R19	16.4	15.5	16.8	15.9	15.9	0.0	Negligible
R20	18.2	17.4	18.5	17.7	17.7	0.0	Negligible
R21	19.5	17.6	20.9	18.9	19.0	0.1	Negligible
R22	19.5	18.8	19.8	19.0	19.0	0.0	Negligible
R23	18.7	17.5	19.4	18.1	18.1	0.0	Negligible
R24	19.1	17.6	20.2	18.5	18.6	0.1	Negligible
R25	18.7	16.7	20.0	17.9	17.9	0.0	Negligible
R26	18.1	17.2	18.5	17.5	17.5	0.0	Negligible
R27	17.5	16.7	17.7	17.0	17.0	0.0	Negligible

Table 18.46 Annual Mean $PM_{2.5}$ Results ($\mu g/m^3$) for Human Health Receptors

ID	Background 2016	Background 2020	2016 Base	2020 DM	2020 DS	2020 Change	Impact Magnitude
R1	13.4	12.9	13.9	13.3	13.3	0.0	Negligible
R2	12.7	12.2	13.1	12.6	12.6	0.0	Negligible
R3	12.6	12.2	13.2	12.7	12.7	0.0	Negligible
R4	12.9	12.3	13.3	12.7	12.7	0.0	Negligible
R5	12.5	11.9	13.2	12.5	12.6	0.1	Negligible
R6	12.3	11.7	12.7	12.1	12.1	0.0	Negligible
R7	11.9	11.4	12.3	11.8	11.8	0.0	Negligible
R8	12.0	11.6	12.1	11.7	11.7	0.0	Negligible
R9	11.7	11.2	12.0	11.5	11.6	0.1	Negligible
R10	11.3	10.8	11.4	10.9	11.0	0.1	Negligible
R11	11.3	10.8	11.3	10.8	10.8	0.0	Negligible
R12	11.3	10.8	11.3	10.8	10.8	0.0	Negligible
R13	11.4	10.9	11.4	10.9	11.0	0.1	Negligible
R14	11.2	10.7	11.2	10.7	10.8	0.1	Negligible
R15	11.3	10.9	11.4	10.9	10.9	0.0	Negligible
R16	11.3	10.8	11.3	10.8	10.8	0.0	Negligible
R17	11.3	10.8	11.3	10.8	10.8	0.0	Negligible
R18	12.6	12.2	12.8	12.4	12.4	0.0	Negligible
R19	11.6	11.1	11.8	11.3	11.3	0.0	Negligible
R20	12.4	12.0	12.6	12.2	12.2	0.0	Negligible
R21	12.7	12.2	13.6	13.0	13.1	0.1	Negligible
R22	13.3	12.8	13.5	13.0	13.0	0.0	Negligible
R23	12.6	12.1	13.1	12.5	12.5	0.0	Negligible
R24	12.3	11.9	13.0	12.5	12.5	0.0	Negligible
R25	12.2	11.6	13.1	12.3	12.4	0.1	Negligible
R26	12.2	11.7	12.4	12.0	12.0	0.0	Negligible
R27	12.1	11.7	12.3	11.8	11.8	0.0	Negligible

18.E.3 Ecological Receptors

Table 18.47 Annual Mean NO_x concentrations (µg/m³) at Ecological Receptors

ID	Background (APIS 2013 - 2015)	2016 Base	2020 DM	2020 DS	2020 Change
E1	23.58	26.0	25.5	31.1	5.6
E2	23.58	26.0	25.5	30.0	4.5
E3	23.58	26.0	25.5	29.2	3.7
E4	23.58	26.0	25.5	28.6	3.1
E5	23.58	26.0	25.5	27.8	2.3
E6	23.58	26.0	25.6	26.7	1.1
E7	23.58	26.1	25.8	26.2	0.5
E8	23.58	26.2	26.0	25.9	-0.1
E9	23.58	26.6	26.7	25.7	-1.0
E10	23.58	27.0	27.4	25.7	-1.7
E11	23.58	27.6	28.2	25.7	-2.6
E12	23.58	28.8	30.2	25.6	-4.6
E13	22.19	24.0	23.5	30.0	6.5
E14	22.19	24.0	23.5	27.4	3.9
E15	22.19	24.0	23.5	26.4	2.8
E16	22.19	24.0	23.5	25.8	2.2
E17	20.65	22.4	22.0	23.6	1.6
E18	20.65	22.4	22.0	23.0	1.0
E19	20.65	22.4	22.0	22.7	0.7
E20	20.65	22.4	22.0	22.6	0.6

Table 18.48 Annual Mean Nitrogen Deposition (kg N/ha/yr) at Ecological Receptors

ID	Background (APIS 2013 - 2015)	2016 Base	2020 DM	2020 DS	2020 Change
E1	14.6	14.7	14.7	15.0	0.3
E2	14.6	14.7	14.7	14.9	0.2
E3	14.6	14.7	14.7	14.9	0.2
E4	14.6	14.7	14.7	14.9	0.2
E5	14.6	14.7	14.7	14.8	0.1
E6	14.6	14.7	14.7	14.8	0.1
E7	14.6	14.7	14.7	14.7	0.0
E8	14.6	14.7	14.7	14.7	0.0
E9	14.6	14.8	14.8	14.7	-0.1
E10	14.6	14.8	14.8	14.7	-0.1
E11	14.6	14.8	14.8	14.7	-0.1
E12	14.6	14.9	14.9	14.7	-0.2
E13	13.7	13.8	13.8	14.1	0.3
E14	13.7	13.8	13.8	14.0	0.2
E15	13.7	13.8	13.8	13.9	0.1
E16	13.7	13.8	13.8	13.9	0.1
E17	13.7	13.8	13.8	13.9	0.1
E18	13.7	13.8	13.8	13.8	0.0
E19	13.7	13.8	13.8	13.8	0.0
E20	13.7	13.8	13.8	13.8	0.0