A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Proposed Free Range Egg-Laying Chicken Houses at Red House, Guilsfield in Powys

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27th April 2021
Revision 1 9th July 2021

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Gerallt Davies, of Roger Parry & Partners LLP, on behalf of Mr. D. Farmer, to use computer modelling to assess the impact of ammonia emissions from the proposed free range egg-laying chicken houses at Red House, Guilsfield in Powys. SY21 9LW.

Ammonia emission rates from the proposed poultry houses have been assessed and quantified based upon the Environment Agency's standard ammonia emission factors. Ammonia emissions from ranging areas have been assessed and quantified based upon the baseline parameters used to calculate the National Atmospheric Emission Inventory (NAEI) emission factor for grazing free range hens and information from a variety of peer reviewed scientific papers. 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

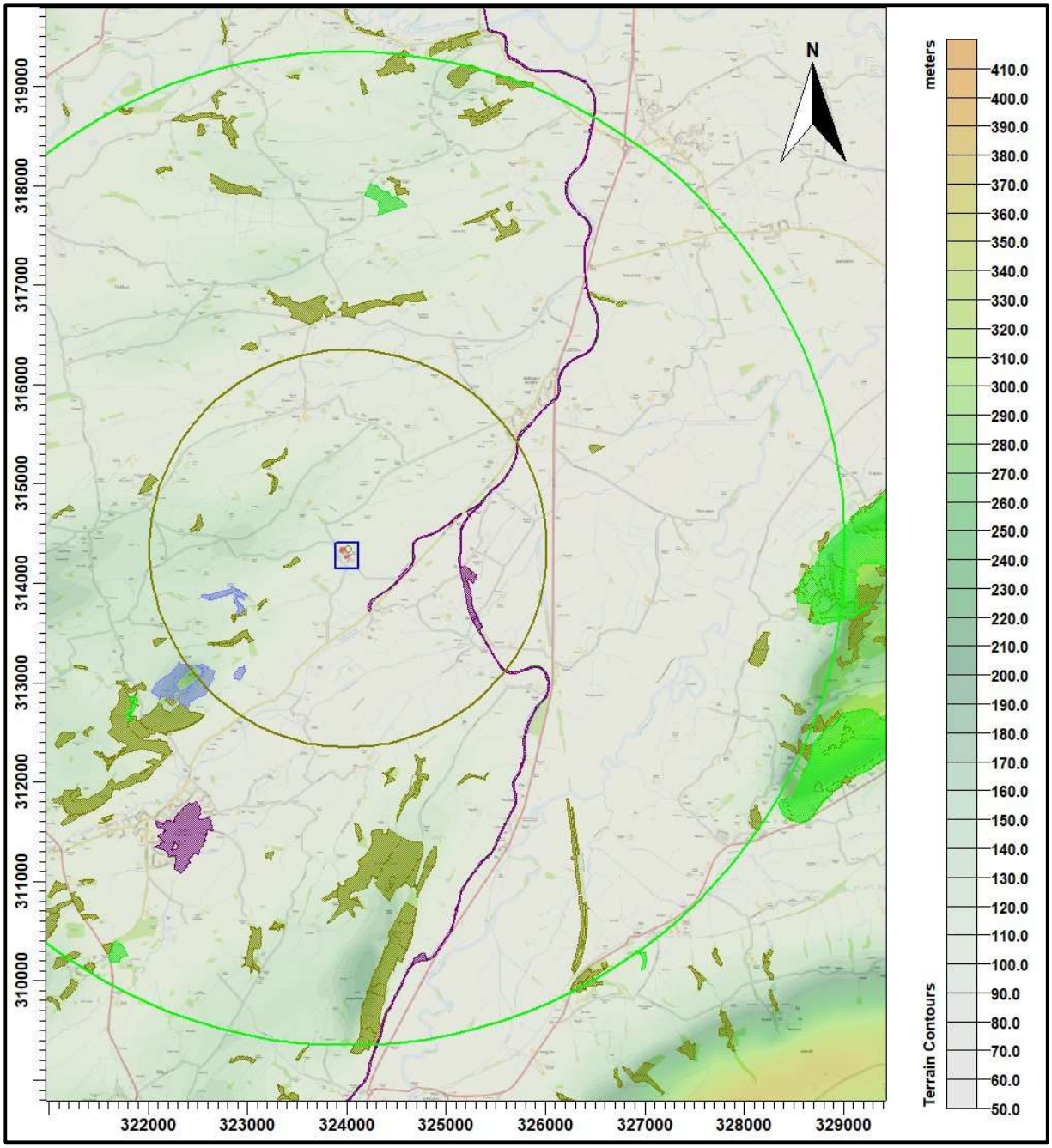
Red House is in an isolated rural area, approximately 2.75 km to the north-east of the village of Guilsfield, in Powys. The surrounding land is used predominantly for livestock farming, grazing and forage production and there are some isolated semi-natural wooded areas and arable fields nearby. The site is at an altitude of around 100 m, with the land rising to higher ground to the north and west and falling to the River Severn to the east.

It is proposed that two new poultry houses be constructed at Red House. These poultry houses would provide accommodation for up to 12,000 egg-laying chickens, which would have day-time access to outside ranging areas via a series of pop holes along the sides of the houses. Ventilation would be provided by high speed ridge fans, each with a short chimney. Every four days, the birds' droppings would be removed from the housing by a belt collection system and stored temporarily on the farm, prior to removal from the site, or spreading to land.

There are nine areas designated as Ancient Woodlands (AWs) within 2 km of the site, three of which are defined by Natural Resources Wales as ammonia sensitive AWs. There are also seven areas designated as Sites of Special Scientific Interest (SSSIs), two of which, Montgomery Canal SSSI and Granllyn SSSI, are also designated as Special Areas of Conservation (SACs).

A map of the surrounding area showing the positions of the proposed poultry houses and the nearby AWs, SSSIs and SACs is provided in Figure 1. In this figure, the AWs are shaded in olive, the ammonia sensitive AWs are shaded in blue, the SSSIs are shaded in green, the SACs are shaded in purple and the position of the proposed poultry houses at Red House is outlined in blue.

Figure 1. The area surrounding Red House –circle radii 2 km (olive) and 5 km (green)



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 (µg-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 background ammonia concentration (annual mean) in the area around Red House and the wildlife sites is 2.76 µg-NH_3/m^3. The background nitrogen deposition rate to woodland is 36.4 kg-N/ha/y and to short vegetation is 21.7 kg-N/ha/y. The background acid deposition rate to woodland is 2.69 keq/ha/y and to short vegetation is 1.62 keq/ha/y. The source of these background figures is the Air Pollution Information System (APIS, April 2021).

3.3 Critical Levels and 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. N.B. 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 (kg-N/ha/y)	Critical Load Acid (keq/ha/y)
AWs, Gwaith Brics, Buttington SSSI	1.0 [1]	-	-
Ammonia sensitive AWs	1.0 [1]	10.0	-
Breidden Hill SSSI	1.0 [1]	10.0 [3]	-
Gweunydd Ty-Brith SSSI, Lower Garth Meadows SSSI, Granllyn SSSI/SAC	3.0 [2]	10.0 [3]	-
Montgomery Canal SSSI/SAC	3.0 [2]	-	-
Gwern-Y-Brain Dingle SSSI	n/a [4]	n/a [4]	n/a [4]

1. A precautionary figure used where no details of the ecology of the site are available, or the citation for the site contains reference to sensitive lichens and/or bryophytes.
2. Based upon the citation of the site.
3. The lower bound of the range of Critical Loads for the site/species, obtained from APIS (November 2020).
4. Designated for geological features.

3.4 Guidance on the Significance of Ammonia Emissions

In March 2017, Natural Resources Wales (Regulation and Permitting Department, EPP) published Operational Guidance Note 41 (OGN 41), "Assessment of ammonia and nitrogen impacts from livestock units when applying for an Environmental Permit or Planning Permission". This guidance was intended to update the way Natural Resources Wales (NRW) assessed emissions, in particular by changing the thresholds of insignificance and the upper threshold process contributions for designated sites. These designated sites include European sites, such as Special Areas of Conservation (SACs), Special Protection Areas (SPAs) and Ramsar sites as well as Sites of Special Scientific Interest (SSSIs).

Table 1 in OGN 41 describes the revised screening distance and thresholds for livestock developments; the threshold of insignificant percentage of the designated site Critical Level or Load is given as 1%; the upper threshold percentage of the designated site Critical Level or Load is given as 8%.

Table 2 in OGN 41 describes the possible outcomes of assessment and for detailed modelling of the application alone, where process contributions, considered in isolation, are up to 1% of the designated site Critical Level or Load, then it should be determined that there is no significant environmental effect/no likely significant effect/damage to scientific interest.

Where process contributions, considered in isolation, are between 1% and 8% of the designated site Critical Level or Load, an in-combination assessment is required. Should the in-combination process contributions be between 1% and 8% of the designated site Critical Level or Load then it should be

determined that the application would cause no significant environmental effect/likely significant effect/damage to scientific interest.

When considering process contributions in isolation or in-combination, if they exceed 1% of the designated site Critical Level or Load it is necessary to consider background concentrations and whether the designated site Critical Level or Load is breached and whether additional controls may be necessary. The application will then be determined based on whether there will be significant environmental effect/adverse effect/damage to scientific interest.

The latter Natural Resources Wales document OGN 020 contains essentially the same thresholds.

For Local Nature Reserves (LNRs), Local Wildlife Sites (LWSs) and Ancient Woodlands (AWs), the current assessment procedure still applies, namely the Environment Agency's horizontal guidance, H1 Environmental Risks Assessment, H1 Annex B - Intensive Farming. The following are taken from this document.

"An emission is insignificant where Process Contribution (PC) is <50% for local and national nature reserves (LNRs & NNRs), ancient woodland and local wildlife sites." And "Where modelling predicts a process contribution >100% at a NNR, LNR, ancient woodland or local wildlife site, your proposal may not be considered acceptable. In such cases, your assessment should include proposals to reduce ammonia emissions."

This document was withdrawn February 1st 2016 and replaced with a web-page titled "Intensive farming risk assessment for your environmental permit", which contains essentially the same criteria. It is assumed that the upper threshold and lower threshold on the web-page refers to the levels that were previously referred to as levels of insignificance and acceptability in Annex B - Intensive Farming.

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%).

3.6 Quantification of ammonia emissions

Ammonia emission rates from poultry houses depend on many factors and are likely to be rather 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.

3.6.1 Housing emissions

The Environment Agency provides an Intensive Farming guidance note which lists standard ammonia emission factors for a variety of livestock, including poultry. For egg laying chickens with frequent removal of droppings using a belt system, such as the proposed poultry houses, the Environment Agency figure is 0.08 kg-NH_3/bird place/year.

3.5.2 Ranging area emissions

As the birds would have access to outdoor ranging areas, some of the birds' droppings, which is the source of the ammonia, would be deposited on these ranging areas. To estimate the ammonia emissions from the ranges for each scenario, it is assumed that laying hens produce 0.75 kg-N/y in their droppings (NAEI) of which 70% is ammoniacal nitrogen, that is nitrogen in a form that may readily be converted to ammonia (NAEI), and that 35% of ammoniacal nitrogen is emitted as ammonia (NAEI).

Three scenarios are considered for ranging area emissions:

- Scenario 1 - The Realistic Scenario - in which ranging emissions are based upon a figure of 7.34% range usage obtained from recent peer reviewed scientific investigations of very similar housing/ranging systems (Pettersson *et al*). This equates to an emission factor of 0.016 kg-NH3/bird-place/y.
- Scenario 2 - The Pessimistic Scenario - in which ranging emissions based upon a figure of 12% range usage which is at the higher end of the range of percentages obtained from available peer reviewed scientific investigations (Campbell *et al*; Larsen *et al*; Chielo *et al*; Dawkins *et al*; Hegelund *et al*; Pettersson *et al*; Sossidou *et al* and Whay *et al*). This equates to an emission factor of 0.027 kg-NH3/bird-place/y.
- Scenario 3 - The Unsound Scenario - in which ranging emissions based upon a figure of 20% range usage which is a figure that has been mandated by Natural Resources Wales, but is not based upon any peer reviewed literature and has not been included in the UK Ammonia Emission Inventory since 2015 (prior to which the figure was mentioned, but only as personal correspondence, with no reference to any peer reviewed work). It should be noted that the maintainers of the NAEI state the following, "We have no specific measurement/observational data for this number". This equates to an emission factor of 0.045 kg-NH3/bird-place/y.

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

The Atmospheric Dispersion Modelling System (ADMS) ADMS 5 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.

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).

The GFS is a spectral model: the physics/dynamics model has an equivalent resolution of approximately 13 km (latterly 9 km); terrain is understood to be resolved at a resolution of approximately 2 km, with sub-13/9 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). The use of NWP data has advantages over traditional meteorological records because:

- Calm periods in traditional records may be over represented because the instrumentation used may not record wind speed 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 because 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 of the proposed poultry houses is shown in Figure 2b; it should be noted that elsewhere in the modelling domain the modified wind roses may differ, reflecting the local flow in that part of the domain. The resolution of the wind field in terrain runs in the preliminary modelling is approximately 150 m and in the detailed modelling is 100 m. Please also note that FLOWSTAR 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.

Figure 2a. The wind rose. Raw GFS derived data, for 52.723 N, 3.125 W, 2017–2020

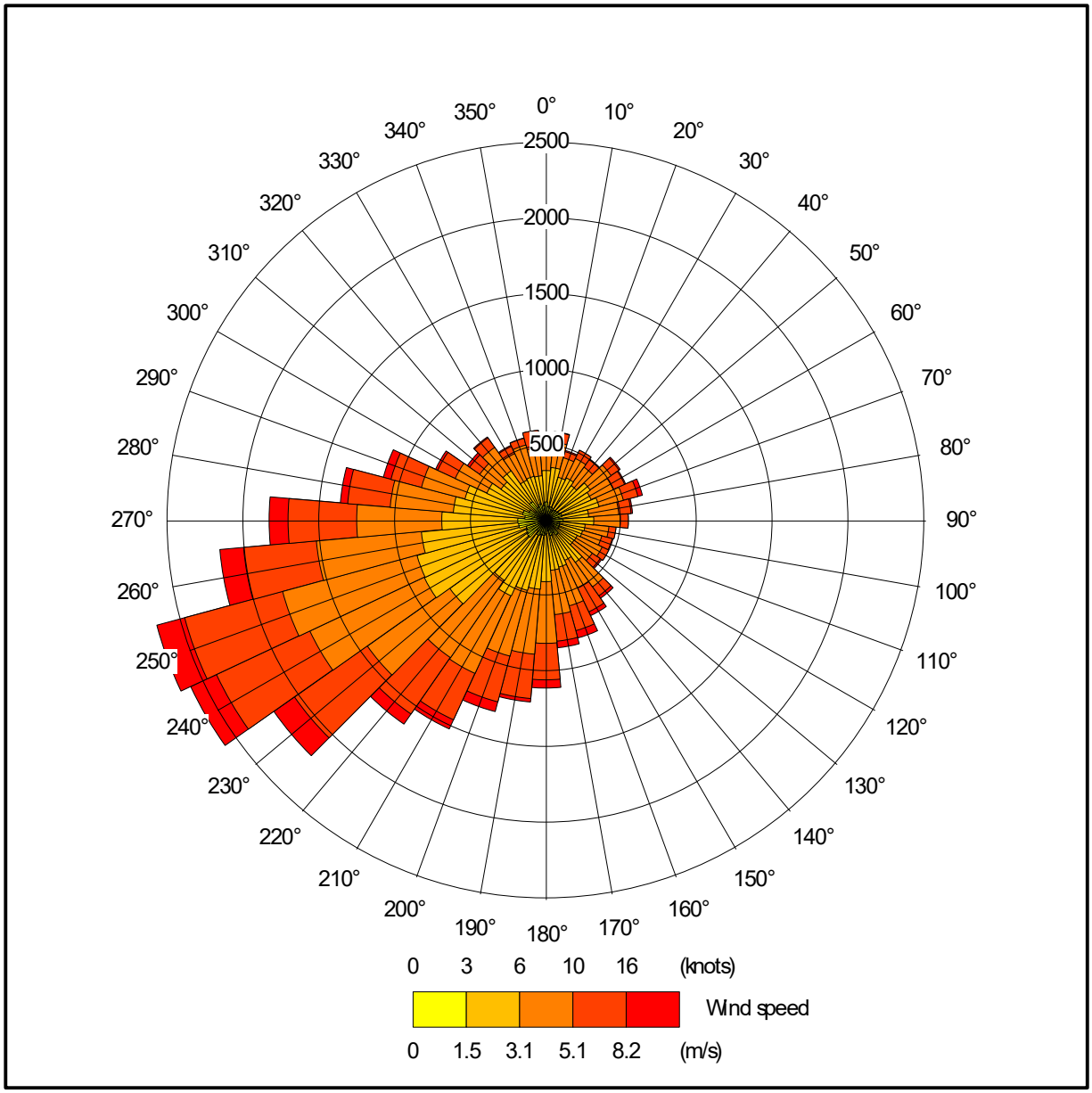
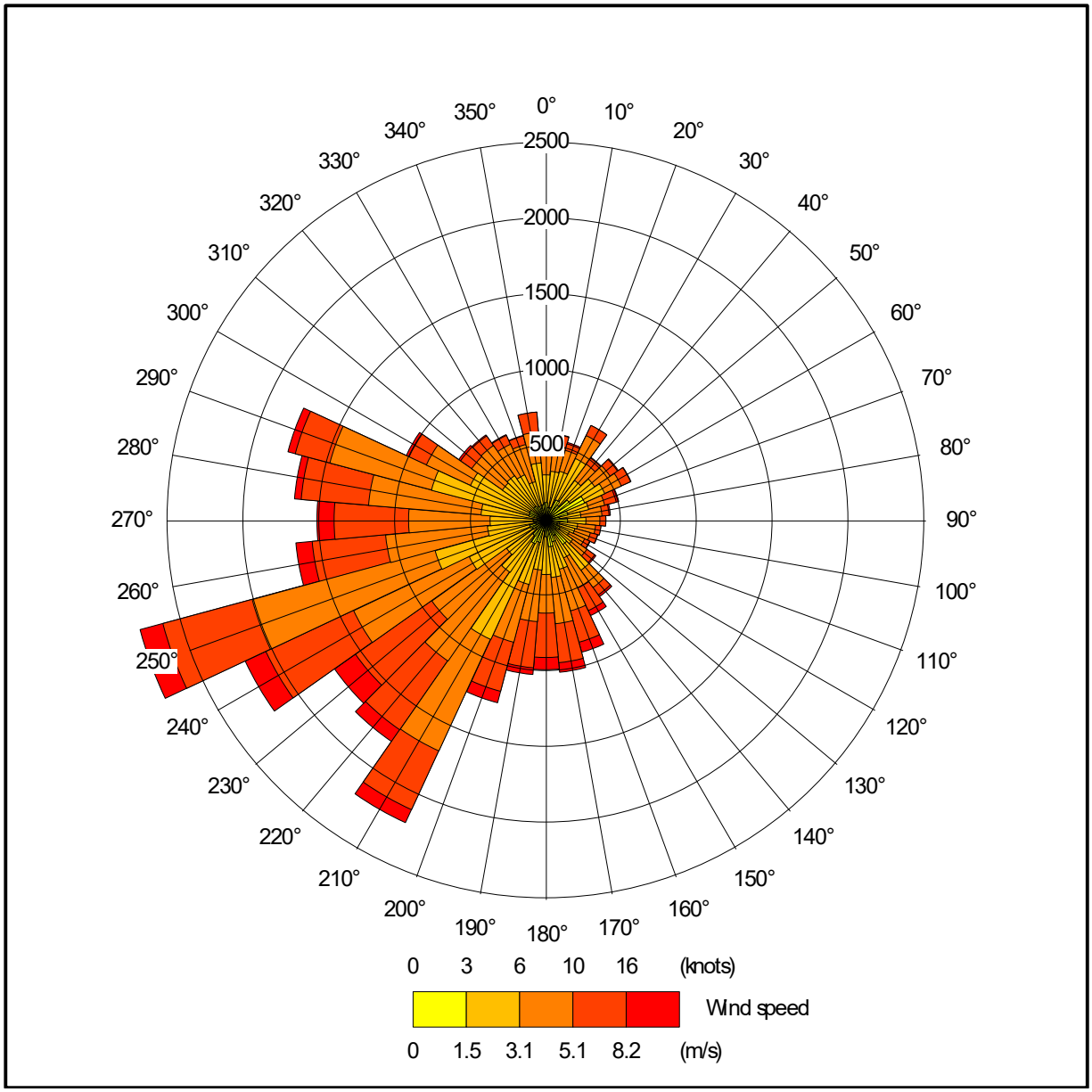


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 324100, 314500, 2016-2019



4.2 Emission sources

4.2.1 The proposed poultry housing and ranging areas

Emissions from the chimneys of the high speed ridge fans that would be used to ventilate the proposed poultry houses are represented by three point sources per house within ADMS (PR1 and PR2; 1, 2 & 3).

The poultry houses would have ranging areas, which are represented by area sources within ADMS (PR1_RAN and PR2_RAN). Note that the area source covers the parts of the ranges most likely to be used frequently and not the whole ranging area.

Details of the source parameters are provided in Table 2a and Table 2b and the positions of the sources are shown in Figure 3.

Table 2a. Point source parameters

Source ID (scenario)	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (˚C)	Emission rate per source (g-NH_3/s)
PR1 & PR2 1, 2 & 3 (unsound)	5.5	0.8	11.0	21.0	0.004056
PR1 & PR2 1, 2 & 3 (pessimistic)	5.5	0.8	11.0	21.0	0.004462
PR1 & PR2 1, 2 & 3 (realistic)	5.5	0.8	11.0	21.0	0.004698

Table 2b. Area source parameters

Source ID	Area (m^2)	Base height (m)	Emission temperature (°C)	Emission rate (g-NH_3/s)
PR1_RAN & PR2_RAN (unsound)	3,079 & 2,406	0.0	Ambient	0.008556
PR1_RAN & PR2_RAN (pessimistic)	3,079 & 2,406	0.0	Ambient	0.005133
PR1_RAN & PR2_RAN (realistic)	3,079 & 2,406	0.0	Ambient	0.003042

4.3 Modelled buildings

The structure of the proposed poultry houses may affect the plumes from the point sources. Therefore, the buildings have been modelled within ADMS. The position of the modelled buildings may be seen in Figure 3, where they are marked by grey rectangles.

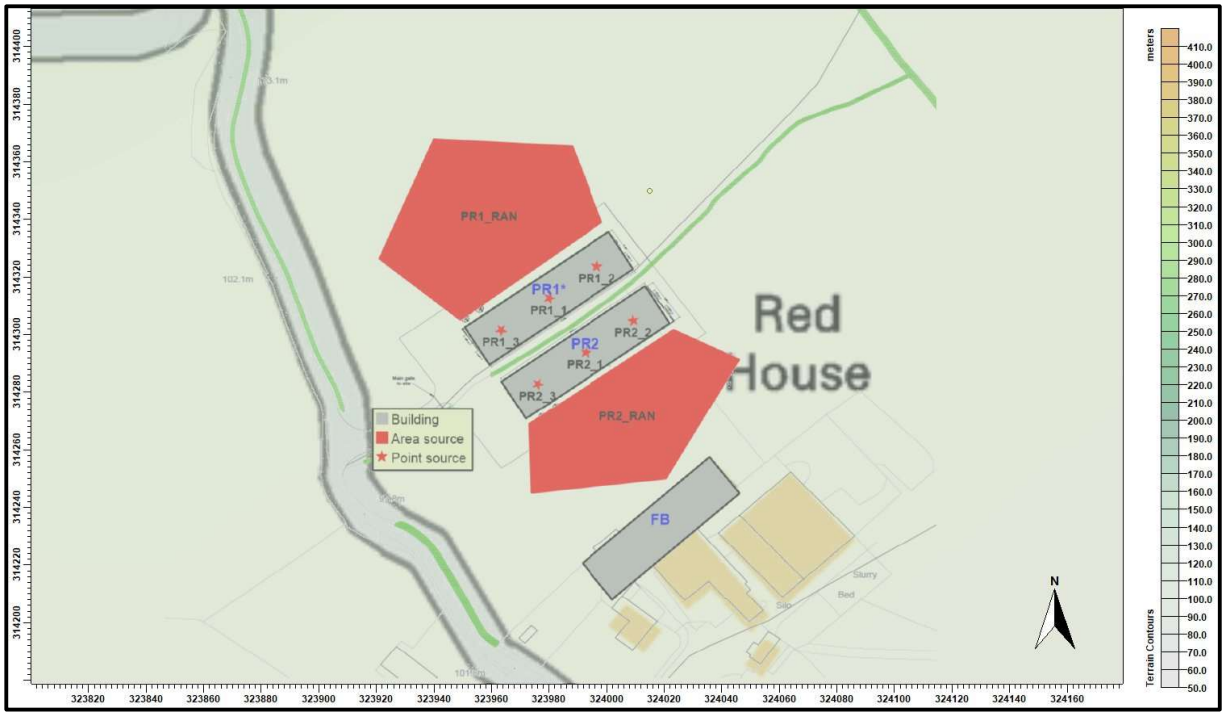
4.4 Discrete receptors

Twenty-four discrete receptors have been defined; nine at the AWs (1 to 9), three of which are at ammonia sensitive AWs, five at the SSSIs (10 to 14) and ten at the SACs (15 to 24). These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figure 4, where they are marked by enumerated pink rectangles.

4.5 Cartesian grid

To produce the contour plots presented in Section 5 of this report, a regular Cartesian grid has been defined within ADMS. The grid receptors are defined at ground level within ADMS. The position of the Cartesian grid may be seen in Figure 4, where it is marked by grey lines.

Figure 3. The positions of modelled buildings and sources



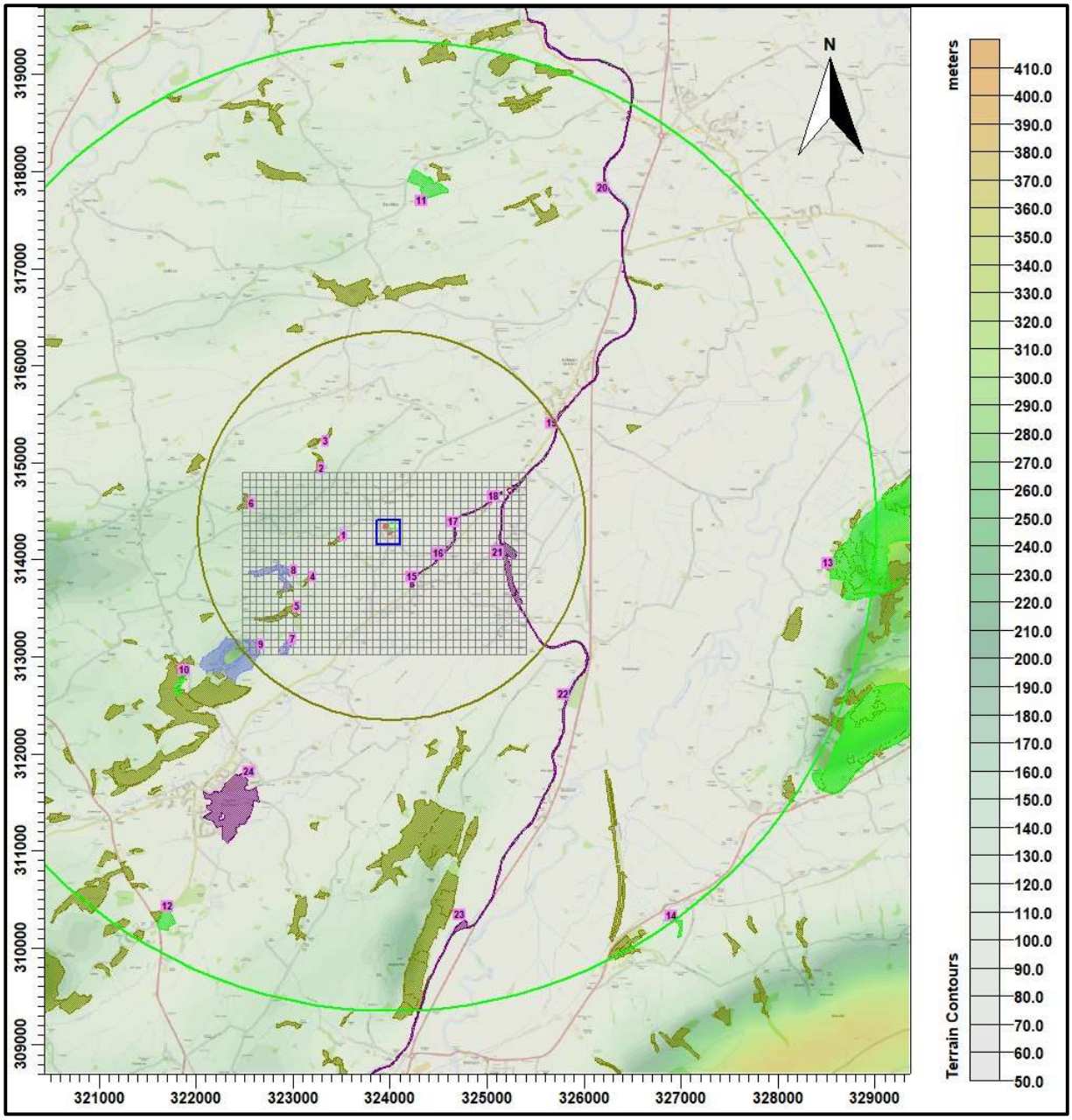
4.6 Terrain data

Terrain has been considered in the modelling. The terrain data are based upon the Ordnance Survey 50 m Digital Elevation Model. A 10.0 km by 10.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS for the preliminary modelling runs that include terrain and a 6.4 km by 6.4 km domain has been resampled at 50 m horizontal resolution for use within ADMS for the detailed modelling runs. The resolution of FLOWSTAR is 64 by 64 grid points; therefore, the effective resolution of the wind field for the terrain runs is approximately 150 m for the preliminary modelling and is 100 m for the detailed modelling.

4.7 Roughness Length

A fixed surface roughness length of 0.25 m has been applied over the entire modelling domain. As a precautionary measure, the GFS meteorological data is assumed to have a roughness length of 0.225 m. The effect of the difference in roughness length is precautionary as it increases the frequency of low wind speeds and stability and therefore increases predicted ground level concentrations.

Figure 4. The discrete receptors and regular Cartesian grid



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 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 heavily grazed grassland. Where deposition over water surfaces is calculated, a deposition velocity of 0.005 m/s is used.

- 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 a deposition velocity field. The deposition velocities used are provided in Table 3.

Table 3. Deposition velocities

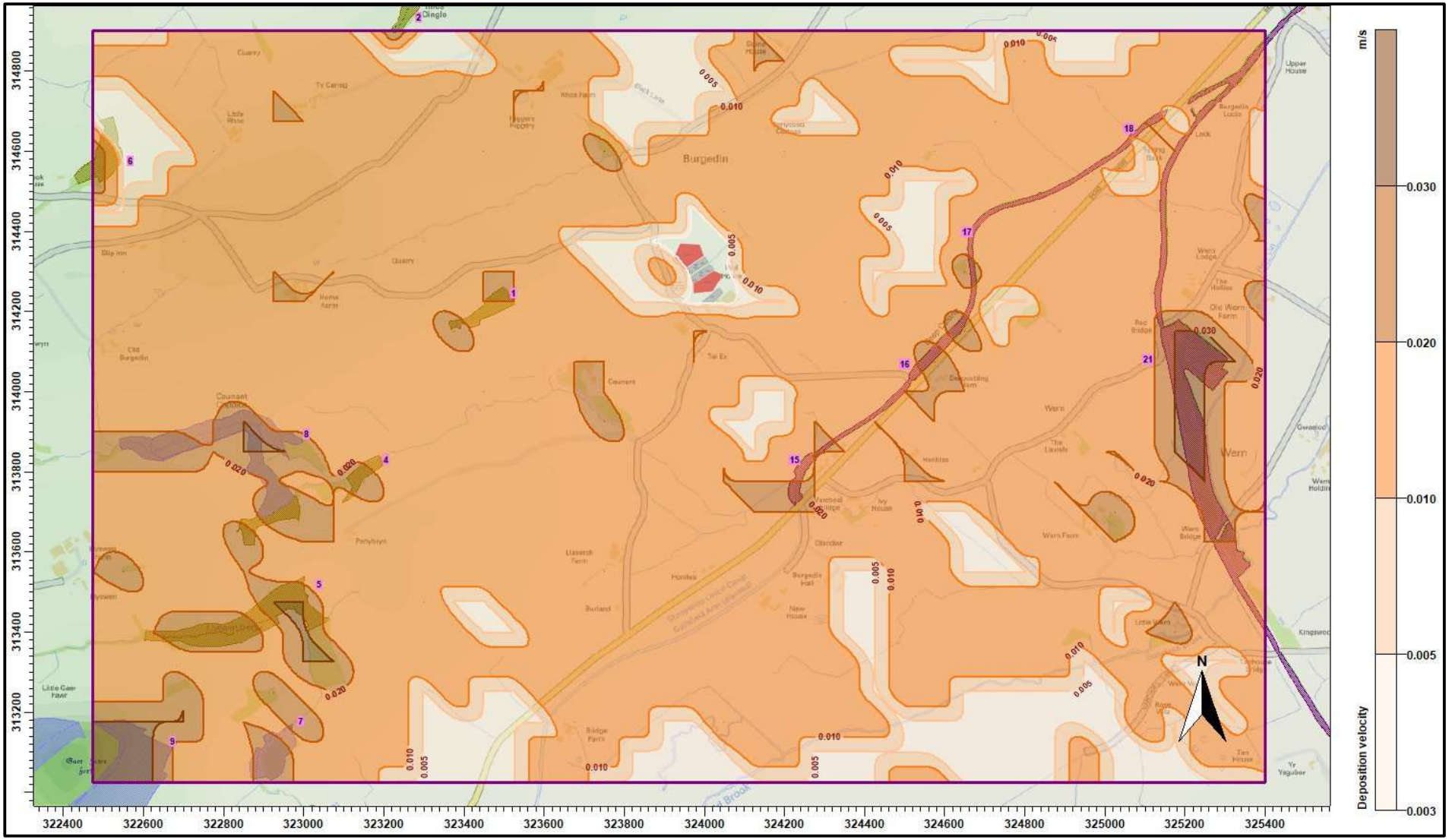
NH_3 concentration (PC + background) ($\mu g/m^3$)	< 10	10 - 20	20 - 30	30 – 80	> 80
Deposition velocity – woodland (m/s)	0.03	0.015	0.01	0.005	0.003
Deposition velocity – short vegetation (m/s)	0.02 (0.010 to 0.015 over heavily grazed grassland)	0.015	0.01	0.005	0.003
Deposition velocity – arable farmland/rye 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 is provided in Figure 5.

In this case, the model has also been run with a fixed deposition at 0.003 m/s and similarly to not modelling deposition at all, the predicted ammonia concentrations (and nitrogen and acid deposition rates) are always higher than if spatially varying deposition were modelled explicitly, particularly where there is some distance between the source and a receptor.

Figure 5. The spatially varying deposition field



5. Details of the Model Runs and Results

5.1 Preliminary modelling and model sensitivity tests

ADMS was run a total of sixteen times; once for each year of the meteorological record, in the following four modes:

- In basic mode without calms or terrain – GFS data.
- With calms and without terrain – GFS data.
- Without calms and with terrain – GFS data.
- Without calms, with terrain and fixed deposition at 0.003 m/s – GFS data.

For each mode, statistics for the maximum annual mean ammonia concentration at each receptor were compiled. Note that these are preliminary results for screening and sensitivity testing; because deposition of ammonia and the consequent plume depletion are not accounted for or not fully accounted for, the results are precautionary. Therefore, predicted ammonia concentrations (and nitrogen and acid deposition rates) are always higher than if deposition were modelled explicitly, particularly where there is some distance between the source and a receptor. In this case, a preliminary fixed deposition velocity run has been conducted, it should be noted that this is also precautionary, with a lower fixed deposition velocity applied when compared to the detailed modelling where a spatially varying deposition field is used.

Details of the predicted annual mean ammonia concentrations at each receptor are provided in Table 4 (The Unsound Scenario). In the Table, predicted ammonia concentrations (or concentrations equivalent to deposition rates) that are in excess of the Natural Resources Wales or Environment Agency upper threshold percentage of the relevant Critical Level or Critical Load (8% for an ammonia sensitive AW, SSSI or SAC, 100% for a non-statutory site) are coloured red. Concentrations (or concentrations equivalent to deposition rates) in the range between the Natural Resources Wales or Environment Agency lower and upper threshold percentage of the relevant Critical Level or Critical Load (1% and 8% for an ammonia sensitive AW, SSSI or SAC, 100% and 100% for a non-statutory site) are coloured blue.

For convenience, cells referring to the AWs are shaded olive, cells referring to the ammonia sensitive AWs are shaded blue, cells referring to the SSSIs are shaded green and cells referring to the SACs are shaded purple.

Table 4. Predicted annual mean ammonia concentration at the discrete receptors – preliminary modelling

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	GFS No Calms Terrain Fixed depo 0.003 m/s
1	323525	314245	AW	0.196	0.187	0.236	0.100
2	323287	314934	AW	0.046	0.045	0.052	0.023
3	323338	315223	AW	0.040	0.038	0.048	0.021
4	323206	313830	AW	0.076	0.074	0.084	0.034
5	323039	313519	AW	0.045	0.044	0.048	0.019
6	322568	314574	AW	0.023	0.023	0.026	0.009
7	322993	313177	AW (ammonia sensitive)	**0.032**	**0.031**	**0.031**	**0.013**
8	323008	313894	AW (ammonia sensitive)	**0.058**	**0.056**	**0.063**	**0.024**
9	322674	313126	AW (ammonia sensitive)	**0.025**	**0.024**	**0.024**	0.009
10	321876	312861	Gwern-Y-Brain Dingle SSSI	0.015	0.015	0.013	0.004
11	324324	317697	Gweunydd Ty-Brith SSSI	0.012	0.012	0.013	0.005
12	321708	310428	Lower Garth Meadows SSSI	0.006	0.006	0.006	0.002
13	328511	313967	Breidden Hill SSSI	**0.011**	**0.010**	**0.011**	0.005
14	326899	310327	Gwaith Brics Buttington SSSI	0.004	0.004	0.005	0.002
15	324226	313829	Montgomery Canal SSSI/SAC	**0.149**	**0.145**	**0.065**	**0.045**
16	324502	314068	Montgomery Canal SSSI/SAC	**0.211**	**0.204**	**0.148**	**0.106**
17	324655	314397	Montgomery Canal SSSI/SAC	**0.226**	**0.217**	**0.204**	**0.128**
18	325061	314656	Montgomery Canal SSSI/SAC	**0.108**	**0.104**	**0.114**	**0.061**
19	325671	315409	Montgomery Canal SSSI/SAC	**0.039**	**0.038**	**0.050**	0.024
20	326191	317835	Montgomery Canal SSSI/SAC	0.009	0.009	0.012	0.006
21	325108	314081	Montgomery Canal SSSI/SAC	**0.079**	**0.076**	**0.046**	**0.035**
22	325787	312608	Montgomery Canal SSSI/SAC	0.015	0.015	0.017	0.008
23	324718	310341	Montgomery Canal SSSI/SAC	0.007	0.007	0.006	0.002
24	322538	311811	Granllyn SSSI/SAC	0.012	0.011	0.011	0.005

5.2 Detailed modelling

The detailed modelling has been carried out for all of the discrete receptors and over a restricted domain that includes the proposed poultry houses at Red House and the two ammonia sensitive AWs to the west and the closer stretches of Montgomery Canal SSSI/SAC to the east. These two wildlife sites are the areas where the preliminary modelling runs which included terrain and a fixed deposition velocity indicate that the process contribution to ammonia concentration could exceed Natural Resources Wales lower threshold percentage of the relevant Critical Level or Critical Load.

Terrain effects may be significant at some receptors; therefore, the detailed deposition run was made with terrain. Calms cannot be used with terrain or spatially varying deposition; however, in this case, the impact of calms upon the predicted ammonia concentrations and nitrogen deposition rates is not significant.

The predicted maximum annual mean ground level ammonia concentrations and nitrogen deposition rates are shown in Table 5a (The Unsound Scenario), Table 5b (The Pessimistic Scenario) and Table 5c (The Realistic Scenario). In these Tables, predicted ammonia concentrations (or concentrations equivalent to deposition rates) that are in excess of the Natural Resources Wales or Environment Agency upper threshold percentage of the relevant Critical Level or Critical Load (8% for an ammonia sensitive AW, SSSI or SAC, 100% for a non-statutory site) are coloured red. Concentrations (or concentrations equivalent to deposition rates) in the range between the Natural Resources Wales or Environment Agency lower and upper threshold percentage of the relevant Critical Level or Critical Load (1% and 8% for an ammonia sensitive AW, SSSI or SAC, 100% and 100% for a non-statutory site) are coloured blue.

Contour plots of the predicted process contribution, for The Realistic Scenario, to ground level maximum annual mean ammonia concentrations and nitrogen deposition rates are shown in Figure 6a and Figure 6b.

Table 5a. Predicted annual mean ammonia concentration at the discrete receptors – detailed modelling, The Unsound Scenario

Receptor number	X(m)	Y(m)	Designation	Site Parameters			Maximum annual 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	323525	314245	AW	0.03	1.0	10.0	0.056	5.6	0.433	4.3
2	323287	314934	AW	0.03	1.0	10.0	0.015	1.5	0.114	1.1
3	323338	315223	AW	0.03	1.0	10.0	0.014	1.4	0.105	1.1
4	323206	313830	AW	0.03	1.0	10.0	0.016	1.6	0.128	1.3
5	323039	313519	AW	0.03	1.0	10.0	0.009	0.9	0.068	0.7
6	322568	314574	AW	0.03	1.0	10.0	0.005	0.5	0.039	0.4
7	322993	313177	AW (ammonia sensitive)	0.03	1.0	10.0	0.006	0.6	0.047	0.5
8	323008	313894	AW (ammonia sensitive)	0.03	1.0	10.0	0.011	**1.1**	0.085	0.8
9	322674	313126	AW (ammonia sensitive)	0.03	1.0	10.0	0.004	0.4	0.030	0.3
10	321876	312861	Gwern-Y-Brain Dingle SSSI	-	-	-	0.002	-	-	-
11	324324	317697	Gweunydd Ty-Brith SSSI	0.02	3.0	10.0	0.003	0.1	0.015	0.2
12	321708	310428	Lower Garth Meadows SSSI	0.03	3.0	10.0	0.001	0.0	0.007	0.1
13	328511	313967	Breidden Hill SSSI	0.03	1.0	10.0	0.004	0.4	0.029	0.3
14	326899	310327	Gwaith Brics Buttington SSSI	-	1.0	-	0.002	0.2	-	-
15	324226	313829	Montgomery Canal SSSI/SAC	-	3.0	-	0.033	**1.1**	-	-
16	324502	314068	Montgomery Canal SSSI/SAC	-	3.0	-	0.082	**2.7**	-	-
17	324655	314397	Montgomery Canal SSSI/SAC	-	3.0	-	0.096	**3.2**	-	-
18	325061	314656	Montgomery Canal SSSI/SAC	-	3.0	-	0.041	**1.4**	-	-
19	325671	315409	Montgomery Canal SSSI/SAC	-	3.0	-	0.014	0.5	-	-
20	326191	317835	Montgomery Canal SSSI/SAC	-	3.0	-	0.004	0.1	-	-
21	325108	314081	Montgomery Canal SSSI/SAC	-	3.0	-	0.027	0.9	-	-
22	325787	312608	Montgomery Canal SSSI/SAC	-	3.0	-	0.006	0.2	-	-
23	324718	310341	Montgomery Canal SSSI/SAC	-	3.0	-	0.002	0.1	-	-
24	322538	311811	Granllyn SSSI/SAC	0.03	3.0	10.0	0.002	0.1	0.016	0.2

Table 5b. Predicted annual mean ammonia concentration at the discrete receptors – detailed modelling, The Pessimistic Scenario

Receptor number	X(m)	Y(m)	Designation	Site Parameters			Maximum annual 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	323525	314245	AW	0.03	1.0	10.0	0.041	4.1	0.318	3.2
2	323287	314934	AW	0.03	1.0	10.0	0.013	1.3	0.099	1.0
3	323338	315223	AW	0.03	1.0	10.0	0.012	1.2	0.090	0.9
4	323206	313830	AW	0.03	1.0	10.0	0.013	1.3	0.100	1.0
5	323039	313519	AW	0.03	1.0	10.0	0.007	0.7	0.056	0.6
6	322568	314574	AW	0.03	1.0	10.0	0.004	0.4	0.033	0.3
7	322993	313177	AW (ammonia sensitive)	0.03	1.0	10.0	0.005	0.5	0.039	0.4
8	323008	313894	AW (ammonia sensitive)	0.03	1.0	10.0	0.009	0.9	0.068	0.7
9	322674	313126	AW (ammonia sensitive)	0.03	1.0	10.0	0.003	0.3	0.025	0.2
10	321876	312861	Gwern-Y-Brain Dingle SSSI	-	-	-	0.002	-	-	-
11	324324	317697	Gweunydd Ty-Brith SSSI	0.02	3.0	10.0	0.003	0.1	0.014	0.1
12	321708	310428	Lower Garth Meadows SSSI	0.03	3.0	10.0	0.001	0.0	0.007	0.1
13	328511	313967	Breidden Hill SSSI	0.03	1.0	10.0	0.004	0.4	0.030	0.3
14	326899	310327	Gwaith Brics Buttington SSSI	-	1.0	-	0.001	0.1	-	-
15	324226	313829	Montgomery Canal SSSI/SAC	-	3.0	-	0.027	0.9	-	-
16	324502	314068	Montgomery Canal SSSI/SAC	-	3.0	-	0.068	**2.3**	-	-
17	324655	314397	Montgomery Canal SSSI/SAC	-	3.0	-	0.076	**2.5**	-	-
18	325061	314656	Montgomery Canal SSSI/SAC	-	3.0	-	0.035	**1.2**	-	-
19	325671	315409	Montgomery Canal SSSI/SAC	-	3.0	-	0.012	0.4	-	-
20	326191	317835	Montgomery Canal SSSI/SAC	-	3.0	-	0.003	0.1	-	-
21	325108	314081	Montgomery Canal SSSI/SAC	-	3.0	-	0.024	0.8	-	-
22	325787	312608	Montgomery Canal SSSI/SAC	-	3.0	-	0.005	0.2	-	-
23	324718	310341	Montgomery Canal SSSI/SAC	-	3.0	-	0.001	0.0	-	-
24	322538	311811	Granllyn SSSI/SAC	0.03	3.0	10.0	0.002	0.1	0.014	0.1

Table 5c. Predicted annual mean ammonia concentration at the discrete receptors – detailed modelling, The Realistic Scenario

Receptor number	X(m)	Y(m)	Designation	Site Parameters			Maximum annual ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level (µg/m^3)	Critical Load (kg/ha)	Process Contribution (µg/m^3)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	323525	314245	AW	0.03	1.0	10.0	0.032	3.2	0.248	2.5
2	323287	314934	AW	0.03	1.0	10.0	0.012	1.2	0.090	0.9
3	323338	315223	AW	0.03	1.0	10.0	0.010	1.0	0.080	0.8
4	323206	313830	AW	0.03	1.0	10.0	0.011	1.1	0.083	0.8
5	323039	313519	AW	0.03	1.0	10.0	0.006	0.6	0.048	0.5
6	322568	314574	AW	0.03	1.0	10.0	0.004	0.4	0.029	0.3
7	322993	313177	AW (ammonia sensitive)	0.03	1.0	10.0	0.004	0.4	0.034	0.3
8	323008	313894	AW (ammonia sensitive)	0.03	1.0	10.0	0.007	0.7	0.057	0.6
9	322674	313126	AW (ammonia sensitive)	0.03	1.0	10.0	0.003	0.3	0.022	0.2
10	321876	312861	Gwern-Y-Brain Dingle SSSI	-	-	-	0.002	-	-	-
11	324324	317697	Gweunydd Ty-Brith SSSI	0.02	3.0	10.0	0.003	0.1	0.013	0.1
12	321708	310428	Lower Garth Meadows SSSI	0.03	3.0	10.0	0.001	0.0	0.006	0.1
13	328511	313967	Breidden Hill SSSI	0.03	1.0	10.0	0.004	0.4	0.030	0.3
14	326899	310327	Gwaith Brics Buttington SSSI	-	1.0	-	0.001	0.1	-	-
15	324226	313829	Montgomery Canal SSSI/SAC	-	3.0	-	0.023	0.8	-	-
16	324502	314068	Montgomery Canal SSSI/SAC	-	3.0	-	0.059	**2.0**	-	-
17	324655	314397	Montgomery Canal SSSI/SAC	-	3.0	-	0.064	**2.1**	-	-
18	325061	314656	Montgomery Canal SSSI/SAC	-	3.0	-	0.031	**1.0**	-	-
19	325671	315409	Montgomery Canal SSSI/SAC	-	3.0	-	0.011	0.4	-	-
20	326191	317835	Montgomery Canal SSSI/SAC	-	3.0	-	0.003	0.1	-	-
21	325108	314081	Montgomery Canal SSSI/SAC	-	3.0	-	0.022	0.7	-	-
22	325787	312608	Montgomery Canal SSSI/SAC	-	3.0	-	0.005	0.2	-	-
23	324718	310341	Montgomery Canal SSSI/SAC	-	3.0	-	0.001	0.0	-	-
24	322538	311811	Granllyn SSSI/SAC	0.03	3.0	10.0	0.002	0.1	0.013	0.1

Figure 6a. Maximum annual mean ammonia concentration – The Realistic Scenario

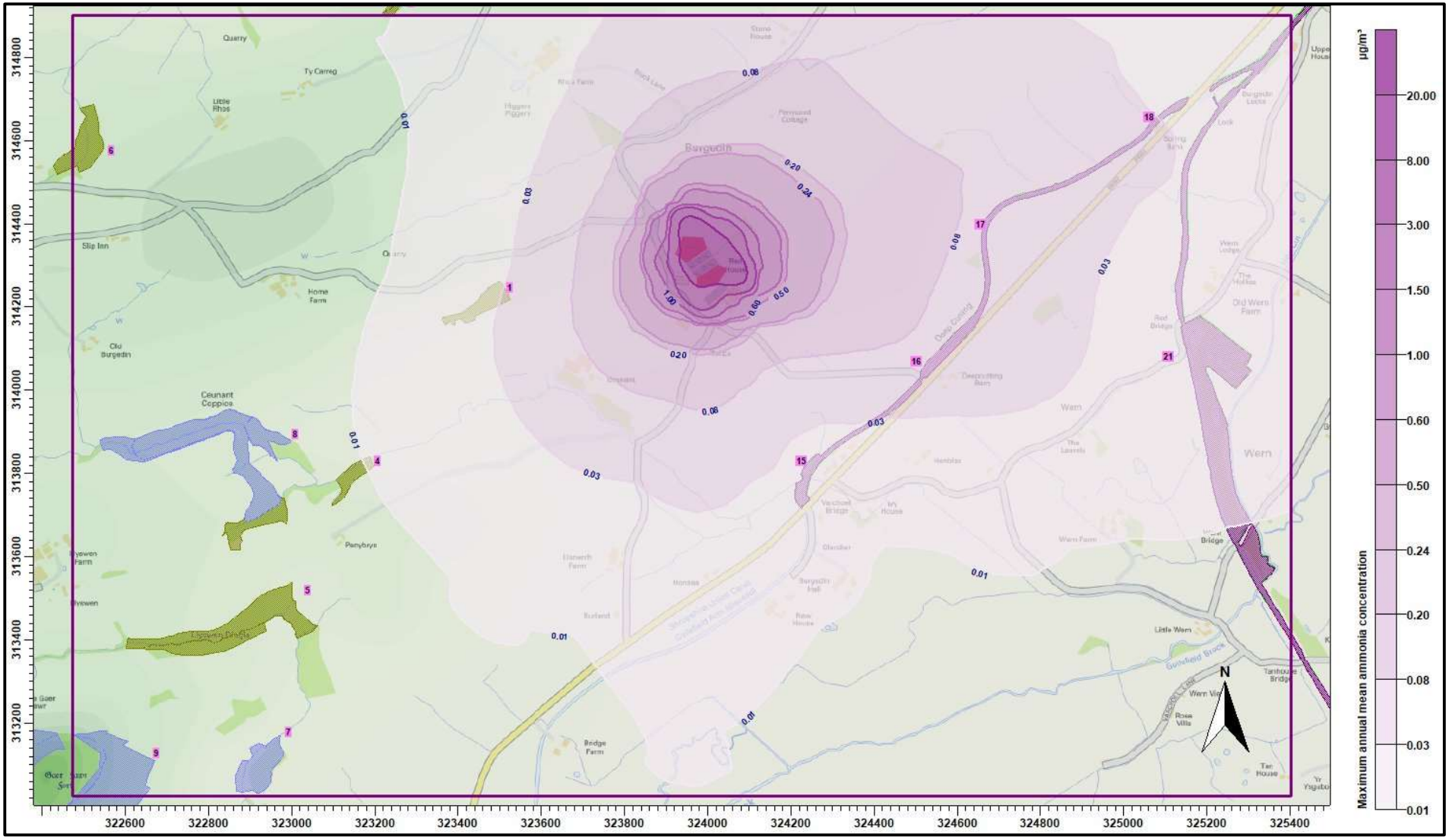
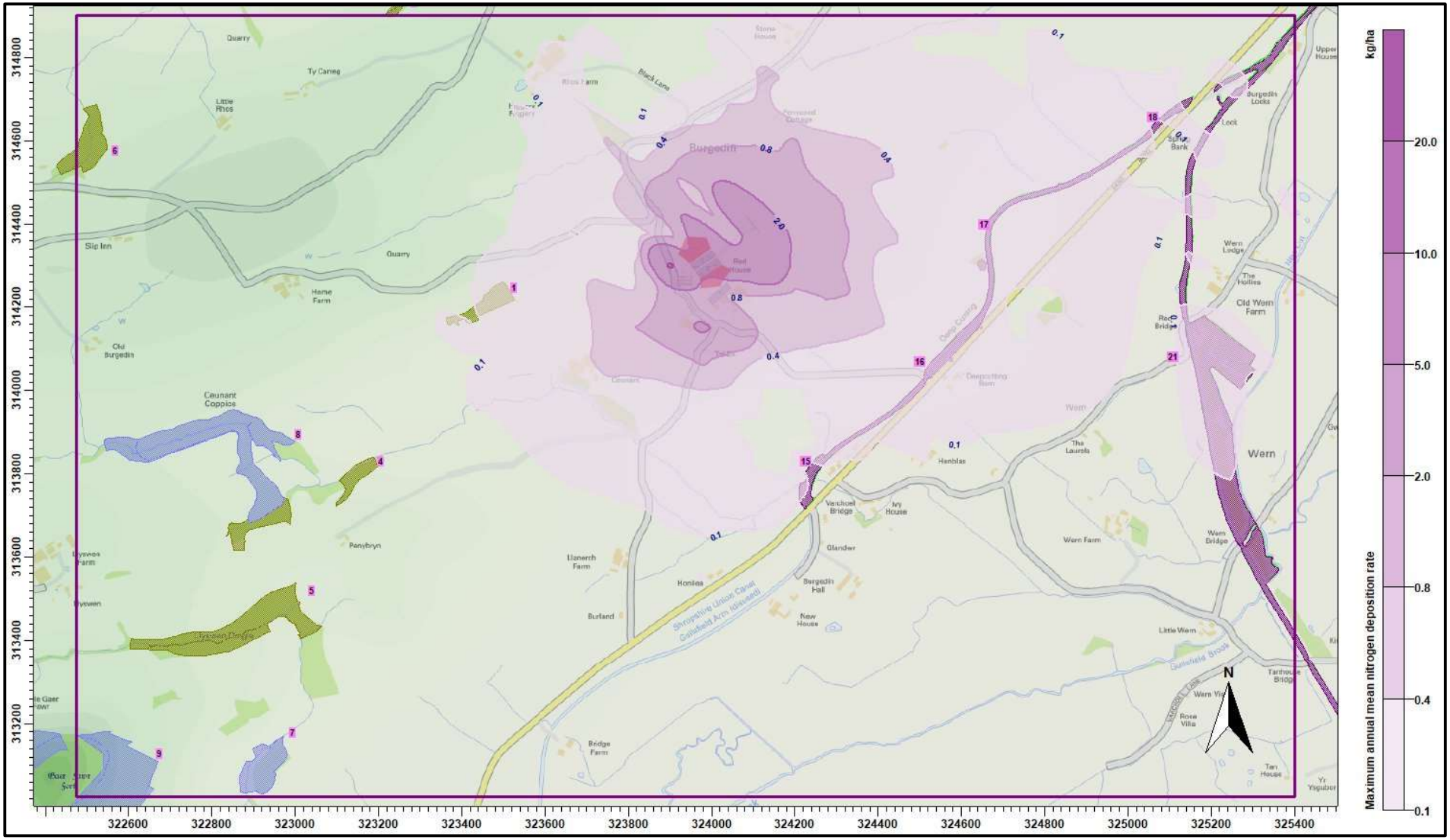


Figure 6b. Maximum annual mean nitrogen deposition rates – The Realistic Scenario



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Geralllt Davies, of Roger Parry & Partners LLP, on behalf of Mr. D. Farmer, to use computer modelling to assess the impact of ammonia emissions from the proposed free range egg-laying chicken houses at Red House, Guilsfield in Powys. SY21 9LW.

Ammonia emission rates from the proposed poultry houses have been assessed and quantified based upon the Environment Agency's standard ammonia emission factors. Ammonia emissions from ranging areas have been assessed and quantified based upon the baseline parameters used to calculate the National Atmospheric Emission Inventory (NAEI) emission factor for grazing free range hens and information from a variety of peer reviewed scientific papers. 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.

Preliminary modelling

The modelling predicts that:

- Process contributions from the proposed poultry houses to ammonia concentrations might potentially exceed the Natural Resources Wales lower threshold percentage of the relevant Critical Level at two of the ammonia sensitive AWs to the west and at nearby sections of Montgomery Canal SSSI/SAC to the south and east.

- Process contributions would be below the Environment Agency's lower threshold percentage of the precautionary Critical Level of 1.0 µg/m³ at all nearby AWs that are not defined ammonia sensitive by Natural Resources Wales.

- Process contributions would be below the Natural Resources Wales lower threshold percentage of the relevant Critical Level and Critical Load at Gweunydd Ty-Brith SSSI, Lower Garth Meadows SSSI, Breidden Hill SSSI, Gwaith Brics Buttington SSSI or Granllyn SSSI/SAC.

Detailed modelling

The modelling predicts that:

- For all three scenarios, there is an exceedance of the Natural Resources Wales lower threshold percentage of the Critical Level of 3.0 µg/m³ at nearby stretches of Montgomey Canal SSSI/SAC. This exceedance is predicted to impact a stretch of the SSSI/SAC that measures approximately 1 km in length.

- For the Unsound Scenario, there would be a small exceedance of the Natural Resources Wales lower threshold percentage of the Critical Level of 1.0 µg/m³ at the closest ammonia sensitive AW to the east-south-east. This exceedance is predicted to impact upon approximate 0.01 ha of the ammonia sensitive AWs.

- For both The Realistic Scenario and The Pessimistic Scenario there are no exceedances of the Natural Resources Wales lower threshold percentage of the Critical Level at any of the other discrete receptors located at the ammonia sensitive AWs.

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