A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Existing Egg Laying Chicken Houses and the Proposed Pullet Rearing House at Court House Farm, Mellington, near Church Stoke in Powys

Prepared by Steve Smith

AS Modelling & Data Ltd.

Email: stevesmith@asmodata.co.uk

Telephone: 01952 462500

21st July 2018

1. Introduction

AS Modelling & Data Ltd. has been instructed by John Ward, on behalf of David Davies Resources Ltd., to use computer modelling to assess the impact of ammonia emissions from the existing egg laying chicken houses and the proposed pullet rearing house at Court House Farm, Mellington, Churchstoke, Montgomery, Powys. SY15 6TQ.

Ammonia emission rates from the existing and 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

Court House Farm is in a rural area, approximately 1.8 km to the south-south-west of the village of Churchstoke in Powys. The surrounding land is used predominantly for livestock and arable farming, but there are some wooded areas and areas of semi-natural grassland nearby. The site is southern side of the valley formed by Camlad and Caebitra at an altitude of around 144 m, with the land falling gently towards the rivers to the north and rising to hills/mountains to the south.

There are currently three poultry houses at Court House Farm, these houses accommodate up to 39,999 egg laying chickens. The birds droppings collect within the houses and is removed at the end of each flock cycle, which is approximately once per year. The houses are ventilated by cowled side mounted fans.

Under the proposal, the existing poultry houses would be demolished and replaced by a single new poultry house. The new poultry house would provide accommodation for up to 100,000 pullets which would be reared from day old chicks to around 18 weeks old, prior to transfer to egg laying units elsewhere. The poultry house would be ventilated by uncapped high speed ridge/roof mounted fans, each with a short chimney.

There are several areas of Ancient Woodlands (AWs) within 2 km of Court House Farm. One of the AWs is directly to the west of the farm; however, the AW has been subject to residential development and probably retains very few characteristics of AW. There are also five Sites of Special Scientific Interest (SSSIs) that are within 5 km of the farm. There are no internationally designated wildlife sites within 5 km of the farm. Further details of the SSSIs are provided below.

- Coed Pentre SSSI – approximately 1.5 km to the east-south-east.
- Brithdir a Chwm Mawr SSSI - approximately 4.0 km to the east-north-east (bryophytes are noted in the citation for the site).
- Roundton Hill SSSI - approximately 3.5 km to the north-east (lichens and bryophytes are noted in the citation for the site).
- Spy Wood & Aldress Dingle SSSI - approximately 3.6 km to the north-north-east (designated for geological features).
- Corndon Hill SSSI - approximately 5.0 km to the north-east (bryophytes are noted in the citation for the site).

A map of the surrounding area showing the positions of the proposed poultry house and the nearby wildlife sites is provided in Figures 1a and 1b. In these figures, the AWs are outlined in olive, the SSSIs are shaded green and the site of Court House Farm is outlined in blue.

Figure 1a. The area surrounding Court House Farm – concentric circles radii at 2 km (olive) and 5 km (green)

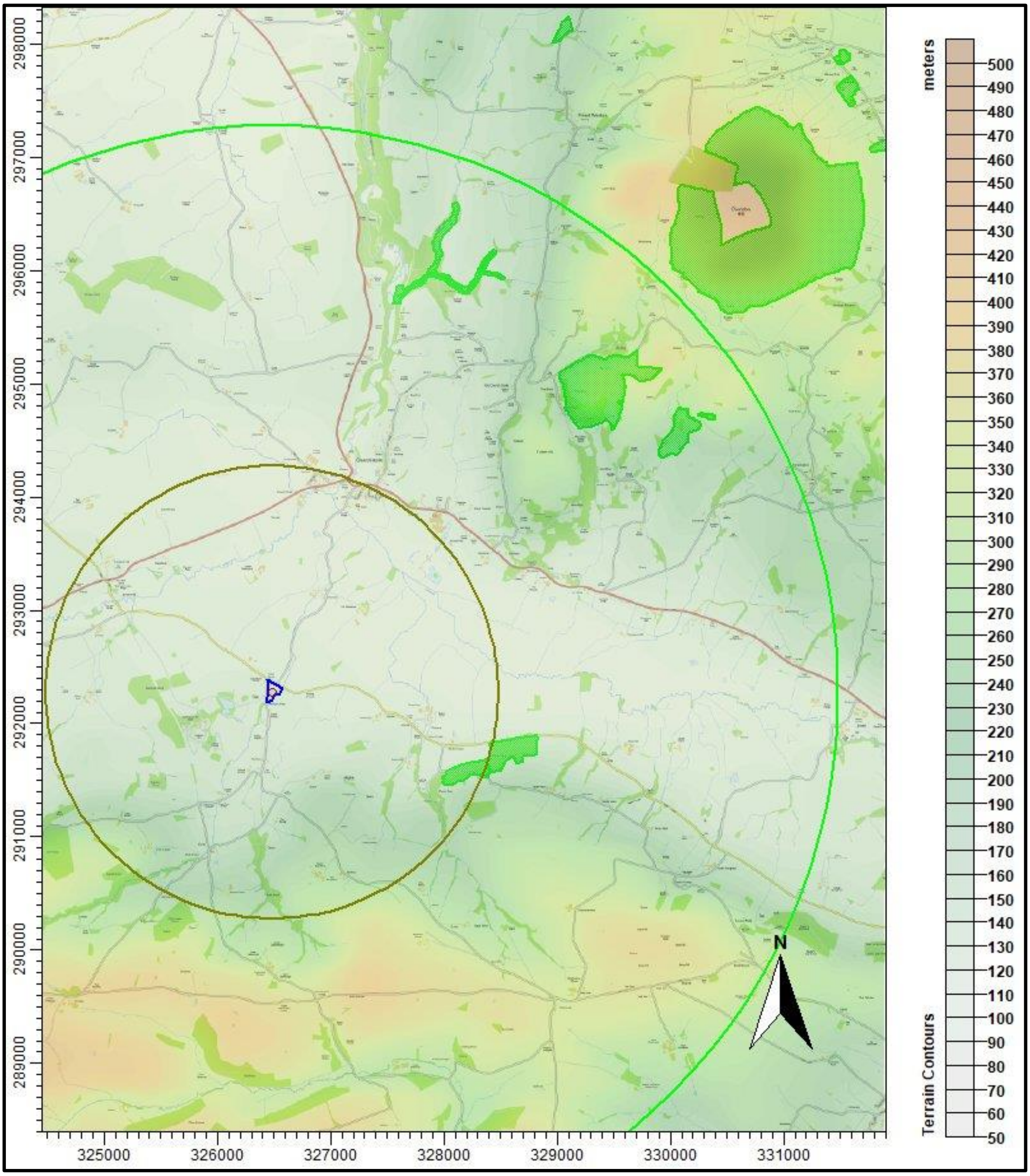
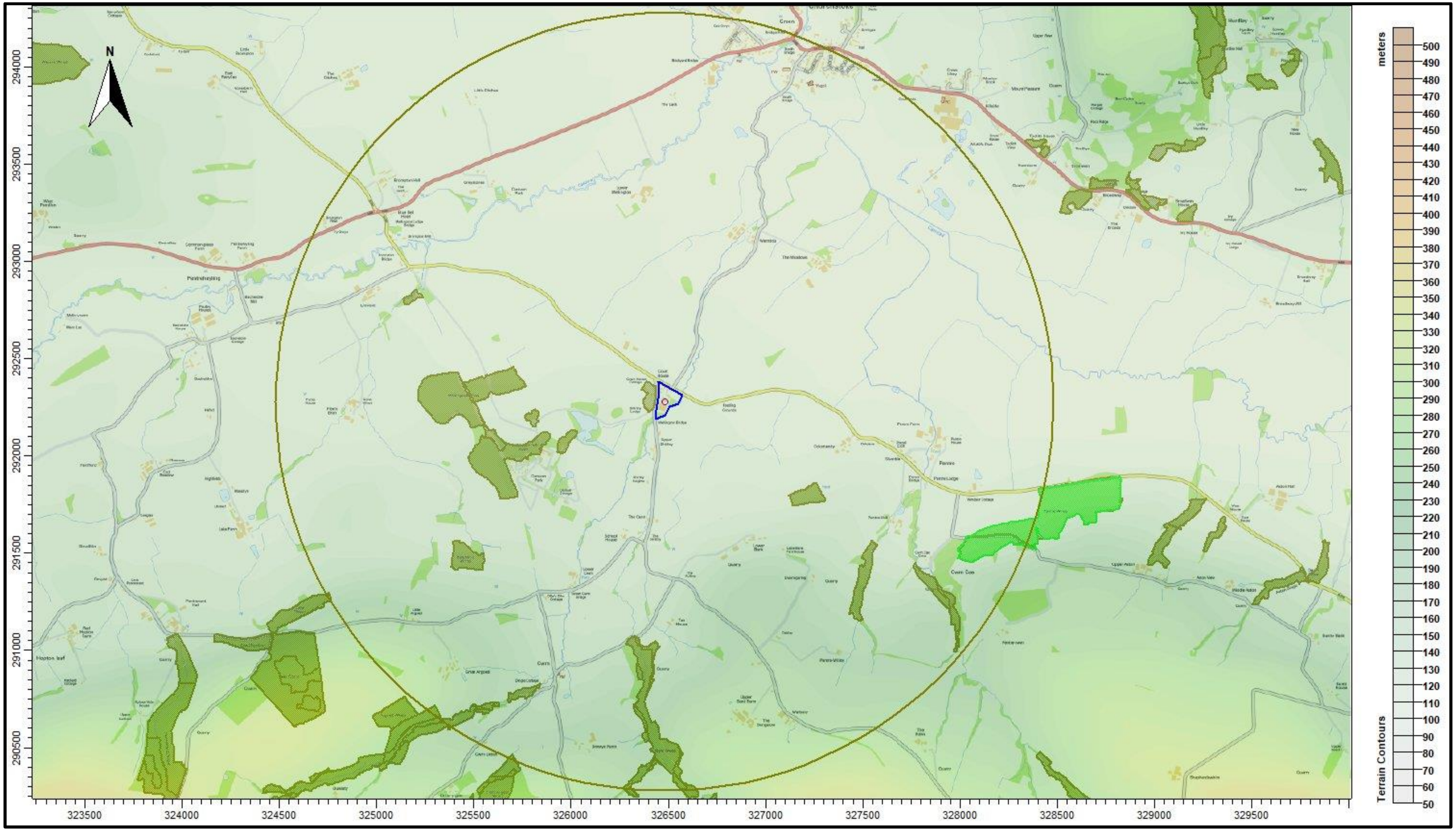


Figure 1b. The area surrounding Court House Farm – a closer view showing the AWs



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 background ammonia concentration (annual mean) in the area around Court House Farm and the wildlife sites is 2.11 $\mu g\text{-}NH_3/m^3$. The background nitrogen deposition rate to woodland is 33.60 kg-N/ha/y and to short vegetation is 21.28 kg-N/ha/y. The background acid deposition rate to woodland is 2.51 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, July 2018).

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 $\mu g\text{-}NH_3/m^3$ 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 $\mu g\text{-}NH_3/m^3$ 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. However, it may be necessary to consider nitrogen deposition should a Critical Load of 5.0 kg-N/ha/y be appropriate. 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	1.0 [1]	-	-
Coed Pentre SSSI	3.0 [2]	10.0 [2]	-
Spy Wood & Aldress Dingle SSSI	n/a	n/a	n/a
Roundton Hill SSSI, Brithdir a Chwm Mawr SSSI and Corndon Hill SSSI	3.0 [2]	10.0 [2]	-

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 in the citation for the site and information obtained from the APIS website (June 2018).

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, 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.

For Local Nature Reserves (LNRs), Local Wildlife Sites (LWSs) and Ancient Woodlands (AWs), the current assessment procedure usually applied is based on 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%).

3.5 IAQM Position Statement on the use of the 1% criterion

A Position Statement issued by the Institute of Air Quality Management (IAQM) in January 2016 further clarifies the use of the 1% criterion for the determination of an '*insignificant*' effect of air quality impacts on sensitive habitats. The Position Statement states: "*the use of a criterion of 1% of an environmental standard or assessment level in the context of habitats should be used only to screen out impacts that will have an insignificant effect. It should not be used as a threshold above which damage is implied*". Furthermore, if the impacts are plainly above 1% then this should be regarded as potentially significant; where impacts are just slightly greater than 1% then a degree of professional judgement should be applied with regards to the theoretical risk.

3.6 Quantification of ammonia emissions

Ammonia emission rates from poultry houses, ranging areas and manure spreading 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.

3.6.1 Existing egg laying chicken housing ammonia 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, where manure collects within the housing through the lifetime of the flock, the Environment Agency figure is 0.29 kg-NH_3/bird place/year. Note that the figure of 0.29 kg-NH_3/bird place/year is used in this study as a realistic figure; it is not the same as the Environment Agency/BREF Achievable Emission Level figure of 0.21 kg-NH_3/bird place/year.

3.6.2 Proposed pullet rearing housing ammonia emissions

The Environment Agency provides an Intensive Farming guidance note which lists standard ammonia emission factors for a variety of livestock, including poultry. For pullet rearing, where manure collects within the housing, the Environment Agency figure is 0.06 kg-NH_3/bird place/year.

Details of the bird numbers and type and emission rates used in the modelling are provided in Table 2.

Table 2. Details of poultry numbers and ammonia emission rates

Source	Animal numbers	Type or weight	Emission factor (kg-NH_3/place/y)	Emission rate (g-NH_3/s)
Existing Housing	39,999	Egg laying chickens, deep pit/litter	0.29 (EA figure)	0.367573
Proposed Housing	100,000	Pullet rearing	0.06 (EA/BREF figure)	0.190129

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 including: 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). In this case, observational meteorological data from the recording stations at Lake Vyrnwy and RAF Shawbury have also been considered.

The GFS is a spectral model and data are archived at a horizontal resolution of 0.25 degrees, which is approximately 25 km over the UK (formerly 0.5 degrees, or approximately 50 km). 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 observational records may be over represented, 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.

The wind rose for the raw GFS 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 location of Court House Farm is shown in Figure 2b. It should be noted that the local wind flow is strongly affected by the River Severn valley and nearby hills/mountains and 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 in terrain runs is approximately 180 m in the preliminary and low resolution detailed modelling and 100 m in the high resolution 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.

Data from the meteorological recording stations at Lake Vyrnwy and RAF Shawbury have also been considered. However, neither Lake Vyrnwy, nor RAF Shawbury, has an aspect that in any way could be considered similar to the area around Court House Farm; therefore, it should be noted that the frequency of winds from a particular direction in Lake Vyrnwy and RAF Shawbury data may be either high or low in comparison to what might occur at Court House Farm, which means mean concentrations downwind may be either over or under predicted. Additionally, periods of light winds and calms cannot be properly modelled. Therefore, it is the opinion of AS Modelling & Data Ltd. that the results obtained using the GFS data, particularly when modified by using FLOWSTAR, should be given more weight when interpreting the results of the modelling.

The wind roses for Lake Vyrnwy and RAF Shawbury are shown in Figures 2c and 2d.

Figure 2a. The wind rose. Raw GFS derived data, for 52.523 N, 3.084 W, 2014-2017

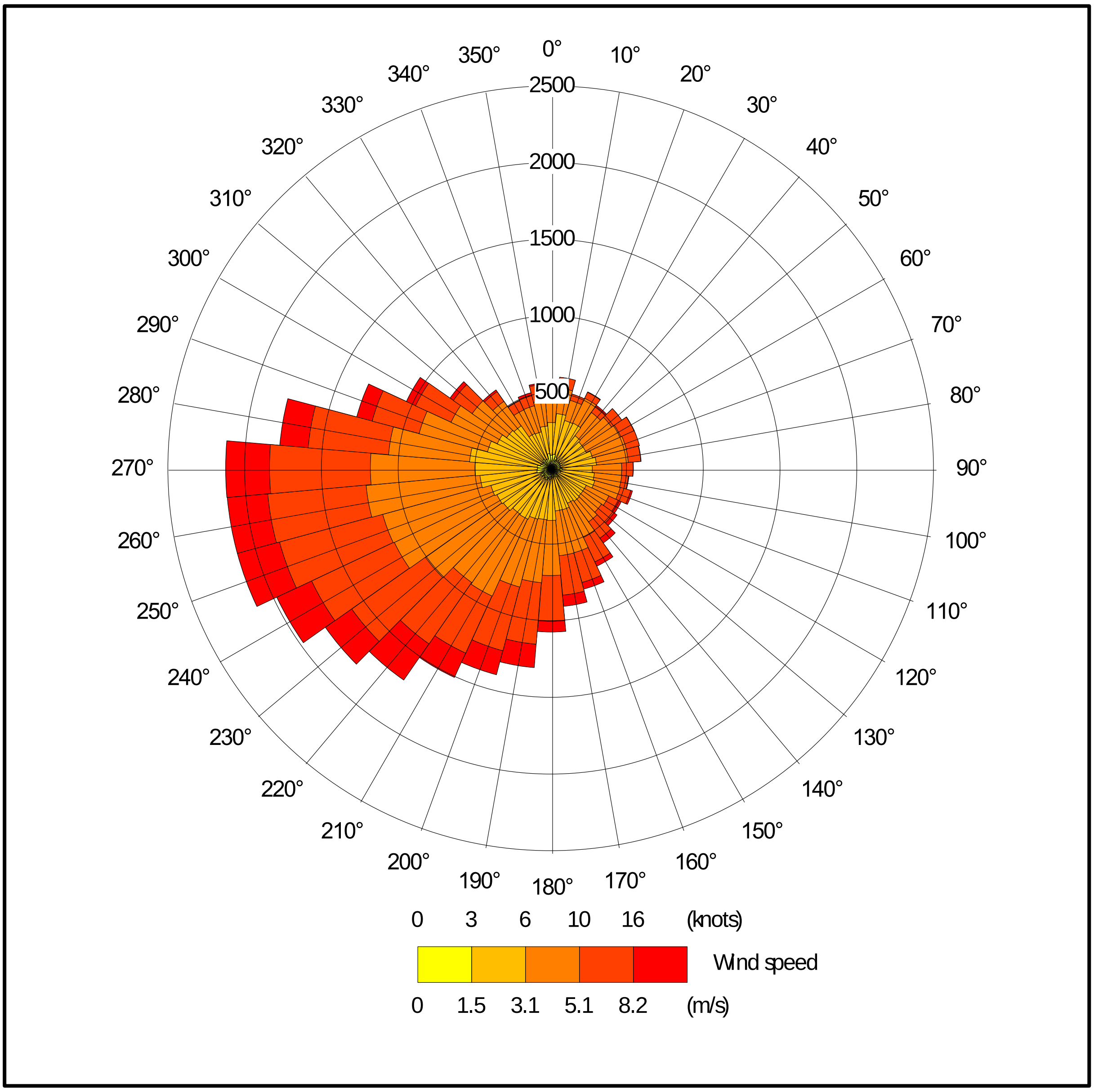


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 326500, 292250

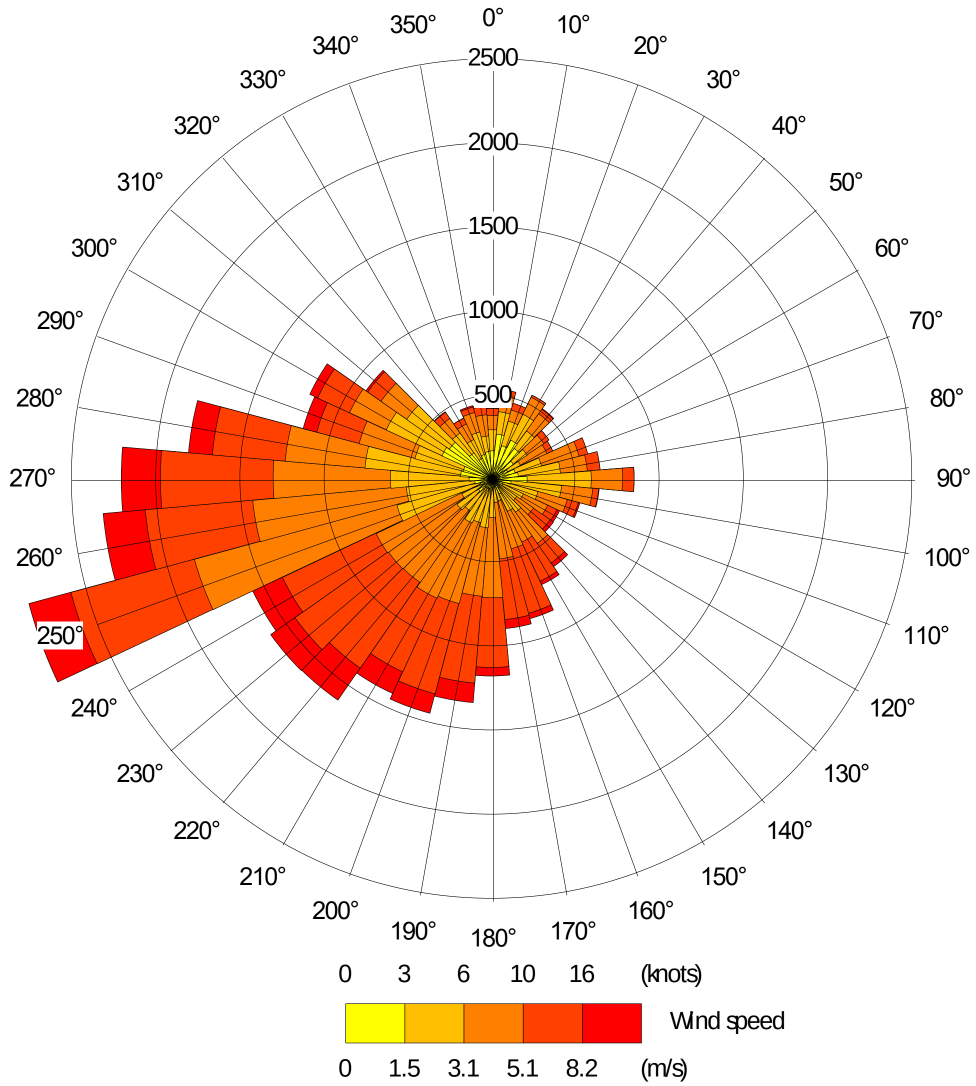


Figure 2c. The wind rose. Lake Vyrnwy, 2014 -2017

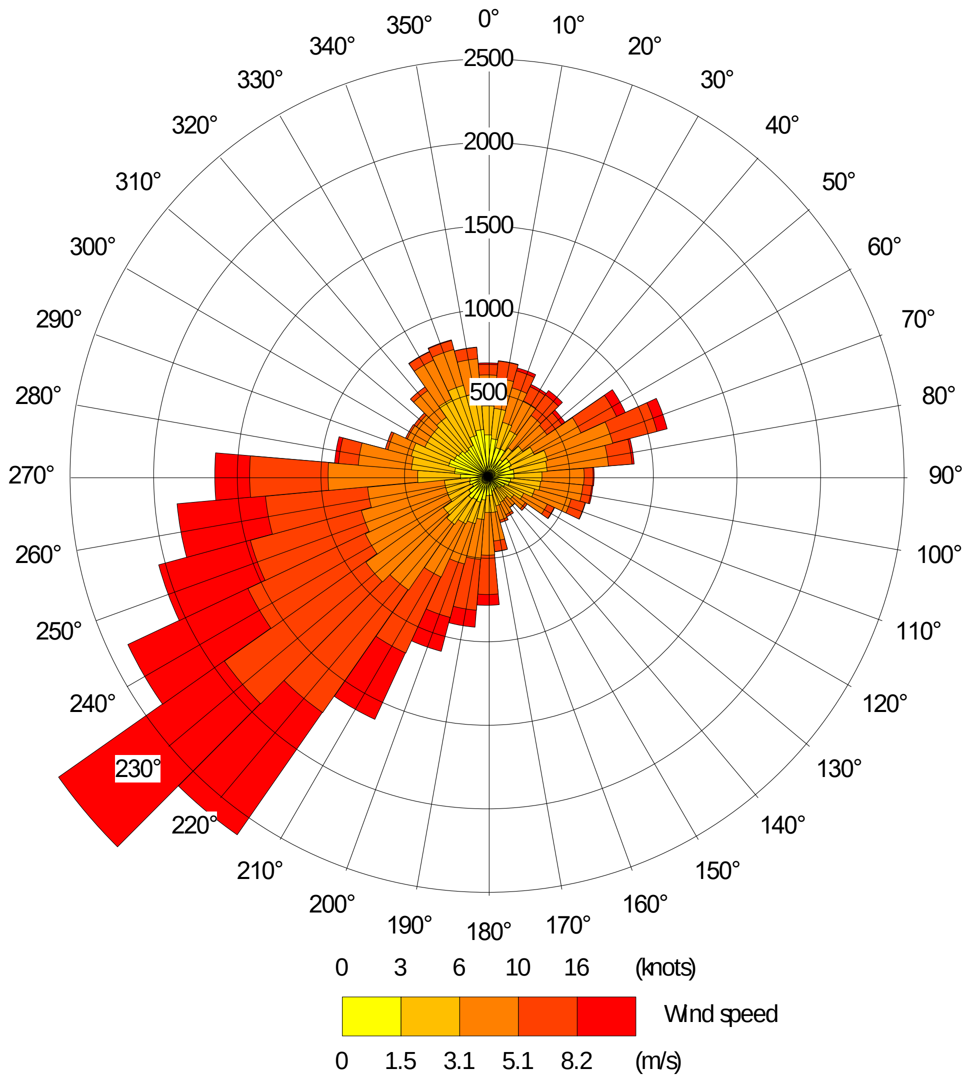
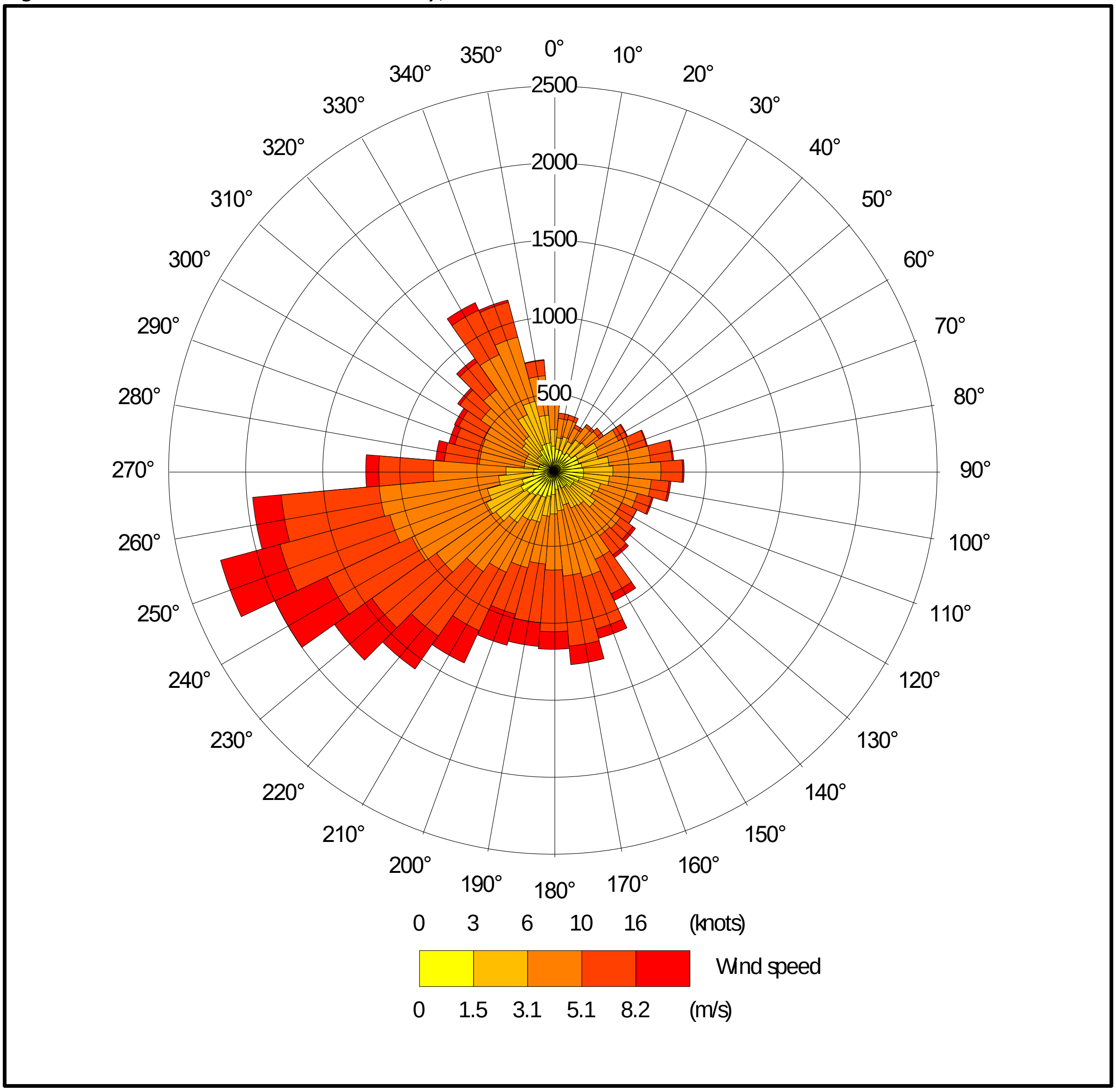


Figure 2d. The wind rose. RAF Shawbury, 2014 -2017



4.2 Emission sources

Emission from the cowled side fans on the existing poultry houses are represented by three volume sources within ADMS (EX1, EX2 & EX3).

Emissions from the high speed ridge/roof fans that would be used to ventilate the proposed poultry house are represented by three point sources within ADMS (PR1 a, b & c).

Details of the volume and point source parameters are shown in Tables 3a and 3b. The positions of the volume and point source may be seen in Figure 3.

Table 3a. Volume source parameters

Source ID	Length Y (m)	Width X (m)	Depth (m)	Base height (m)	Emission temperature (°C)	Emission rate (g-NH_3/s)
EX1	35.63	16.86	3.0	0.0	Ambient	0.122524
EX2	39.15	14.42	3.0	0.0	Ambient	0.122524
EX3	39.15	14.42	3.0	0.0	Ambient	0.122524

Table ~~3a~~3b. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (˚C)	Emission rate per source (g-NH_3/s)
PR1 a, b & c	7.0	0.8	11.0	21.0	0.063376

4.3 Modelled buildings

The structure of the poultry house may affect the plumes from the point sources. Therefore, the proposed poultry house is modelled within ADMS. The position of the modelled building may be seen in Figure 3, where it is marked by a grey rectangle.

4.4 Discrete receptors

Thirty-nine discrete receptors have been defined: twenty-six at the AWs (1 to 26) and thirteen at the SSSIs (27 to 39). These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figures 4a and 4b, where they are marked by enumerated pink rectangles. For the detailed modelling of the adjacent AWs, receptors have also been defined at 7.5 m above ground level; these receptors are referred to as receptors 1C to 6C and are at the same location as receptors 1 to 6.

4.5 Cartesian grid

To produce the high and low resolution contour plots presented in Section 5 of this report and to define the spatially varying deposition fields used in the detailed modelling, two regular Cartesian grids have been defined at ground level within ADMS. The positions of the Cartesian grids may be seen in Figures 4a and 4b, where they are 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 12.0 km x 12.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS. N.B. The resolution of FLOWSTAR is 64 x 64 grid points; therefore, the effective resolution of the wind field is approximately 180 m.

4.7 Roughness Length

A fixed surface roughness length of 0.30 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 0.25 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 3. The positions of the modelled buildings and sources

Figure 4a. The discrete receptors and regular Cartesian grids – a broadscale view

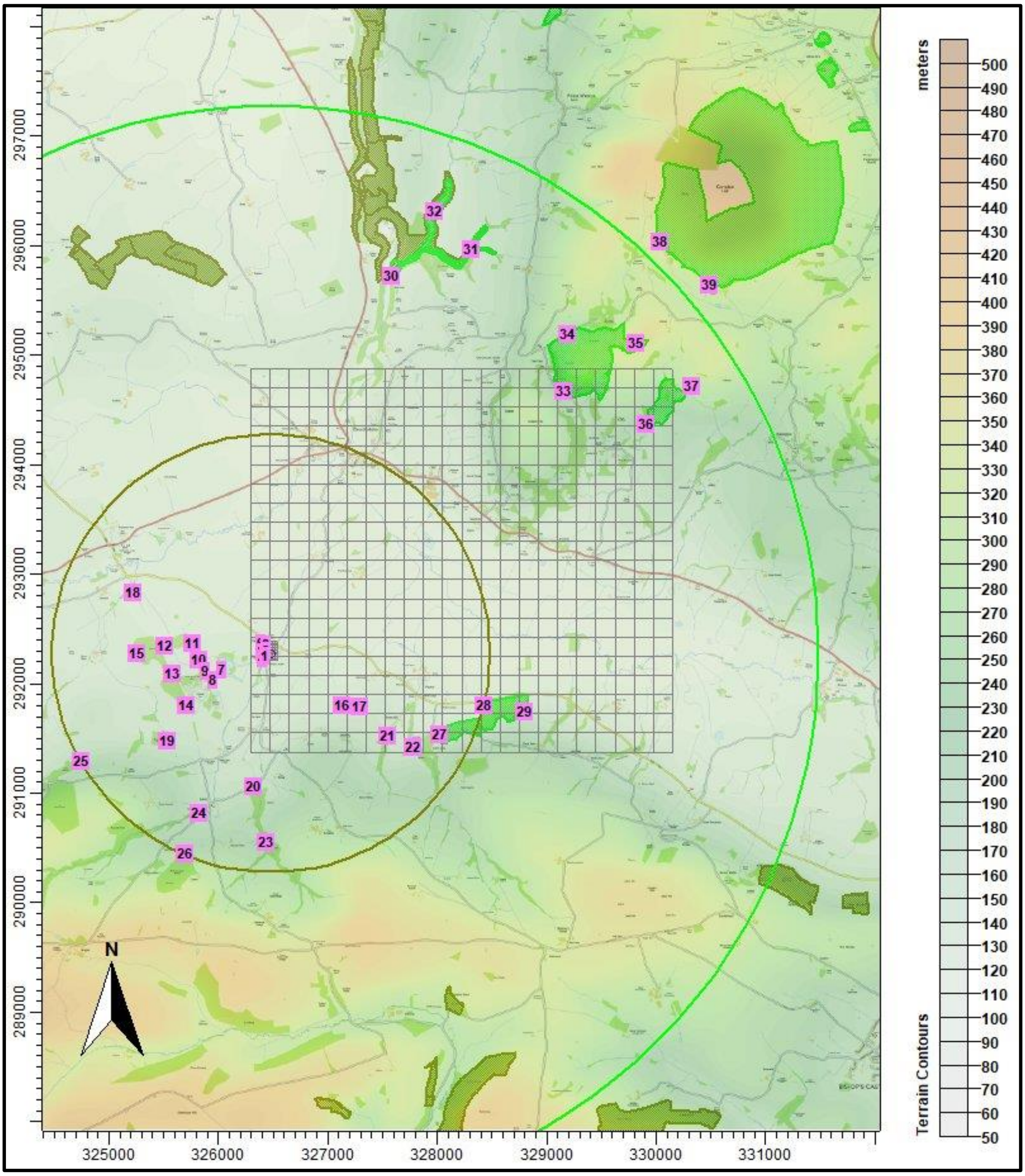
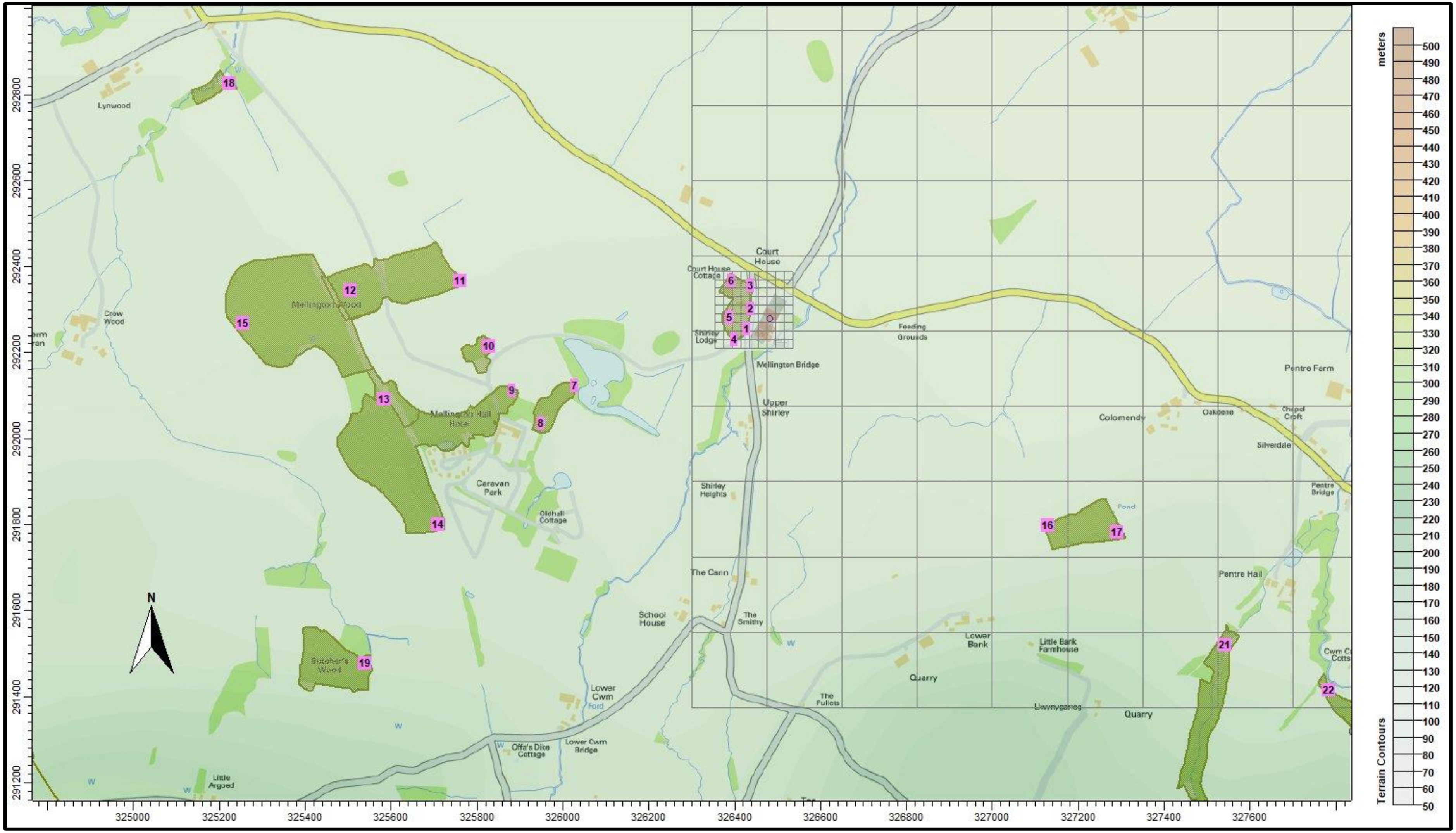


Figure 4b. The discrete receptors and regular Cartesian grids – a closer view



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

NH3 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.

Contour plots of the high and low resolution spatially varying deposition fields are provided in Figures 5a and 5b.

Figure 5a. The high resolution spatially varying deposition field

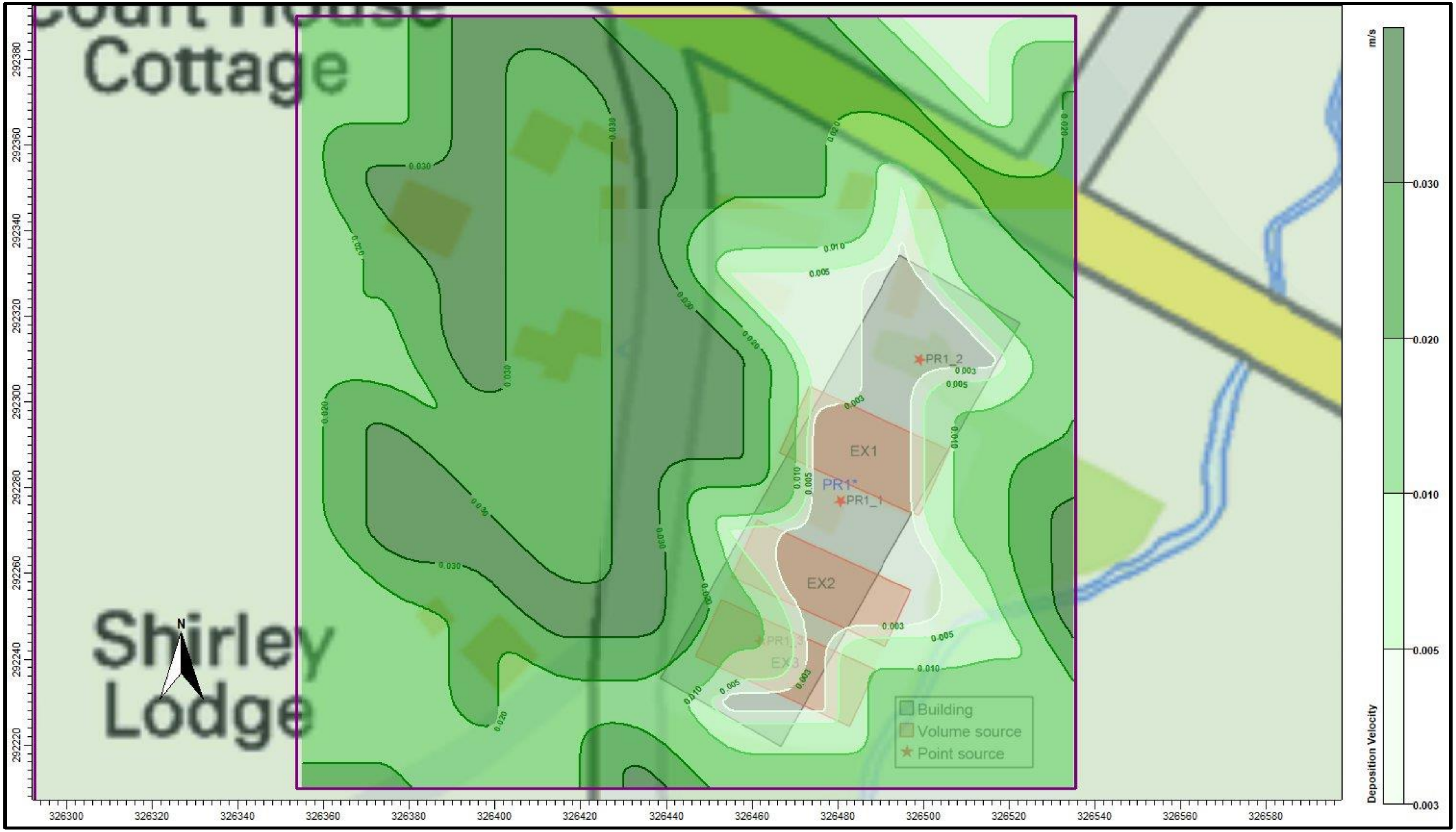
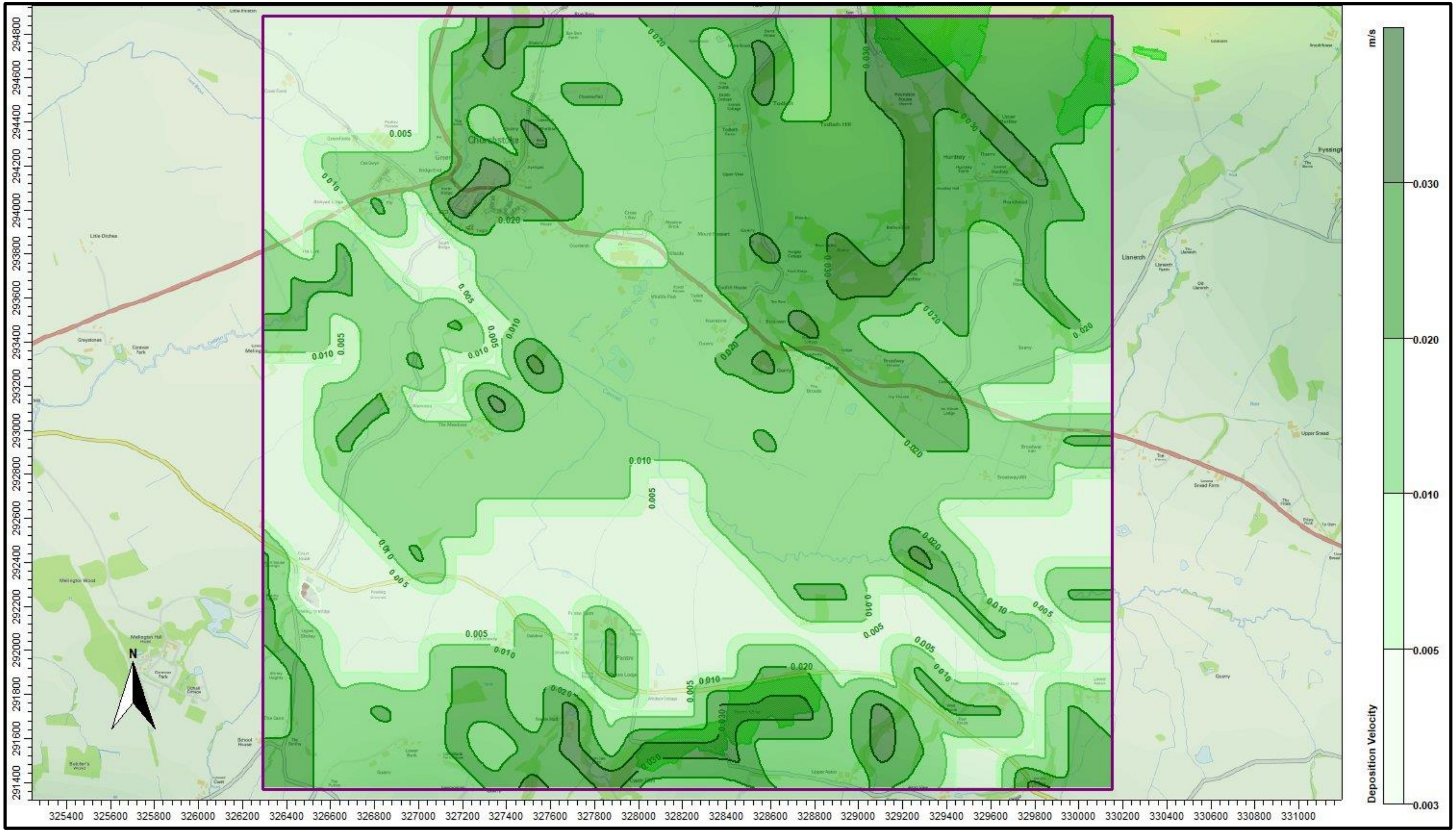


Figure 5b. The low resolution spatially varying deposition field



5. Details of the Model Runs and Results

5.1 Preliminary modelling

ADMS was run a total of twenty-four times; once for each year of the meteorological record and in the following six 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 a fixed deposition at 0.003 m/s – GFS data.
- In basic mode without calms or terrain – Lake Vyrnwy data.
- In basic mode without calms or terrain – RAF Shawbury data.

For each mode, statistics for the maximum annual mean ammonia concentration at each receptor were compiled for both the existing and proposed scenarios.

Details of the predicted annual mean ammonia concentrations at each receptor are provided in Table 5a (Existing Scenario) and Table 5b (Proposed Scenario). In these Tables, predicted ammonia concentrations, including those that would lead to a nitrogen deposition rate, that are in excess of the Natural Resources Wales upper threshold (8% of Critical Level or Load for a SSSI and 100% of a Critical Level or Load for an AW) are coloured red. Concentrations in the range between the Natural Resources Wales upper threshold and lower threshold (1% to 8% for a SSSI and 50%[1] to 100% for an AW) are coloured blue. For convenience, cells referring to the SSSIs are shaded green and cells referring to the AWs are shaded olive.

1. The Pre-February 2016 figure is retained.

Table 5a. Predicted maximum annual mean ammonia concentration at the discrete receptors – Existing Scenario

Receptor number	X(m)	Y(m)	Designation	Maximum annual mean ammonia concentration - (µg/m³)					
				Existing					
				GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS No Calms Terrain Fixed depo 0.003 m/s	Lake Vyrnwy No Calms No Terrain	Shawbury No Calms No Terrain
1	326429	292255	AW	**141.816**	**167.084**	**162.885**	**131.621**	**144.283**	**158.848**
2	326436	292301	AW	**92.872**	**113.478**	**105.756**	**85.794**	**67.803**	**101.759**
3	326436	292356	AW	**29.728**	**38.684**	**28.221**	**22.297**	**19.890**	**38.014**
4	326399	292230	AW	**55.029**	**65.906**	**61.673**	**46.815**	**69.401**	**66.642**
5	326388	292281	AW	**47.467**	**56.157**	**60.680**	**44.742**	**41.570**	**52.202**
6	326392	292366	AW	**17.559**	**23.153**	**21.091**	**15.550**	**12.148**	**23.100**
7	326027	292123	AW	**2.589**	**3.144**	**2.717**	**1.613**	**3.265**	**3.198**
8	325949	292035	AW	**1.641**	**2.048**	**1.648**	**0.944**	**2.359**	**2.215**
9	325882	292111	AW	**1.695**	**2.043**	**1.823**	**1.018**	**2.010**	**2.074**
10	325829	292214	AW	**1.664**	**1.968**	**2.151**	**1.111**	**1.606**	**2.023**
11	325760	292366	AW	**1.378**	**1.624**	**2.427**	**1.146**	**1.107**	**1.526**
12	325506	292345	AW	**0.832**	**0.981**	**1.386**	**0.623**	**0.683**	**0.950**
13	325583	292092	AW	**0.889**	**1.065**	**1.015**	**0.519**	**0.978**	**1.094**
14	325708	291799	AW	**0.665**	**0.868**	**0.702**	0.363	**1.077**	**0.940**
15	325255	292268	AW	**0.565**	**0.668**	**0.787**	0.352	0.495	**0.671**
16	327128	291797	AW	**1.018**	**1.199**	**1.491**	**0.781**	**1.931**	**0.708**
17	327291	291782	AW	**0.883**	**1.014**	**1.209**	**0.624**	**1.546**	**0.504**
18	325224	292825	AW	0.394	0.483	0.473	0.222	0.331	0.404
19	325538	291478	AW	0.386	**0.507**	**0.593**	0.252	**0.608**	0.495
20	326317	291059	AW	**0.545**	**0.649**	**0.935**	0.375	**1.161**	0.455
21	327542	291521	AW	0.442	**0.521**	**0.710**	0.333	**0.848**	0.299
22	327783	291415	AW	0.341	0.398	**0.632**	0.281	**0.637**	0.209
23	326432	290547	AW	0.268	0.328	0.414	0.142	**0.679**	0.269
24	325818	290809	AW	0.335	0.403	**0.526**	0.187	**0.613**	0.276
25	324749	291295	AW	0.170	0.223	0.193	0.074	0.278	0.249
26	325697	290444	AW	0.237	0.284	0.358	0.116	0.434	0.189
27	328019	291537	Coed Pentre SSSI	**0.370**	**0.417**	**0.659**	**0.293**	**0.596**	**0.183**
28	328424	291804	Coed Pentre SSSI	**0.359**	**0.395**	**0.610**	**0.289**	**0.408**	**0.155**
29	328801	291735	Coed Pentre SSSI	**0.267**	**0.295**	**0.402**	**0.188**	**0.300**	**0.116**
30	327580	295725	Spy Wood & Aldress Dingle SSSI	0.071	0.091	0.072	0.047	0.073	0.096
31	328306	295964	Spy Wood & Aldress Dingle SSSI	0.060	0.076	0.032	0.021	0.069	0.081
32	327974	296314	Spy Wood & Aldress Dingle SSSI	0.054	0.070	0.046	0.029	0.056	0.073
33	329151	294668	Roundton Hill SSSI	**0.091**	**0.109**	**0.014**	**0.013**	**0.105**	**0.131**
34	329195	295194	Roundton Hill SSSI	**0.072**	**0.086**	**0.011**	0.009	**0.084**	**0.103**
35	329810	295106	Roundton Hill SSSI	**0.067**	**0.079**	0.009	0.008	**0.076**	**0.097**
36	329912	294367	Brithdir a Chwm Mawr SSSI	**0.079**	**0.093**	**0.016**	**0.013**	**0.083**	**0.119**
37	330319	294712	Brithdir a Chwm Mawr SSSI	**0.064**	**0.076**	0.012	0.009	**0.068**	**0.097**
38	330040	296035	Corndon Hill SSSI	**0.047**	**0.056**	0.006	0.005	**0.054**	**0.067**
39	330483	295646	Corndon Hill SSSI	**0.050**	**0.059**	0.007	0.006	**0.057**	**0.072**

Table 5b. Predicted maximum annual mean ammonia concentration at the discrete receptors – Proposed Scenario

Receptor number	X(m)	Y(m)	Designation	Maximum annual mean ammonia concentration - (µg/m³)					
				Proposed					
				GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS No Calms Terrain Fixed depo 0.003 m/s	Lake Vyrnwy No Calms No Terrain	Shawbury No Calms No Terrain
1	326429	292255	AW	**2.119**	**2.077**	**2.671**	**2.591**	**3.215**	**2.150**
2	326436	292301	AW	**2.496**	**2.472**	**2.666**	**2.591**	**1.918**	**3.246**
3	326436	292356	AW	**2.442**	**2.410**	**2.329**	**2.289**	**1.152**	**3.030**
4	326399	292230	AW	**2.176**	**2.140**	**2.446**	**2.386**	**3.140**	**2.026**
5	326388	292281	AW	**1.877**	**1.858**	**2.375**	**2.314**	**2.242**	**2.347**
6	326392	292366	AW	**1.430**	**1.414**	**1.506**	**1.475**	**0.745**	**1.725**
7	326027	292123	AW	0.239	0.237	0.202	0.183	0.308	0.233
8	325949	292035	AW	0.163	0.162	0.132	0.119	0.244	0.164
9	325882	292111	AW	0.172	0.171	0.143	0.124	0.204	0.171
10	325829	292214	AW	0.151	0.150	0.191	0.152	0.160	0.173
11	325760	292366	AW	0.112	0.111	0.249	0.201	0.104	0.136
12	325506	292345	AW	0.078	0.078	0.174	0.132	0.073	0.096
13	325583	292092	AW	0.103	0.103	0.093	0.072	0.109	0.107
14	325708	291799	AW	0.080	0.080	0.055	0.049	0.124	0.081
15	325255	292268	AW	0.063	0.063	0.118	0.084	0.058	0.076
16	327128	291797	AW	0.134	0.133	0.095	0.077	0.118	0.103
17	327291	291782	AW	0.124	0.123	0.083	0.068	0.101	0.080
18	325224	292825	AW	0.050	0.050	0.064	0.049	0.040	0.044
19	325538	291478	AW	0.053	0.053	0.027	0.023	0.071	0.048
20	326317	291059	AW	0.062	0.061	0.056	0.035	0.088	0.039
21	327542	291521	AW	0.070	0.069	0.049	0.035	0.072	0.050
22	327783	291415	AW	0.058	0.058	0.037	0.025	0.061	0.038
23	326432	290547	AW	0.036	0.036	0.015	0.011	0.069	0.033
24	325818	290809	AW	0.045	0.045	0.037	0.023	0.068	0.027
25	324749	291295	AW	0.028	0.028	0.011	0.009	0.047	0.033
26	325697	290444	AW	0.036	0.036	0.017	0.011	0.055	0.021
27	328019	291537	Coed Pentre SSSI	**0.066**	**0.065**	**0.035**	**0.029**	**0.062**	**0.034**
28	328424	291804	Coed Pentre SSSI	**0.072**	**0.071**	**0.061**	**0.048**	**0.056**	**0.030**
29	328801	291735	Coed Pentre SSSI	**0.058**	**0.057**	**0.049**	**0.037**	**0.047**	**0.023**
30	327580	295725	Spy Wood & Aldress Dingle SSSI	0.019	0.019	0.038	0.025	0.015	0.019
31	328306	295964	Spy Wood & Aldress Dingle SSSI	0.017	0.017	0.026	0.016	0.015	0.018
32	327974	296314	Spy Wood & Aldress Dingle SSSI	0.015	0.015	0.030	0.018	0.013	0.016
33	329151	294668	Roundton Hill SSSI	**0.024**	**0.024**	**0.043**	**0.017**	**0.026**	**0.029**
34	329195	295194	Roundton Hill SSSI	**0.019**	**0.019**	**0.013**	0.008	**0.022**	**0.024**
35	329810	295106	Roundton Hill SSSI	**0.019**	**0.019**	**0.011**	0.006	**0.020**	**0.023**
36	329912	294367	Brithdir a Chwm Mawr SSSI	**0.023**	**0.023**	**0.015**	0.009	**0.022**	**0.029**
37	330319	294712	Brithdir a Chwm Mawr SSSI	**0.019**	**0.019**	**0.010**	0.006	**0.019**	**0.025**
38	330040	296035	Corndon Hill SSSI	**0.014**	**0.014**	0.007	0.004	**0.016**	**0.018**
39	330483	295646	Corndon Hill SSSI	**0.015**	**0.015**	0.007	0.004	**0.016**	**0.019**

5.2 Detailed deposition modelling

The detailed modelling was carried out over two restricted domains where the preliminary modelling of the proposed scenario indicated that annual mean ammonia concentrations could potentially exceed the relevant lower threshold percentage of the Critical Level of 1.0 $\mu g\text{-}NH_3/m^3$. The domains cover the proposed poultry house at Court House Farm, the AWs directly to the west and proposed poultry house at Court House Farm and Coed Pentre SSSI, and closer parts of Roundton Hill SSSI and Brithdir a Chwm Mawr SSSI. At all other receptors considered, the preliminary modelling of the proposed scenario indicated that ammonia levels (and nitrogen and acid deposition rates) would be below the Natural Resources Wales lower threshold percentage of Critical Level/Load for the designation of the site.

The predicted maximum annual mean ground level ammonia concentrations and nitrogen deposition rates for the proposed scenario at the discrete receptors at high and low resolution are shown in Tables 6a and 6b respectively. In the tables, predicted ammonia concentrations or nitrogen deposition rates that are in excess of the Natural Resources Wales upper threshold (8% of Critical Level or Load for a SSSI and 100% of Critical Level or Load for an AW) are coloured red. Concentrations that are in the range between the Natural Resources Wales lower and upper thresholds (1% to 8% for a SSSI and 50%[1] to 100% for an AW) are coloured blue.

Contour plots of the predicted ground level maximum annual mean ammonia concentration at high and low resolution for the proposed scenario are shown in Figures 6a and 6b. Contour plots of the predicted ground level maximum nitrogen deposition rates at high and low resolution are shown in Figures 7a and 7b.

1. The pre-February 2016 figure is retained.

Table 6a. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors over a high resolution domain

Receptor number	X(m)	Y(m)	Name	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	326435	292210	AW (ground level)	0.03	1.0	10.0	2.247	**224.7**	17.51	**175.1**
2	326455	292210	AW (ground level)	0.03	1.0	10.0	2.262	**226.2**	17.62	**176.2**
3	326475	292210	AW (ground level)	0.03	1.0	10.0	2.055	**205.5**	16.01	**160.1**
4	326495	292210	AW (ground level)	0.03	1.0	10.0	2.151	**215.1**	16.76	**167.6**
5	326515	292210	AW (ground level)	0.03	1.0	10.0	2.054	**205.4**	16.00	**160.0**
6	326535	292210	AW (ground level)	0.03	1.0	10.0	1.295	**129.5**	10.09	**100.9**
1C	326355	292230	AW (Canopy)	0.03	1.0	10.0	4.615	**461.5**	35.95	**359.5**
2C	326375	292230	AW (Canopy)	0.03	1.0	10.0	3.994	**399.4**	31.11	**311.1**
3C	326395	292230	AW (Canopy)	0.03	1.0	10.0	2.422	**242.2**	18.87	**188.7**
4C	326415	292230	AW (Canopy)	0.03	1.0	10.0	2.330	**233.0**	18.15	**181.5**
5C	326435	292230	AW (Canopy)	0.03	1.0	10.0	2.387	**238.7**	18.60	**186.0**
6C	326455	292230	AW (Canopy)	0.03	1.0	10.0	1.412	**141.2**	11.00	**110.0**

Table 6b. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors over a low resolution domain

Receptor number	X(m)	Y(m)	Name	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
27	328019	291537	Coed Pentre SSSI	0.03	3.0	10.0	0.021	0.7	0.17	**1.7**
28	328424	291804	Coed Pentre SSSI	0.03	3.0	10.0	0.036	**1.2**	0.28	**2.8**
29	328801	291735	Coed Pentre SSSI	0.03	3.0	10.0	0.027	0.9	0.21	**2.1**
33	329151	294668	Roundton Hill SSSI	0.02	1.0	10.0	0.008	0.8	0.04	0.4
36	329912	294367	Brithdir a Chwm Mawr SSSI	0.02	1.0	10.0	0.006	0.6	0.03	0.3

Figure 6a. Maximum annual ammonia concentration – high resolution domain

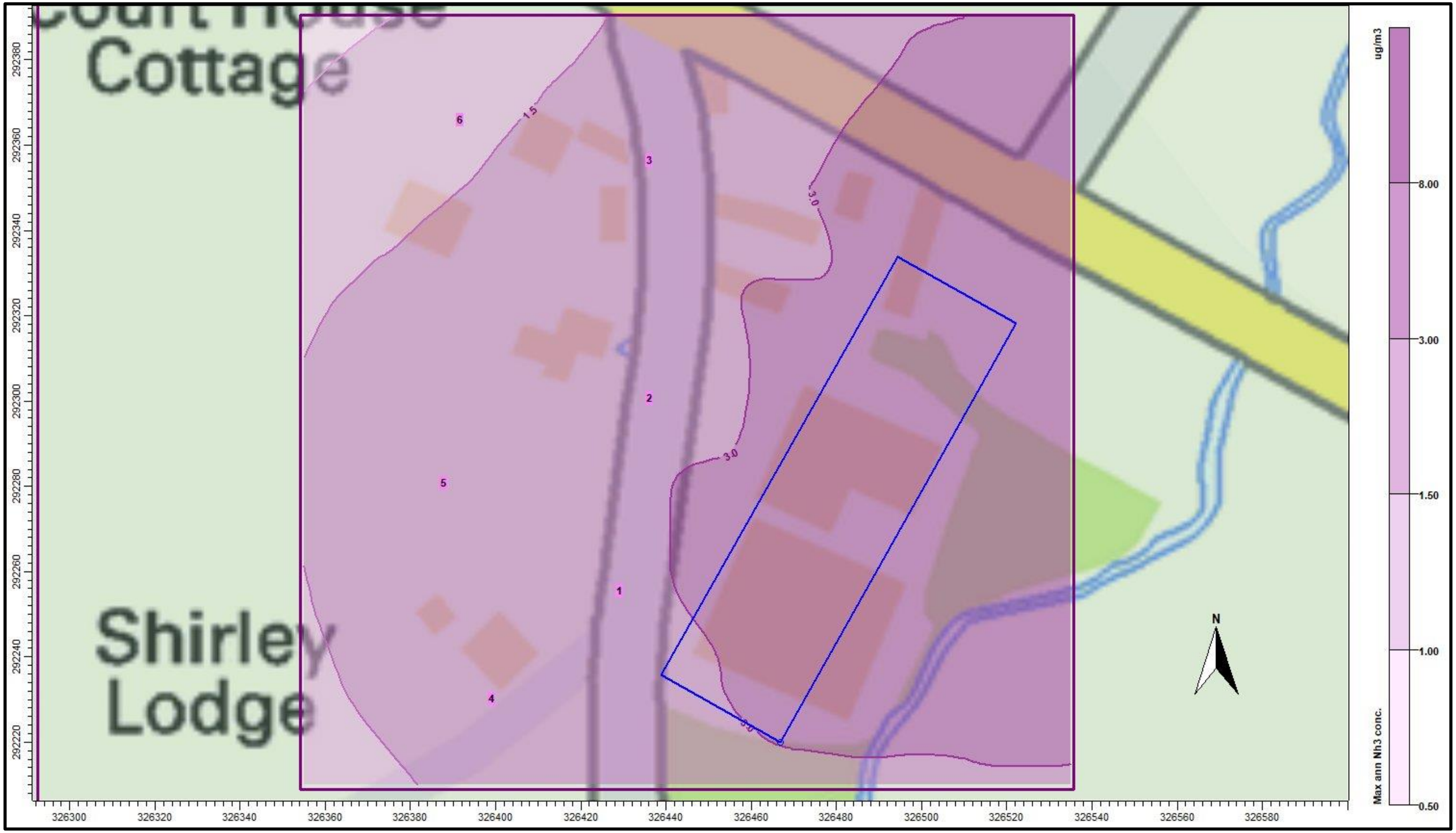


Figure 6b. Maximum annual ammonia concentration – low resolution domain

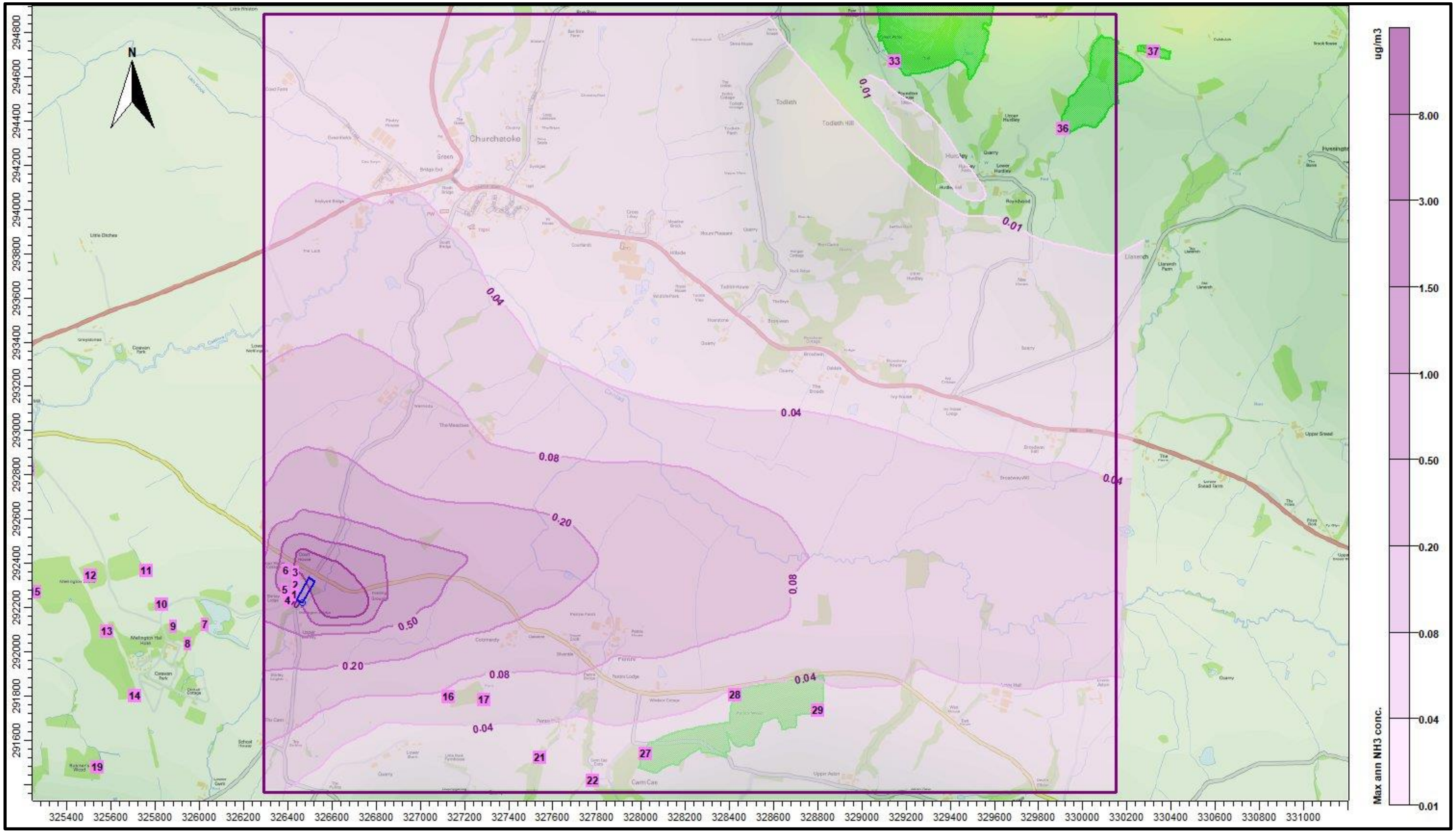


Figure 7a. Maximum annual nitrogen deposition rate – high resolution domain

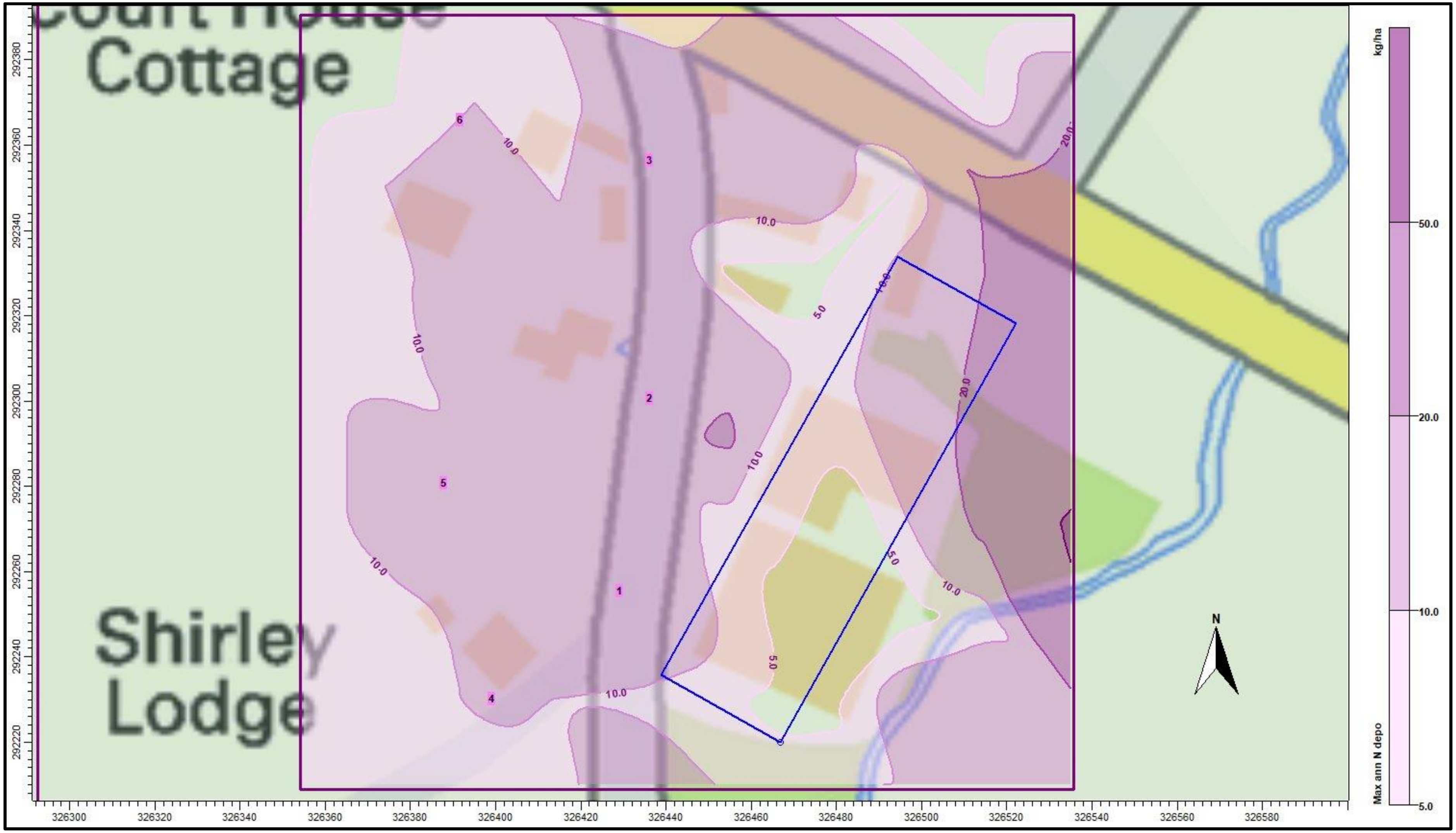
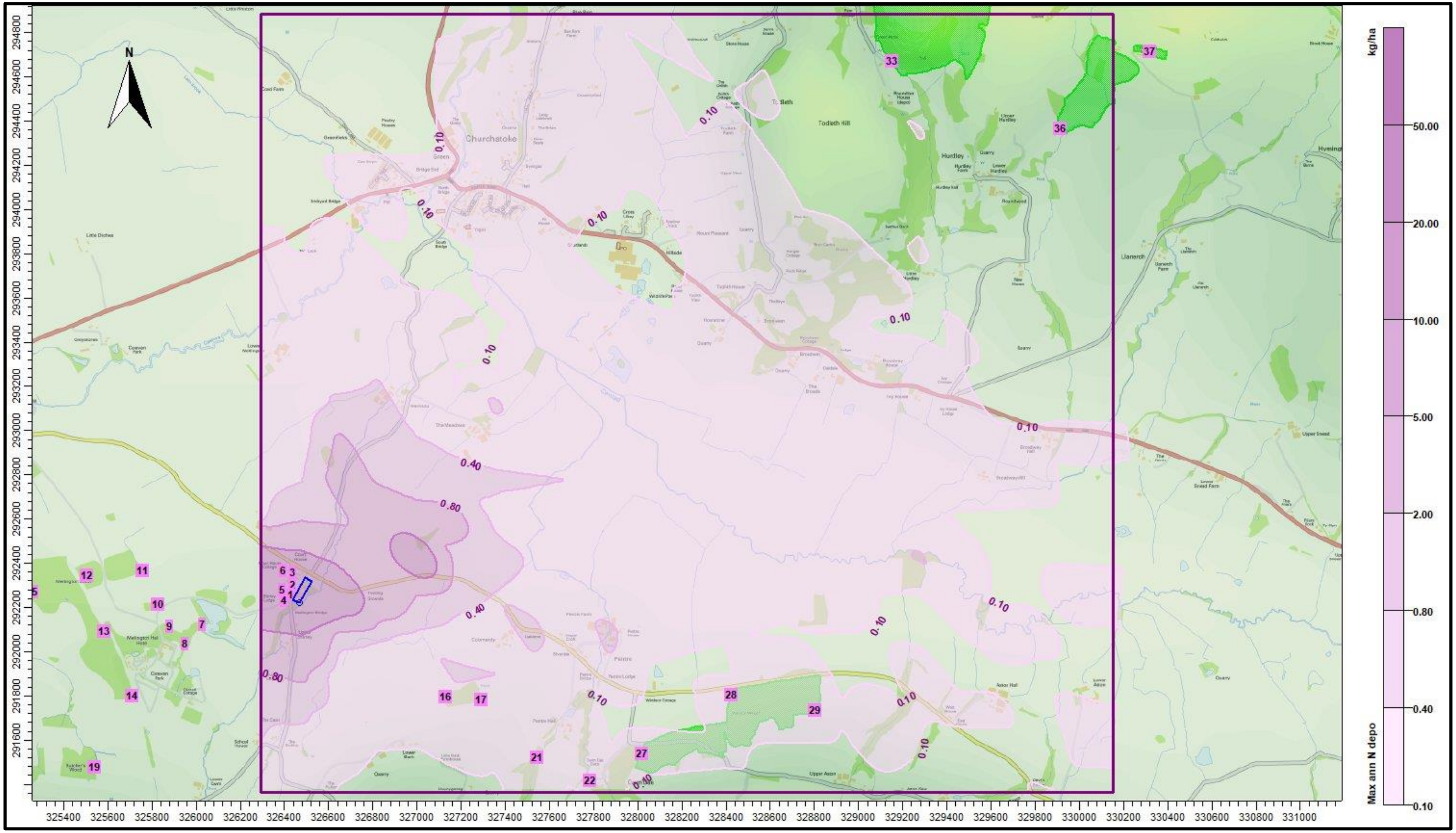


Figure 7b. Maximum annual nitrogen deposition rate – low resolution domain



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by John Ward, on behalf of David Davies Resources Ltd., to use computer modelling to assess the impact of ammonia emissions from the existing egg laying chicken houses and the proposed pullet rearing house at Court House Farm, Mellington, Church Stoke, Montgomery, Powys. SY15 6TQ.

Ammonia emission rates from the existing and 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.

Preliminary modelling

The preliminary modelling predicts that:

- The process contribution to annual mean ammonia concentrations and nitrogen deposition rates at nearby wildlife sites would be much lower under the proposed scenario than they currently are.

- The process contribution to ammonia concentrations and nitrogen deposition rates at the AW to the west of Court House Farm would potentially exceed the Natural Resources Wales lower threshold of the Critical Level or Load for the site (100% for an AW).

- At all other AWs, the process contribution to the annual ammonia concentration and the nitrogen deposition rate would be below the Natural Resources Wales lower threshold percentage of Critical Level or Critical Load for the site (100% for an AW).

- The process contribution to ammonia concentrations and nitrogen deposition rates at Coed Pentre SSSI, and closer parts of Roundton Hill SSSI and Brithdir a Chwm Mawr SSSI would potentially exceed the Natural Resources Wales lower threshold of the Critical Level or Load for the site (1% for a SSSI).

- At all other SSSIs, the process contribution to the annual ammonia concentration and the nitrogen deposition rate would be below the Natural Resources Wales lower threshold percentage of Critical Level or Critical Load for the site (1% for a SSSI).

Detailed deposition modelling

The detailed modelling predicts that, when deposition and consequent plume depletion are fully considered:

- The process contribution to annual mean ammonia concentrations at the AW directly to the west of Court House Farm would exceed the Natural Resources Wales upper threshold percentage of the Critical Level and Critical Load (100% for an AW).

- The process contribution to ammonia concentrations and nitrogen deposition rates at Coed Pentre SSSI would exceed the Natural Resources Wales lower threshold of the Critical Level and Load for the site (1% for a SSSI).

- The process contribution to ammonia concentrations and nitrogen deposition rates at Roundton Hill SSSI and Brithdir a Chwm Mawr SSSI would be below the Natural Resources Wales lower threshold of the Critical Level or Load for the site (1% for a SSSI).

7. References

Beasley. *et al*. Agroforestry Systems for Ammonia Abatement. Defra project AC0103.

Cambridge Environmental Research Consultants (CERC) (website).
http://www.cerc.co.uk/environmental-software/ADMS-model.html

Environment Agency H1 Risk Assessment (website).
https://www.gov.uk/government/collections/horizontal-guidance-environmental-permitting

M. A. Sutton *et al*. Measurement and modelling of ammonia exchange over arable croplands.
https://enviro.doe.gov.my/lib/digital/1386301476-1-s2.0-S0166111606802748-main.pdf

Misselbrook. *et al*. Inventory of Ammonia Emissions from UK Agriculture 2011
http://uk-air.defra.gov.uk/assets/documents/reports/cat07/1211291427_nh3inv2011_261112_FINAL_corrected.pdf

Frederik Schrader and Christian Brümmer. Land Use Specific Ammonia Deposition Velocities: a Review of Recent Studies (2004–2013)
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4176955/

United Nations Economic Commission for Europe (UNECE) (website).
http://www.unece.org/env/lrtap/WorkingGroups/wge/definitions.htm

UK Air Pollution Information System (APIS) (website).
http://www.apis.ac.uk/