A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Proposed Free Range Egg Laying Chicken House at Carno, Near Caersws, Powys in Wales

AS Modelling & Data Ltd.

www.asmodata.co.uk

Prepared by Sally Young

BSc (Hons), MSc in Applied Meteorology & Climatology, CSci, MIEnvSc, MIAQM

sally@asmodata.co.uk
07483 345124
19th August 2025

Reviewed by Steve Smith

stevesmith@asmodata.co.uk
07523 993370
20th August 2025

1. Introduction

AS Modelling & Data Ltd. has been instructed by Ms. Rosina Riddle, of Roger Parry & Partners LLP, to use computer modelling to assess the impact of ammonia emissions from the proposed free range egg-laying chicken house at Carno, Near Caersws, Powys. SY17 5JY.

Ammonia emission rates from poultry have been assessed and quantified based upon the Natural Resources Wales standard ammonia emission factors. The ammonia emission rates have then been used as inputs to an atmospheric dispersion and deposition model which calculates ammonia exposure levels and nitrogen and acid deposition rates in the surrounding area.

This report is arranged in the following manner:

- Section 2 provides relevant details of the farm and potentially sensitive receptors in the area.

- Section 3 provides some general information on ammonia; details of the method used to estimate ammonia emissions; relevant guidelines and legislation on exposure limits and where relevant, details of likely background levels of ammonia.

- Section 4 provides some information about ADMS, the dispersion model used for this study and details the modelling procedure.

- Section 5 contains the results of the modelling.

- Section 6 provides a discussion of the results and conclusions.

2. Background Details

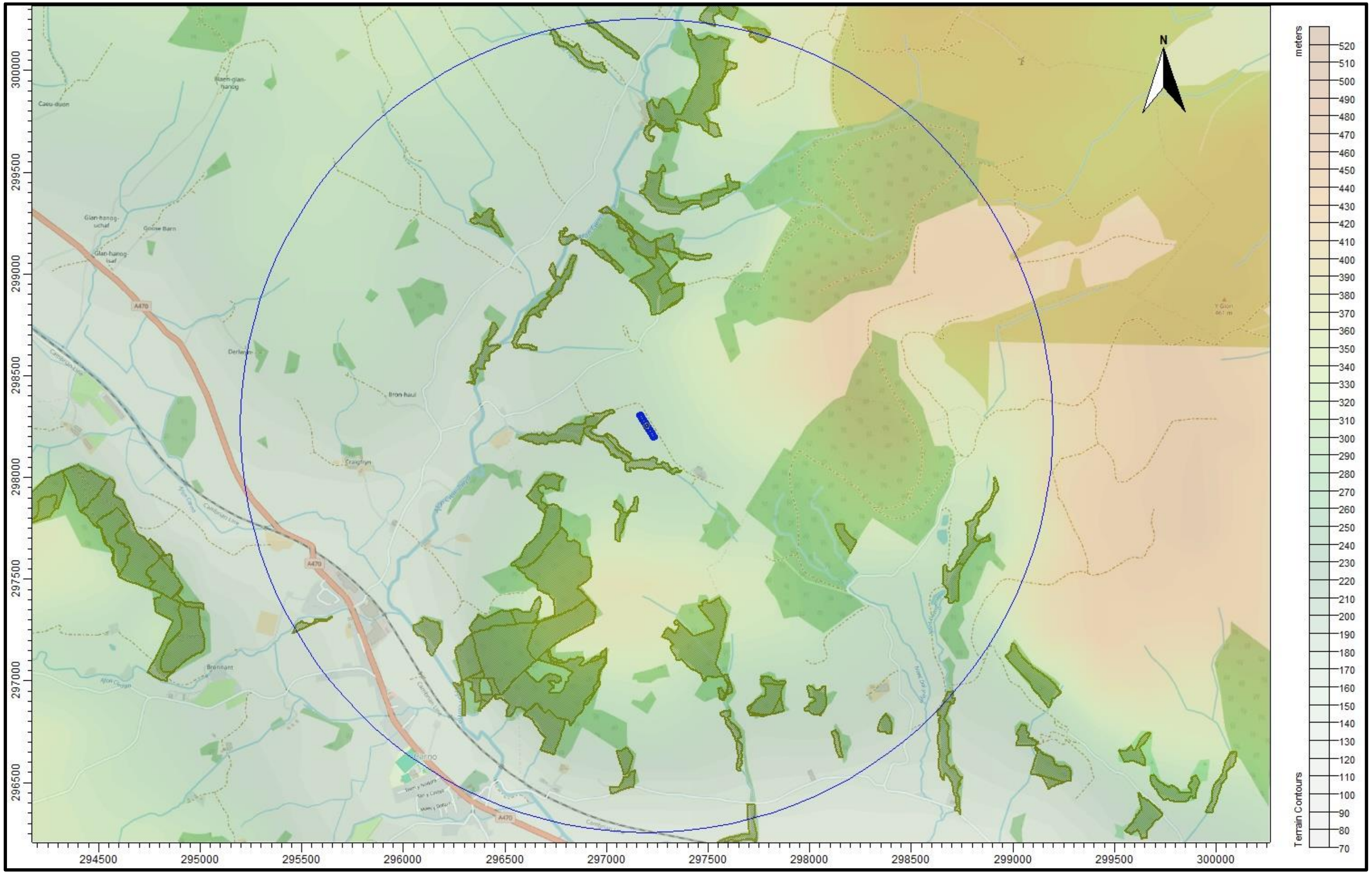
The site of the proposed poultry house is in a rural area approximately 1.5 km to the south-west of the small village of Carno in Powys. The surrounding land is used mainly for livestock grazing with several large areas of semi-natural woodlands nearby. The farm is at an elevation of approximately 260 m in the valley of the River Dyfi, with land rising steeply toward a hill to the south and mountains to the east.

Under the proposal, a single poultry house would be constructed at the site. The poultry house would provide accommodation for up to 32,000 free range egg-laying chickens (in two adjoined 16,000 bird units). The poultry house would be ventilated by high-speed ridge/roof mounted fans and a belt collection system within the house would be used to remove manure twice weekly prior to removal from the site. There would be pop holes along the side of the building, which would provide the birds with daytime access to outside ranging areas.

There are several Ancient Woodlands (AWs) within 2 km (the normal screening distance for non-statutory wildlife sites) of the site. There are no SSSIs, Ammonia sensitive AWs or internationally designated sites within 3 km (the Natural Resources Wales screening distance for developments of 32,000 or fewer free range layer chickens with belt removal) of the site.

A map of the surrounding area showing the site of the proposed poultry house (outline in blue) and the AWs (shaded in olive) is provided in Figure 1.

Figure 1. The area surrounding the site – circle radius 2 km



3. Ammonia, Background Levels, Critical Levels & Loads & Emission Rates

3.1 Ammonia concentration and nitrogen and acid deposition

When assessing potential impact on ecological receptors, ammonia concentration is usually expressed in terms of micrograms of ammonia per metre cubed of air ($\mu g\text{-}NH_3/m^3$) as an annual mean. Ammonia in the air may exert direct effects on the vegetation, or indirectly affect the ecosystem through deposition which causes both hyper-eutrophication (excess nitrogen enrichment) and acidification of soils. Nitrogen deposition, specifically in this case the nitrogen load due to ammonia deposition/absorption, is usually expressed in kilograms of nitrogen per hectare per year (kg-N/ha/y). Acid deposition is expressed in terms of kilograms equivalent (of H^+ ions) per hectare per year (keq/ha/y).

3.2 Background ammonia levels and nitrogen and acid deposition

The source of the background figures is the Air Pollution Information System (APIS, August 2025). It should be noted that the 1 km APIS database background levels are extrapolated from 5 km modelled data. Ammonia levels may vary markedly over relatively short distances and the APIS website itself notes that, the background values should be used only to assist the user in obtaining a broad indication of the likely pollutant impact at a specific location and cannot be considered representative of any particular location within the 5 km grid square; extrapolation to a 1 km grid does not alter this.

The APIS figures for background ammonia concentration in the area around the site is 0.91 $\mu g\text{-}NH_3/m^3$. The background nitrogen deposition rate to woodland is 27.13 kg-N/ha/y and to short vegetation is 16.78 kg-N/ha/y. The background acid deposition rate to woodland is 2.03 keq/ha/y and to short vegetation is 1.25 keq/ha/y.

The APIS background figures are subject to correction and revision and appear to change fairly frequently, the latest figures can be obtained at https://www.apis.ac.uk/search-location.

3.3 Critical Levels & Critical Loads

Critical Levels and Critical Loads are a benchmark for assessing the risk of air pollution impacts to ecosystems. It is important to distinguish between a Critical Level and a Critical Load. The Critical Level is the gaseous concentration of a pollutant in the air, whereas the Critical Load relates to the quantity of pollutant deposited from air to the ground.

Critical Levels are defined as, "concentrations of pollutants in the atmosphere above which direct adverse effects on receptors, such as human beings, plants, ecosystems or materials, may occur according to present knowledge" (UNECE).

Critical Loads are defined as, "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" (UNECE).

For ammonia concentration in air, the Critical Level for higher plants is 3.0 µg-NH_3/m^3 as an annual mean. For sites where there are sensitive lichens and bryophytes present, or where lichens and bryophytes are an integral part of the ecosystem, the Critical Level is 1.0 µg-NH_3/m^3 as an annual mean.

Critical Loads for nutrient nitrogen are set under the Convention on Long-Range Transboundary Air Pollution. They are based on empirical evidence, mainly observations from experiments and gradient studies. Critical Loads are given as ranges (e.g. 10-20 kg-N/ha/y); these ranges reflect variation in ecosystem response across Europe.

The Critical Levels and Critical Loads at the wildlife sites assumed in this study are provided in Table 1. Where the Critical Level of 1.0 µg-NH_3/m^3 is assumed, it is usually unnecessary to consider the Critical Load as the Critical Level provides the stricter test. Normally, the Critical Load for nitrogen deposition provides a stricter test than the Critical Load for acid deposition.

Table 1. Critical Levels and Critical Loads at the wildlife sites

Site	Critical Level (µg-NH_3/m^3)	Critical Load - Nitrogen Deposition (kg-N/ha/y)	Critical Load - Acid Deposition (keq/ha/y)
AWs	3.0 [1]	10. 0 [1]	-

1. NRW guidance states that 'some of the most sensitive sites will have a critical level of 1.0 µg/m^3 whilst others will have critical levels of 3.0 µg/m^3'. AS Modelling & Data Ltd. normally assume a precautionary Critical Level of 1.0 µg/m^3, where there is no contrary evidence; however, because none of the AWs are considered to be sensitive by NRW it is assumed in this case that, whilst lichens or bryophytes may be present, they do not form a key part of the ecosystem integrity, therefore a Critical Level of 3.0 µg/m^3 has been used.

3.4 Guidance on the Significance of Ammonia Emissions

3.4.1 Natural Resources Wales guidance

In May 2021, Natural Resources Wales published web-based guidance for the assessment of ammonia emissions from intensive livestock farming. The guidance includes the following:

- Ammonia assessments for developments that require a permit or planning permission
- Ammonia assessments: initial screening and evidence gathering (GN 020)
- How to carry out detailed modelling of ammonia emissions (GN 036)
- Detailed modelling of ammonia emissions stage 1 (GN 036)
- Detailed modelling of ammonia emissions stage 2 (GN 036)
- How to interpret the results from your screening or modelling exercise for Ammonia Emissions (GN 020)
- Ammonia scrubber design and use
- Applications that reduce the impact or risk of pollution (GN 020)
- Emission factors for poultry for modelling and reporting
- Emission factors for pigs for modelling and reporting
- Emission factors for cattle for modelling and reporting
- Reducing ammonia emissions from agriculture

The Natural Resources Wales guidance has been followed for this assessment, however it appears to apply only to statutory sites and some Ancient Woodlands deemed ammonia sensitive by Natural Resources Wales. For Local Nature Reserves (LNRs), Local Wildlife Sites (LWSs) and other Ancient Woodlands (AWs), it is assumed that the Environment Agency's "Intensive farming risk assessment for your environmental permit" is still applicable as there is no other official guidance that AS Modelling & Data Ltd. are aware of. Within the range between the lower and upper thresholds, whether or not the impact is deemed acceptable is at the discretion of the Environment Agency. N.B. In the case of LWSs and AWs, the Environment Agency do not usually consider other farms that may act in-combination and therefore a PC of up to 100% of Critical Level or Critical Load is usually deemed acceptable for permitting purposes and therefore the upper and lower thresholds are the same (100%).

3.5 Quantification of Ammonia Emissions

Ammonia emission rates from poultry houses depend on many factors and are likely to be highly variable. However, the benchmarks for assessing impacts of ammonia and nitrogen deposition are framed in terms of an annual mean ammonia concentration and annual nitrogen deposition rates. To obtain relatively robust figures for these statistics, it is not necessary to model short term temporal variations and a steady continuous emission rate can be assumed. In fact, modelling short term temporal variations might introduce rather more uncertainty than modelling continuous emissions.

The emission factors used for the poultry housing and ranging area have been obtained from: https://naturalresources.wales/guidance-and-advice/business-sectors/farming/ammonia-assessments/emission-factors-for-poultry-for-modelling-and-reporting/?lang=en.

Details of the poultry numbers and types and emission factors used and calculated ammonia emission rates are provided in Table 2.

Table 2. Details of poultry numbers and ammonia emission rates

Source	Animal numbers/Tonnes	Type or weight	Emission factor (kg-NH_3/place/y or kg-NH_3/t/y)	Calculated emission rate (g-NH_3/s)
Proposed Housing	32,000	Multi-tier free range layers	0.066	0.066925
Proposed Ranging	32,000	Ranging Hens	0.024	0.024336

4. The Atmospheric Dispersion Modelling System (ADMS) and model parameters

The Atmospheric Dispersion Modelling System (ADMS) ADMS 6 is a new generation Gaussian plume air dispersion model, which means that the atmospheric boundary layer properties are characterised by two parameters; the boundary layer depth, and the Monin-Obukhov length rather than in terms of the single parameter Pasquill-Gifford class.

Dispersion under convective meteorological conditions uses a skewed Gaussian concentration distribution (shown by validation studies to be a better representation than a symmetrical Gaussian expression).

ADMS has a number of model options that include: dry and wet deposition; NO_x chemistry; impacts of hills, variable roughness, buildings and coastlines; puffs; fluctuations; odours; radioactivity decay (and γ-ray dose); condensed plume visibility; time varying sources and inclusion of background concentrations.

ADMS has an in-built meteorological pre-processor that allows flexible input of meteorological data both standard and more specialist. Hourly sequential and statistical data can be processed and all input and output meteorological variables are written to a file after processing.

The user defines the pollutant, the averaging time (which may be an annual average or a shorter period), which percentiles and exceedance values to calculate, whether a rolling average is required or not and the output units. The output options are designed to be flexible to cater for the variety of air quality limits, which can vary from country to country and are subject to revision.

4.1 Meteorological data

Computer modelling of dispersion requires hourly sequential meteorological data and to provide robust statistics the record should be of a suitable length; preferably four years or longer.

There are no observational weather data available that are likely to be representative of the site.

The meteorological data used in this study is obtained from assimilation and short-term forecast fields of the Numerical Weather Prediction (NWP) system known as the Global Forecast System (GFS)[1].

The GFS is a discrete model. The physics/dynamics model has a resolution or had a resolution of approximately 7 km over the central UK; terrain is understood to be resolved at a resolution of approximately 2 km, with sub-7 km terrain effects parameterised. Site specific data may be extrapolated from nearby archive grid points or a most representative grid point chosen. The GFS resolution adequately captures major topographical features and the broad-scale characteristics of the weather over the UK. Smaller scale topological features may be included in the dispersion modelling by using the flow field module of ADMS (FLOWSTAR[2]). The use of NWP data has advantages over traditional meteorological records because:

- Calm periods in traditional observational records may be overrepresented, this is because the instrumentation used may not record wind speeds below approximately 0.5 m/s and start up wind speeds may be greater than 1.0 m/s. In NWP data, the wind speed is continuous down to 0.0 m/s, allowing the calms module of ADMS to function correctly.

- Traditional records may include very local deviations from the broad-scale wind flow that would not necessarily be representative of the site being modelled; these deviations are difficult to identify and remove from a meteorological record. Conversely, local effects at the site being modelled are relatively easy to impose on the broad-scale flow and provided horizontal resolution is not too great, the meteorological records from NWP data may be expected to represent well the broad-scale flow.

- Information on the state of the atmosphere above ground level which would otherwise be estimated by the meteorological pre-processor may be included explicitly.

A wind rose showing the distribution of wind speeds and directions in the GFS derived data is shown in Figure 2a. Wind speeds are modified by the treatment of roughness lengths (see Section 4.7) and where terrain data is included in the modelling, the raw GFS wind speeds and directions will be modified. The terrain and roughness length modified wind rose for the site is shown in Figure 2b; it should be noted that this is the wind regime in close proximity to the site and elsewhere in the modelling domain wind roses may differ very markedly. Please note that FLOWSTAR[2] is used to obtain a local flow field, not to explicitly model dispersion in complex terrain as defined in the ADMS User Guide; therefore, the ADMS default value for minimum turbulence length has been amended [3].

1. The GFS data used is derived from the high-resolution operational GFS datasets, the data is not obtained from the lower resolution (0.5 degree) long-term archive.
2. Note that FLOWSTAR requirements are for meteorological data representative of the upwind flow over the modelling domain and that single site meteorological data (observational or from high resolution modelled data)

that is representative of the application site is not generally suitable (personal correspondence: CERC 2019 and UK Met O 2015). If data are deemed representative of a particular application site, either wholly or partially, then these data cannot also be representative of the upstream flow over the modelling domain. Furthermore, it would be extremely poor practice to use such data as the boundary conditions for a flow-solver, such as FLOWSTAR.

3. When modelling complex terrain with ADMS, by default, the minimum turbulence length has 0.1 m added to the flat terrain value (calculated from the Monin-Obukhov length). Whilst this might be appropriate over hill/mountain tops in terrain with slopes > 1:10 (and quite possibly only in certain wind directions) in lesser terrain it introduces model behaviour that is not desirable where FLOWSTAR is simply being used to modify the upwind flow. Specifically, the parameter sigma z of the Gaussian plume model is overly constrained, which for elevated point sources emissions, may on occasion cause over prediction of ground level concentrations in stable weather conditions and light winds (Steven R. Hanna & Biswanath Chowdhury, 2013), conversely for low level emission sources, this will cause gross under prediction. Note that this becomes particularly important overnight and if calm and light wind conditions are not being ignored, as they often are when using traditional observational meteorological datasets. To reduce this behaviour, where terrain is modelled, AS Modelling & Data Ltd. have set a minimum turbulence length of 0.025 m in ADMS. This approximates the normal behaviour of ADMS with flat terrain.

Figure 2a. The wind rose. Raw GFS derived data for 52.572 N, 3.515 W, 2021-2024

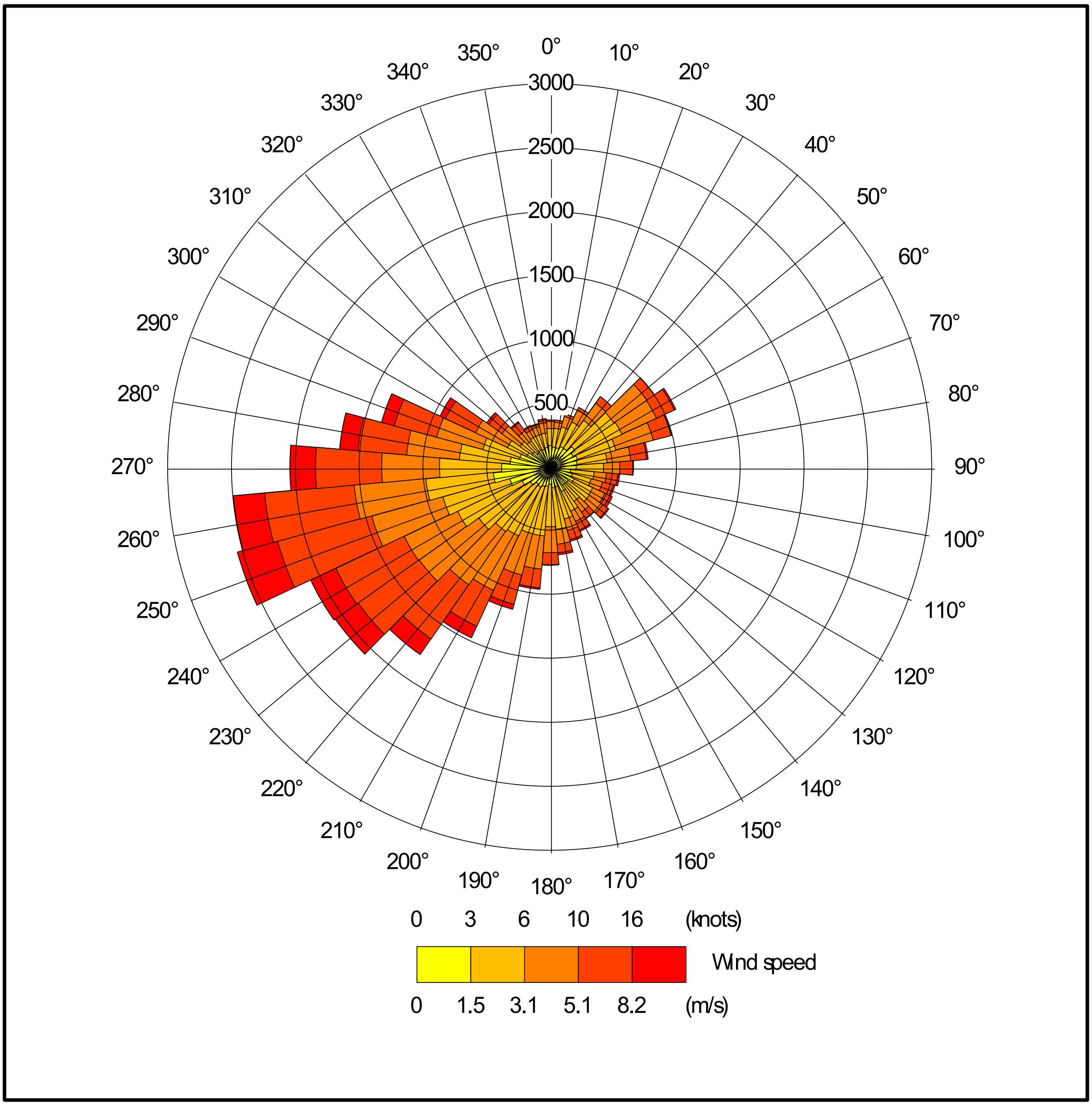
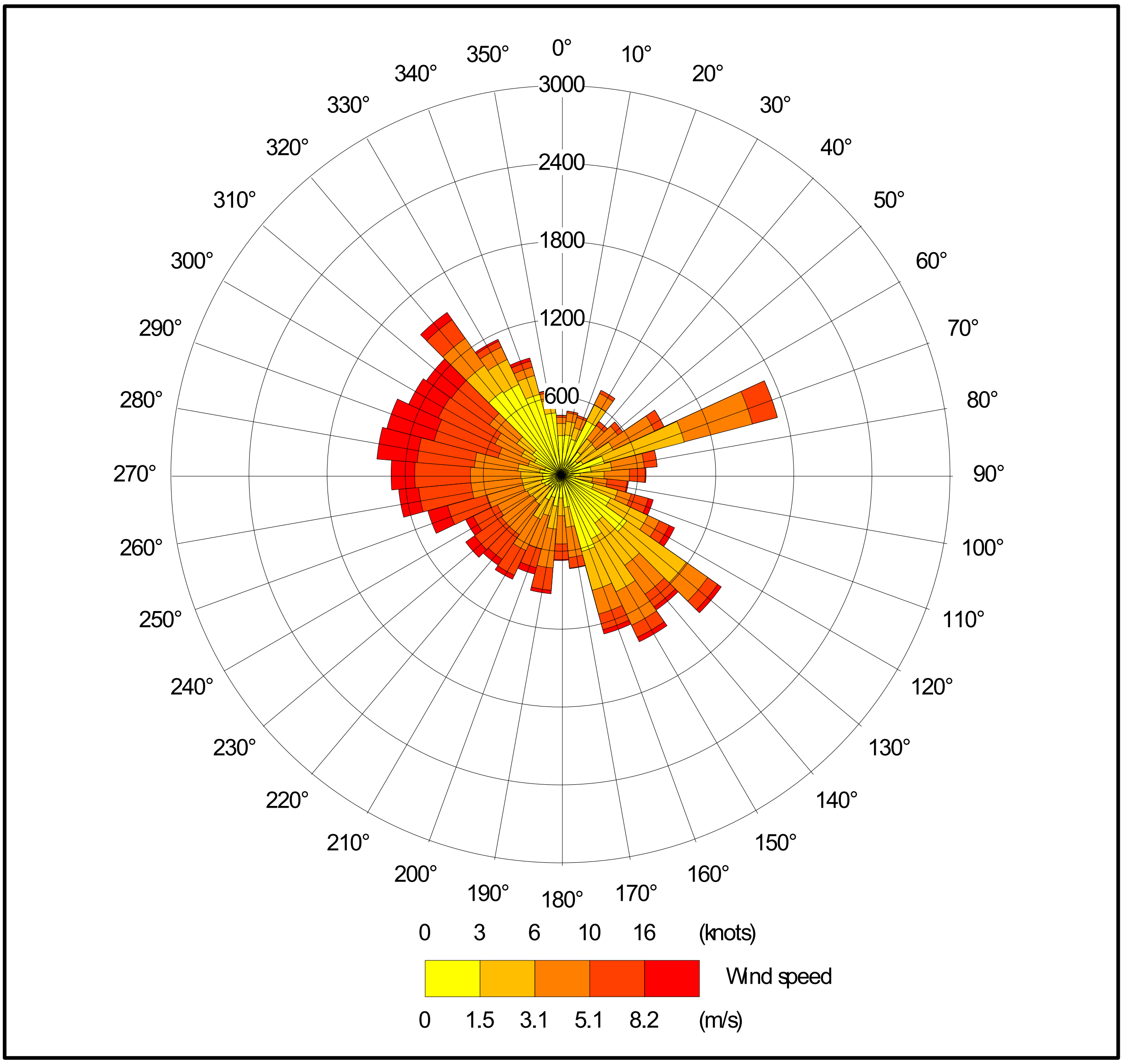


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 297350,298200 2021-2024



4.2 Emission sources

Emissions from the uncapped chimneys of the high-speed ridge/roof mounted fans are represented by three point sources within ADMS.

The chickens would have access to a ranging area, represented by an area source within ADMS. Note that the area source covers the parts of the range most likely to be used frequently and not the whole of the ranging area.

Details of the point and area source parameters are provided in Tables 3a and 3b. The positions of the volume and area sources are shown in Figure 3 (marked by green shaded circles and a red shaded polygon, respectively).

Table 3a. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (˚C)	Emission rate per source (g/s)
HOUSE 1, 2 & 3	6.0	0.8	11.0	22.0	0.022308

Table 3b. Area source parameters

Source ID	Area (m^2)	Base height (m)	Emission temperature (°C)	Baseline emission rate (g-NH_3/s)
RAN	8,131.7	0.0	Ambient	0.024336

4.3 Modelled buildings

The structure of the poultry house may affect the plumes from the point sources. Therefore, the buildings are modelled within ADMS. The position of the modelled building may be seen in Figure 3 (marked by grey rectangles).

4.4 Discrete receptors

Eleven discrete receptors have been defined at the nearby wildlife sites. These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figure 4 (marked by enumerated pink rectangles).

4.5 Cartesian grid

To produce the contour plots presented in Section 5 of this report and to define the spatially varying deposition velocity field, a regular Cartesian grid has been defined within ADMS. The individual grid receptors are defined at ground level within ADMS. The positions of the Cartesian grids may be seen in Figure 4 (marked by grey lines).

4.6 Terrain data

Terrain has been considered in the modelling. The terrain data are based upon the Ordnance Survey 50 m Digital Elevation Model. A 24.0 km by 24.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS for the modelling. The resolution of FLOWSTAR is 64 x 64 grid points; therefore, the effective resolution of the wind field for the terrain runs is approximately 360 m.

4.7 Roughness Length

In this case, a spatially varying roughness length file has been defined, this is based upon the UK Centre for Ecology and Hydrology 25 m land use database, with permission. The GFS meteorological data is assumed to have a roughness length of 0.227 m (arithmetic average of the spatially varying roughness over the modelling domain). The sample of the central area of the spatially varying roughness length field is shown in Figure 5.

Figure 3. The positions of the modelled building and sources

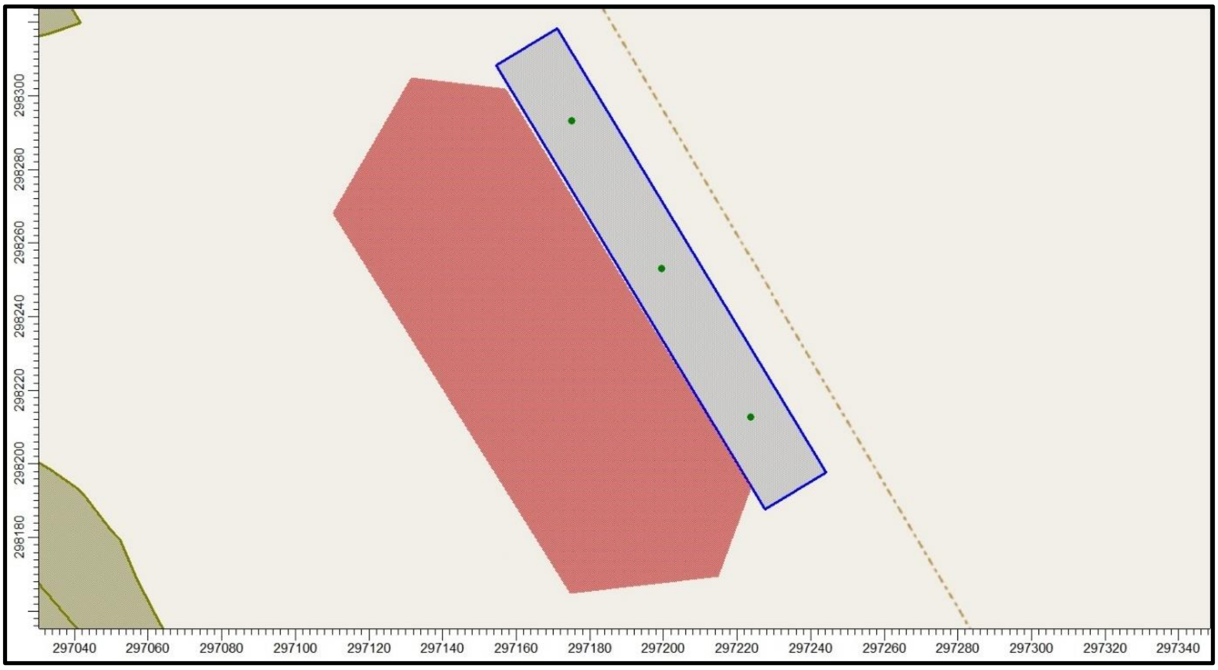


Figure 4. The discrete receptors and regular Cartesian grid

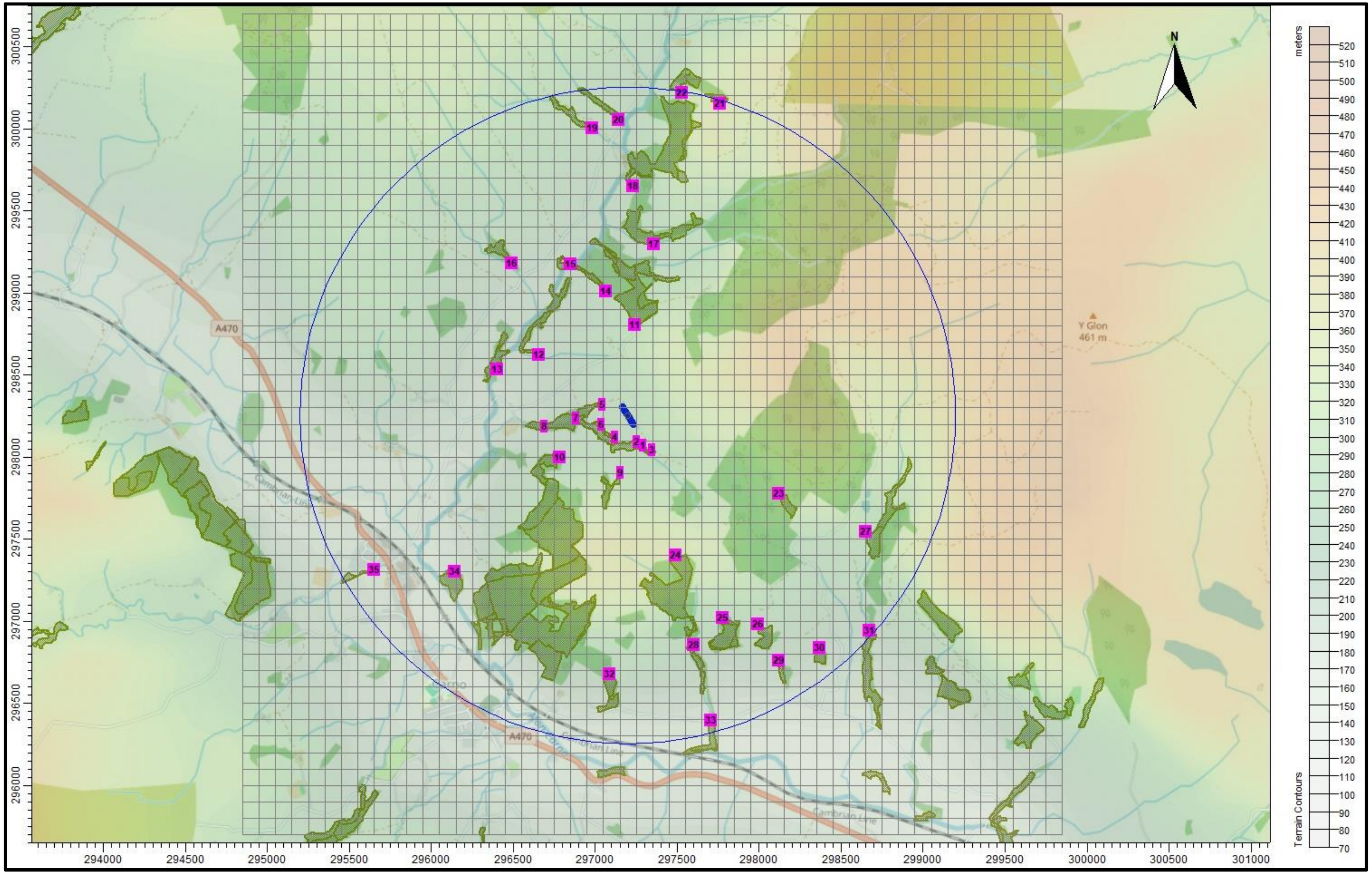
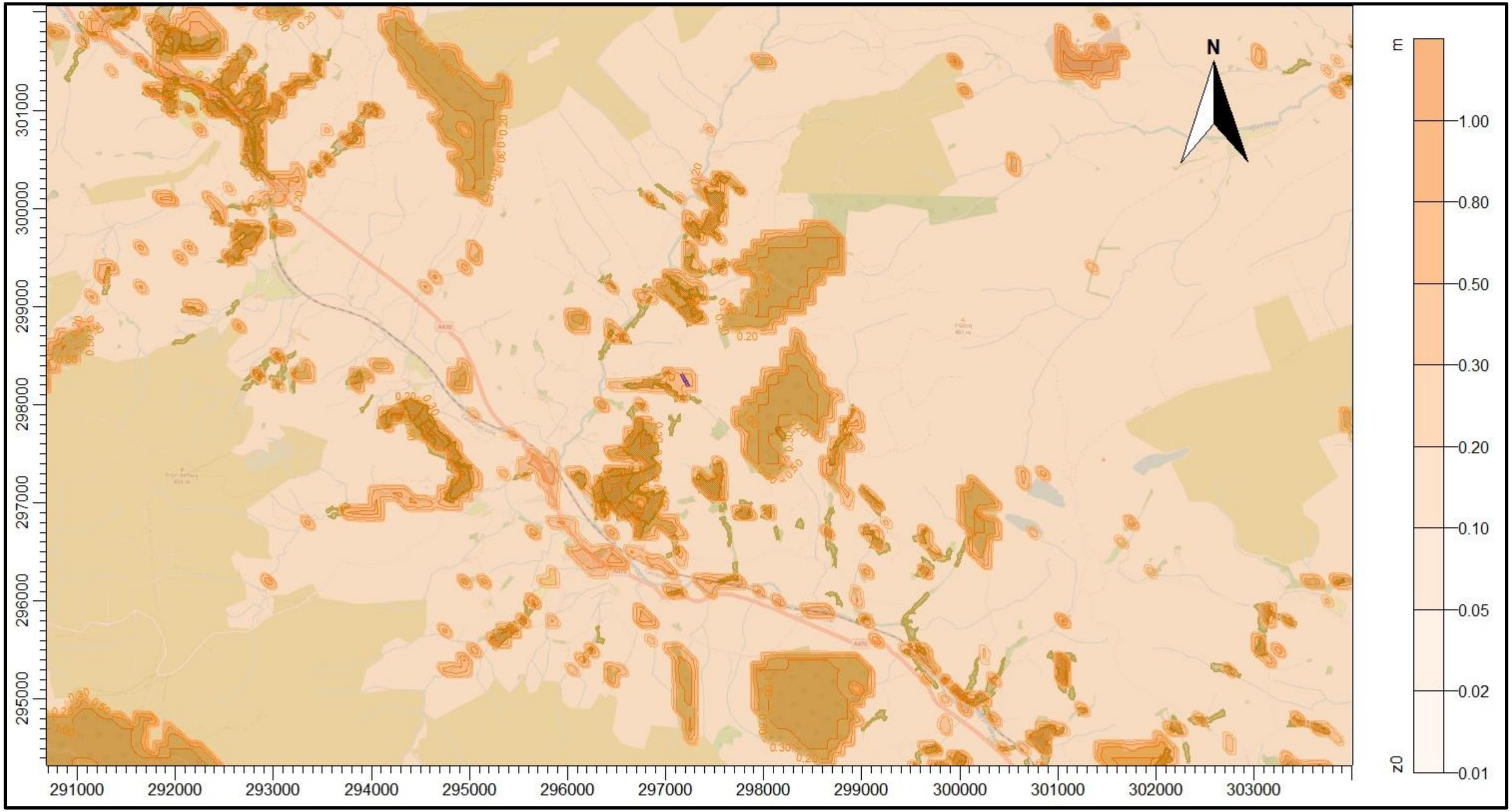


Figure 5. The spatially varying surface roughness field (central area)



4.8 Deposition

The method used to model deposition of ammonia and consequent plume depletion is based primarily upon figures obtained from Frederik Schrader and Christian Brümmer. Land Use Specific Ammonia Deposition Velocities: a Review of Recent Studies (2004-2013). AS Modelling & Data Ltd. has restricted deposition over arable farmland and heavily grazed and fertilised rye-grass pasture; this is to compensate for possible saturation effects due to fertilizer application and to allow for periods when fields are clear of crops (Sutton), the deposition is also restricted over areas with little or no vegetation and the deposition velocity is set to 0.002 m/s where grid points are over the poultry housing and 0.010 m/s to 0.015 m/s over grazed grassland. Where deposition over water surfaces is calculated, a deposition velocity of 0.005 m/s is used.

In summary, the method is as follows:

- A preliminary run of the model without deposition is used to provide an ammonia concentration field.
- The preliminary ammonia concentration field, along with land usage, has been used to define two deposition velocity fields. The deposition velocities used are provided in Table 4.

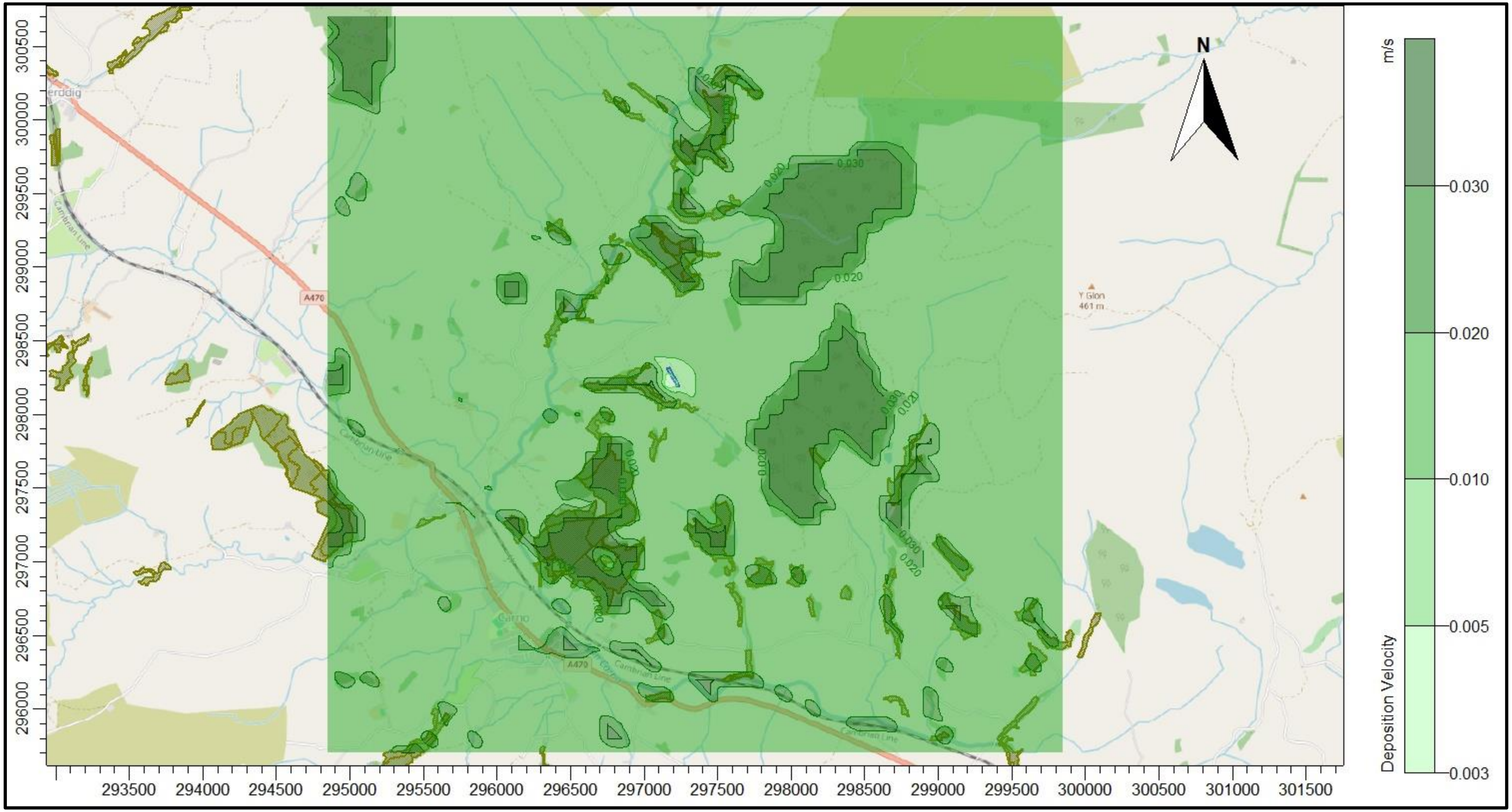
Table 4. Deposition velocities

NH_3 concentration (PC + background) (µg/m^3)	< 10	10 - 20	20 - 30	30 - 80	> 80
Deposition velocity - woodland (m/s)	0.03	0.015	0.01	0.005	0.003
Deposition velocity - short vegetation (m/s)	0.02 (0.010 to 0.015 over heavily grazed grassland)	0.015	0.01	0.005	0.003
Deposition velocity - arable farmland/rye grass (m/s)	0.005	0.005	0.005	0.005	0.003

- The model is then rerun with the spatially varying deposition module.

A contour plot of the spatially varying deposition field used in this study is provided in Figure 6.

Figure 6. The spatially varying deposition field



5. Details of the Model Runs and Results

5.1 Preliminary modelling and model sensitivity tests

ADMS was effectively run a total of twelve times; once for each year of the meteorological record in the following modes:

- In basic mode without calms, or terrain – GFS data.
- With calms and without terrain – GFS data.
- Without calms and with terrain – GFS data.

For each mode, statistics for the maximum annual mean ammonia concentration at each receptor were compiled. Details of the predicted annual mean ammonia concentrations at each receptor are provided in Table 5. The primary purpose of the preliminary modelling is to assess the effect of calms on the results.

Table 5. Predicted maximum annual mean ammonia concentration at the discrete receptors – preliminary modelling runs

Receptor number	X(m)	Y(m)	Designation	Maximum annual mean ammonia concentration - (µg/m³)		
				GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms Terrain
1	297289	298068	AW	1.301	1.237	1.798
2	297250	298092	AW	2.006	1.915	2.596
3	297345	298045	AW	0.890	0.846	1.399
4	297122	298120	AW	3.878	3.637	5.084
5	297042	298319	AW	2.514	2.389	4.290
6	297038	298197	AW	3.669	3.459	5.930
7	296883	298237	AW	0.818	0.786	1.239
8	296686	298189	AW	0.365	0.351	0.497
9	297153	297903	AW	0.558	0.523	0.558
10	296784	298001	AW	0.574	0.539	0.675
11	297240	298805	AW	0.317	0.305	0.415
12	296654	298624	AW	0.196	0.186	0.348
13	296400	298535	AW	0.122	0.117	0.153
14	297066	299008	AW	0.160	0.157	0.234
15	296849	299173	AW	0.107	0.103	0.163
16	296489	299181	AW	0.078	0.075	0.179
17	297355	299297	AW	0.119	0.115	0.145
18	297228	299649	AW	0.067	0.065	0.088
19	296982	300001	AW	0.046	0.046	0.068
20	297143	300055	AW	0.045	0.044	0.062
21	297761	300153	AW	0.049	0.048	0.044
22	297531	300222	AW	0.046	0.044	0.047
23	298118	297777	AW	0.138	0.131	0.197
24	297491	297400	AW	0.099	0.096	0.076
25	297776	297022	AW	0.049	0.047	0.044
26	297991	296983	AW	0.040	0.038	0.048
27	298648	297547	AW	0.072	0.068	0.135
28	297599	296856	AW	0.046	0.045	0.042
29	298118	296763	AW	0.031	0.030	0.036
30	298368	296841	AW	0.031	0.030	0.066
31	298672	296944	AW	0.032	0.031	0.089
32	299000	297174	AW	0.040	0.039	0.072
33	299035	296768	AW	0.026	0.025	0.048
34	297085	296679	AW	0.044	0.042	0.046
35	297707	296395	AW	0.030	0.029	0.029
36	297114	296126	AW	0.028	0.027	0.041
37	296144	297302	AW	0.087	0.083	0.111
38	295649	297316	AW	0.069	0.065	0.097

5.2 Detailed deposition modelling

In this case, detailed modelling has been carried out over a high resolution 5.0 km x 5.0 km domain surrounding the site. The primary purpose is to determine the magnitude of deposition of ammonia and consequent plume depletion close to the sources where it is of the greatest importance. Outside of the domain, a fixed deposition velocity of 0.005 m/s is assumed (with appropriate deposition velocities applied post-modelling at the discrete receptors).

The detailed deposition run was made with terrain. Calms cannot be used with terrain or spatially varying deposition; therefore, calms have not been included in the detailed modelling. The results of the preliminary modelling indicate that the effects of calms are not significant in this case.

The predicted maximum annual mean ground level ammonia concentrations and annual nitrogen deposition rates at the discrete receptors are shown in Table 6. In the Table, there are no predicted ammonia concentrations at AWs that are in excess of 100% of the assumed Critical Level or Critical Load.

Contour plots of the predicted ground level maximum annual mean ammonia concentration and maximum annual nitrogen deposition rates are shown in Figures 7a and 7b.

Table 6. Predicted maximum annual mean ammonia concentrations and nitrogen deposition rates at the discrete receptors

Receptor number	X(m)	Y(m)	Designation	Site Parameters			Maximum annual mean ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level (µg/m³)	Critical Load (kg/ha)	Process Contribution (µg/m³)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	297289	298068	AW	0.030	3.0	10.0	0.679	22.6	5.29	52.9
2	297250	298092	AW	0.030	3.0	10.0	1.065	35.5	8.29	82.9
3	297345	298045	AW	0.030	3.0	10.0	0.535	17.8	4.17	41.7
4	297122	298120	AW	0.030	3.0	10.0	1.087	36.2	8.47	84.7
5	297042	298319	AW	0.030	3.0	10.0	1.088	36.3	8.48	84.8
6	297038	298197	AW	0.030	3.0	10.0	0.939	31.3	7.31	73.1
7	296883	298237	AW	0.030	3.0	10.0	0.168	5.6	1.31	13.1
8	296686	298189	AW	0.030	3.0	10.0	0.066	2.2	0.51	5.1
9	297153	297903	AW	0.030	3.0	10.0	0.080	2.7	0.62	6.2
10	296784	298001	AW	0.030	3.0	10.0	0.102	3.4	0.79	7.9
11	297240	298805	AW	0.030	3.0	10.0	0.150	5.0	1.17	11.7
12	296654	298624	AW	0.030	3.0	10.0	0.087	2.9	0.68	6.8
13	296400	298535	AW	0.030	3.0	10.0	0.025	0.8	0.20	2.0
14	297066	299008	AW	0.030	3.0	10.0	0.080	2.7	0.62	6.2
15	296849	299173	AW	0.030	3.0	10.0	0.048	1.6	0.37	3.7
16	296489	299181	AW	0.030	3.0	10.0	0.046	1.5	0.36	3.6
17	297355	299297	AW	0.030	3.0	10.0	0.042	1.4	0.33	3.3
18	297228	299649	AW	0.030	3.0	10.0	0.024	0.8	0.19	1.9
19	296982	300001	AW	0.030	3.0	10.0	0.018	0.6	0.14	1.4
20	297143	300055	AW	0.030	3.0	10.0	0.015	0.5	0.12	1.2
21	297761	300153	AW	0.030	3.0	10.0	0.009	0.3	0.07	0.7
22	297531	300222	AW	0.030	3.0	10.0	0.011	0.4	0.08	0.8
23	298118	297777	AW	0.030	3.0	10.0	0.049	1.6	0.38	3.8
24	297491	297400	AW	0.030	3.0	10.0	0.014	0.5	0.11	1.1
25	297776	297022	AW	0.030	3.0	10.0	0.010	0.3	0.08	0.8
26	297991	296983	AW	0.030	3.0	10.0	0.015	0.5	0.11	1.1
27	298648	297547	AW	0.030	3.0	10.0	0.031	1.0	0.24	2.4

Receptor number	X(m)	Y(m)	Designation	Site Parameters			Maximum annual mean ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level ($\mu g/m^3$)	Critical Load (kg/ha)	Process Contribution ($\mu g/m^3$)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
28	297599	296856	AW	0.030	3.0	10.0	0.008	0.3	0.06	0.6
29	298118	296763	AW	0.030	3.0	10.0	0.011	0.4	0.09	0.9
30	298368	296841	AW	0.030	3.0	10.0	0.025	0.8	0.20	2.0
31	298672	296944	AW	0.030	3.0	10.0	0.029	1.0	0.22	2.2
34	297085	296679	AW	0.030	3.0	10.0	0.009	0.3	0.07	0.7
35	297707	296395	AW	0.030	3.0	10.0	0.006	0.2	0.05	0.5
37	296144	297302	AW	0.030	3.0	10.0	0.022	0.7	0.17	1.7
38	295649	297316	AW	0.030	3.0	10.0	0.017	0.6	0.14	1.4

Figure 7a. Process contribution to maximum annual mean ammonia concentrations

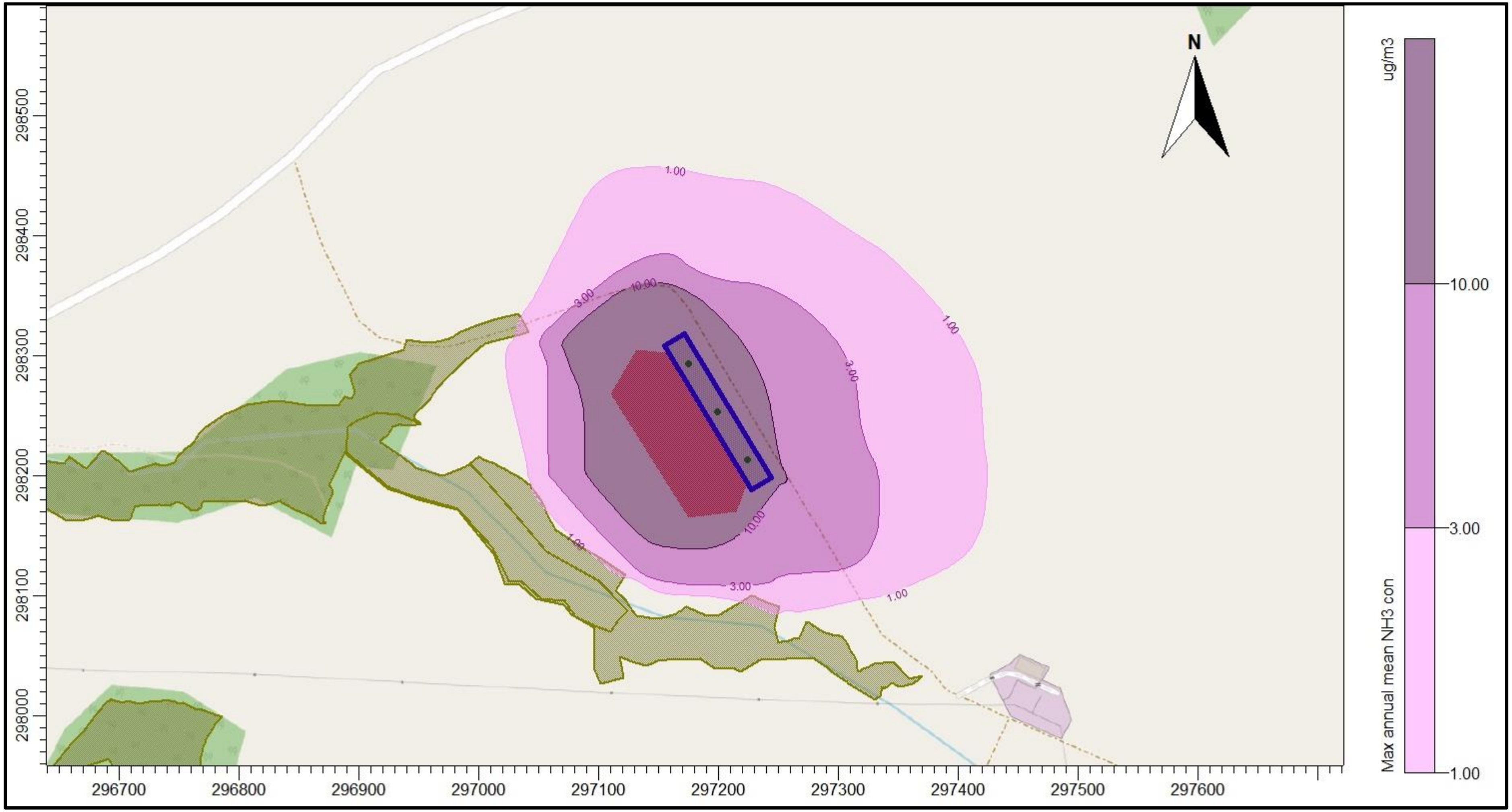
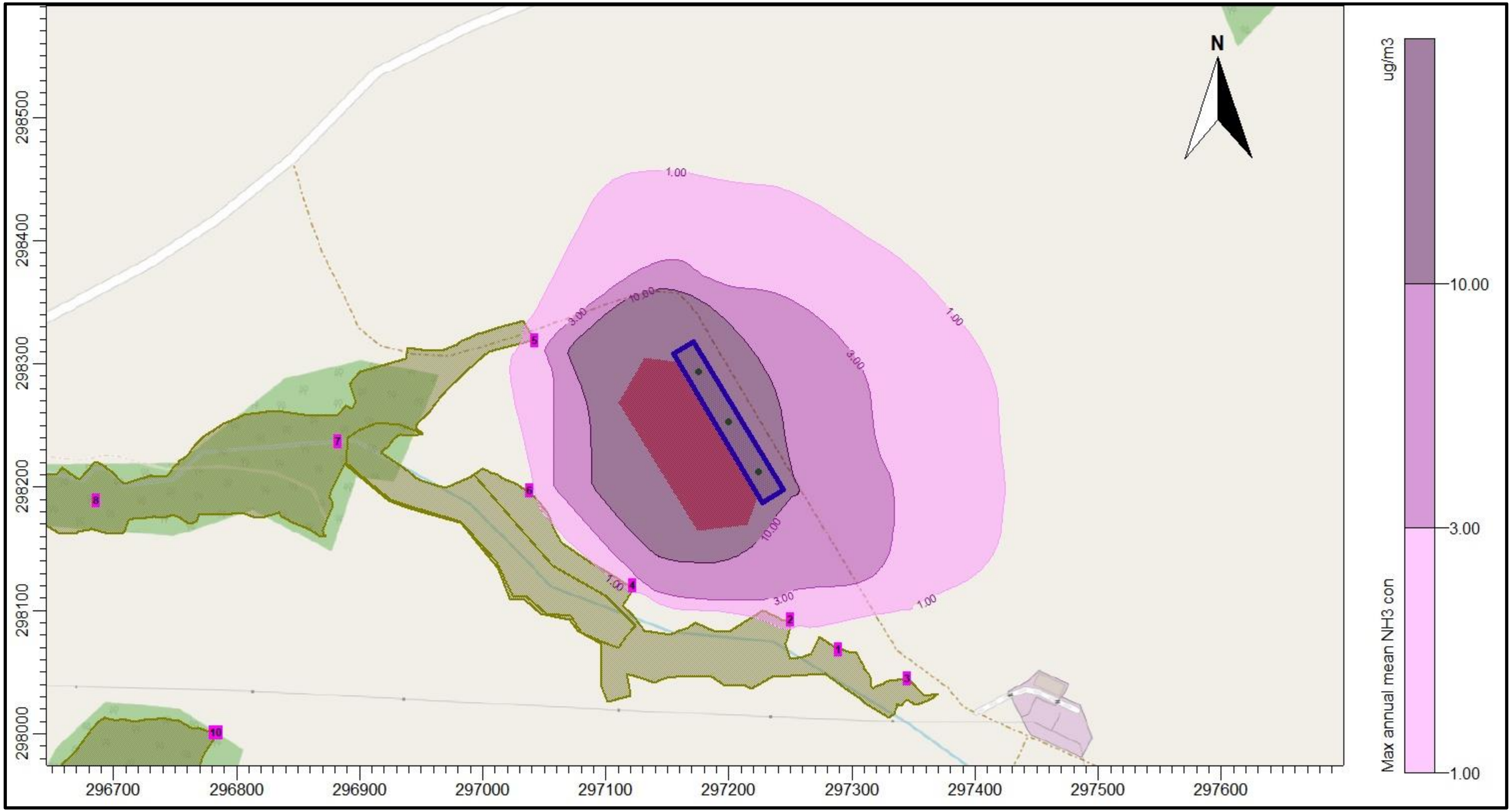


Figure 7b. Process contribution to maximum annual nitrogen deposition rates



6. Summary and Conclusions

Ammonia emission rates from poultry have been assessed and quantified based upon the Natural Resources Wales standard ammonia emission factors. The ammonia emission rates have then been used as inputs to an atmospheric dispersion and deposition model which calculates ammonia exposure levels and nitrogen and acid deposition rates in the surrounding area.

The model predicts that, should the proposed development proceed, the process contributions to the maximum annual mean ammonia concentrations and annual nitrogen deposition rates would be below 100% of the assumed Critical Level and Load at all wildlife sites that have been identified for this modelling study.

7. References

Cambridge Environmental Research Consultants (CERC) (website).

Environment Agency H1 Risk Assessment (website).

M. A. Sutton *et al*. Measurement and modelling of ammonia exchange over arable croplands.

Misselbrook. *et al*. Ammonia emission factors for UK agriculture.

Natural Resources Wales 'Ammonia Assessments' (website).

Frederik Schrader and Christian Brümmer. Land Use Specific Ammonia Deposition Velocities: a Review of Recent Studies (2004–2013).

Ricardo Energy for Defra, "Developing New Ammonia Emissions Factors for Modern Livestock Housing (Phase 2) Layers, broilers and dairy cattle"

Rothamstead Research, 2022 "Inventory of Ammonia Emissions from UK Agriculture"

United Nations Economic Commission for Europe (UNECE) (website).

UK Air Pollution Information System (APIS) (website).