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Wylfa Newydd

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Document revisions

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2	Final Report 17252i1	July 2017
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8	Final Report 18052i2	February 2018

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1. Introduction

1.1 Purpose of this report

This report has been produced for the purpose of providing the methodology and results for the detailed dispersion modelling of Project-wide emissions from road traffic. The modelling quantifies the potential impacts on local air quality associated with emissions to air from road traffic generated during the construction and operational phase of the Wylfa Newydd Project. It comprises modelling along the A55, A5025, A5 and other local roads, as well as incorporating emissions from the Park and Ride Facility at Dalar Hir (hereafter referred to as the 'Park and Ride') and the Logistics Centre at Parc Cybi (hereafter referred to as the 'Logistics Centre'). It is based on the latest design data at the time of undertaking the assessment (December2017). Where data has not been established at this stage of the design, assumptions based on best practice or typical values have been adopted.

This report presents a factual account of the modelling methodology and results without interpretation or assessment of significance.

1.2 Terms and definitions

Table 1.1 Terms and definitions

Term	Definition
ADMS	Atmospheric Dispersion Modelling System
AQMA	Air Quality Management Area
AQO	Air Quality Objective
AQS	Air Quality Standard
CBL	Convective Boundary Layer
CERC	Cambridge Environmental Research Consultants
CURED	Calculator Using Realistic Emissions for Diesels
DCO	Development Consent Order
Defra	Department for Environment, Food and Rural Affairs
EFT	Emissions Factors Toolkit
ES	Environmental Statement
IACC	Isle of Anglesey County Council
LAQM	Local Air Quality Management
NO_x	Oxides of Nitrogen
NO_2	Nitrogen Dioxide
NWP	Numerical Weather Prediction
O_3	Ozone
OS	Ordnance Survey
PBL	Planetary Boundary Layer

Term	Definition
PC	Process Contribution
PEC	Predicted Environmental Concentration
$PM_{2.5}$	Particulate matter less than 2.5 micrometres in diameter
PM_{10}	Particulate matter less than 10 micrometres in diameter
USEPA	United States Environmental Protection Agency

2. Methodology

2.1 Air pollutants considered

Emissions from road traffic primarily consist of oxides of nitrogen (NO_x, consisting of nitrogen monoxide (NO) and nitrogen dioxide (NO_2)) and particulates (PM_{10} and $PM_{2.5}$). As such, these pollutants are the focus of this assessment. NOx, in turn, contributes to nitrogen and acid deposition with the assessment aiming to quantify the additional contribution to background deposition levels as a result of additional emissions of this specific pollutant.

2.2 Selection of dispersion model

This study uses the ADMS Roads version 4.1 model, with version 7.0 of the Emission Factors Toolkit (EFT)[1], supported by the Calculator Using Realistic Emissions for Diesels (CURED)[2].

The ADMS Roads model was developed in the UK by Cambridge Environmental Research Consultants (CERC) to predict the potential impact of emissions to air from motor vehicles on roads and motorways. It has been validated by CERC[3]. ADMS Roads is termed a 'new generation' model, parameterising stability and turbulence in the planetary boundary layer (PBL) by the Monin-Obukhov length and the boundary layer depth. This approach allows the vertical structure of the PBL to be more accurately defined than by the stability classification methods of earlier dispersion models. Like these earlier models, ADMS Roads adopts a symmetrical Gaussian profile of the concentration distribution in the vertical and crosswind directions in neutral and stable conditions. However, unlike the old generation models, the ADMS Roads vertical concentration profile in convective conditions assumes a skewed Gaussian distribution to take account of the heterogeneous nature of the vertical velocity distribution in the Convective Boundary Layer (CBL).

The EFT is published by Defra and the Devolved Administrations to assist local authorities in carrying out Review and Assessment of local air quality as part of their duties under the Environmental Act 1995. The EFT allows users to calculate road vehicle pollutant emission rates for a specified year, road type, vehicle speed and vehicle fleet composition. The EFT is updated periodically due to updates to underlying data including emissions factors.

CURED is a spreadsheet tool developed by Air Quality Consultants which allows predicted road traffic emission rates of NOx obtained by the EFT to be uplifted to take in to account real world data which indicates NOx emission rates from modern diesel vehicles are underestimated using EFT only.

2.3 Assessment scenarios

A number of scenarios have been used in the assessment robustly to characterise the periods of peak emissions from road traffic during the construction and operational phases of the Wylfa Newydd Project. Best available information regarding traffic flows have been used to inform the following scenarios:

- Verification case (using 2016 traffic flows and 2016 monitored data);
- Year A – 2020:
  - Baseline (no Wylfa Newydd Project), existing A5025 alignment (i.e. no A5025 Off-line Highway Improvements);
  - Wylfa Newydd Project with bypasses, new A5025 alignment (i.e. with the A5025 Off-line Highway Improvements in place); and

[1] https://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html
[2] http://www.aqconsultants.co.uk/News/August-2016/Updated-CURED-to-V2A.aspx
[3] http://www.cerc.co.uk/environmental-software/model-validation.html

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  - Wylfa Newydd Project without bypasses, existing A5025 alignment; (i.e. no A5025 Off-line Highway Improvements).
- Year B – 2023:
  - Baseline (no Wylfa Newydd Project), existing A5025 alignment (i.e. no A5025 Off-line Highway Improvements); and
  - Wylfa Newydd Project with bypasses, new A5025 alignment (i.e. with the A5025 Off-line Highway Improvements in place).
- Year C – 2033 (modelled assessment year 2028 as a conservative approach):
  - Baseline (no Wylfa Newydd Project), existing A5025 alignment (i.e. no A5025 Off-line Highway Improvements); and
  - Wylfa Newydd Project with bypasses, new A5025 alignment (i.e. with the A5025 Off-line Highway Improvements in place).

Traffic data in the Years A, B and C 'with-project' scenarios includes traffic travelling to and from the Wylfa Newydd Development Area (e.g., carrying raw materials and equipment as well as personnel), in addition to the normal traffic not associated with the Project. In the Verification and Baseline scenarios, only traffic flows not associated with the Wylfa Newydd Project are included.

Year C is intended to represent the peak traffic flows that could occur during the operational phase of the Wylfa Newydd Project. The assessment year has been modelled at 2028 as a conservative approach, based on the assumption that 2028 is the first full year of operation of both units and with vehicle emission factors and background concentrations being higher in 2028 than 2033.

The purpose of the Verification case is to test the model against monitored concentration data and adjust the model predictions, if necessary.

2.4 Emission calculations methodology

Road links

Traffic data provided by Jacobs, from a traffic and transport model, contained traffic flows for individual links along transport routes expected to be used during the Wylfa Newydd Project. For each link, a total 24-hour Annual Average Daily Traffic (AADT) flow, the fraction of heavy duty vehicles (HDVs) and the assumed speed were provided. A combination of 1-way and 2-way flows were used depending on the road link. These flows were subsequently divided by 24 to convert them into hourly HDV and light duty vehicle (LDV) flows for input to the model. The centre lines of roads were digitised to a set of polylines, and subsequently ADMS roads sources, using Ordnance Survey MasterMap Integrated Transport Network data.

Emissions were calculated using the road traffic flow, traffic composition and emission factors from ADMS Roads. These calculations were performed separately for each specific assessment year, including the 2016 Verification. All calculations of emission factors used version 7.0 of the EFT[4], which is contained within the ADMS Roads model, for the typical age mix of vehicles on a given road type (here set to "Wales Rural") in a given year. Due to the uncertainty in emission factors for NO_x for certain types of vehicle, the emission factors output from EFT were uplifted using an additional factor calculated using CURED[5] V2A, developed by Air Quality Consultants Ltd. Traffic data is imported into this tool which calculates uplifted NO_x emissions which are then imported back into ADMS Roads for use in the modelling.

In order to identify air quality effects at those sensitive receptors located along the roads affected by the Wylfa Newydd Project, major transport routes and other minor roads, including stretches of the A55 and A5025, were included in the assessment. The relevant sections are shown in Figure 2.1. The ADMS Roads

[4] https://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

[5] http://www.aqconsultants.co.uk/News/August-2016/Updated-CURED-to-V2A.aspx

models were split into sections according to the most representative meteorological data available, details of which are contained in Section 2.4.

Appendix A provides supplementary information used in the roads assessment, including road widths, speeds and coordinates. The traffic data for each road link modelled can be found in Appendix B. Detailed maps of the road sections assessed are continued within Appendix C.

Park and Ride and Logistics Centre

An emissions inventory of NO_x and PM_{10}/$PM_{2.5}$ has been developed using a methodology based on that set out in LAQM.TG(16)[6]. The following aspects have been considered:

- Vehicles entering the car park at the Park and Ride and locating a parking space;
- HGVs and other vehicles entering the Logistics Centre and locating a parking space;
- Cold start emissions upon departure and manoeuvring to the exits of the Park and Ride or Logistics Centre;
- Idling buses, coaches and minibuses at the Park and Ride; and
- Idling HGVs at the Logistics Centre.

Cold start emissions have been estimated using the number of trip ends (half the number of overall movements) and the NAEI cold start emission factors in accordance with LAQM.TG(16). Emissions from idling vehicles and vehicles entering/leaving each of the two facilities have been derived from the latest version of the Emissions Factor Toolkit based on a vehicle speed of 5 km h^{-1} (the lowest speed possible in the EFT). The total emissions from vehicles entering and leaving each facility have been calculated based on an average distance travelled. This data was then input to ADMS Roads and the emissions were modelled as a volume source release with the total emissions distributed uniformly over the site area.

The Park and Ride and the Logistics Centre have been modelled with relevant road links using the RAF Valley meteorological data in each of the 'with project' scenarios where there are traffic flows into and out of each site. The results from the Park and Ride and Logistics Centre modelling have been directly incorporated into the results at receptors.

2.5 Meteorology

For meteorological data to be suitable for dispersion modelling purposes a number of meteorological parameters need to be measured on an hourly basis. These parameters include wind speed, wind direction, cloud cover and temperature.

As the roads modelling covers a large area across Anglesey, it was not considered best practice to model the entire area with only one meteorological data set. Therefore, a number of meteorological data sets have been used to accurately represent the different geographical areas. These are as follows:

- A synoptic station at RAF Valley;
- A synoptic station at Mona airfield; and
- Numerical Weather Prediction (NWP) data (centred on the Wylfa Newydd Development Area).

Figure 2.1 indicates the different meteorological datasets that have been applied on a geographical basis and also the locations of the two synoptic stations at RAF Valley and Mona airfield, as well as the origin of the NWP data set.

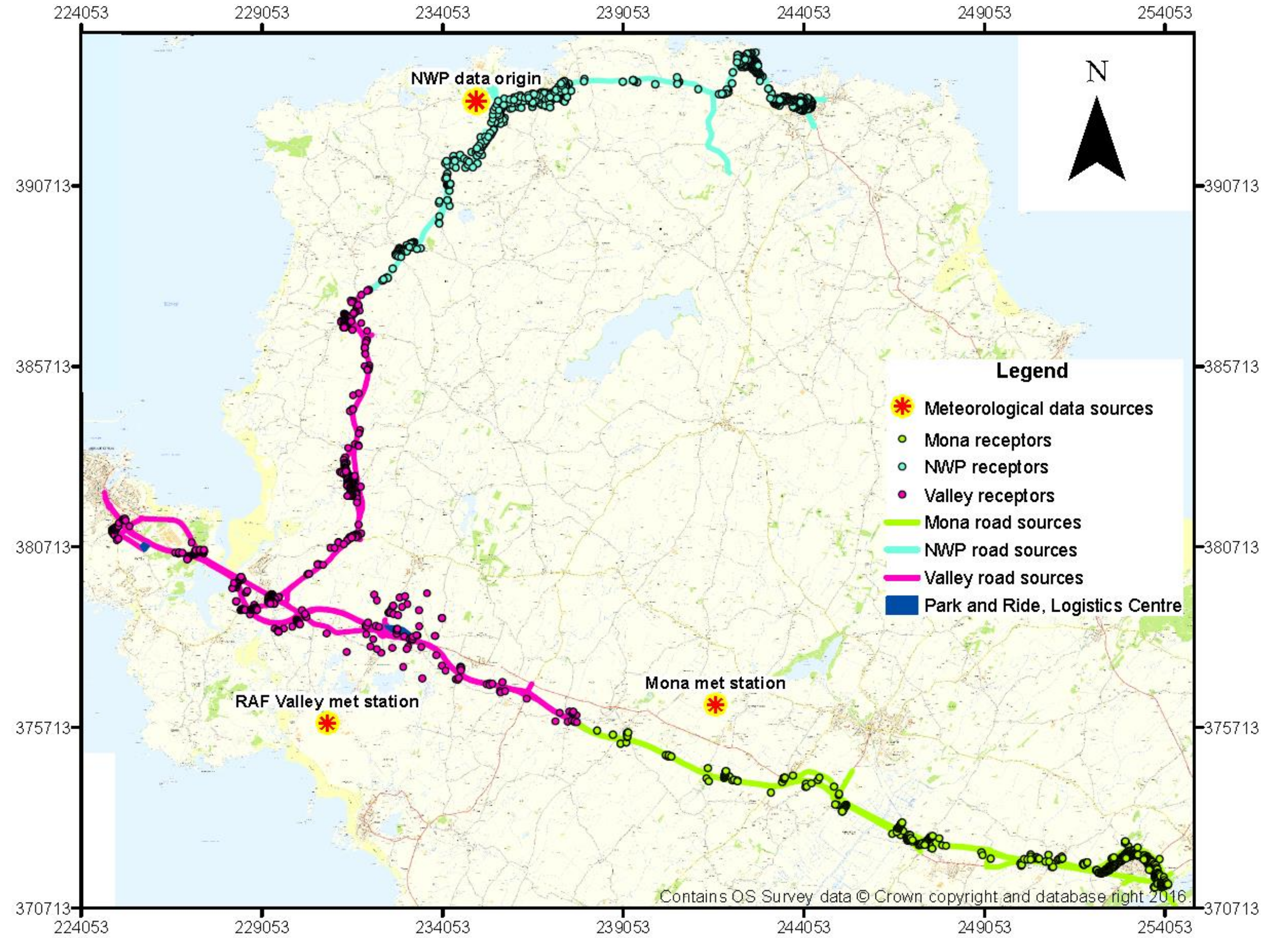
The NWP data set has been used for modelling the areas in closest proximity to the site, up to Amlwch in the east, and down to Llanfaethlu (located on the A5025) to the south. The RAF Valley data set has been used

[6] https://laqm.defra.gov.uk/documents/LAQM-TG16-April-16-v1.pdf

for the remaining A5025 and the western A55/A5. The Mona airfield meteorological data has been used for the eastern A55 to the Britannia Bridge.

This assessment has used Mona airfield, RAF Valley and NWP data for 2016, as the most recent calendar year for which ambient monitoring data is available. Wind rose figures illustrating the frequency of wind speed and direction for each of the datasets over this period can be found in Appendix E.

Figure 2.1 Modelled road sources and modelled human and ecological receptors



Contains Ordnance Survey data © Crown copyright and database right 2016.

2.6 Model domain and receptors

Model domain

A fixed model domain was not set-up in the ADMS Roads models. Since no receptor grids were included, modelled concentrations of air pollutants have been calculated at discrete receptor points.

Human receptors

The human receptors considered were based on where people may be located and judged in terms of the likely duration of their exposure, including residential properties, schools, care homes, gardens and footpaths. Human receptors within 200 m of each road link affected by the Wylfa Newydd Project have been included in the modelling, in accordance with the recommendations of the Design Manual for Roads and Bridges (DMRB)[7]. Additional human receptors outside of the 200 m extent have also been incorporated in

[7] http://www.standardsforhighways.co.uk/ha/standards/dmrb/

some locations, including around the Park and Ride. Listings of human receptors considered in the modelling were provided in spreadsheet format by Jacobs and are contained within Appendix D.

Ecological receptors

The DMRB requires that the potential effects of emissions from road traffic should be assessed at ecological receptors that lie within a 400 m wide corridor centred upon the road links being considered in the assessment. This guidance has been used for the purpose of including ecological receptors within this modelling. Listings of ecological receptors considered in the modelling were provided in spreadsheet format by Jacobs and are listed in Appendix D. These include the following designations:

- Special Areas of Conservation (SAC);
- Sites of Special Scientific Interest (SSSI);
- Ancient Woodland; and
- Candidate Wildlife Sites.

2.7 Terrain and elevation

The ground level concentrations of pollutants arising from emissions in areas of complex terrain differ from those found in simple, level terrain due to a number of topographical-induced effects on the three dimensional flow and turbulent fields over the terrain. These effects are most pronounced when terrain gradients exceed 1 in 10. Given that the receptors are very close to the roads emission sources, a digital terrain file was not used for the majority of road links modelled. Terrain was, however, included for the Britannia bridge road links over the Menai Strait, as a special case where the difference in gradient is much more pronounced. The elevation of the road sources were also modelled at height in order to represent the height of the bridge relative to the surrounding receptors. All other road links were modelled at ground level, i.e. zero elevation.

2.8 Surface characteristics

The predominant surface characteristics and land use in a model domain have an important influence in determining turbulent fluxes and, hence, the stability of the boundary layer and atmospheric dispersion. Factors pertinent to this determination are detailed below.

Surface Roughness

Roughness length, z_0, represents the aerodynamic effects of surface friction and is defined as the height at which the extrapolated surface layer wind profile tends to zero. This value is an important parameter used by meteorological pre-processors to interpret the vertical profile of wind speed and estimate friction velocities which are, in turn, used to define heat and momentum fluxes and, consequently, the degree of turbulent mixing in the boundary layer.

The surface roughness length is related to the height of surface elements; typically, the surface roughness length is approximately 10% of the height of the main surface features. Thus, it follows that surface roughness is higher in urban and developed areas than in rural and open areas. Oke (1987)[8] and CERC (2014)[9] suggest typical roughness lengths for various land use categories (Table 2.1).

[8] Oke (1987) Boundary layer Climates.
[9] CERC (2014) The Met Input Module.

Table 2.1 Typical surface roughness lengths for different land uses

Type of surface	Typical surface roughness length (m)
Ice	0.00001
Smooth snow	0.00005
Smooth sea	0.0002
Lawn grass	0.01
Pasture	0.2
Isolated settlement (farms, trees, hedges)	0.4
Parkland, woodlands, villages, open suburbia	0.5-1.0
Forests/cities/industrialised areas	1.0-1.5
Heavily industrialised areas	1.5-2.0

Increasing surface roughness increases turbulent mixing in the lower boundary layer. For sources close to the ground surface, such as road traffic emissions and the Park and Ride and Logistics Centre, the overall impact on ground level concentration is strongly correlated with the distance of a receptor from the emission source. Given the proximity of receptors to the roads emission sources, a uniform surface roughness of 0.3 m was used in the ADMS Roads models.

Surface Energy Budget

One of the key factors governing the generation of convective turbulence is the magnitude of the surface sensible heat flux. This, in turn, is a function of the incoming solar radiation. However, not all solar radiation arriving at the Earth's surface is available to be emitted back to atmosphere in the form of sensible heat. By adopting a surface energy budget approach, it can be identified that, for fixed values of incoming short and long wave solar radiation, the surface sensible heat flux is inversely proportional to the surface albedo and latent heat flux.

The surface albedo is a measure of the fraction of incoming short-wave solar radiation reflected by the Earth's surface. This parameter is dependent upon surface characteristics and varies throughout the year. Oke (1987)[6] recommends average surface albedo values of 0.6 for snow covered ground and 0.23 for non-snow covered ground, respectively.

The latent heat flux is dependent upon the amount of moisture present at the surface. The modified Priestly-Taylor parameter can be used to represent the amount of moisture available for evaporation. Areas where moisture availability is greater will experience a greater proportion of incoming solar radiation released back to atmosphere in the form of latent heat, leaving less available in the form of sensible heat and, thus, decreasing convective turbulence. Holstag and van Ulden (1983)[10] suggest modified Priestly-Taylor values of 0.45 and 1.0 for dry grassland and moist grassland respectively.

Selection of Appropriate Surface Characteristic Parameters for the Model Domain

A detailed analysis of the effects of surface characteristics on ground level concentrations by Auld et al. (2002)[11] led them to conclude that, with respect to uncertainty in model predictions:

> *"…the energy budget calculations had relatively little impact on the overall uncertainty"*

[10] van Ulden and Holstag (1983). 'The Stability of the Atmospheric Surface Layer during Nighttime'. American Met. Soc., 6th Symposium on Turbulence and Diffusion.
[11] Auld et al (2002). 'Uncertainty in Deriving Dispersion Parameters from Meteorological Data'. Atmospheric Dispersion Modelling Liaison Committee (ADMLC). Annual Report 2002-2003.

In this regard, it is not considered necessary to vary the surface energy budget parameters, spatially or temporally, and annual averaged values have been adopted throughout the model domain for this assessment.

As snow covered ground is only likely to be present for a small fraction of the year, the surface albedo of 0.23 for non-snow covered ground advocated by Oke (1987)[6] has been used, whilst the model default modified Priestly-Taylor parameter value of 1.0 has also been retained.

2.9 Conversion of NO to NO_2 in the atmosphere

Emissions of NOx from combustion processes are predominantly in the form of nitrogen monoxide (NO). Excess oxygen in the combustion gases and further atmospheric reactions cause the oxidation of NO to NO_2. NOx chemistry in the lower troposphere is strongly interlinked in a complex chain of reactions involving Volatile Organic Compounds (VOCs) and Ozone (O_3). Two of the key reactions interlinking NO and NO_2 are detailed below:

$$NO_2 + hv \xrightarrow{O_2} NO + O_3 \qquad \text{(R1)}$$

$$NO + O_3 \longrightarrow NO_2 + O_2 \qquad \text{(R2)}$$

Where *hv* is used to represent a photon of light energy (i.e., sunlight).

Taken together, reactions R1 and R2 produce no net change in O_3 concentrations, and NO and NO_2 adjust to establish a near steady state reaction (photo-equilibrium). However, the presence of VOCs and CO in the atmosphere offer an alternative production route of NO_2 for photolysis, allowing O_3 concentrations to increase during the day with a subsequent decrease in the NO_2:NOx ratio.

However, at night, the photolysis of NO_2 ceases, allowing reaction R2 to promote the production of NO_2, at the expense of O_3, with a corresponding increase in the NO_2:NOx ratio.

Near to an emission source of NO, the result is a net increase in the rate of reaction R2, suppressing O_3 concentrations immediately downwind of the source, and increasing further downwind as the concentrations of NO begin to stabilise to typical background levels.

In order to calculate the NO_2 concentrations likely to arise at the selected discrete receptors identified in the ADMS roads modelling as a result of emissions from road vehicles, an established procedure was used, recommended in LAQM.TG(16)[4] for local air quality management. This uses Defra’s NOx to NO_2 calculator (version 5.1)[12], which calculates the proportions of primary and secondary NO_2 that make up the total NO_2 concentration at receptors. The full procedure, which includes the model verification and adjustment process, is included in Appendix F.

2.10 Deposition

Nitrogen and acid deposition

The predominant route by which emissions will affect land in the vicinity of a release is by deposition of material from the plume. Ecological receptors can potentially be sensitive to the deposition of pollutants, particularly nitrogen and sulphur compounds, which can affect the character of the habitat through eutrophication and acidification.

Deposition processes in the form of dry and wet deposition remove material from a plume and alter the plume concentration. Dry deposition occurs when particles are brought to the surface by gravitational settling and turbulence. They are then removed from the atmosphere by deposition on the land surface or on vegetation. Wet deposition occurs due to rainout (within cloud) scavenging and washout (below cloud) scavenging of the material in the plume. These processes lead to a variation with downwind distance of the plume strength and may alter the shape of the vertical concentration profile, as dry deposition only occurs at the surface.

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

Near to sources of pollutants (< 2 km), dry deposition is generally the predominant removal mechanism for pollutants such as NOx, SO_2 and NH_3 (Fangmeier et al. 1994)[13]. Dry deposition may be quantified from the near-surface plume concentration and the deposition velocity (Chamberlin and Chadwick, 1953)[14]:

$$F_d = v_d C(x, y, 0)$$

Where:

F_d = dry deposition flux (µg m^{-2} s^{-1})

v_d = deposition velocity (m s^{-1})

$C(x, y, 0)$ = ground level concentration (µg m^{-3})

Environment Agency guidance recommends deposition velocities for various pollutants dependent upon the habitat type (Table 2.2).

Table 2.2 Pollutant specific deposition velocities

Pollutant	Deposition velocity (m s^{-1})	
	Short vegetation	Long vegetation
NO_2	0.0015	0.003

In order to assess the impacts of deposition, habitat-specific critical loads and critical levels have been developed. These are generally defined as (e.g., Nilsson and Grennfelt, 1988)[15];

"...a quantitative estimate of exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge"

It is important to distinguish between a critical load and a critical level. The critical load relates to the quantity of a material deposited from air to the ground, whilst critical levels refer to the concentration of a material in air. The UK Air Pollution Information System (APIS[16]) provides critical load data for ecological sites in the UK.

The critical loads used to assess the impact of compounds deposited to land which result in eutrophication and acidification are expressed in terms of kilograms of nitrogen deposited per hectare per year (kg N ha^{-1} y^{-1}) and also as kilo equivalents deposited per hectare per year (keq ha^{-1} y^{-1}). The unit of 'equivalents' (eq) is used for the purposes of assessing acidification, rather than a unit of mass. The unit eq (1 keq ≡ 1,000 eq) refers to molar equivalent of potential acidity resulting from e.g. sulphur, oxidised and reduced nitrogen, as well as base cations. Essentially, it means 'moles of charge' and is a measure of how acidifying a particular chemical species can be.

To convert the predicted concentration in air the following algorithm is used:

$$DR_i = C_i v_{d_i} f_i$$

Where:

DR_i = annual deposition of N or S (kg N ha^{-1} y^{-1} or kg S ha^{-1} y^{-1})

C_i = annual mean concentration of the *i*th chemical species (µg m^{-3})

v_{d_i} = deposition velocity of *i*th species

[13] A. Fangmeier et al. (1994) Effects of Atmospheric Ammonia on Vegetation – A Review. Environ. Pollution, 86 278-291.

[14] A. C. Chamberlin & R. C. Chadwick (1953) Deposition of Airborne Radioactive Vapour. Nucleonics 11 22-25.

[15] J. Nilsson & P. Grennfelt (1988) Critical Loads for Sulphur and Nitrogen. Miljorapport 1988:15, Nordic Council of Ministers, Copenhagen.

[16] http://www.apis.ac.uk/

f_i = factor to convert from µg m^{-2} s^{-1} to kg ha^{-1} y^{-1} for the *i*th species

Table 2.3 provides the relevant conversion factors.

Table 2.3 Deposition rate conversion factors

From	Conversion factor (µg m^{-2} s^{-1} to kg ha^{-1} y^{-1} for the *i*th species)	
	Convert to	**Factor**
NO_2	N	96

In order to convert deposition of N to acid equivalents, the following relationships can be used:

- 1 keq ha^{-1} y^{-1} = 14 kg N ha^{-1} y^{-1}.

With respect to wet deposition, Environment Agency (2014) states:

"*It is considered that wet deposition of SO_2, NO_2 and NH_3 is not significant within a short range*"

Therefore, the assessment only considers dry deposition of nitrifying and acidifying N compounds.

2.11 Background contributions

Background concentrations are summarised in the baseline air quality report prepared by Jacobs, contained in Appendix B5-01 of the Environmental Statement. In summary, the following data sources have been used to quantify background concentrations:

- NO_x and NO_2: Concentrations from the Defra 2013 background maps have been used, representative of the locations of each modelled receptor. The background mapped values range from 5.5 – 11.2 µg m^{-3} for NOx and 4.3 – 8.5 µg m^{-3} for NO_2. This assumes no reduction in future year concentrations;
- PM_{10}: An annual mean value of 14.9 µg m^{-3} has been used for all the road links modelled, as this is the highest measured concentration from the 2013/2014 or 2016 IACC surveys recorded around the Wylfa Newydd Development Area. This assumes no reduction in future year concentrations; and
- $PM_{2.5}$: For those receptors closest to the Development Area and using the NWP meteorological data an annual mean value of 7.8 µg m^{-3} has been used. This is highest measured concentration from the 2013/2014 or 2016 IACC surveys recorded around the Wylfa Newydd Development Area. For those road links located away from the Development Area (i.e. using RAF Valley and Mona meteorological data) the 2013 background map value has been used. The background map $PM_{2.5}$ values range from 6.8 – 8.1 µg m^{-3} at receptors. This assumes no reduction in future year concentrations.

Where Defra background maps have been used, contributions from major road sources within each relevant grid square have been removed in order to prevent 'double counting' of emissions. Due to the non-linearity in NO_x and NO_2 concentrations, Defra's NO_2 adjustment for NO_x sector removal tool (version 5.1, June 2016)[17] was used to correct the background NO_2 estimate after removal of the relevant NO_x contribution from major road sources within the grid square.

2.12 Sensitivity analysis and model uncertainty

Emissions have been modelled under expected operation using the standard steady state algorithms in ADMS to determine the impact on local human and ecological receptors. In order to model atmospheric dispersion using standard Gaussian methods, the following assumptions and limitations have to be made and appreciated:

[17] https://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxsector

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- Conservation of mass – the entire mass of emitted pollutant remains in the atmosphere and no allowance is made for loss due to chemical reactions or deposition processes (although the standard Gaussian model can be modified to include such processes, as is the case with ADMS). Portions of the plume reaching the ground are assumed to be dispersed back away from the ground by turbulent eddies (eddy reflection);
- Steady state emissions – emission rates are assumed to be constant and continuous over the time averaging period of interest; and
- Steady state meteorology – no variations in wind speed, direction or turbulent profiles occur during transport from the source to the receptor. This assumption is reasonable within a few kilometres of a source but may not be valid for receptor distances in the order of tens of kilometres. For example, for a receptor 50 km from a source and with a wind speed of 5 m s^{-1} it will take nearly three hours for the plume to travel this distance during which time many different processes may change (e.g., the sun may rise or set and clouds may form or dissipate affecting the turbulent profiles). For this reason, Gaussian models are practically limited to predicting concentrations within ~20 km of a source.

Another area of uncertainty arises from using historical meteorological data to estimate future concentrations. The key limiting assumption here is that conditions in the future will be the same as in the past; however, in reality, no two years are the same. Defra’s Technical Guidance LAQM.TG(16) reviews a number of studies examining inter-annual variability of meteorological data and the effect on dispersion model output; it is suggested that variability in source contribution should be no more than 30% between any two years.

As a result of the above, and in combination with other factors, not least attempting to replicate stochastic processes (e.g., turbulence) by deterministic methods, dispersion modelling is inherently uncertain, but is nonetheless a useful tool in the prediction of ground level concentrations. The use of dispersion models has been widely applied in the UK for both regulatory and compliance purposes for a number of years and is an accepted approach for this type of assessment.

This assessment has incorporated a number of worst-case assumptions which should result in an overestimation of the predicted ground level concentrations. Attempts to minimise uncertainty have been made by assuming no reduction in background/baseline concentrations in future assessment years and uplifting the emission factors in the EFT using the CURED tool. Additionally, the ‘Year C’ scenario has been modelled with an assessment year of 2028 (as opposed to 2033) as a conservative approach, based on the assumption that 2028 is the first full year of operation of both units and with vehicle emission factors and background concentrations higher in 2028 than 2033. This scenario is intended to represent the peak traffic flows during operation of the Wylfa Newydd Project.

Verification adjustment has been undertaken to minimise the uncertainties in the differences between monitored and modelled data. A number of statistical procedures have also been used to evaluate the model performance – this is presented in Appendix F.

Given the above, the results provided by this assessment are considered to be robust.

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3. Model results

3.1 Tabulated results

Tabulated results for each of the scenarios discussed in section 2.2 are presented in Appendix G. These results are the highest concentrations predicted for individual receptors obtained. The modelled Predicted Environmental Concentration (PEC) outputs are as follows:

- $PEC_{(R\text{-}BASELINE)}$, described as the verified PEC at each receptor for the baseline assessment scenarios; and
- $PEC_{(R\text{-}PROJECT)}$, described as the verified PEC at each receptor determined for the with Wylfa Newydd Project assessment scenarios.

Results are provided for annual mean NO_x, NO_2, PM_{10} and $PM_{2.5}$, as well as daily mean NO_x, nitrogen deposition and acid deposition for each scenario.

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Appendix A
Supplementary information

The Excel spreadsheet below contains information on each of the road links modelled, including speeds, widths and coordinates. It also includes information on the sources modelled at the Park and Ride and the Logistics Centre.

[This appendix will not be shown in the hard copy and only available electronically due to the size of the appendix]

Appendix B
Traffic data

The spreadsheet below contains the traffic data and traffic flows used in the roads dispersion modelling for all scenarios assessed.

[This appendix will not be shown in the hard copy and only available electronically due to the size of the appendix]

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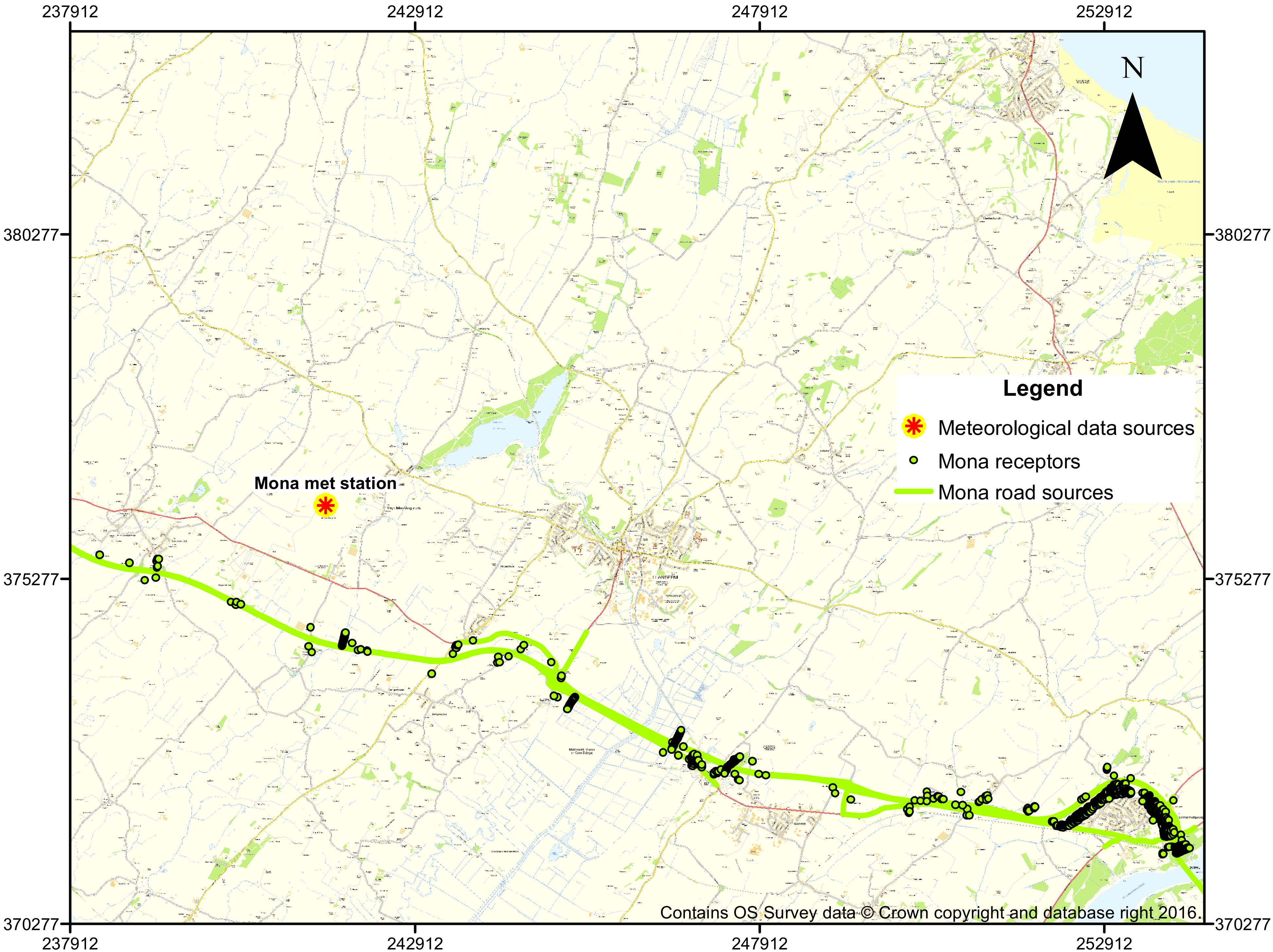
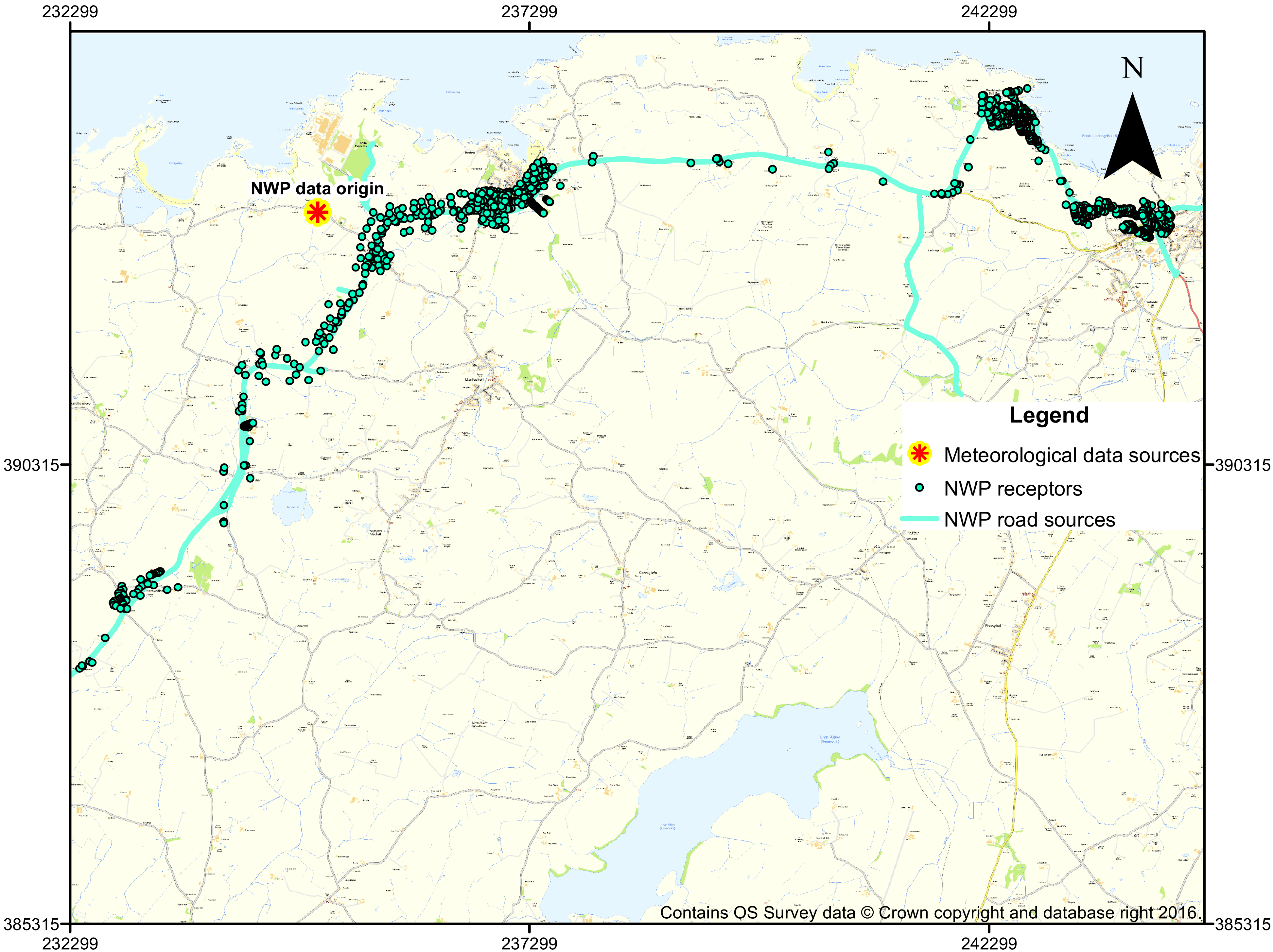
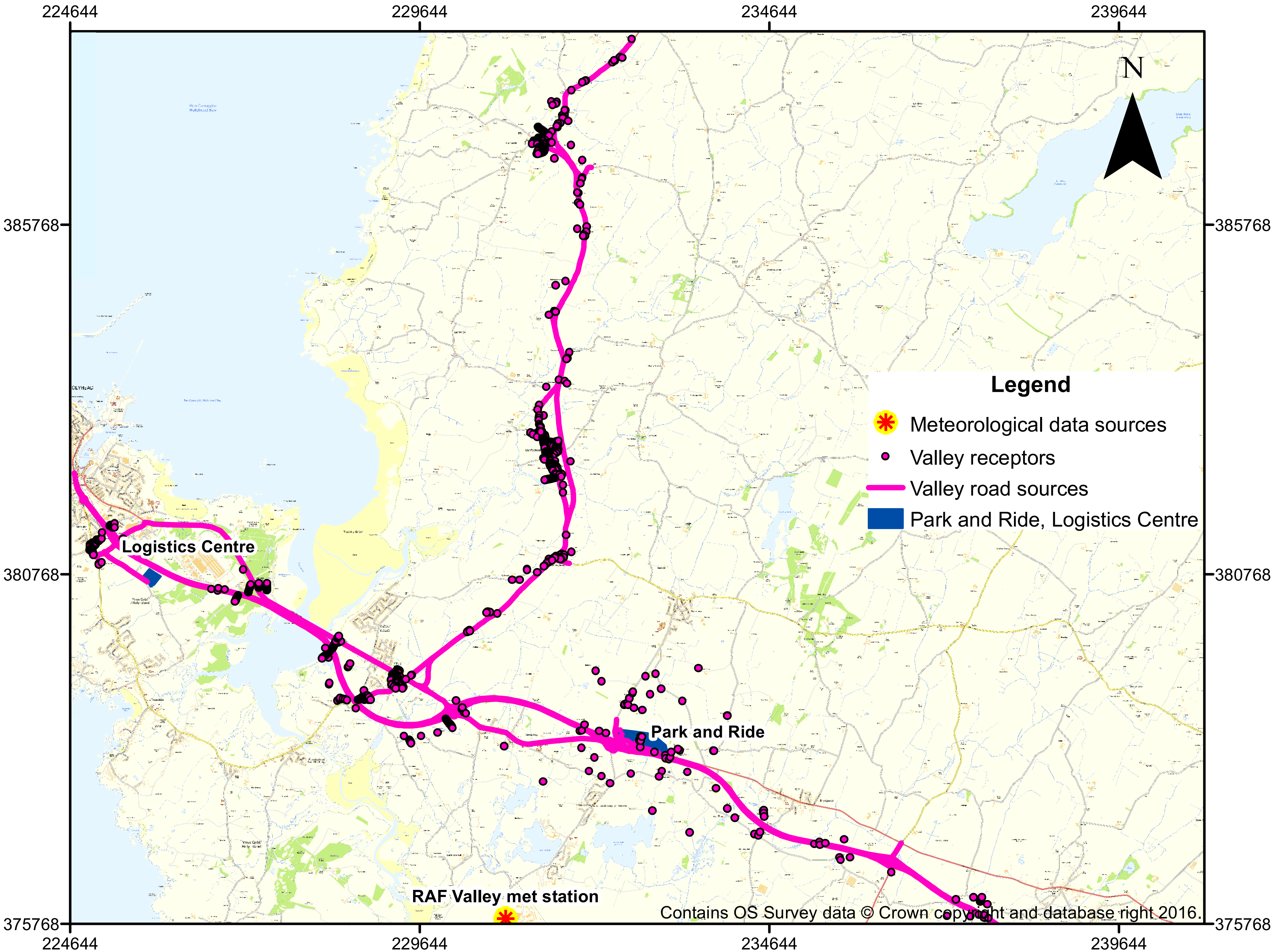
NOT PROTECTIVELY MARKED

Appendix C
Modelled road links visualisations


237912
242912
247912
252912
380277
375277
370277
N
Legend
Meteorological data sources
Mona receptors
Mona road sources
Mona met station
Contains OS Survey data © Crown copyright and database right 2016.



232299
237299
242299
390315
385315
N
NWP data origin
Legend
Meteorological data sources
NWP receptors
NWP road sources
Contains OS Survey data © Crown copyright and database right 2016.



224644
229644
234644
239644
385768
380768
375768
N
Legend
Meteorological data sources
Valley receptors
Valley road sources
Park and Ride, Logistics Centre
Logistics Centre
Park and Ride
RAF Valley met station
Contains OS Survey data © Crown copyright and database right 2016.

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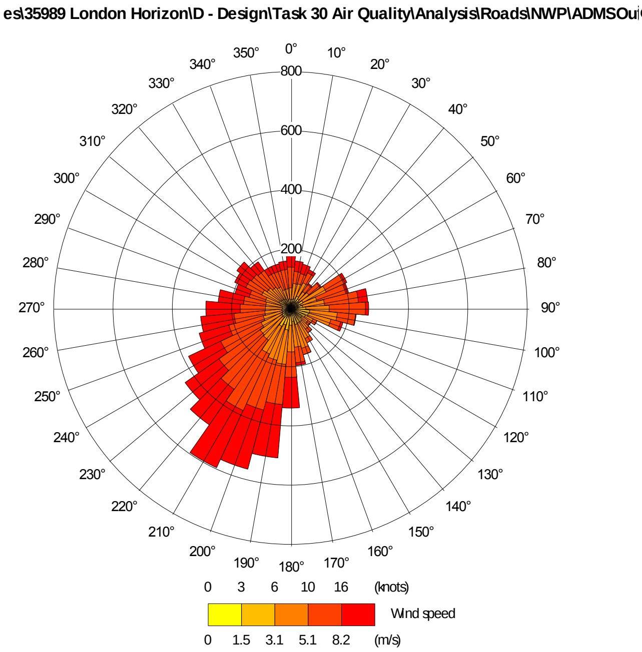
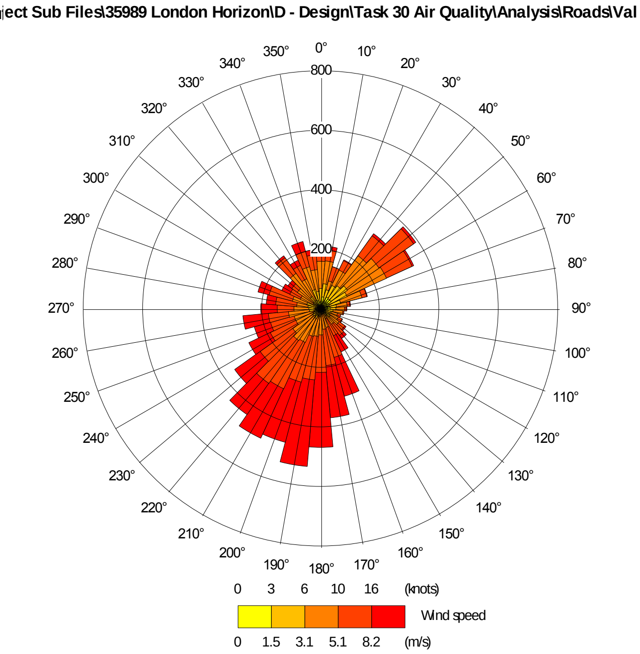
Appendix D
Receptor locations

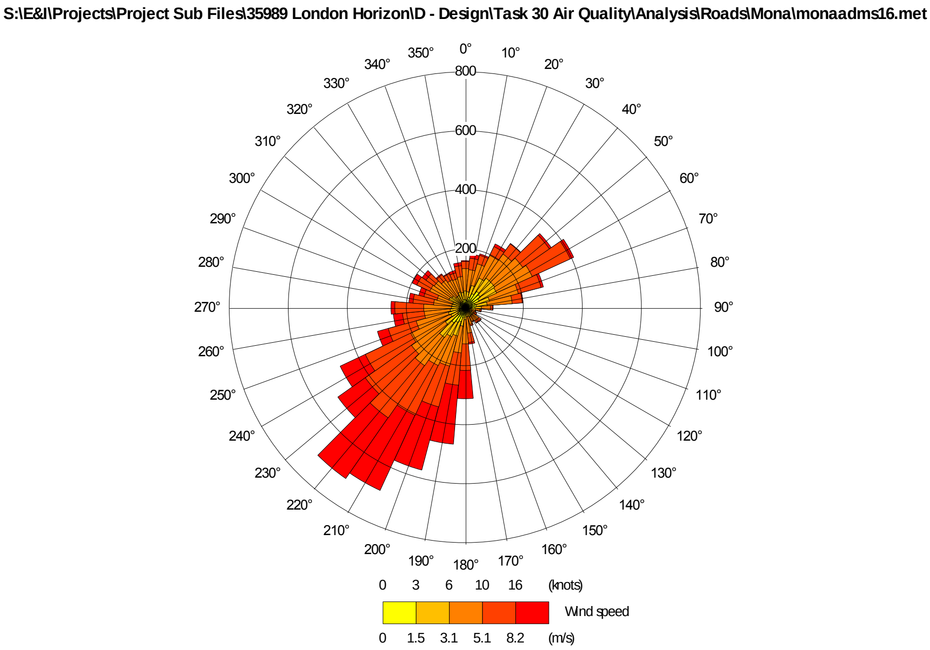
The spreadsheet below contains the coordinates and descriptions of all human and ecological receptors considered in the roads modelling.

[This appendix will not be shown in the hard copy and only available electronically due to the size of the appendix]

Appendix E
Wind roses for NWP, RAF Valley and Mona meteorological datasets 2016







Appendix F
Model verification

Model verification

The ADMS Roads dispersion model has been widely validated for this type of assessment and is specifically listed in the Defra's LAQM.TG(16) guidance as an accepted dispersion model. However, model validation undertaken by the software developer (CERC) will not have included validation in the vicinity of the proposed Wylfa Newydd Development Area. It is therefore necessary to perform a comparison of modelled results with local monitoring data at relevant locations. This process of verification attempts to minimise modelling uncertainty and systematic error by correcting modelled results by an adjustment factor to gain greater confidence in the final results.

The predicted results from a dispersion model may differ from measured concentrations for a large number of reasons, including uncertainties associated with:

- Background concentration estimates;
- Source activity data such as traffic flows and emissions factors;
- Monitoring data, including locations; and
- Overall model limitations.

Model verification is the process by which these and other uncertainties are investigated and, where possible, minimised. In reality, the differences between modelled and monitored results are likely to be a combination of all of these aspects.

Model setup parameters and input data were checked prior to running the models in order to reduce these uncertainties. The following were checked to the fullest extent possible to ensure accuracy:

- Traffic data;
- Distance between sources and monitoring as represented in the model;
- Vertical geometry of road sources relative to the receptor locations e.g. height adjusted to account for embankments;
- Speed estimates on roads;
- Background monitoring and background estimates; and
- Monitoring data.

Comparison has been made between modelled concentrations and local NO_2 monitoring data, with specific reference to 12 NO_2 diffusion tube locations, detailed in Table F1 and Figure F1.

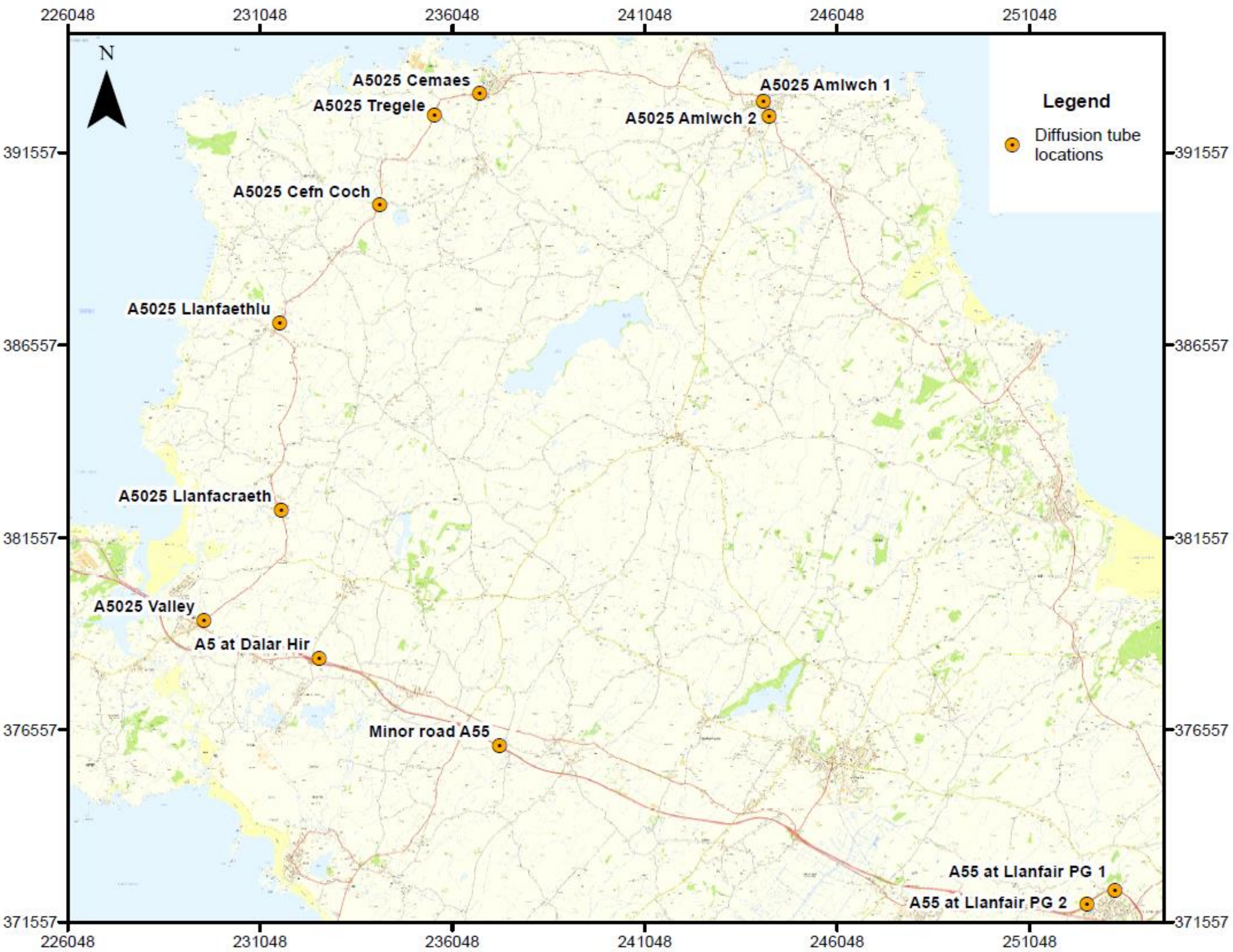
Table F1 NO_2 diffusion tube monitoring locations used in the verification

Diffusion tube ID	Monitoring location	X (m)	Y (m)	Approximate distance from kerbside (m)
A	A55 at Llanfair PG 1	253263	372367	3 m
B	Minor road A55	237267	376129	1.2 m
C	A5 at Dalar Hir	232573	378407	1.5 m
D	A5025 Valley	229588	379382	0.5 m

Diffusion tube ID	Monitoring location	X (m)	Y (m)	Approximate distance from kerbside (m)
E	A5025 Llanfacraeth	231593	382274	1.65 m
F	A5025 Llanfaethlu	231555	387112	1.5 m
G	A5025 Cefn Coch	234152	390193	3.5 m
H	A5025 Tregele	235575	392545	1.6 m
I	A5025 Cemaes	236752	393090	1.7 m
K	A5025 Amlwch 1	244130	392885	1.4 m
L	A5025 Amlwch 2	244270	392498	1.15 m
N/A	A55 at Llanfair PG 2	252527	372031	1.8 m

Notes: The coordinates and distances above have been supplied by Jacobs apart from monitoring location “A55 at Llanfair PG 2”, where reference has been made to OS MasterMap data and satellite photography/Google Streetview.

Figure F1 NO_2 diffusion tube monitoring locations



Contains Ordnance Survey data © Crown copyright and database right 2016.

As there are no suitable roadside monitoring locations available for the purposes of verifying predicted PM_{10} and $PM_{2.5}$ modelled concentrations, PM_{10} and $PM_{2.5}$ results have been verified by applying the same adjustment factor as that determined for NO_x. This is considered valid in certain scenarios, as LAQM.TG(16) states:

"… in the absence of any PM_{10} data for verification, it may be appropriate to apply the road-NO_X adjustment to the modelled road-PM_{10}. If this identifies exceedences of the objective, then it would be appropriate to monitor PM_{10} to confirm the findings."

Verification Calculations

The verification of the modelling output was performed in accordance with the methodology provided in LAQM.TG(16).

For the verification and adjustment of NO_x/NO_2, diffusion tube monitoring data was used as detailed above. As with the other roads modelling scenarios, the verification modelling was also split into different areas, according to the most suitable meteorological data set for each geographical area.

Additionally, as the diffusion tubes located at Cefn Coch, Tregele and Cemaes are situated some distance away from those at Amlwch, the NWP verification models were split into two sections. The first NWP verification model takes account of the diffusion tube locations at Cefn Coch, Tregele and Cemaes, whilst the second assesses the diffusion tubes located in Amlwch. This resulted in a total of four verification scenarios used to assess the uncertainty between the monitored and modelled data and hence four different adjustment factors were applied to receptors located in the different areas. A summary of the meteorological data used and the areas where each adjustment factor was applied is provided in Table F2. A visualisation is provided in Figure F2.

Table F2 Verification model summary

Site	Meteorological data set used	Description
A55 at Llanfair PG 1	Mona airfield	Used for receptors from the Britannia Bridge in the east, along the A55 up to Gwalchmai.
A55 at Llanfair PG 2	Mona airfield	
Minor road A55	RAF Valley	Used for receptors from Gwalchmai along to Holyhead on the A55, and up to Llanfaethlu on the A5025.
A5 at Dalar Hir	RAF Valley	
A5025 Valley	RAF Valley	
A5025 Llanfacraeth	RAF Valley	
A5025 Llanfaethlu	RAF Valley	
A5025 Cefn Coch	NWP (1)	Used for receptors from the north of Llanfaethlu, Cemaes and other isolated receptors along the western side of the A5025 between Cemaes and Amlwch.
A5025 Tregele	NWP (1)	
A5025 Cemaes	NWP (1)	
A5025 Amlwch 1	NWP (2)	Used for receptors along the eastern side of the A5025 between Cemaes and Amlwch, inclusive of receptors in Amlwch.
A5025 Amlwch 2	NWP (2)	

Figure F2 Verification model areas and receptors

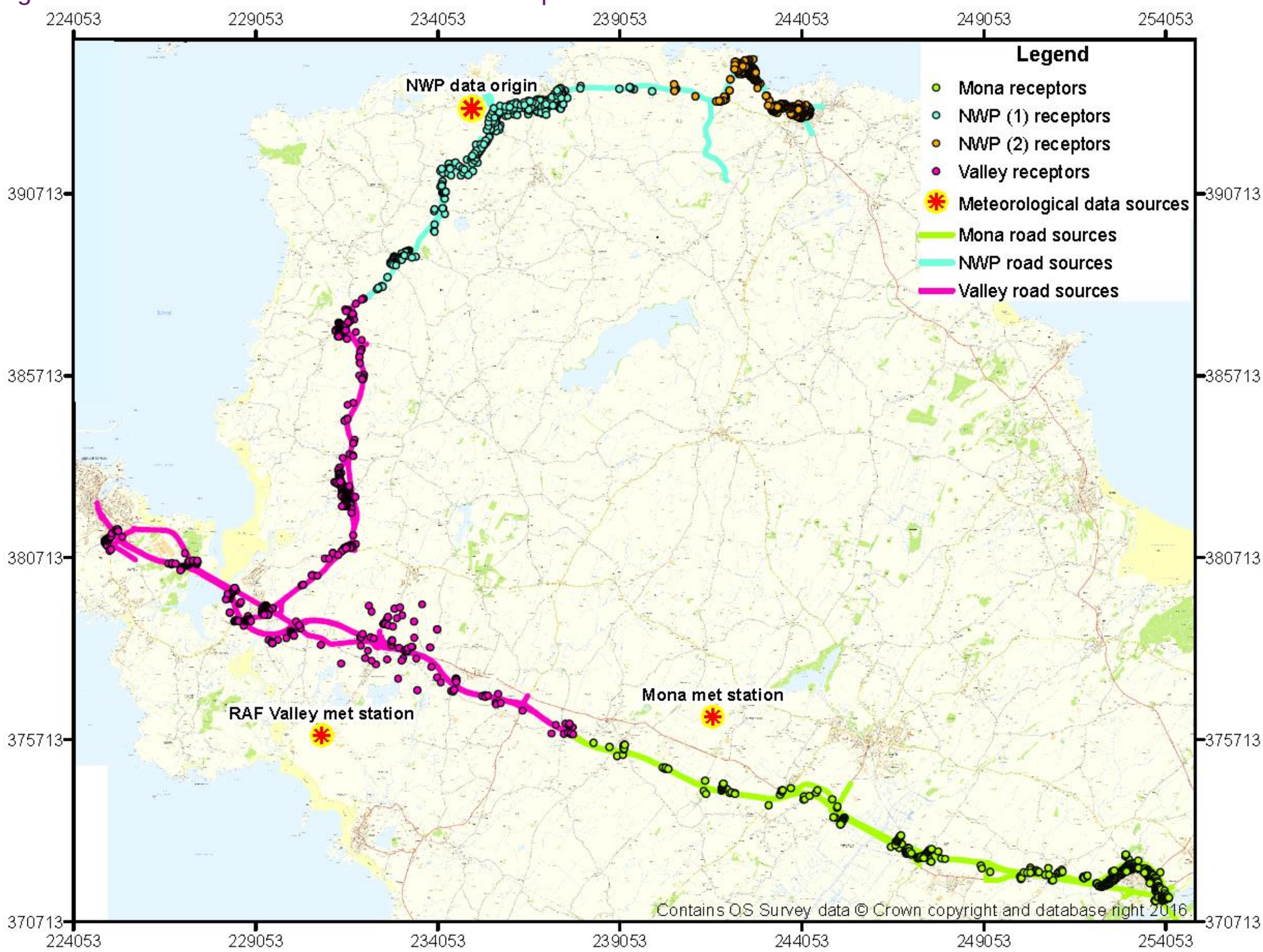


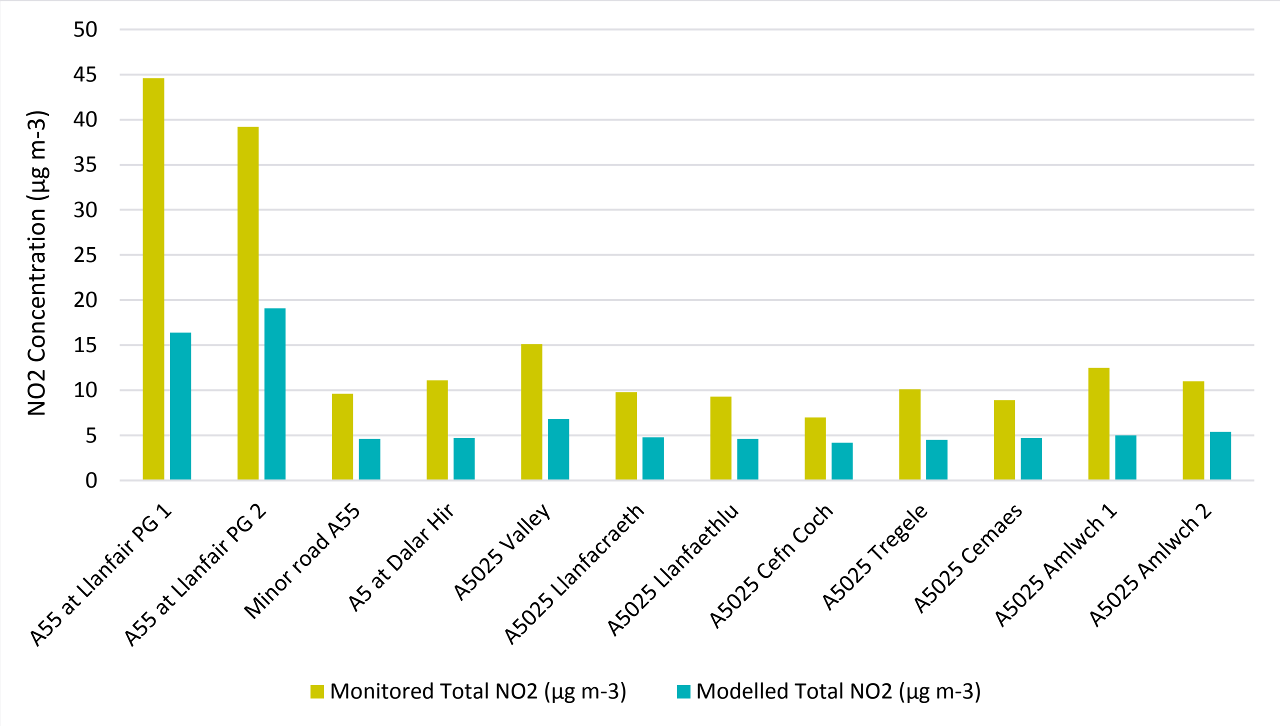
Table F3 below shows an initial comparison of the monitored and unverified modelled NO_2 results for the year 2016 for each diffusion tube location to determine if verification and adjustment was required. Figure F3 presents a visual comparison of NO_2 concentrations before verification.

Table F3 Comparison of unverified modelled and monitored NO_2 concentrations

Site	Background NO_2 ($\mu g\ m^{-3}$)	Monitored Total NO_2 ($\mu g\ m^{-3}$)	Modelled Total NO_2 ($\mu g\ m^{-3}$)	% Difference (Modelled vs. Monitored)
A55 at Llanfair PG 1	4.4	44.6	16.4	-63%
A55 at Llanfair PG 2	4.4	39.2	19.1	-51%
Minor road A55	3.8	9.6	4.6	-52%
A5 at Dalar Hir	3.9	11.1	4.7	-58%
A5025 Valley	4.5	15.1	6.8	-55%
A5025 Llanfacraeth	3.9	9.8	4.8	-51%
A5025 Llanfaethlu	3.8	9.3	4.6	-51%
A5025 Cefn Coch	3.7	7.0	4.2	-39%

Site	Background NO_2 ($\mu g\ m^{-3}$)	Monitored Total NO_2 ($\mu g\ m^{-3}$)	Modelled Total NO_2 ($\mu g\ m^{-3}$)	% Difference (Modelled vs. Monitored)
A5025 Tregele	4.0	10.1	4.5	-55%
A5025 Cemaes	4.3	8.9	4.7	-48%
A5025 Amlwch 1	4.0	12.5	5.0	-60%
A5025 Amlwch 2	4.0	11.0	5.4	-51%

Figure F3 Plot of unverified modelled total NO_2 and monitored total NO_2



Based on the difference between modelled and monitored concentrations, adjustment of modelled results was considered necessary.

Model adjustment needs to be undertaken based on NO_x and not NO_2. For the diffusion tube monitoring results used in the calculation of the model adjustment, NO_x was derived from NO_2 using Defra's NO_x to NO_2 Conversion Tool (version 5.1)[18]. The steps used to calculate the verification were as follows:

- Use the monitored total NO_2 (Table F3) and covert this into monitored road contribution NO_x using the NO_x to NO_2 conversion tool;
- Compare the monitored road contribution NO_x to the modelled road contribution NO_x (from the dispersion modelling) and calculate the model adjustment based on regression analysis;
- Adjust the modelled road contribution NO_x using the calculated adjustment factor; and
- Convert this to adjusted modelled total NO_2 using the NO_x to NO_2 calculator.

Table F4 provides the relevant data required to calculate the model adjustment based on regression analysis of the modelled and monitored road source contribution to NO_x.

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

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Table F4 Data required for model adjustment

Site	Monitored road contribution NOx ($\mu g\ m^{-3}$)	Modelled road contribution NOx ($\mu g\ m^{-3}$)
A55 at Llanfair PG 1	86.39	23.37
A55 at Llanfair PG 2	72.81	28.91
Minor road A55	11.96	3.82
A5 at Dalar Hir	14.79	3.81
A5025 Valley	21.57	4.45
A5025 Llanfacraeth	12.02	4.04
A5025 Llanfaethlu	11.36	3.85
A5025 Cefn Coch	5.88	1.76
A5025 Tregele	11.06	1.59
A5025 Cemaes	8.34	1.18
A5025 Amlwch	15.58	2.30
A5025 Amlwch	12.74	3.06

Figures F4 to F7 provide a comparison of the modelled road contribution NO_x versus monitored road contribution NO_x, and the equation of the trend line based on linear regression through zero for each of the verification areas. The equation of the trend lines presented in each gives an adjustment factor for the modelled results which are presented in Table F5. The factors outlined were applied to the relevant road contribution NO_x concentrations predicted by the model to arrive at the final NO_2 concentrations. For all the diffusion tube sites, the verified results and adjustment factors used are provided in Table F5.

Figure F4 Modelled road contribution NOx versus monitored road contribution NOx – Mona airfield verification area

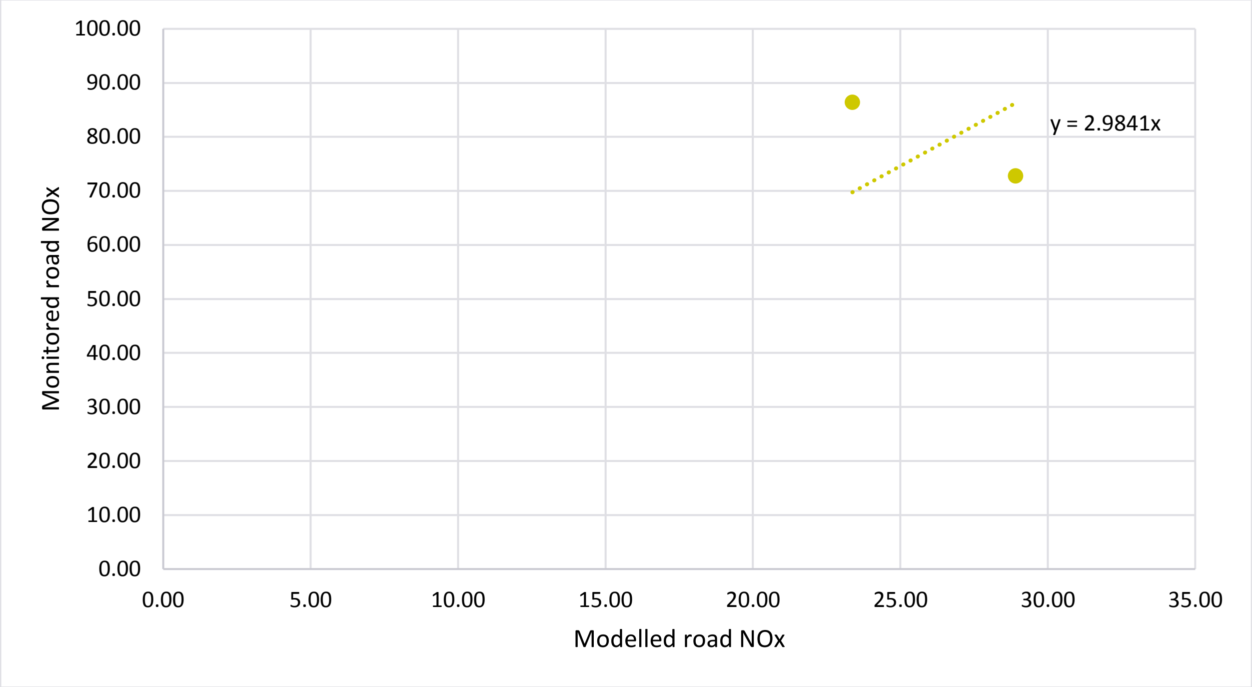


Figure F5 Modelled road contribution NOx versus monitored road contribution NOx – RAF Valley verification area

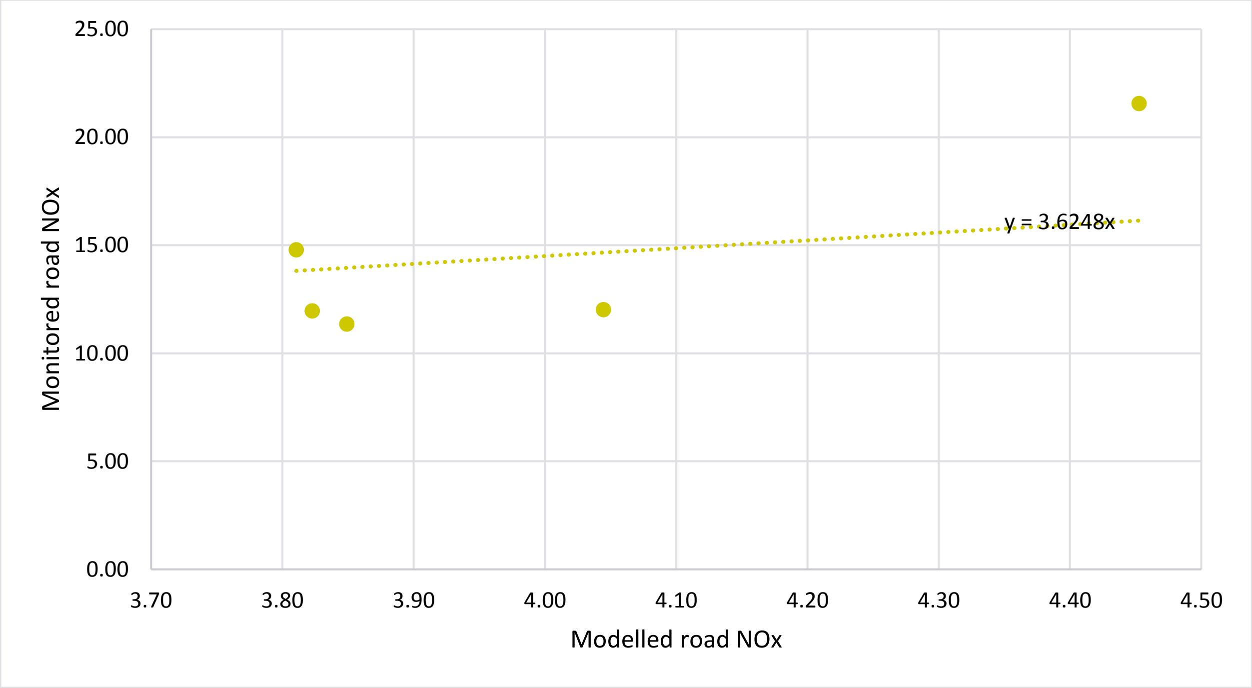


Figure F6 Modelled road contribution NOx versus monitored road contribution NOx – NWP (1) verification area

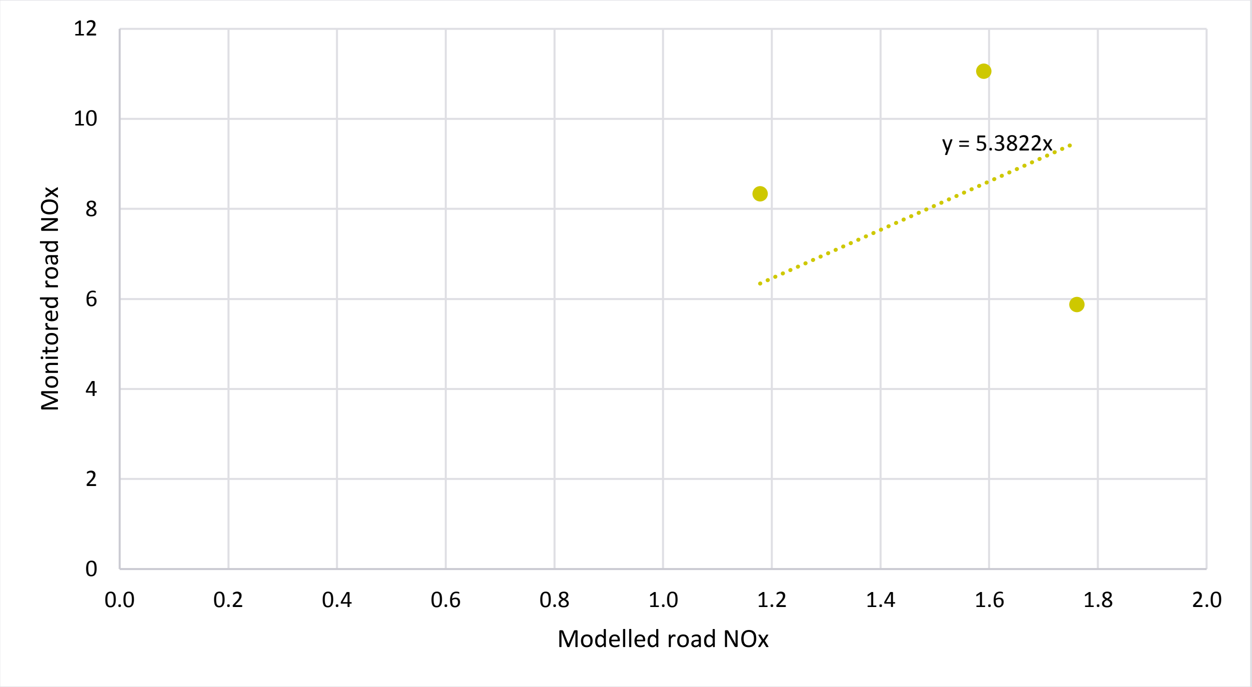


Figure F7 Modelled road contribution NOx versus monitored road contribution NOx – NWP (2) verification area

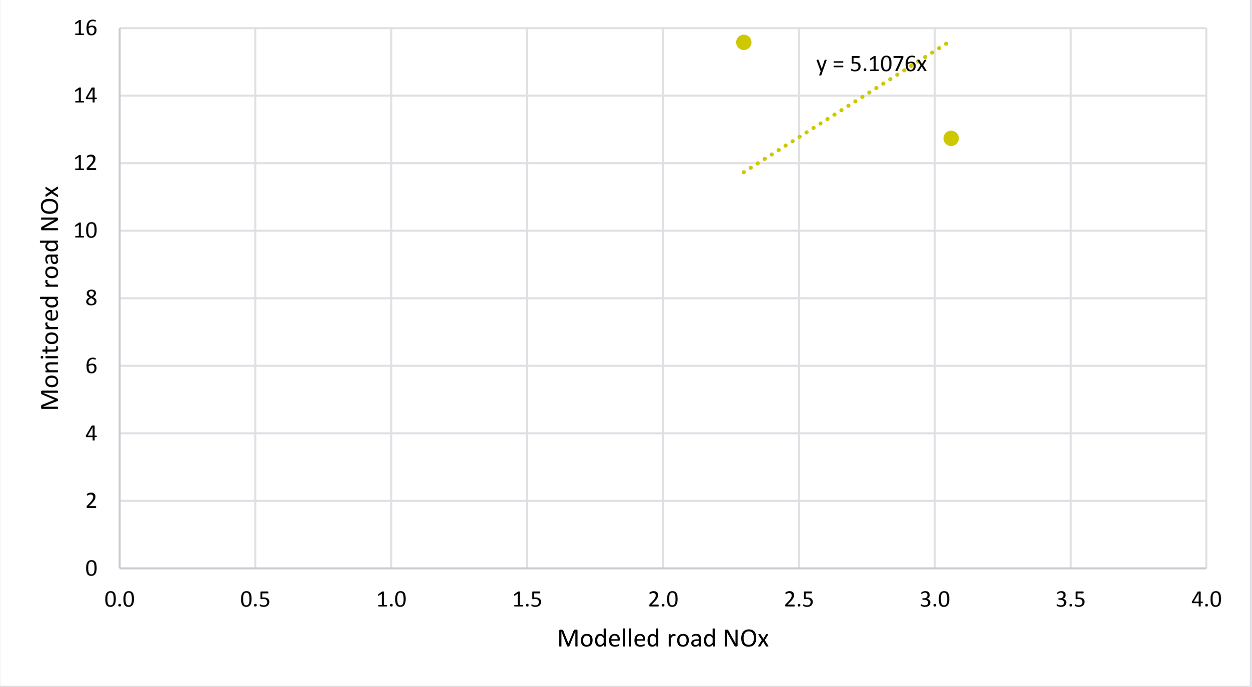
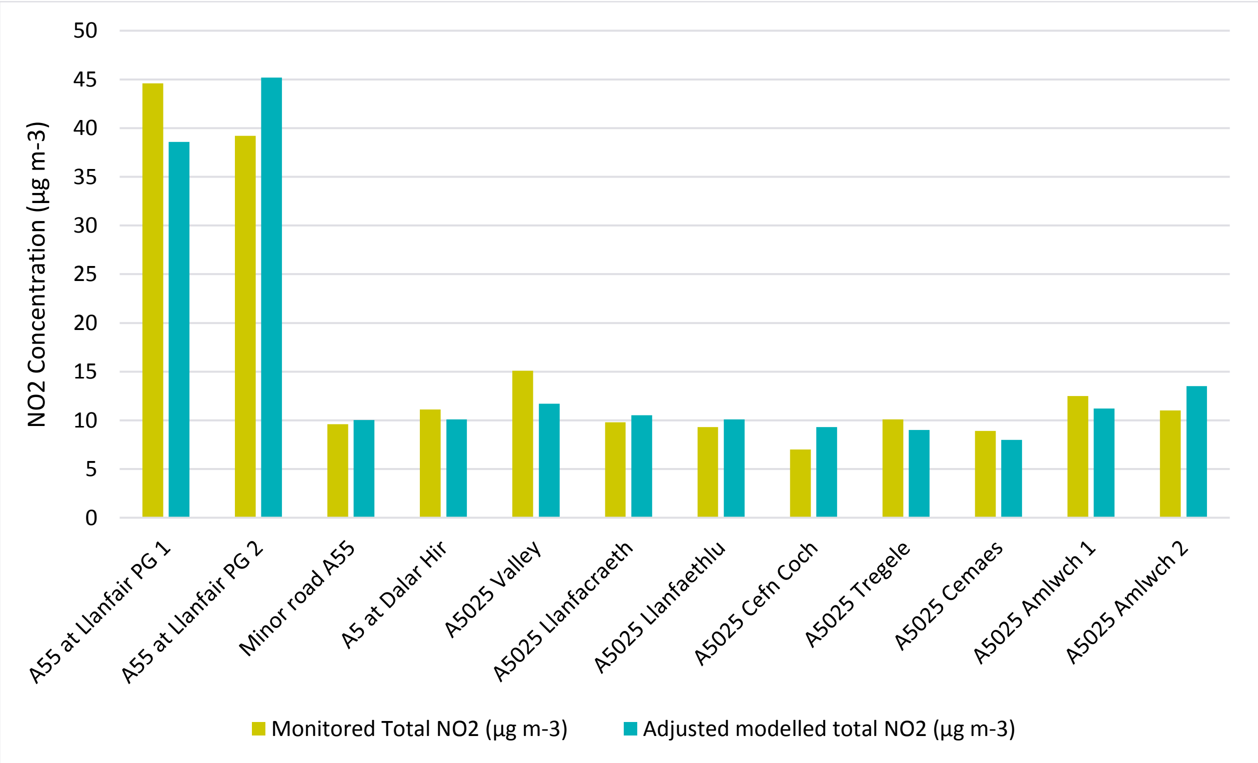


Table F5 Model results after verification

Site	Monitored total NO_2 (µg m^{-3})	Modelled total NO_2 (µg m^{-3})	% Difference (Modelled vs. Monitored)	Adjustment factor used
A55 at Llanfair PG 1	44.6	37.9	-15%	2.98
A55 at Llanfair PG 2	39.2	44.5	+14%	2.98
Minor road A55	9.6	11.3	+18%	3.62
A5 at Dalar Hir	11.1	11.4	+3%	3.62
A5025 Valley	15.1	13.2	-12%	3.62
A5025 Llanfacraeth	9.8	11.9	+22%	3.62
A5025 Llanfaethlu	9.3	11.4	+23%	3.62
A5025 Cefn Coch	7.0	8.8	+25%	5.38
A5025 Tregele	10.1	8.6	-15%	5.38
A5025 Cemaes	8.9	7.7	-14%	5.38
A5025 Amlwch	12.5	10.6	-16%	5.10
A5025 Amlwch	11.0	12.7	+15%	5.10

Figure F8 provides a comparison of monitored total NO_2 and the total modelled NO_2 concentrations after verification adjustment.

Figure F8 Plot of verified (adjusted) modelled total NO_2 and monitored total NO_2



Although the derived adjustment factors are higher than might be considered ideal, it must be stressed that the absolute concentrations in this case, with the exception of the two locations on the A55 in Llanfair PG, are relatively low. Therefore, small variations between the monitored and modelled concentration in absolute terms can manifest as large variations when expressed in percentage or fractional terms (which is, ultimately, how the adjustment factor is expressed). In order to further explore the robustness of the model predictions, a number of statistical procedures provided in LAQM.TG(16) have been undertaken. These statistical procedures include calculation of the:

- Correlation coefficient;
- Fractional bias; and
- Root Mean Square Error (RMSE).

Table F6 below summarises the results of these parameters for each of the verification model areas.

Table F6 Model uncertainty results before and after verification

Verification model area	Correlation coefficient		Fractional bias		RMSE	
	Before verification	After verification	Before verification	After verification	Before verification	After verification
Mona airfield	-*	-*	0.81	0.02	24.49	5.99
RAF Valley	0.97	0.91	0.74	-0.07	6.05	1.76
NWP (1)	0.71	-0.29	0.64	-0.04	4.36	1.52
NWP (2)	-*	-*	0.77	-0.05	6.63	1.99

*Correlation coefficient not reported as the data set is too small.

LAQM.TG(16) advises that the correlation coefficient is more useful for larger data sets and has, therefore, only been calculated for RAF Valley and NWP (1) verification models. The ideal value for the correlation coefficient is 1.0. Therefore, the data in Table F6 indicates that there is strong correlation for the RAF Valley data set where this parameter has been calculated.

The RMSE provides an estimate of average error of the model. For the different verification models presented in Table F6, the RMSE (in annual mean NO_2 concentrations) is in the range 4.4 – 24.5 µg m^{-3} before verification and 1.5 – 6.0 µg m^{-3} after verification. With regard to RMSE values, LAQM.TG(16) states:

"Ideally an RMSE within 10% of the air quality objective would be derived, which equates to 4µg/m^3 for the annual average NO_2 objective"

Consequently, the majority of RMSE values above demonstrate an acceptable level of performance of the road traffic emissions model after verification. Although the RMSE of the 'Mona airfield' verification area is above 4 µg m^{-3}, it is still less than 10 µg m^{-3}, a level where LAQM.TG(16) advises the model parameters and verification should be revisited. Furthermore, the calculated fractional bias after verification indicates a slight tendency for the road traffic emissions model to over predict for the 'RAF Valley' and both 'NWP' areas. Therefore, predictions from the road traffic emissions model are considered to be robust.

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Appendix G
Tabulated results

Results for all scenarios modelled

Tabulated results are contained within excel spreadsheets for each of the following scenarios.

2020 baseline:

2023 baseline:

2028 baseline:

2020 Project without bypasses:

2020 Project with bypasses:

2023 Project with bypasses:

2028 Project with bypasses:

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