A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Proposed Broiler Chicken Rearing Houses at Dunnimere Farm, Portway Lane, Harlaston in Herefordshire

Prepared by Sally Howse

AS Modelling & Data Ltd.

Email: sally@asmodata.co.uk

Telephone: 01952 462500

25th July 2019

1. Introduction

AS Modelling & Data Ltd. has been instructed by Gail Jenkins of Roger Parry & Partners LLP, on behalf of the applicants, R M & D C Calcott, to use computer modelling to assess the impact of ammonia emissions from the proposed broiler chicken rearing houses at Dunnimere Farm, Portway Lane, Harlaston in Herefordshire. B79 9LA.

Ammonia emission rates from the proposed poultry houses have been assessed and quantified based upon the Environment Agency's 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

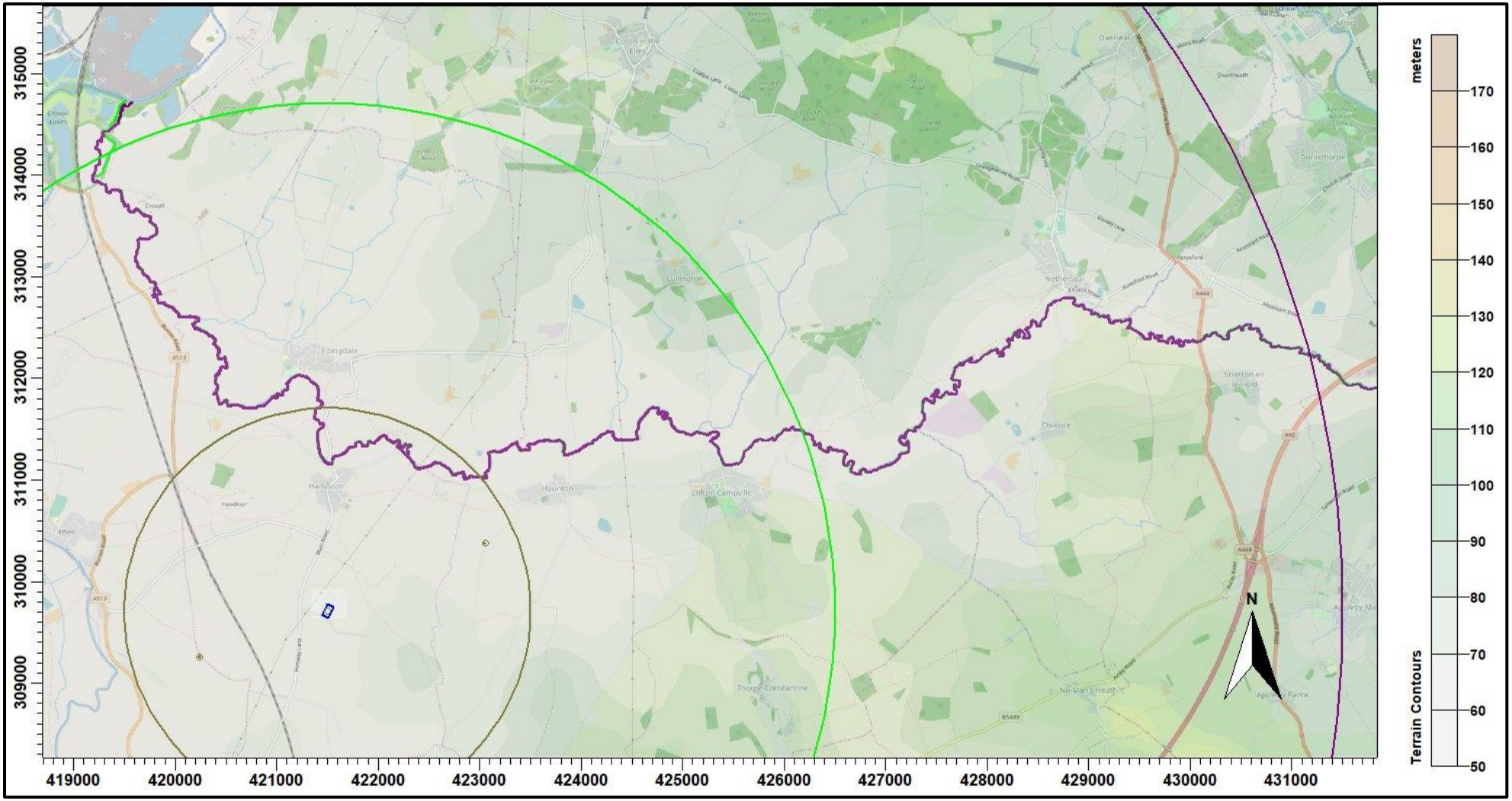
Dunnimere Farm is in a rural area approximately 900 m to the south of the village of Harlaston in Herefordshire. The land surrounding Dunnimere Farm is used primarily for arable farming, with some meadows and isolated wooded areas nearby. The site is at an altitude of around 60 m on gently sloping land, with the River Tame to the west and, generally, the land rises to slightly higher ground to the south-east.

Under the proposals, two new broiler chicken rearing houses would be constructed to the east of Portway Lane. The new poultry houses would provide accommodation for up to 120,000 broiler chickens and would be ventilated by uncapped high speed ridge mounted fans, each with a short chimney. The chickens would be reared from day old chicks up to 35 days old and there would be approximately 7.5 flocks per annum.

There are two areas designated as Local Wildlife Sites (LWSs) within 2 km of Dunnimere Farm. The River Mease, which is designated as both a Site of Special Scientific Interest (SSSI) and a Special Area of Conservation (SAC), is also within 5 km of the proposed poultry houses. There are no other internationally designated sites within 10 km of the proposed poultry houses at Dunnimere Farm.

A map of the surrounding area showing the positions of the proposed poultry houses, the LWSs, the SSSI and the SAC is provided in Figure 1. In this figure, the LWSs are shaded olive, the SSSI is shaded in green, the SAC is shaded in purple and the site of the proposed poultry houses is outlined in blue.

Figure 1. The area surrounding Dunnimere Farm – concentric circle radii at 2km (olive), 5 km (green) and 10 km (purple)



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 Dunnimere Farm and the wildlife sites is 2.52 µg-NH_3/m^3. The background nitrogen deposition rate to woodland is 35.7 kg-N/ha/y and to short vegetation is 20.72 kg-N/ha/y. The background acid deposition rate to woodland is 2.57 keq/ha/y and to short vegetation is 1.54 keq/ha/y. The source of these background figures is the Air Pollution Information System (APIS, July 2019).

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. 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 does 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)
LWSs	1.0 [1]	10.0	-
River Mease SSSI/SAC	3.0 [2]	-	-

1. A precautionary figure, used where details of the site are unavailable, or citations indicate that sensitive lichens and bryophytes may be present.
2. Based upon the citation for the site and information obtained from APIS.

3.4 Guidance on the significance of ammonia emissions

3.4.1 Environment Agency Criteria

The Environment Agency web-page titled "Intensive farming risk assessment for your environmental permit", contains a set of criteria, with thresholds defined by percentages of the Critical Level or Critical Load, for: internationally designated wildlife sites (Special Protection Areas (SPAs), Special Areas of Conservation (SACs) and Ramsar sites); Sites of Special Scientific Interest (SSSIs) and other non-statutory wildlife sites. The lower and upper thresholds are: 4% and 20% for SACs, SPAs and Ramsar sites; 20% and 50% for SSSIs and 100% and 100% for non-statutory wildlife sites.

If the predicted process contributions to Critical Level or Critical Load are below the lower threshold percentage, the impact is usually deemed acceptable.

If the predicted process contributions to Critical Level or Critical Load are in the range between the lower and upper thresholds; 4% to 20% for SACs, SPAs and Ramsar sites; 20% to 50% for SSSIs and 100% to 100% for other non-statutory wildlife sites, whether or not the impact is deemed acceptable is at the discretion of the Environment Agency. In making their decision, the Environment Agency will consider whether other farming installations might act in-combination with the farm and the sensitivities of the wildlife sites. 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%).

3.4.2 Natural England advisory criteria

Natural England are a statutory consultee at planning and usually advise that, if predicted process contributions exceed 1% of Critical Level or Critical Load at a SSSI, SAC, SPA or Ramsar site, then the local authority should consider whether other farming installations[1] might act in-combination or cumulatively with the farm and the sensitivities of the wildlife sites. This advice is based primarily upon the Habitats Directive, EIA Directive and the Countryside and Rights of Way Act.

1. The process contribution from most farming installations is already included in the background ammonia concentrations and nitrogen and acid deposition rates. Therefore, it is normally only necessary to consider new installations and installations with extant planning permission and proposed developments when understanding the additional impact of a proposal upon nearby ecologies. However, established farms in close proximity may need to be considered given the background concentrations and deposition rates are derived as an average for a 5 km by 5 km grid.

Note that a process contribution of 1% of Critical Level or Critical Load would normally be considered insignificant. A process contribution that is above 1% of Critical Level or Critical Load should be regarded as potentially significant; however, 1% of Critical Level or Critical Load should not be used as a threshold above which damage is implied.

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 Environment Agency provides an Intensive farming guidance note which lists standard ammonia emission factors for a variety of livestock, including broiler chickens. The emission factor for broiler chickens is 0.034 kg-NH_3/bird place/y; this figure is used to calculate the emissions from the proposed poultry houses.

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 rate

Source	Animal numbers	Type or weight	Emission factor (kg-NH_3/place/y)	Emission rate (g-NH_3/s)
Proposed Housing	120,000	Broiler Chickens	0.034	0.129287

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; terrain is understood to be resolved at a resolution of approximately 2 km (with sub-13 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 location 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 markedly, reflecting the local flow in that part of the domain. The resolution of the wind field is approximately 340 m in the preliminary modelling and approximately 150 m in the detailed modelling. 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 52.684 N, 1.681 W, 2015 – 2018

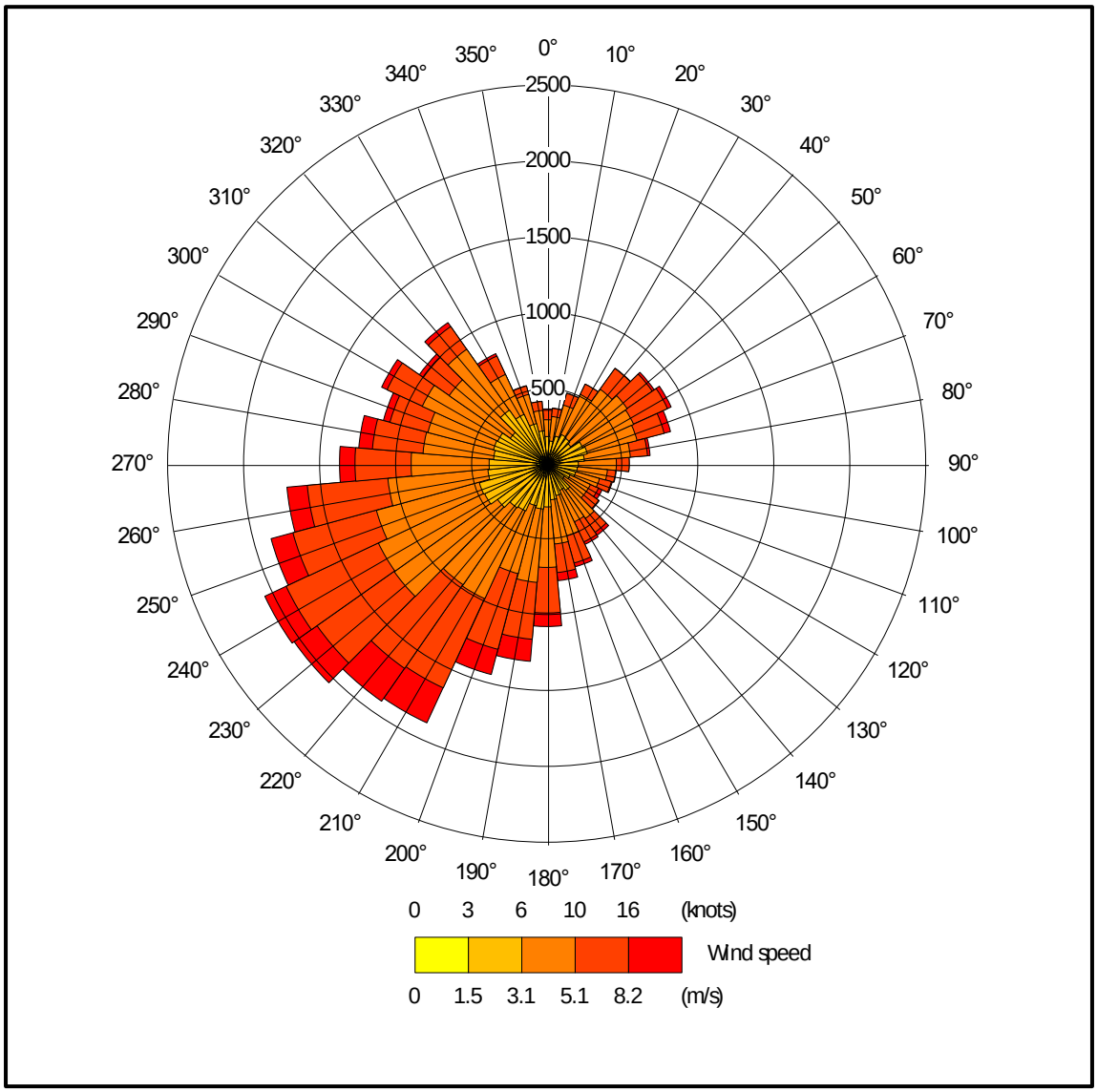
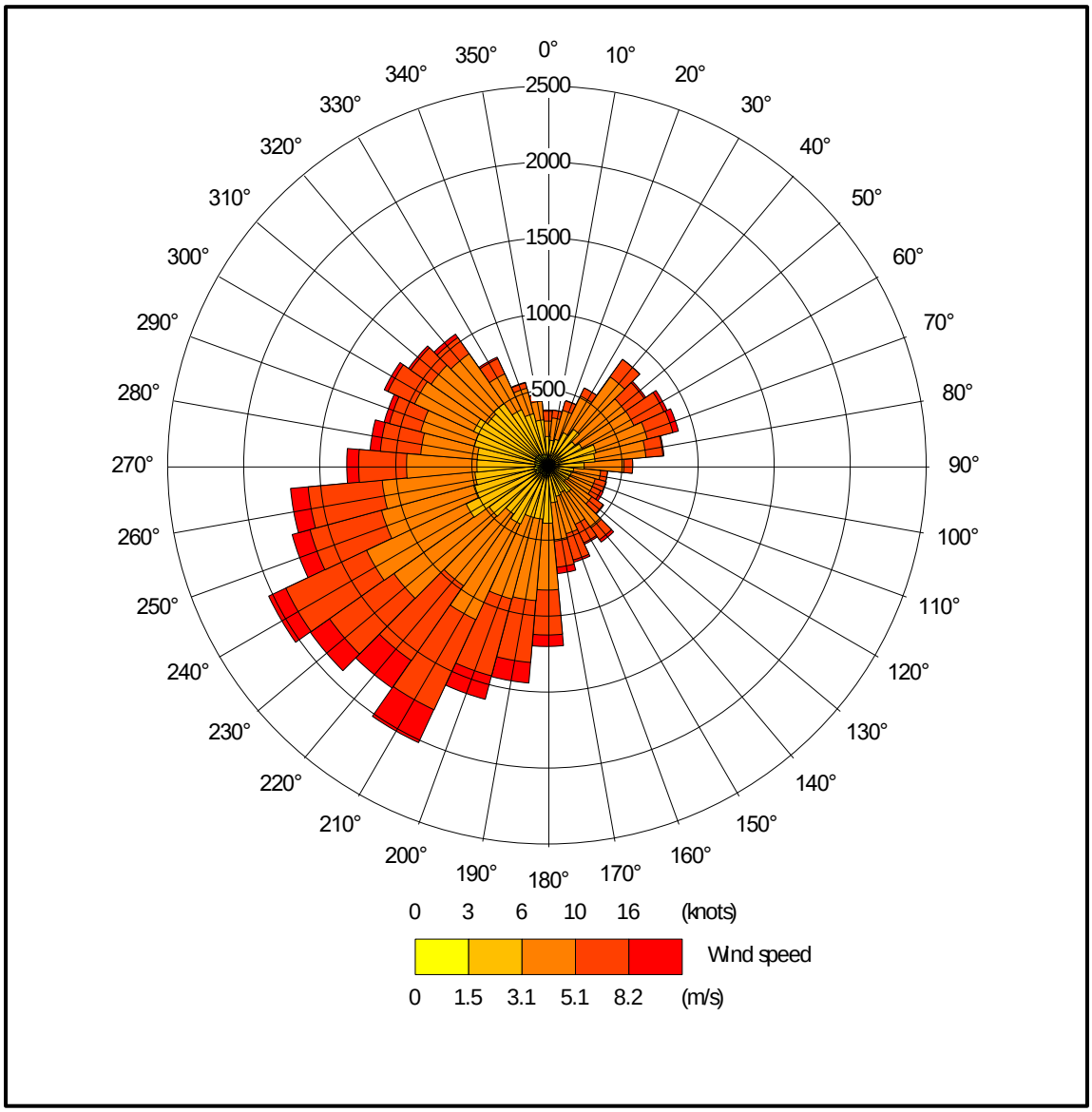


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 421500, 309700 2015–2018



4.2 Emission sources

Emissions from the chimneys of the uncapped high speed fans that would be used for the ventilation of the proposed poultry houses are represented by three point sources per house within ADMS (PR1 a, b & c and PR2 a, b & c).

Details of the point source parameters are shown in Table 3. The positions of the sources may be seen in Figure 3.

Table 3. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (°C)	Emission rate per source ($g\text{-}NH_3/s$)
PR1 a, b & c & PR2 a, b & c	4.5	0.8	11.0	22.0	0.021548

4.3 Modelled buildings

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

4.4 Discrete receptors

Sixteen discrete receptors have been defined: two at the LWSs (1 to 2), one at the SSSI (3) and thirteen at the SAC/SSSI (4 to 16). 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 plot presented in Section 5 of this report and to define spatially varying deposition field used in the detailed modelling, a regular Cartesian grid has been defined within ADMS. The individual 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.

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 22.0 km x 22.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS in the preliminary modelling. A 10.0 km x 10.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS in the detailed modelling. N.B. The resolution of FLOWSTAR is 64 x 64 grid points; therefore, the effective resolution of the wind field is approximately 340 m in the preliminary modelling and approximately 150 m in the detailed modelling.

4.7 Roughness Length

A fixed surface roughness length of 0.175 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 0.15 m. The effect of the difference in roughness length is precautionary as it increases the frequency of low wind speeds and the stability and therefore increases predicted ground level concentrations.

Figure 3. The positions of modelled buildings & sources

4.8 Deposition

The method used to model deposition of ammonia and consequent plume depletion is based on a document titled "Guidance on modelling the concentration and deposition of ammonia emitted from intensive farming" from the Environment Agency's Air Quality Modelling and Assessment Unit, 22 November 2010. N.B. 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 0.015 m/s over heavily 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 a deposition velocity field. The deposition velocities used are provided in Table 4.

Table 4. Deposition velocities

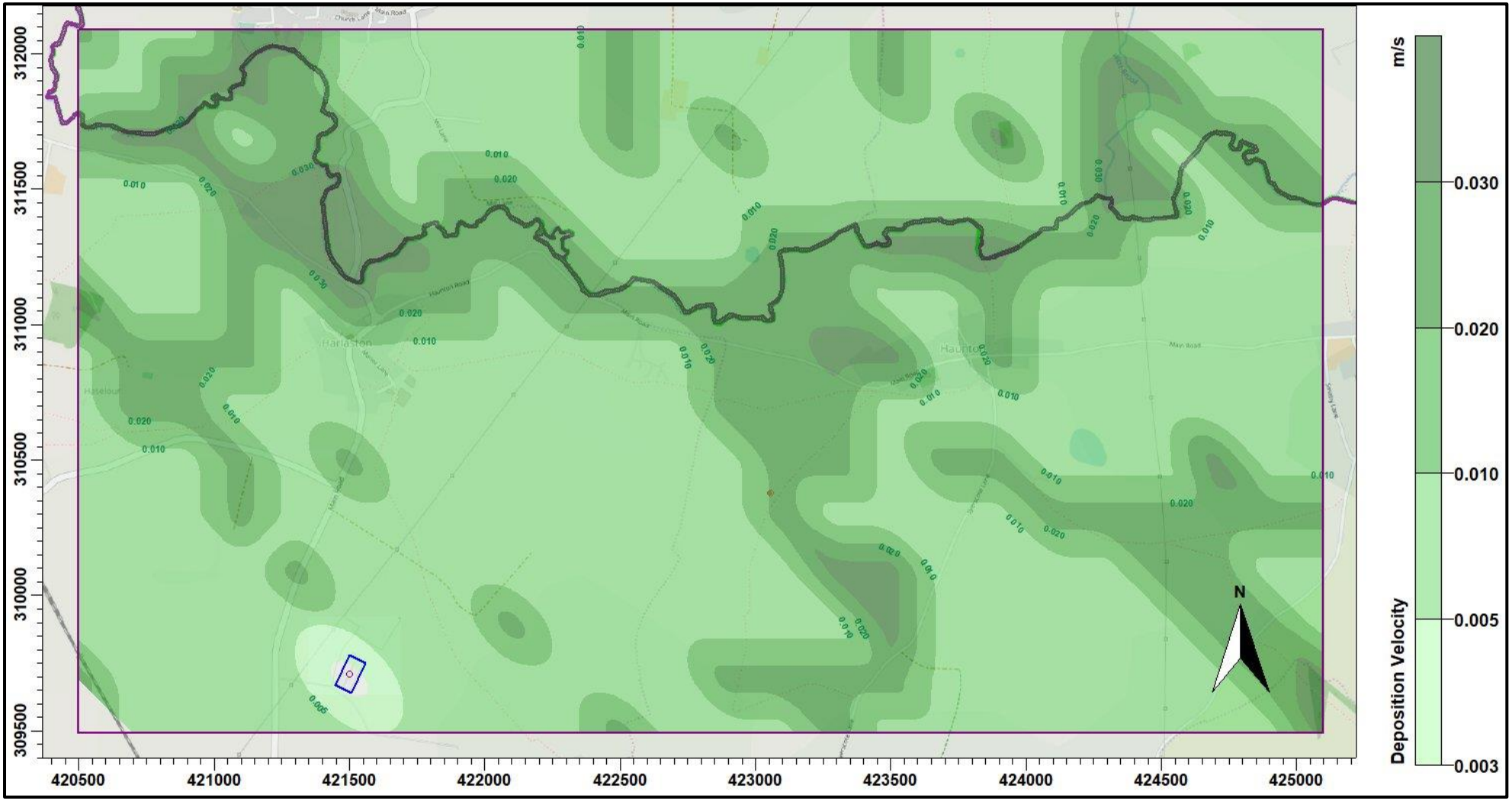
NH_3 concentration (PC + background) (µg/m^3)	< 10	10 - 20	20 - 30	30 – 80	> 80
Deposition velocity – woodland (m/s)	0.03	0.015	0.01	0.005	0.003
Deposition velocity – short vegetation (m/s)	0.02 (0.015 over heavily grazed grassland)	0.015	0.01	0.005	0.003
Deposition velocity – arable farmland/rye grass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

Figure 4. The regular Cartesian grid and discrete receptors

Figure 5. The spatially varying deposition field



5. Details of the Model Runs and Results

ADMS was run a total of twelve times, once for each year of the meteorological record and in the following three 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.

Details of the predicted annual mean ammonia concentrations at each receptor are provided in Table 5. In the Table, predicted ammonia concentrations that are in excess of the Environment Agency's upper percentage threshold of the relevant Critical Level (20% for a SAC, 50% for a SSSI and 100% for a LWS) are coloured red. Predicted ammonia concentrations that are in the range between the Environment Agency's upper percentage threshold and lower percentage threshold of the relevant Critical Level (4% and 20% for a SAC, 20% and 50% for a SSSI and 100% and 100% for a LWS) are coloured blue. Additionally, predicted ammonia concentrations (or concentrations equivalent to nitrogen deposition rates) that are in excess of the Natural England advisory criteria are highlighted in bold text. For convenience, cells referring to the LWSs are shaded olive, cells referring to the SSSI are shaded green and cells referring to the SAC are shaded purple.

Table 5. Predicted maximum annual mean ammonia concentration rate at the discrete receptors

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 Terrain Fixed Dep 0.003 m/s
1	423038	310370	Willow Bottom Lane LWS	0.066	0.065	0.070	0.057
2	420252	309267	Twizles Lane Hedgerows LWS	0.055	0.054	0.061	0.049
3	419225	313985	River Mease SSSI	0.006	0.006	0.007	0.004
4	421521	311153	River Mease SSSI/SAC	**0.047**	**0.047**	**0.058**	**0.047**
5	422389	311109	River Mease SSSI/SAC	**0.050**	**0.050**	**0.050**	**0.044**
6	420762	311700	River Mease SSSI/SAC	0.019	0.019	0.021	0.015
7	420076	312594	River Mease SSSI/SAC	0.010	0.010	0.011	0.008
8	419755	313383	River Mease SSSI/SAC	0.008	0.008	0.009	0.006
9	419516	314677	River Mease SAC	0.006	0.006	0.006	0.004
10	423829	311263	River Mease SSSI/SAC	**0.032**	**0.032**	**0.036**	0.028
11	424814	311593	River Mease SSSI/SAC	0.021	0.021	0.024	0.017
12	426290	311354	River Mease SAC	0.014	0.014	0.015	0.010
13	427145	311367	River Mease SAC	0.011	0.011	0.012	0.007
14	428126	312218	River Mease SAC	0.009	0.009	0.010	0.006
15	429384	312491	River Mease SAC	0.007	0.007	0.008	0.004
16	430695	312387	River Mease SAC	0.006	0.006	0.007	0.004

5.2 Detailed deposition modelling

The preliminary modelling shows that the process contributions to the annual mean ammonia concentration would be below the Environment Agency lower percentage thresholds of the relevant Critical Level or Critical Load for all sites considered (4% for a SAC, 20% for a SSSI and 100% for a LWS). However, closer parts of the River Mease SAC exceed 1% of the relevant Critical Level or Critical Load. Therefore, in this case, detailed modelling has been carried out over a restricted domain covering the closer parts of the River Mease SAC.

The predicted maximum annual mean ground level ammonia concentrations and nitrogen deposition rates at the discrete receptors within the detailed modelling domain are shown in Table 6. In the Table, predicted ammonia concentrations and nitrogen deposition rates that are in excess of the Environment Agency's upper threshold percentage of the relevant Critical Level or Critical Load (20% for a SAC, 50% for a SSSI and 100% for a LWS) are coloured red. Ammonia concentrations and nitrogen deposition rates in the range between the Environment Agency's lower and upper threshold percentage of the relevant Critical Level or Critical Load (4% and 20% for a SAC, 20% and 50% for a SSSI and 100% and 100% for a LWS) are coloured blue. Additionally, predicted ammonia concentrations (or concentrations equivalent to nitrogen deposition rates) that are in excess of the 1% of the relevant Critical Level or Critical Load are highlighted in bold text.

Contour plots of the predicted process contribution by the proposed poultry houses to ground level maximum annual mean ammonia concentrations and to maximum nitrogen deposition rates are shown in Figures 6a and 6b.

Table 6. Predicted process contribution to maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors within the detailed modelling domain

Receptor number	X(m)	Y(m)	Name	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	423038	310370	Willow Bottom Lane LWS	0.03	1.0	10.0	0.048	4.8	0.373	3.7
4	421521	311153	River Mease SSSI/SAC	0.03	3.0	-	0.030	**1.0**	-	-
5	422389	311109	River Mease SSSI/SAC	0.03	3.0	-	0.041	**1.4**	-	-
6	420762	311700	River Mease SSSI/SAC	0.03	3.0	-	0.011	0.4	-	-
10	423829	311263	River Mease SSSI/SAC	0.03	3.0	-	0.020	0.7	-	-
11	424814	311593	River Mease SSSI/SAC	0.03	3.0	-	0.013	0.4	-	-

Figure 6a. Process contribution to maximum annual mean ammonia concentrations

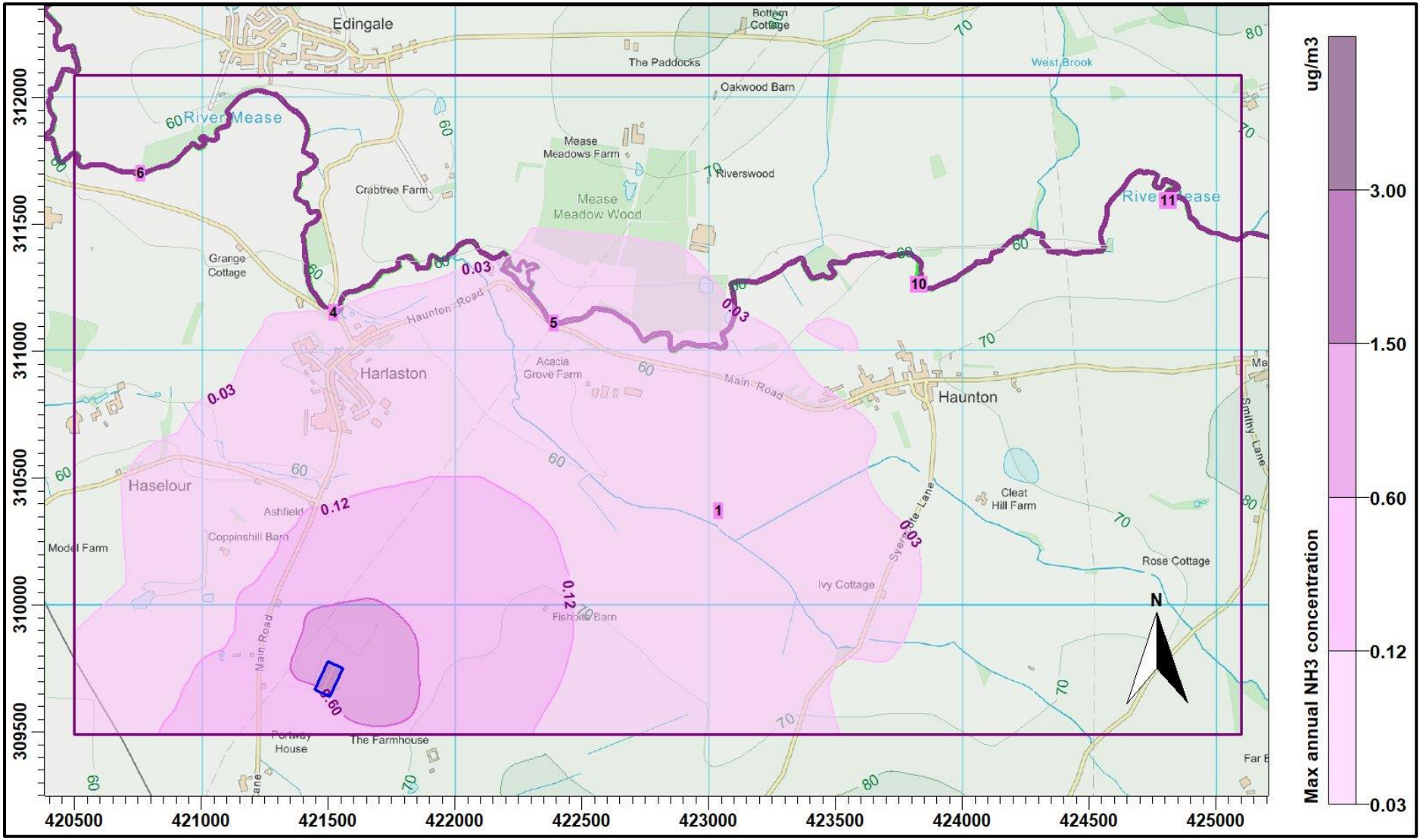
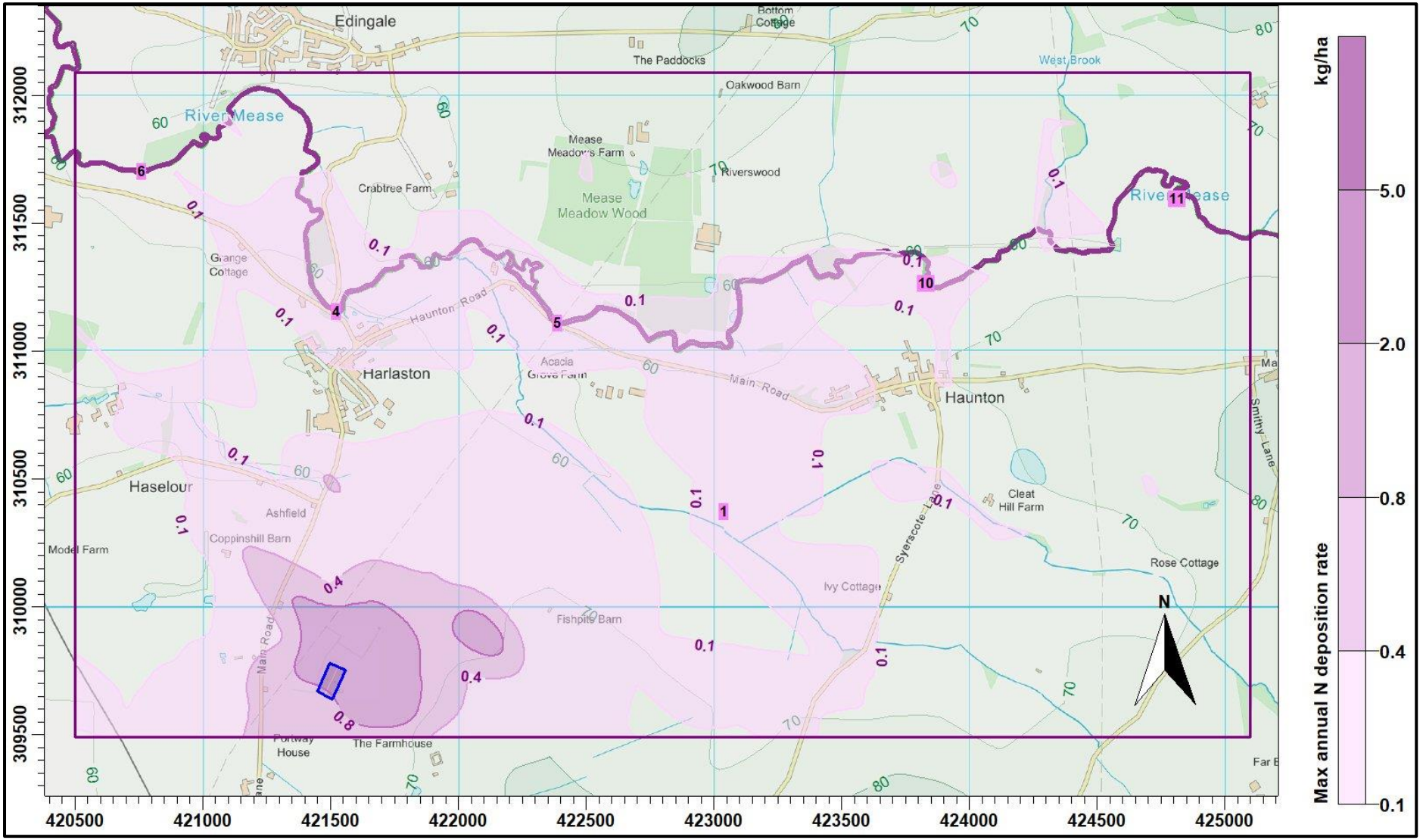


Figure 6b. Process contribution to maximum nitrogen deposition rates



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Gail Jenkins of Roger Parry & Partners LLP, on behalf of the applicants, R M & D C Calcott, to use computer modelling to assess the impact of ammonia emissions from the proposed broiler chicken rearing houses at Dunnimere Farm, Portway Lane, Harlaston in Herefordshire. B79 9LA.

Ammonia emission rates from the proposed poultry houses have been assessed and quantified based upon the Environment Agency's 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 modelling predicts that:

- At all of the wildlife sites identified, the process contribution of the proposed poultry houses to ammonia concentrations and nitrogen deposition rates would be below the Environment Agency's lower threshold percentage of the relevant Critical Level or Critical Load.

- There is a small exceedance of 1% of the Critical Level of 3.0 μg/m³, at the River Mease SAC. This exceedance is predicted to impact upon a stretch of the river of approximate length of 1.4 km.

- Note that a process contribution of 1% of Critical Level or Critical Load would normally be considered insignificant. A process contribution that is above 1% of Critical Level or Critical Load should be regarded as potentially significant; however, 1% of Critical Level or Critical Load should not be used as a threshold above which damage is implied.

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.

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

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

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