A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Existing and Proposed Free Range Egg Laying Chicken Houses at Cloddiau, near Kerry in Powys

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Gail Lewis of Roger Parry & Partners LLP, on behalf of Mr D J Jerman of Kerry Vale Eggs Ltd., to use computer modelling to assess the impact of ammonia emissions from the existing and proposed free range egg laying houses at Cloddiau, Kerry, Newtown in Powys. SY16 4DY.

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

The sites of the existing and proposed free range egg laying chicken houses at Cloddiau are in an isolated rural area. The proposed house will be located approximately 540 m to the north-north-west of the existing house. The surrounding land is used primarily for livestock farming, with some areas of semi-natural woodlands and grassland. The site is at an altitude of approximately 225 m, situated atop a hill sloping gently towards The Mule and River Severn to the south and north-west, respectively.

There is currently one poultry house at Cloddiau, this house provides accommodation for up to 24,000 egg laying chickens. There are pop holes on the eastern side of the house, which provide daytime access to outside ranging areas. The poultry house is ventilated by capped ridge mounted fans. The birds' droppings collect within the house and are removed at the end of each flock cycle, which is approximately once per year.

It is proposed that a new poultry house be constructed on land to the north-north-west of the existing building, this house would provide accommodation for an additional 32,800 egg laying chickens. There would be pop holes on the side of the house which would provide daytime access to outside ranging areas. The houses would be ventilated by high speed ridge mounted fans. The birds' droppings would be removed by a belt collection system, twice weekly, and transferred directly to a trailer for removal from the site, or transferred directly to a manure spreader to be applied to the land locally, or stored temporarily on the farm.

There are several areas of Ancient Woodlands (AWs) within 2 km of the site of the poultry units at Cloddiau. There are also two Sites of Special Scientific Interest (SSSIs) within 5 km of the site; namely Hollybush Pastures and the Montgomery Canal; the Montgomery Canal is also designated as a Special Area of Conservation (SAC). Apart from the Montgomery Canal SAC, there are no other internationally designated sites within 10 km of the farm.

Maps of the surrounding area showing the positions of the poultry unit, the AWs, the SSSIs and the SAC are provided in Figures 1a and 1b. Figure 1a is a broad scale view, showing the positions of the SSSIs and SAC and Figure 1b is a closer view showing the AWs. In these figures, the AWs are shaded in olive, SSSIs are shaded in green and the SSSI/SAC is shaded in purple. The locations of the existing and proposed poultry houses are outlined in blue.

Figure 1a. The area surrounding Cloddiau – concentric circles radii 2.0 km (olive), 5.0 km (green) and 10.0 km (purple)

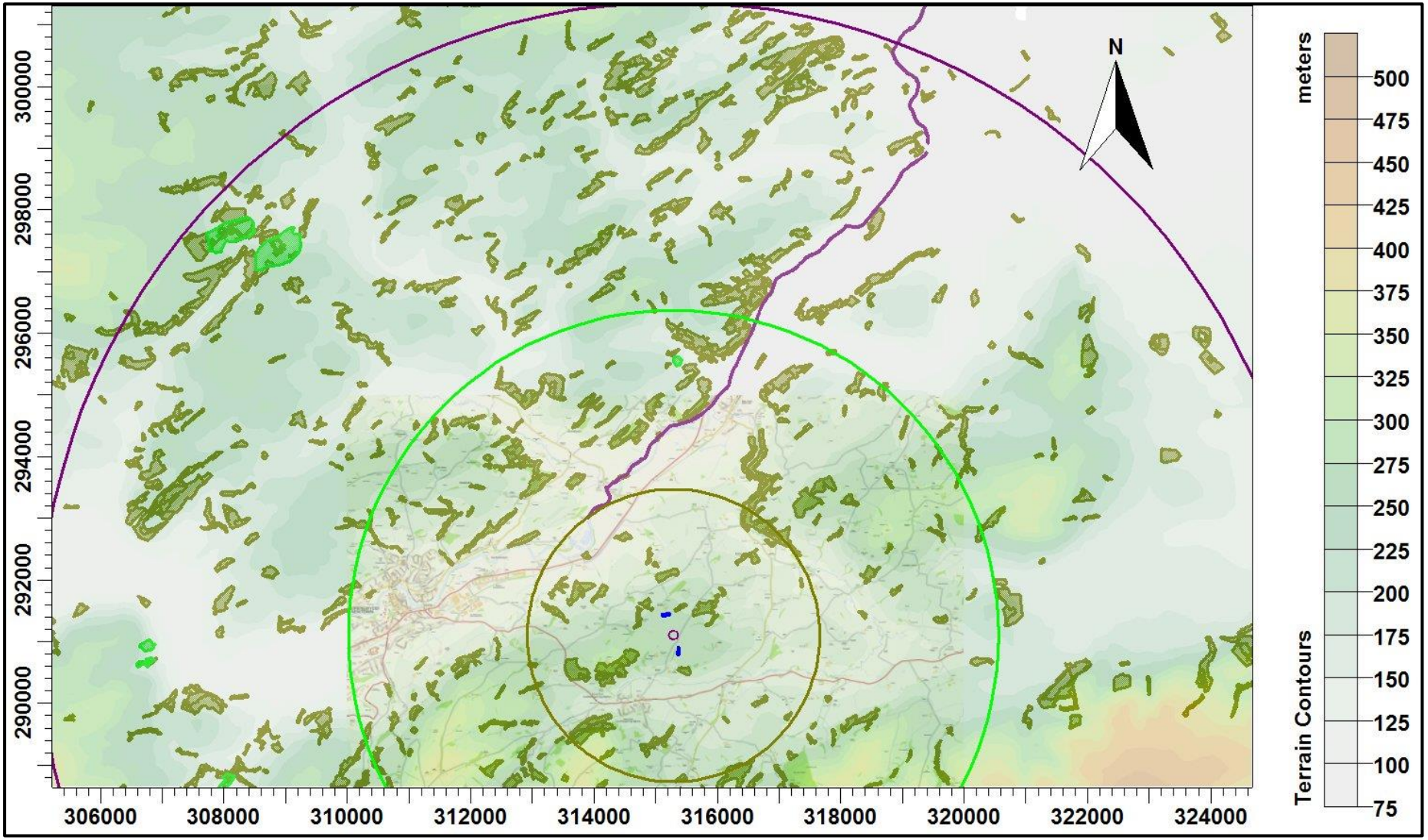
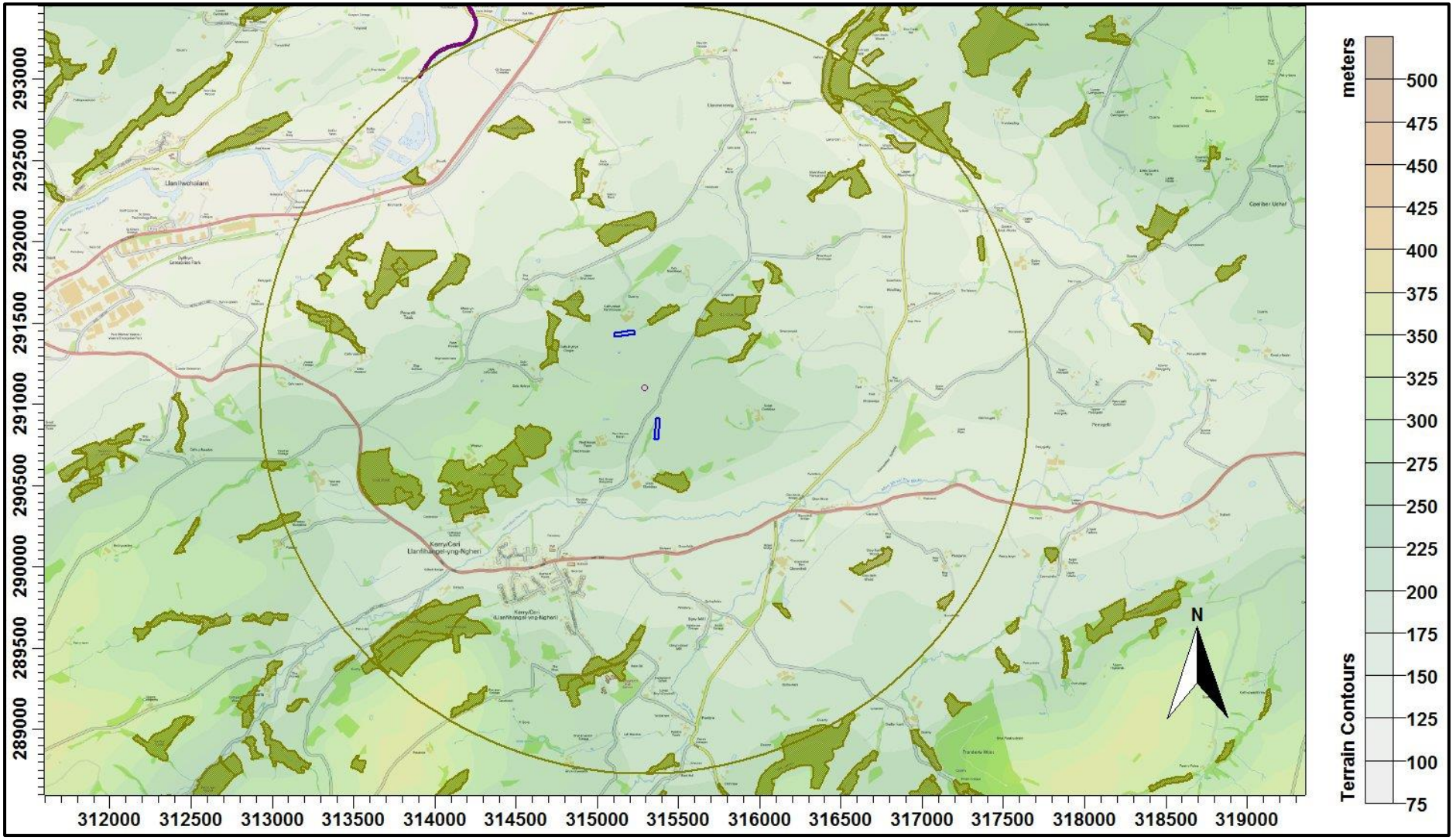


Figure 1b. The area surrounding Cloddiau – a closer view



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 Cloddiau is 1.78 µg-NH_3/m^3. The background nitrogen deposition rate to woodland is 30.24 kg-N/ha/y and to short vegetation is 18.90 kg-N/ha/y. The background acid deposition rate to woodland is 2.27 keq/ha/y and to short vegetation is 1.45 keq/ha/y. The source of these background figures is the Air Pollution Information System (APIS, March 2017).

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 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]	-	-
SSSIs	3.0 [4]	10.0 [2]	-
SAC (bankside vegetation)	3.0 [2]	10.0 [2]	-
SAC (aquatic vegetation)	3.0 [2]	3.0 [3]	

1. A precautionary figure used where no details of the ecology of the site are available, or the citation for the sites indicates that sensitive lichens and/or bryophytes are present.
2. Obtained from APIS (March 2017).
3. The Critical Load for the SAC is for Floating water-plantain, *luronium natans (*N.B. a deposition velocity of 0.005 m/s is assumed*).*
4. Based upon the citation for the site.

3.4 Guidance on the Significance of Ammonia Emissions

The following are obtained from the Environment Agency's horizontal guidance, H1 Environmental Risks Assessment, H1 Annex B - Intensive Farming.

"An emission is insignificant where Process Contribution (PC) is <4% of Critical Levels for SACs, SPAs and Ramsars, <20% for SSSIs, and <50% for local and national nature reserves (LNRs & NNRs), ancient woodland and local wildlife sites."

"Where modelling predicts a process contribution >20% of the Critical Level/Load at a SAC, SPA or Ramsar, >50% at a SSSI or >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. It is understood that Natural Resources Wales used the same criteria as the Environment Agency Annex B – Intensive Farming and therefore it is assumed that they now use the same criteria as defined in the Environment Agency's web-page "Intensive farming risk assessment for your environmental permit".

Within the range between the lower and upper thresholds; 4% to 20% for SACs, SPAs and Ramsars; 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. 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%).

It is understood that Natural Resources Wales currently apply the Environment Agency's criteria.

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 poultry. For Laying chickens where manure collects within the house, such as the existing house, the Environment Agency figure is 0.29 kg-NH_3/bird place/y. For laying chickens, with a belt removal system and frequent removal of manure from the site, such as the proposed house, the Environment Agency figure is 0.035 kg-NH_3/bird place/y. These figures have been used as the basis for the calculation of the ammonia emission rates from the poultry housing used in this modelling study.

As the birds have/would have access to an outdoor ranging area, some of the birds droppings, which is the source of the ammonia, will be deposited on the ranging area. For modelling purposes, it is assumed that 20% of the droppings are deposited on the ranging area, this assumption is based upon Environment Agency guidance. To estimate the ammonia emissions from the range, it has been assumed that laying hens produce 0.8 kg-N/y (Misselbrook) in their droppings and that 20% of ammoniacal nitrogen is emitted as ammonia (typically 40% to 50% is emitted as ammonia from stored manure, but this has been reduced to allow for mineralisation and leaching due to the contact with mineral soils). This equates to an emission factor of 0.194 kg-NH_3/bird/y which is rounded up to 0.2 kg-NH_3/bird/y for use in the emission calculations.

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

Table 2. Details of poultry numbers and ammonia emission rates

Ammonia source	Animal numbers	Type or weight	Emission factor (kg-NH_3/place/y)	Emission rate (g-NH_3/s)
Existing House	24,000 (x0.8)	EA figure for laying chickens with deep pit	0.29	0.176439
Proposed House	32,800 (x0.8)	EA figure for laying chickens with frequent belt removal	0.035	0.029102
Existing Range	24,000 (x0.2)	AS Modelling & Data Ltd. range emission figure	0.20	0.030421
Proposed Range	32,800 (x0.2)	AS Modelling & Data Ltd. range emission figure	0.20	0.041575

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). Data from the meteorological recording stations at Lake Vrynwy and Shobdon have also been used.

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 raw GFS wind speeds are modified by the treatment of roughness lengths (see Section 4.7) and where terrain data is included in the modelling, wind speeds and directions will be further modified. The raw GFS wind rose is shown in figure 2a and the terrain and roughness length modified wind rose for the site of Cloddiau is shown in Figure 2b. Note that elsewhere in the modelling domain the modified wind roses may differ more markedly and that the resolution of the wind field in terrain runs is approximately 600 m.

Data from the meteorological recording stations at Lake Vrynwy and Shobdon have also been considered; these stations are approximately equidistant from Cloddiau. However, neither Lake Vrynwy nor Shobdon have an aspect that in any way could be considered similar to Cloddiau; therefore, it should be noted that the frequency of winds from a particular direction in the Lake Vrynwy and Shobdon data may be either high or low in comparison to what might occur at Cloddiau, 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, are less likely to have gross errors than the results obtained using the observational data and should be given more weight when interpreting the results of the modelling. The wind roses for Lake Vyrnwy and Shobdon are shown in Figures 2c and 2d respectively.

Figure 2a. The wind rose. GFS derived data, for 52.514 N, 3.256 W, 2013 – 2016

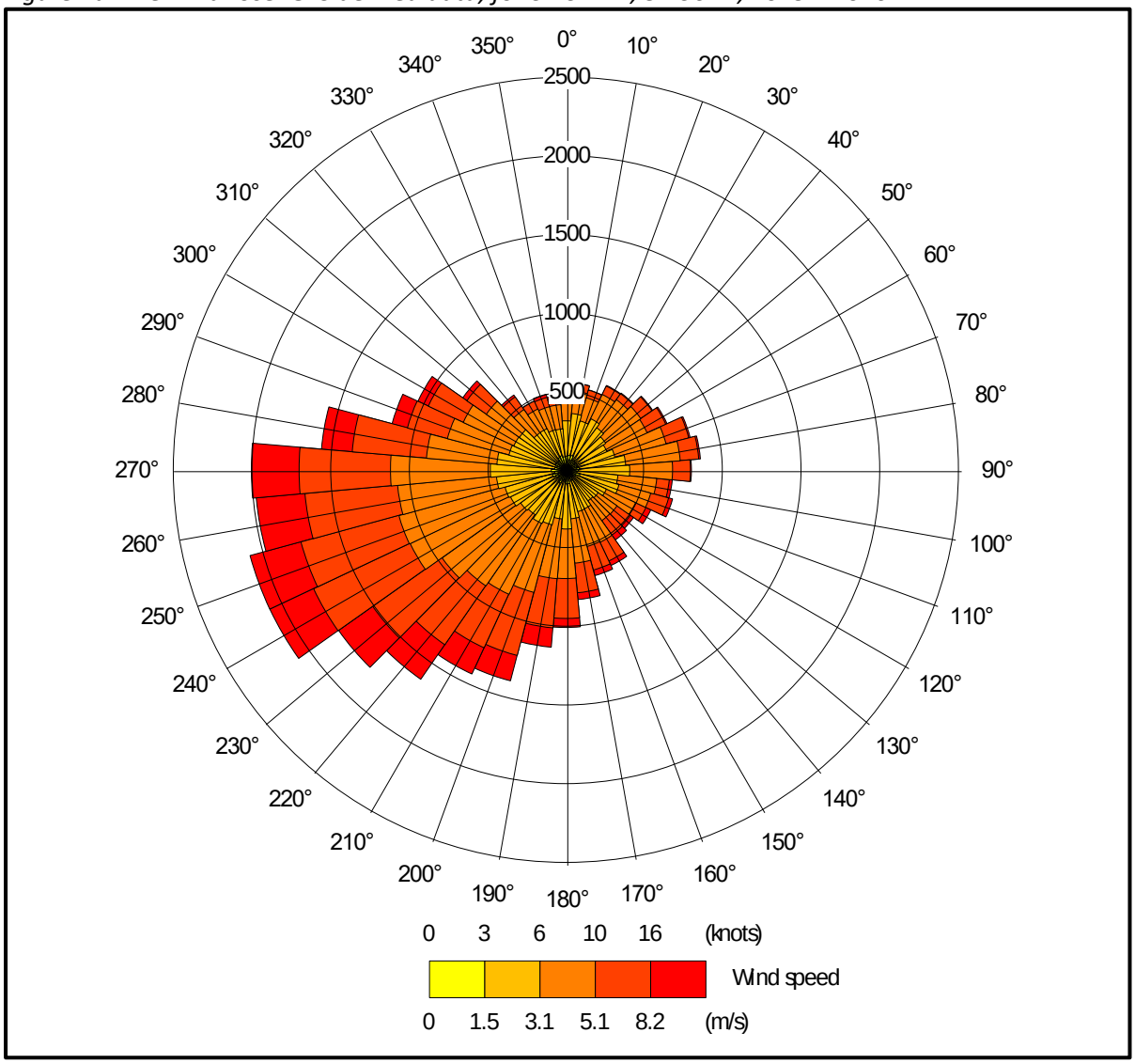


Figure 2b. The wind rose. FLOWSTAR derived data for NGR 315200, 291450, 2013 - 2016

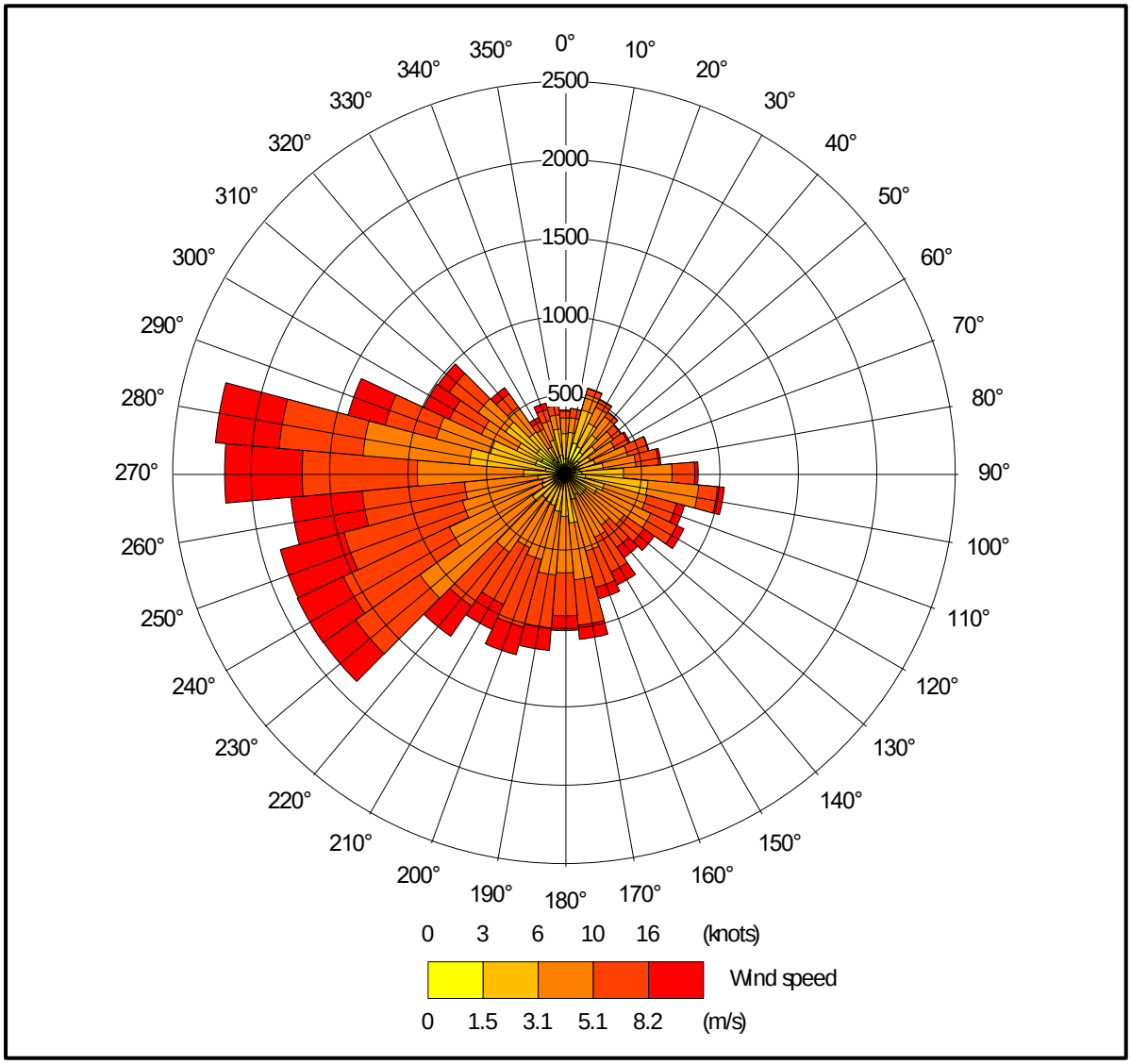


Figure 2c. The wind rose. Lake Vyrnwy, 2013 - 2016

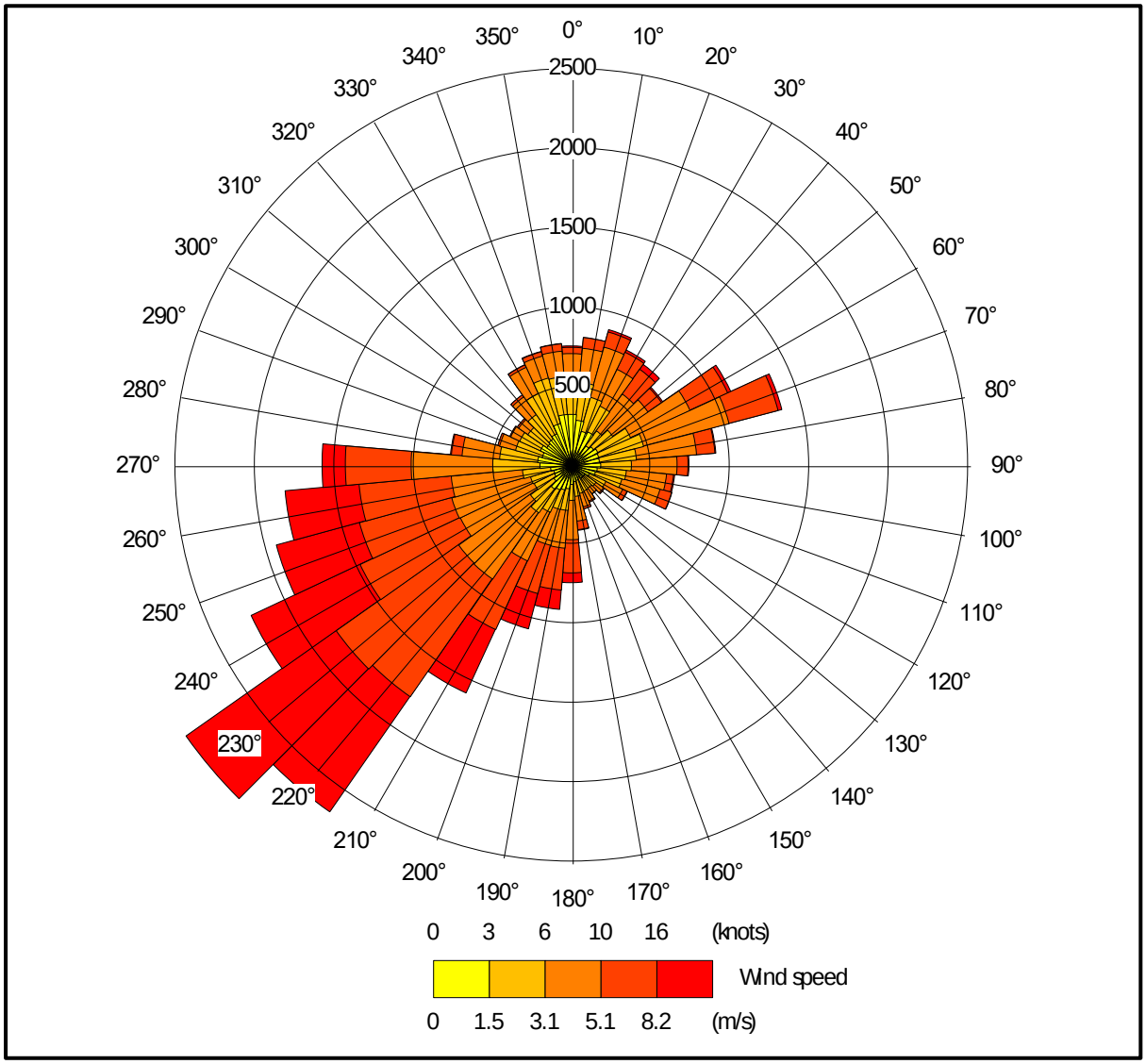
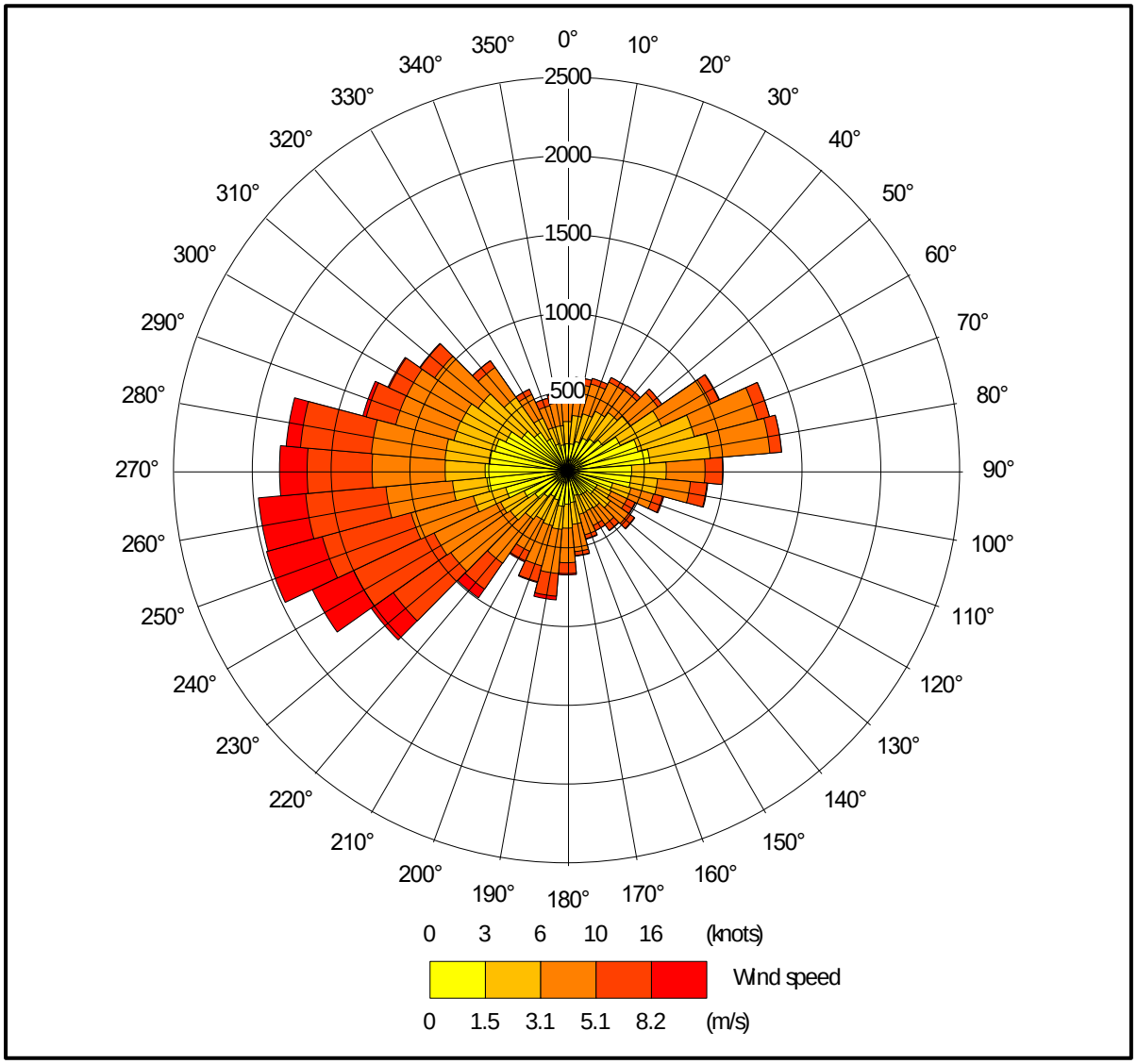


Figure 2d. The wind rose. Shobdon, 2013 - 2016



4.2 Emission sources

Emissions from the chimneys of the capped ridge fans on the existing poultry house and uncapped high speed ridge fans on the proposed poultry house are represented by three point sources per house within ADMS. Details of the point source parameters are shown in Table 3a. The positions of the point sources may be seen in Figure 3.

Table 3a. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (°C)	Emission rate per source (g-NH_3/s)
EX1 a, b & c	5.5	2.0	0.1	21	0.058813
PR1 a, b & c	6	0.8	11	21	0.009701

Emissions from the ranging areas are represented by two area sources within ADMS. The area sources cover the parts of the ranges most likely to be used frequently, not the whole ranging area. Details of the area source parameters are shown in Table 3b. The positions of the area sources may be seen in Figure 3.

Table 3b. Area source parameters

Source ID	Height (m)	Area (m^2)	Emission temperature (°C)	Emission rate per source (g-NH_3/s)
EX1_RAN	0.0	15963.08	Ambient	0.030421
PR1_RAN	0.0	22586.22	Ambient	0.041575

4.3 Modelled buildings

The structure of the 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

Forty-five discrete receptors have been defined: thirty-six at the AWs (1 to 36), one at the SSSI (37) and eight at the SSSI/SAC (38 to 45). 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.

4.5 Cartesian grid

To produce the contour plots presented in Section 5 of this report and to define the spatially varying deposition velocity field, a regular Cartesian grid has been defined within ADMS. The individual grid receptors are defined at ground level within ADMS. The position of the Cartesian grid may be seen in Figure 4b, 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 20.0 km x 20.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS in the preliminary modelling and a 6.4 km x 6.4 km domain has been resampled at 50 m horizontal resolution for use within ADMS in the detailed modelling. N.B. The resolution of FLOWSTAR is 32 x 32 grid points; therefore, the effective resolution of the wind field for the terrain runs is approximately 600 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 0.275 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

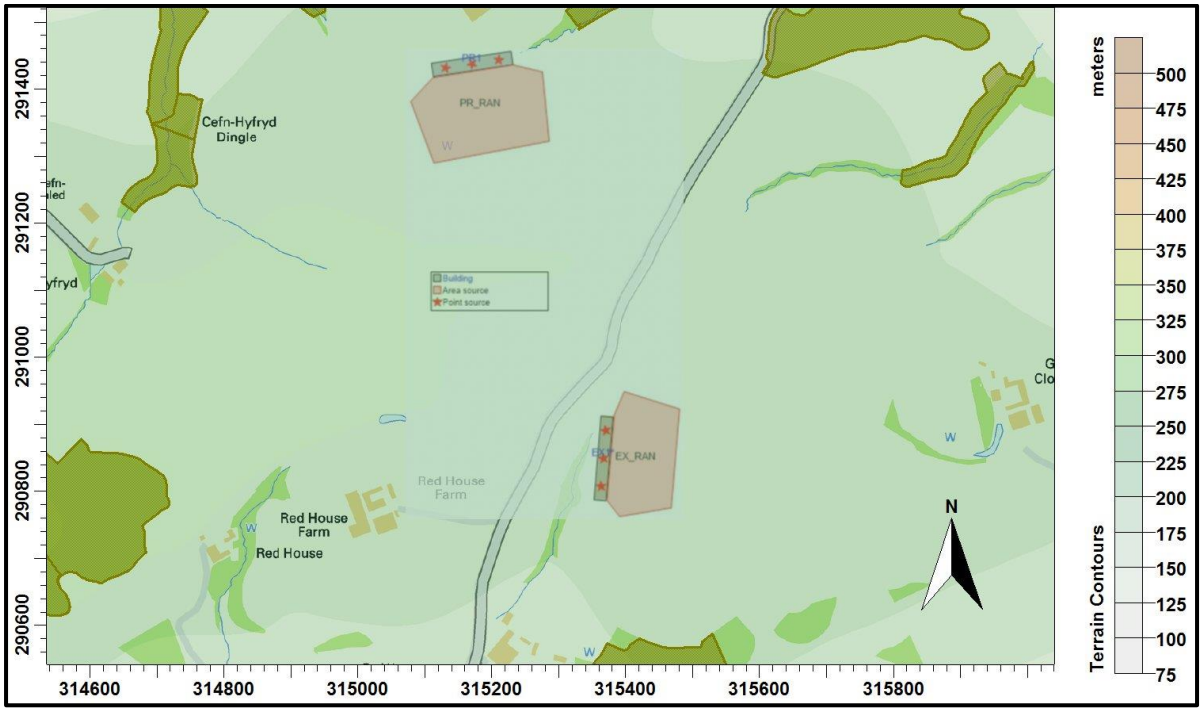


Figure 4a. The discrete receptors – a broad-scale view

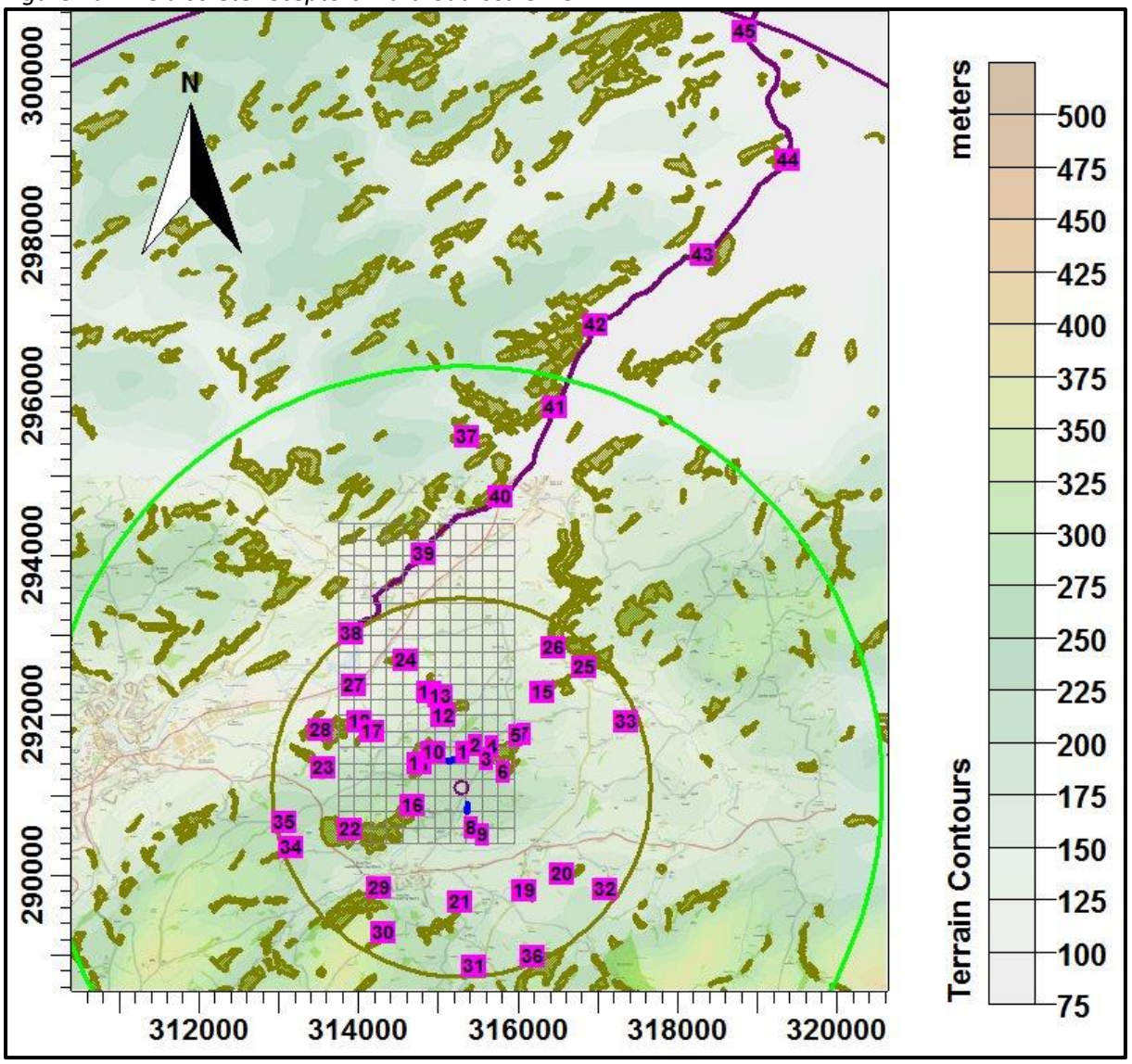
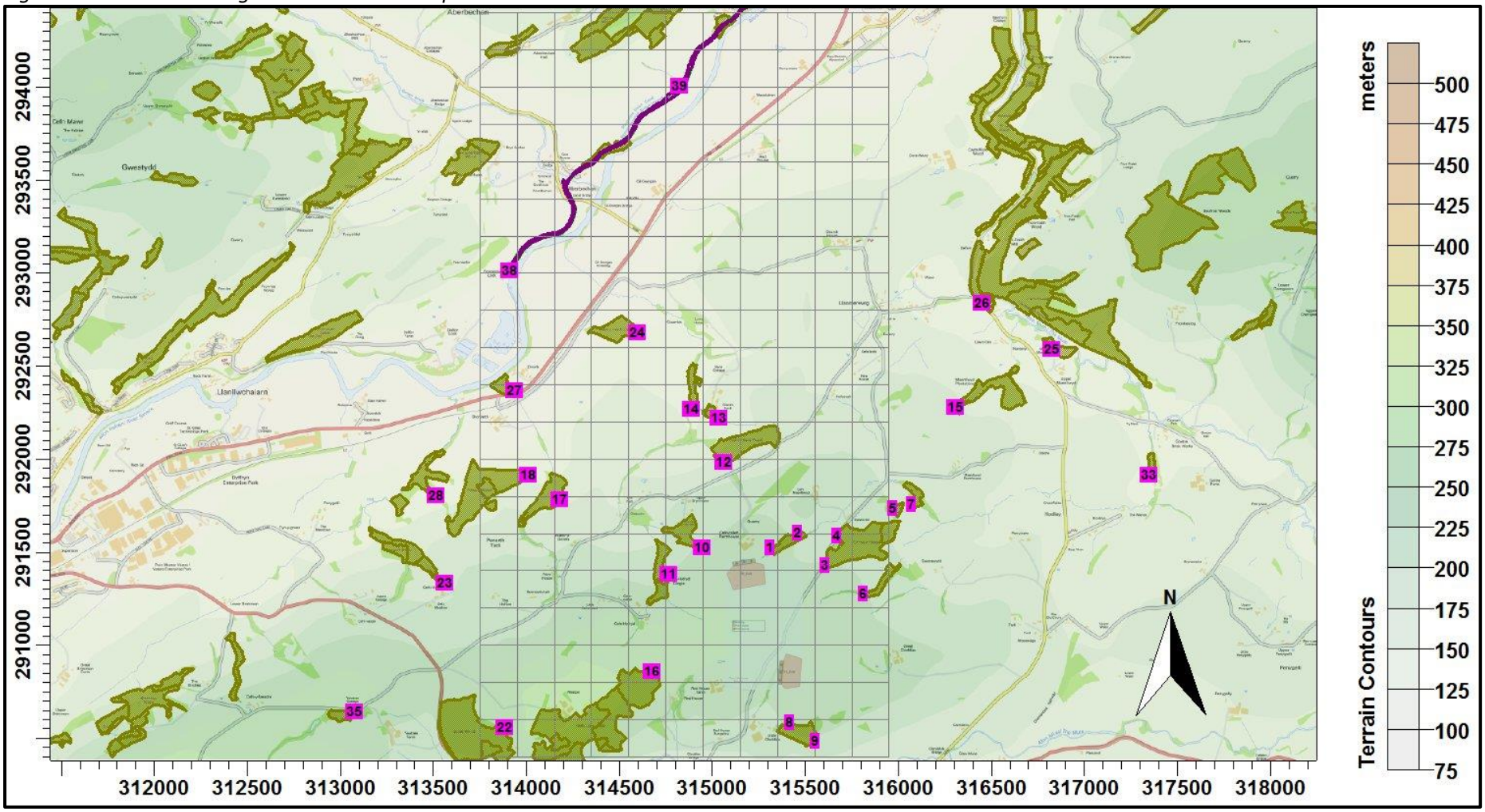


Figure 4b. The Cartesian grid and discrete receptors – a closer view



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 areas with rye grass to 0.05 m/s; 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 velocity is also set to 0.002 m/s where grid points are over the poultry housing or ranging areas and 0.015 m/s over heavily grazed grassland.

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, is used to define a deposition velocity field. The deposition velocities used are provided in Table 4.

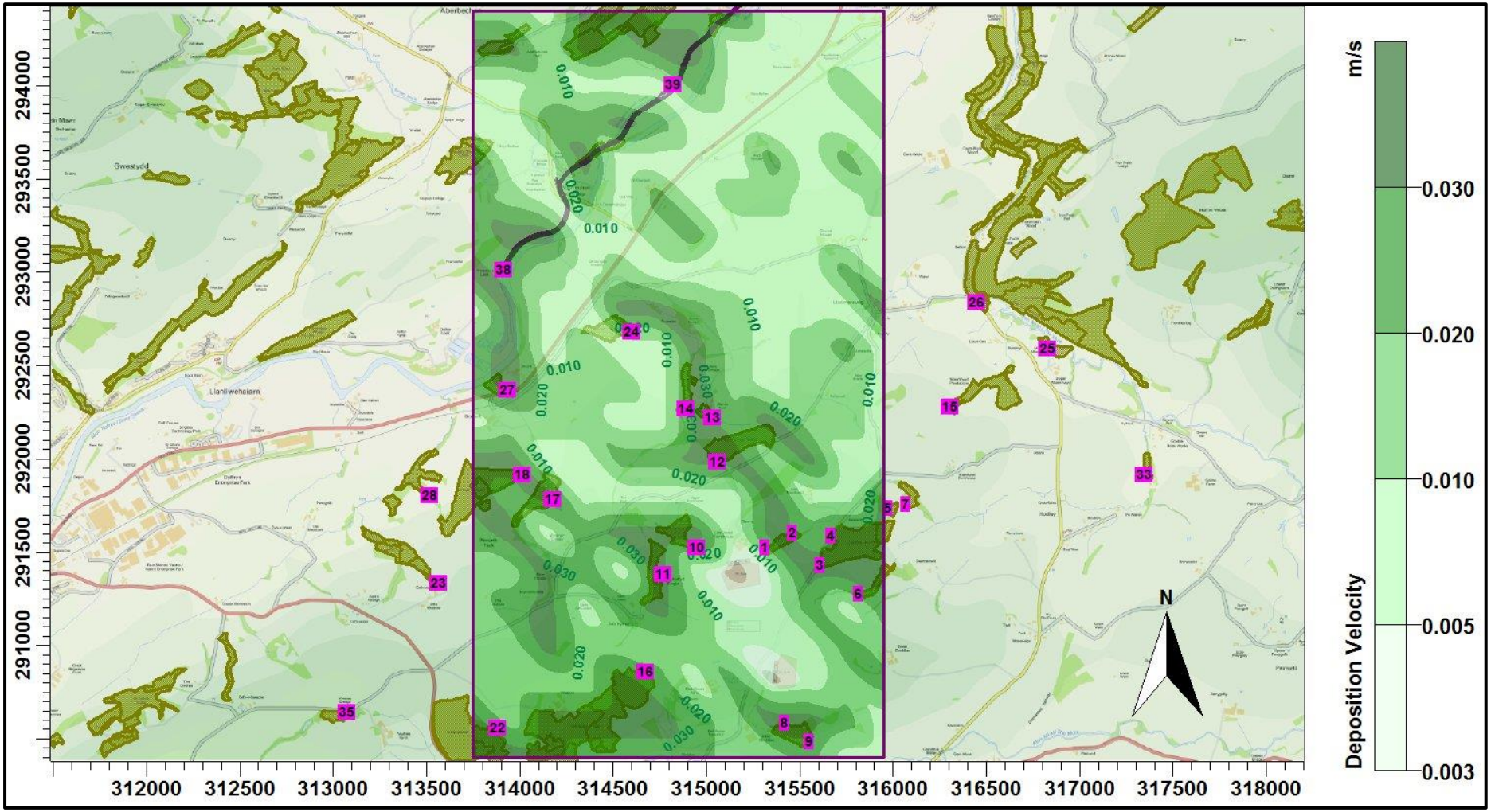
Table 4. Deposition velocities

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	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 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 twenty times, once for each year of the meteorological record, 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.
- In basic mode without calms or terrain – Lake Vyrnwy data.
- In basic mode without calm or terrain – Shobdon 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 (or concentrations equivalent to deposition rates) that are in excess of the Environment Agency's upper threshold (4% of Critical Level or Load for a SAC, 20% of Critical Level or Load for a SSSI and 100% of Critical Level or Load for a non-statutory wildlife site) are coloured red. Concentrations (or concentrations equivalent to deposition rates) in the range between the Environment Agency's lower and upper thresholds (4% and 20% for a SAC, 20% and 50% for a SSSI and 50%[1] and 100% for a non-statutory wildlife site) are coloured blue. For convenience, cells referring to the AWs are shaded olive, cells referring to the SSSI are shaded green and cells referring to the SSSI/SAC are shaded purple. Note that assuming a deposition velocity of 0.03 m/s 4% of the Critical Load of 10 kg/ha/y is equivalent to an annual mean ammonia concentration of 0.051 µg/m^3 and that assuming a deposition velocity of 0.005 m/s, 4% of the Critical Load of 3 kg/ha/y is equivalent to an annual mean ammonia concentration of 0.092 µg/m^3.

1. The pre-February 2016 value is used.

Table 5. Predicted maximum 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	Lake Vyrnwy No Calms No Terrain	Shobdon No Calms No Terrain
1	315311	291517	Unnamed AW	**2.723**	**2.707**	**2.730**	**2.822**	**3.063**
2	315459	291599	Unnamed AW	**1.156**	**1.145**	**1.152**	**1.202**	**1.381**
3	315605	291426	Unnamed AW	**1.194**	**1.185**	**1.226**	**1.348**	**1.842**
4	315665	291583	Unnamed AW	**0.824**	**0.818**	**0.843**	**0.848**	**1.056**
5	315970	291731	Unnamed AW	0.443	0.441	0.431	**0.505**	**0.533**
6	315812	291271	Unnamed AW	**0.981**	**0.972**	**0.933**	**1.240**	**1.457**
7	316068	291750	Unnamed AW	0.389	0.388	0.382	0.458	0.481
8	315416	290579	Unnamed AW	**2.021**	**2.013**	**1.986**	**4.527**	**2.021**
9	315552	290480	Unnamed AW	**1.130**	**1.121**	**1.032**	**2.145**	**1.383**
10	314945	291520	Unnamed AW	**0.987**	**0.978**	**1.025**	**0.715**	**1.135**
11	314766	291376	Unnamed AW	**0.780**	**0.764**	**0.794**	**0.640**	**1.263**
12	315059	291980	Unnamed AW	0.405	0.401	0.432	0.236	0.398
13	315032	292214	Unnamed AW	0.271	0.268	0.293	0.159	0.272
14	314887	292266	Unnamed AW	0.236	0.235	0.240	0.132	0.209
15	316305	292272	Unnamed AW	0.192	0.194	0.177	0.230	0.218
16	314675	290852	Unnamed AW	**0.687**	**0.672**	**0.724**	**0.692**	**1.248**
17	314177	291779	Unnamed AW	0.185	0.185	0.152	0.142	0.228
18	314011	291909	Unnamed AW	0.143	0.144	0.112	0.110	0.177
19	316083	289779	Unnamed AW	0.210	0.210	0.192	0.410	0.328
20	316554	289994	Unnamed AW	0.186	0.186	0.188	0.268	0.479
21	315268	289641	Unnamed AW	0.242	0.244	0.248	**0.586**	0.234
22	313882	290551	Unnamed AW	0.199	0.198	0.200	0.245	**0.532**
23	313563	291327	Unnamed AW	0.163	0.162	0.124	0.148	0.288
24	314597	292675	Unnamed AW	0.134	0.136	0.109	0.075	0.114
25	316826	292584	Unnamed AW	0.118	0.120	0.127	0.149	0.142
26	316449	292832	Unnamed AW	0.114	0.117	0.103	0.137	0.133
27	313935	292365	Unnamed AW	0.094	0.097	0.060	0.075	0.111
28	313516	291799	Unnamed AW	0.118	0.118	0.093	0.105	0.174
29	314263	289827	Unnamed AW	0.155	0.156	0.187	0.242	0.298
30	314311	289270	Unnamed AW	0.131	0.132	0.144	0.206	0.165
31	315440	288851	Unnamed AW	0.112	0.114	0.132	0.281	0.108
32	317097	289803	Unnamed AW	0.113	0.115	0.152	0.163	0.323
33	317345	291908	Unnamed AW	0.134	0.136	0.167	0.148	0.233
34	313163	290322	Unnamed AW	0.104	0.106	0.105	0.135	0.305
35	313073	290637	Unnamed AW	0.113	0.114	0.102	0.122	0.284
36	316175	288959	Unnamed AW	0.102	0.104	0.111	0.222	0.129
37	315354	295475	Hollybush Pastures SSSI	0.032	0.034	0.037	0.025	0.043
38	313911	293008	Montgomery Canal	**0.063**	**0.066**	0.036	0.045	**0.067**
39	314823	294000	Montgomery Canal	**0.061**	**0.063**	**0.082**	0.037	**0.067**
40	315777	294718	Montgomery Canal	0.039	0.041	**0.054**	0.038	**0.058**
41	316455	295830	Montgomery Canal	0.024	0.026	0.034	0.027	0.037
42	316961	296864	Montgomery Canal	0.018	0.020	0.022	0.021	0.027
43	318306	297735	Montgomery Canal	0.015	0.016	0.019	0.018	0.020
44	319383	298930	Montgomery Canal	0.011	0.013	0.017	0.014	0.015
45	318834	300544	Montgomery Canal	0.009	0.010	0.013	0.010	0.012

5.2 Detailed deposition modelling

The detailed modelling was carried out over a restricted domain covering the poultry houses, the nearest AWs and closer parts of the Montgomery Canal SAC; the area where the preliminary modelling indicated that annual mean ammonia concentrations could potentially exceed 100% of the Critical Level of 1.0 µg/m^3 for the AWs and (assuming a deposition velocity of 0.03 m/s) 4% of the Critical Load of 10 kg/ha/y at the Montgomery Canal SAC. At other AWs, the SSSIs and other parts of the SAC, all modes of the preliminary modelling indicated that ammonia levels (and nitrogen deposition rates) would be at levels below the Environment Agency's lower threshold percentage of Critical Level (or Load) for the designation of the site.

Spatially varying deposition and terrain cannot be modelled in conjunction with the calms module of ADMS. In this case, the preliminary modelling suggests that the effect of calms is insignificant. Therefore, the deposition runs were made without calms and with terrain. The model was run four times, once for each year of the meteorological record.

The results of the predicted annual mean ground level ammonia concentrations at the discrete receptors within the restricted modelling domain are shown in Table 6. In the Table, predicted ammonia concentrations that are in excess of the Environment Agency's upper threshold (4% of Critical Level or Load for a SAC and 100% of Critical Level or Load for a non-statutory wildlife site) are coloured red. Concentrations that are between the Environment Agency's lower and upper thresholds (4% and 20% for a SAC and 50% [1] and 100% for a non-statutory wildlife site) are coloured blue.

A contour plot of the predicted ground level maximum annual mean ammonia concentration is shown in Figure 6a and a contour plot of the maximum nitrogen deposition rate is shown in Figure 6b.

1. The pre-February 2016 value for the lower threshold is used for non-statutory sites.

Table 6. Annual ammonia concentration and nitrogen deposition rate at the discrete receptors – detailed deposition modelling

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)	PC (µg/m³)	%age of Critical Level	PC (kg/ha)	%age of Critical Load
1	315311	291517	Unamed AW	0.030	1.0	10.0	1.719	**171.9**	13.39	**133.9**
2	315459	291599	Unamed AW	0.030	1.0	10.0	0.619	**61.9**	4.82	48.2
3	315605	291426	Unamed AW	0.030	1.0	10.0	0.654	**65.4**	5.10	**51.0**
4	315665	291583	Unamed AW	0.030	1.0	10.0	0.435	43.5	3.39	33.9
6	315812	291271	Unamed AW	0.030	1.0	10.0	0.534	**53.4**	4.16	41.6
8	315416	290579	Unamed AW	0.030	1.0	10.0	0.948	**94.8**	7.39	**73.9**
9	315552	290480	Unamed AW	0.030	1.0	10.0	0.442	44.2	3.45	34.5
10	314945	291520	Unamed AW	0.030	1.0	10.0	0.543	**54.3**	4.23	42.3
11	314766	291376	Unamed AW	0.030	1.0	10.0	0.330	33.0	2.57	25.7
12	315059	291980	Unamed AW	0.030	1.0	10.0	0.178	17.8	1.38	13.8
13	315032	292214	Unamed AW	0.030	1.0	10.0	0.114	11.4	0.89	8.9
14	314887	292266	Unamed AW	0.030	1.0	10.0	0.094	9.4	0.73	7.3
16	314675	290852	Unamed AW	0.030	1.0	10.0	0.287	28.7	2.24	22.4
17	314177	291779	Unamed AW	0.030	1.0	10.0	0.070	7.0	0.54	5.4
18	314011	291909	Unamed AW	0.030	1.0	10.0	0.053	5.3	0.41	4.1
22	313882	290551	Unamed AW	0.030	1.0	10.0	0.062	6.2	0.49	4.9
24	314597	292675	Unamed AW	0.030	1.0	10.0	0.050	5.0	0.39	3.9
27	313935	292365	Unamed AW	0.030	1.0	10.0	0.031	3.1	0.24	2.4
38 (bankside)	313911	293008	Montgomery Canal SAC/SSSI	0.030	3.0	10.0	0.018	0.6	0.14	1.4
39 (bankside)	314823	294000	Montgomery Canal SAC/SSSI	0.030	3.0	10.0	0.030	1.0	0.23	2.3
38 (aquatic)	313911	293008	Montgomery Canal SAC/SSSI	0.005	3.0	3.0	0.018	0.6	0.02	0.8
39 (aquatic)	314823	294000	Montgomery Canal SAC/SSSI	0.005	3.0	3.0	0.030	1.0	0.04	1.3

Figure 6a. Maximum annual ammonia concentration

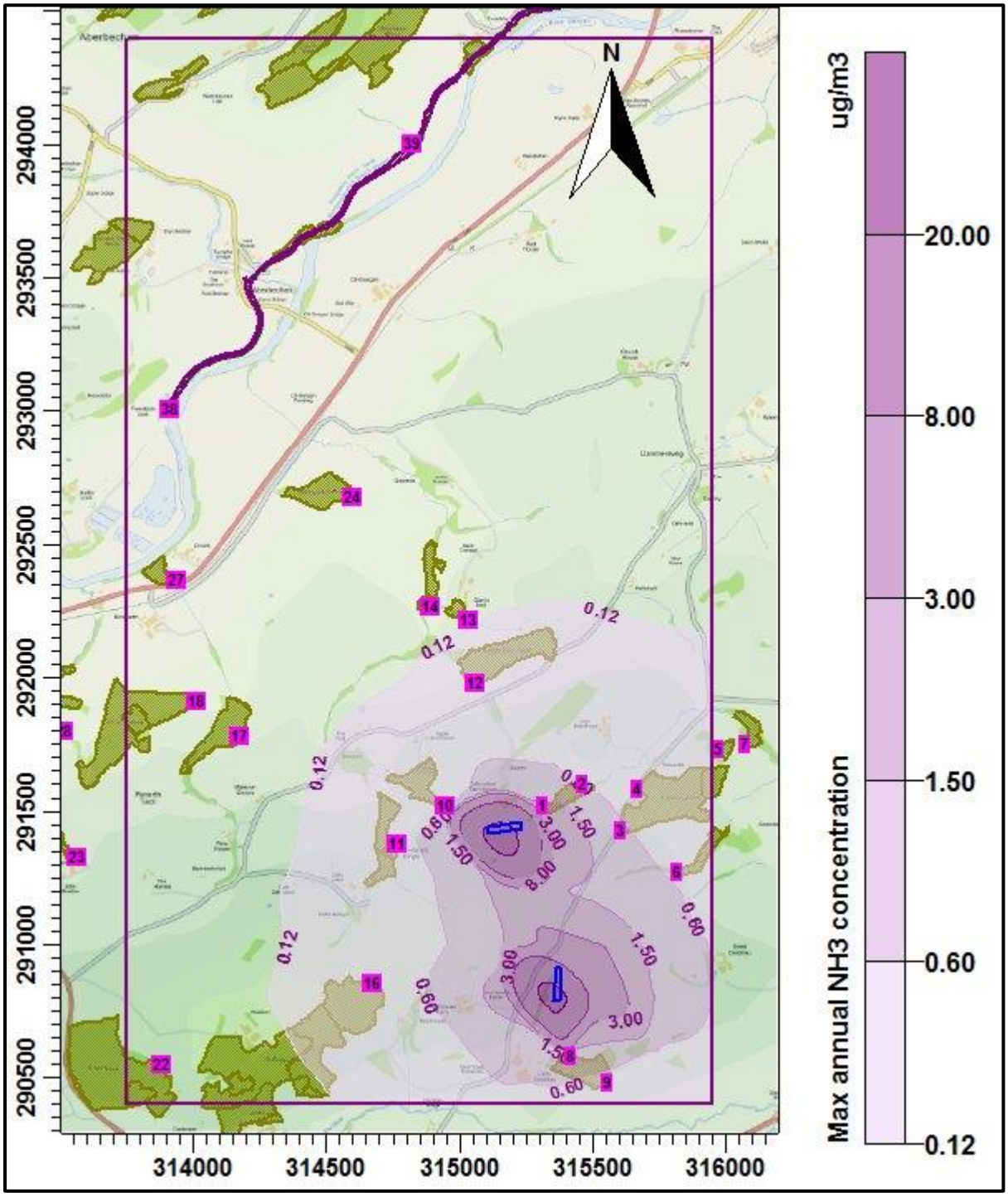
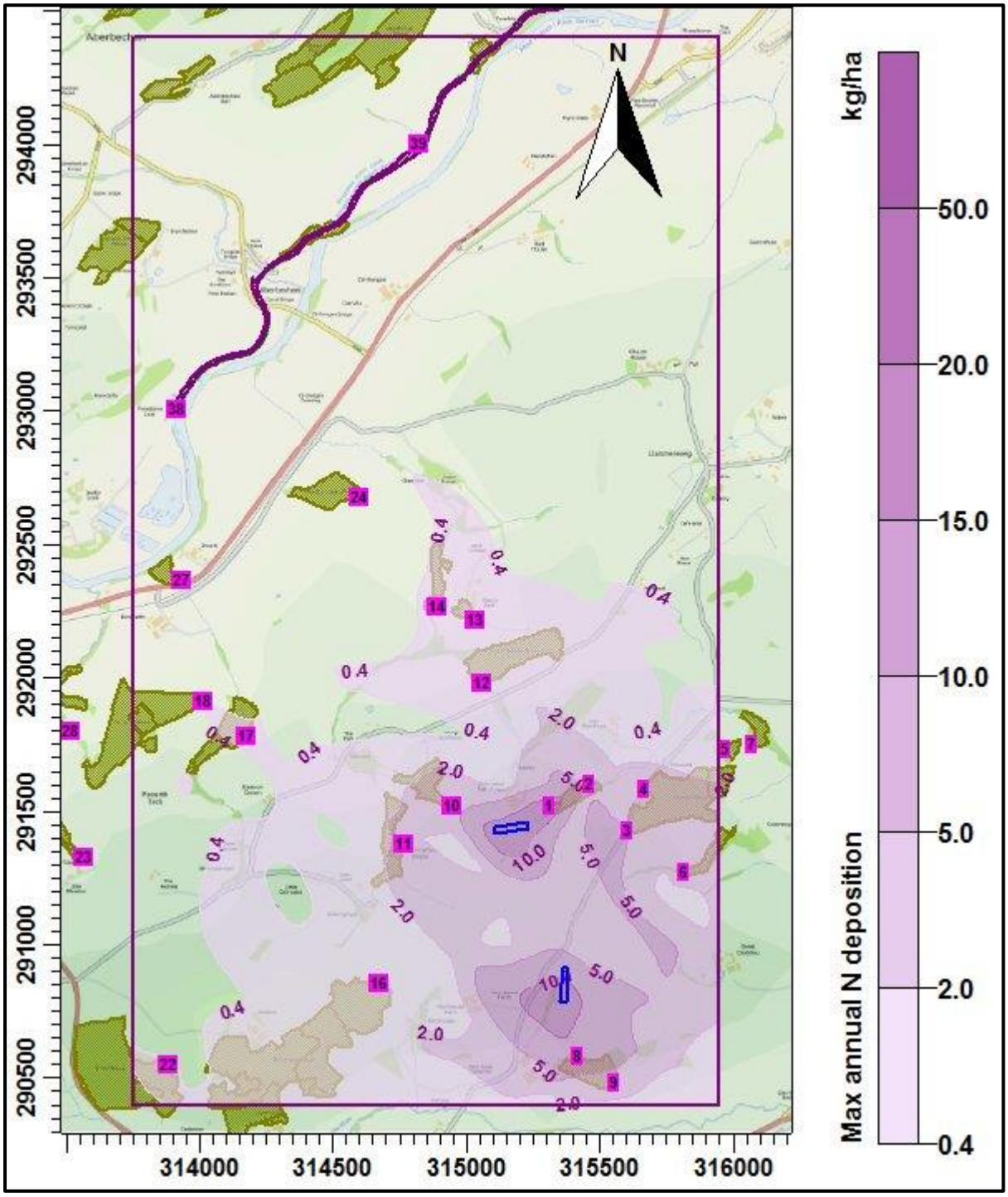


Figure 6b. Maximum annual nitrogen deposition rate



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Gail Lewis of Roger Parry & Partners LLP, on behalf of Mr D J Jerman of Kerry Vale Eggs Ltd., to use computer modelling to assess the impact of ammonia emissions from the existing and proposed free range egg laying houses at Cloddiau, Kerry, Newtown in Powys. SY16 4DY.

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.

The modelling predicts that should the proposed enlargement of the poultry unit at Cloddiau proceed, assuming the Critical Level of 1.0 µg-NH^3/m^3, at AWs, there would be exceedances of 100% (the Environment Agency's upper and lower threshold for non-statutory sites) of the annual mean ammonia concentration over approximately 0.5 ha of an area of the unnamed AW directly to the north-east of the poultry houses. At all other non-statutory sites considered, the process contribution to annual mean ammonia level and the annual nitrogen deposition rate is predicted to be at levels below the Environment Agency's lower threshold for non-statutory sites (100% of Critical Level or Load).

At all sites designated as SSSIs, the process contributions to annual mean ammonia level and the annual nitrogen deposition rate are predicted to be at levels below the Environment Agency's lower threshold percentage of Critical Level or Load for SSSIs (20%).

At the site designated as a SAC, the process contributions to annual mean ammonia level and the annual nitrogen deposition rate are predicted to be at levels below the Environment Agency's lower threshold percentage of Critical Level or Load for SACs (4%).

Where exceedances of the lower threshold for non-statutory sites are predicted, some form of mitigation is usually required. AS Modelling & Data Ltd. would recommend that, if available, to compensate for possible detrimental effects on the nearby AW, the woodland is actively managed for wildlife, and/or, that land of at least a similar area to the exceedance of 100% of the Critical Level (approximately 0.5 ha) is set aside for nature conservation and be planted/seeded with native species. Woodland planting schemes, or restoration to traditional unimproved grassland, could replace what is currently improved grassland with low ecological value. If planted between the poultry unit and the AW, the newly planted woodland would act as a sink for ammonia from the poultry houses and ranges (and from other sources of ammonia), thus reducing ammonia concentrations (and nitrogen and acid deposition rates) at the nearby AW. Such schemes may be particularly effective at increasing bio-diversity if they border, or connect with, existing remnants of woodland or unimproved grasslands.

7. References

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