A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Proposed Pullet Chicken Rearing Houses at Rhosfawr, near Llanfair Caereinion in Powys

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Gail Jenkins of Roger Parry & Partners LLP, on behalf of PL & PG Bumford, to use computer modelling to assess the impact of ammonia emissions from the proposed pullet chicken rearing houses at Rhosfawr, Llanfair Caereinion, Welshpool, Powys. SY21 9HE.

Ammonia emission rates from the proposed poultry houses have been assessed and quantified based upon the Environment Agency's 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 deposition rates in the surrounding area.

This report is arranged in the following manner:

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

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

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

- Section 5 contains the results of the modelling.

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

2. Background Details

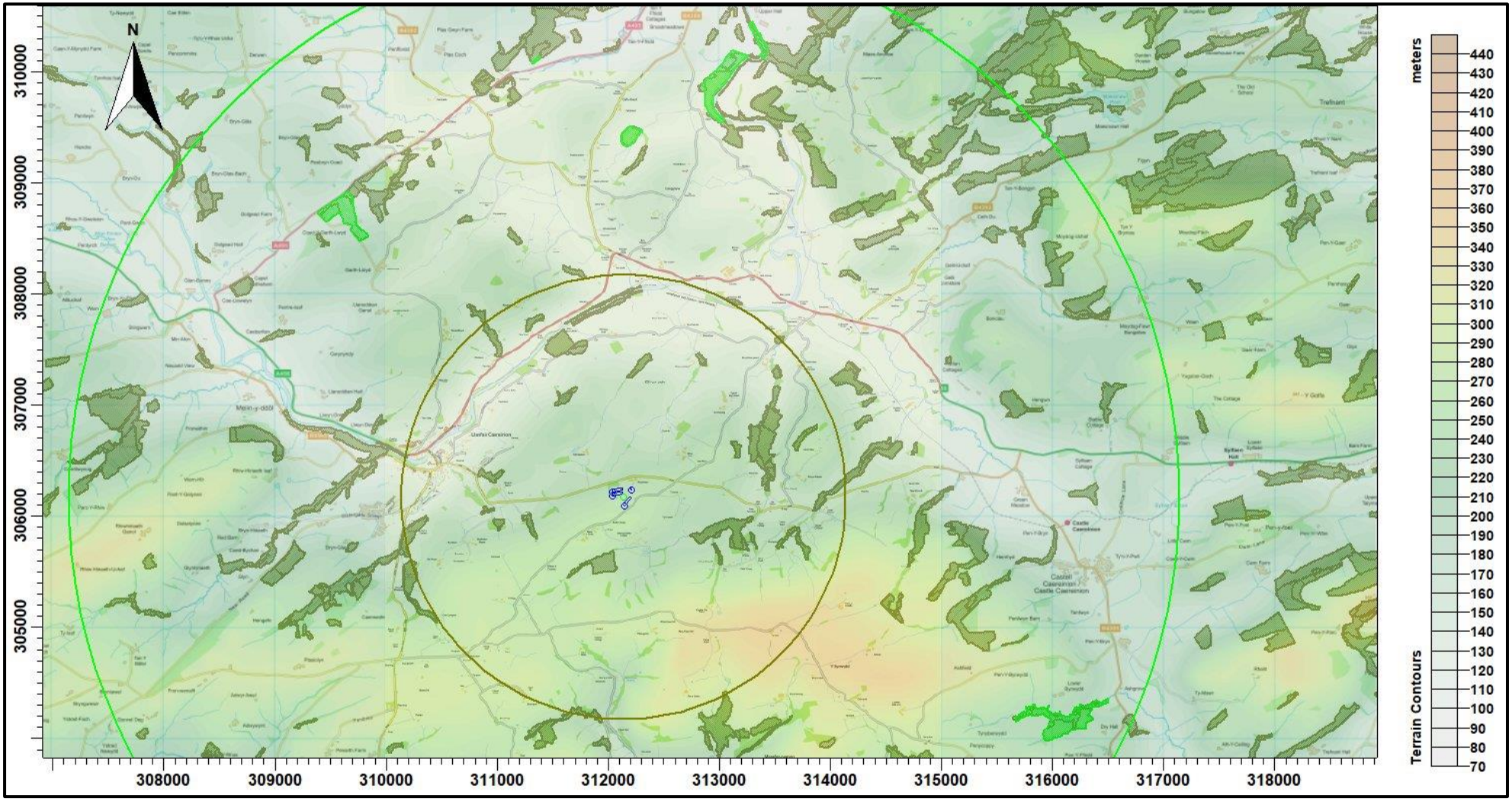
The site of the proposed pullet rearing houses at Rhosfawr is in a rural area, approximately 1 km to the east of the village of Llanfair Caereinion, near Welshpool. The surrounding land is used largely for livestock farming, although there are some isolated wooded areas. The site is at an altitude of around 230 m, with land falling to the north and west towards the River Vyrnwy Valley and rising to hilltops in the south-east.

It is proposed that three new poultry houses be constructed at Rhosfawr. The poultry houses would provide accommodation for up to 114,000 pullets, which would be reared from day old chicks to between 18 to 20 weeks old, prior to transfer to egg laying units elsewhere. The houses would be ventilated by uncapped high speed ridge fans, each with a short chimney. Every four days, the birds' droppings would be removed by a belt collection system and stored temporarily on the farm, prior to being removed from site or spreading to land.

There are several Ancient Woodlands (AWs) within 2 km of Rhosfawr, including: Coed Etinog AW; Coed Y Goat AW; Coed Y Neuadd AW and many unnamed sites. There are also six areas designated as Sites of Special Scientific Interest (SSSIs) within 5 km of the site, namely: Gweunydd Ger Fronhaul SSSI; Cors Cefn Llwyd SSSI; Coed Ty-Mawr SSSI; Afon Banwy Ger Mathrafal SSSI; Ffridd Mathrafal Track Section SSSI and Coed Byrwydd SSSI. There are no internationally designated sites within 5 km of the farm.

A map of the surrounding area showing the positions of the proposed poultry house and the nearby wildlife sites is provided in Figure 1. In the figure, the AWs are shaded in olive, the SSSIs are shaded green and the site of the positions of the proposed poultry houses are outlined in blue.

Figure 1. The area surrounding the site – concentric circles radii at 2 km (olive) and 5 km (bright green)



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

3.1 Ammonia concentration and nitrogen and acid deposition

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

3.2 Background ammonia levels and nitrogen and acid deposition

The background ammonia concentration (annual mean) in the area around Rhosfawr and the wildlife sites is 1.50 µg-NH_3/m^3. The background nitrogen deposition rate to woodland is 28.14 kg-N/ha/y and to short vegetation is 17.92 kg-N/ha/y. The background acid deposition rate to woodland is 2.14 keq/ha/y and to short vegetation is 1.39 keq/ha/y. The source of these background figures is the Air Pollution Information System (APIS, January 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. 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]	-	-
Gweunydd Ger Fronhaul SSSI	3.0 [1]	10.0 [2]	-
Cors Cefn Llwyd SSSI	3.0 [1]	10.0 [2]	-
Coed Ty-Mawr SSSI	1.0 [1]	10.0 [2]	-
Afon Banwy Ger Mathrafal SSSI	1.0 [1]	-	-
Ffridd Mathrafal Track Section SSSI	n/a	n/a	n/a
Coed Byrwydd SSSI	1.0 [1]	10.0 [2]	-

1. A precautionary figure, used where the citation for the site contains reference to lichens or bryophytes, or no details of the ecology of the site are available, or have not been considered.
2. The lower bound of the range of Critical Loads obtained from APIS.

3.4 Guidance on the significance of ammonia emissions

3.4.1 Natural Resources Wales criteria

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

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

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

Where process contributions, considered in isolation, are between 1% and 8% of the designated site Critical Level or Load, an in-combination assessment is required. Should the in-combination process contributions be between 1% and 8% of the designated site Critical Level or Load then it should be determined that the application would cause no significant environmental effect/likely significant effect/damage to scientific interest.

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

Please note that as far as AS Modelling & Data Ltd. is aware, currently, there is no publicly available ledger or database of sites with extant planning permission, or other proposed sites in planning, that would provide sufficient information to make an in-combination modelling assessment. Therefore, if Natural Resources Wales, or the Local Authority concerned do not consider the details of the modelling of ammonia emissions from this site provided by this study as sufficient information to fulfil the requirements of their appropriate assessment, then in most cases, it would not be possible for AS Modelling & Data Ltd. to provide this information.

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%).

3.4.2 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.

3.5 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.

AS Modelling & Data Ltd. understand that the Environment Agency and Natural Resources Wales have agreed to an ammonia emission factor of 0.04 kg-NH_3/bird place/y, which is based on the Environment Agency pullet rearing figure of 0.06 kg-NH_3/bird place/y, reduced by one third to account for the effect of the manure belt system which would remove a significant proportion of the manure from the building.

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 animal numbers and ammonia emission rates

Source	Animal numbers	Type or weight	Emission factor (kg-NH_3/place/y)	Emission rate (g-NH_3/s)
Proposed Housing 1	38,000	Pullet Rearing	0.04	0.048166
Proposed Housing 2	38,000	Pullet Rearing	0.04	0.048166
Proposed Housing 3	38,000	Pullet Rearing	0.04	0.048166

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). Observational meteorological data from Lake Vyrnwy and Shawbury have also been considered.

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) and data are archived at a resolution of 0.25 degrees (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 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.

A wind rose showing the distribution of wind speeds and directions in the GFS derived data is shown in Figure 2a.

Wind speeds are modified by the treatment of roughness lengths (see Section 4.7) and where terrain data is included in the modelling, wind speeds and directions will be further modified. The terrain and roughness length modified wind rose for Rhosfawr is shown in Figure 2b. Note that elsewhere in the modelling domain the modified wind roses may differ significantly and that the resolution of the wind field in terrain runs is approximately 150 m. Please also note that FLOWSTAR is used to obtain a local flow field, not to explicitly model dispersion in complex terrain as defined in the ADMS User Guide; therefore, the ADMS default value for minimum turbulence length has been amended.

Data from the meteorological recording stations at Lake Vyrnwy and Shawbury have also been considered. However, neither Lake Vyrnwy nor Shawbury, has an aspect that in any way could be considered similar to Rhosfawr; therefore, it should be noted that the frequency of winds from a particular direction in the Lake Vyrnwy and Shawbury data may be either high or low in comparison to what might occur at Rhosfawr, which means mean concentrations downwind may be either over or under predicted. Additionally, periods of light winds and calms cannot be properly modelled. Therefore, 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 Shawbury are shown in Figures 2c and 2d.

Figure 2a. The wind rose. Raw GFS derived data for 52.646 N, 3.299 W, 2015-2018

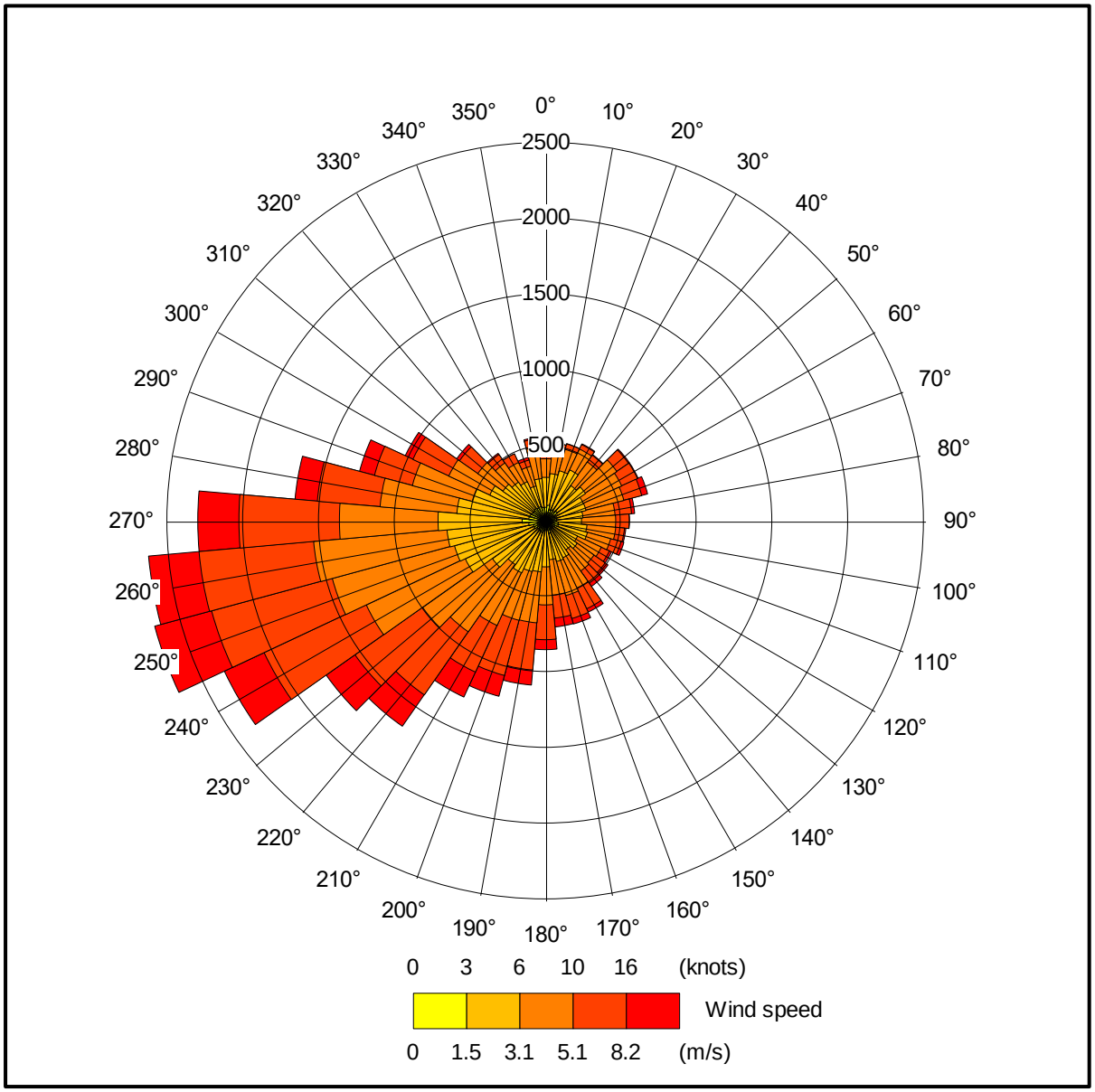


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 312150, 306250, 2015-2018

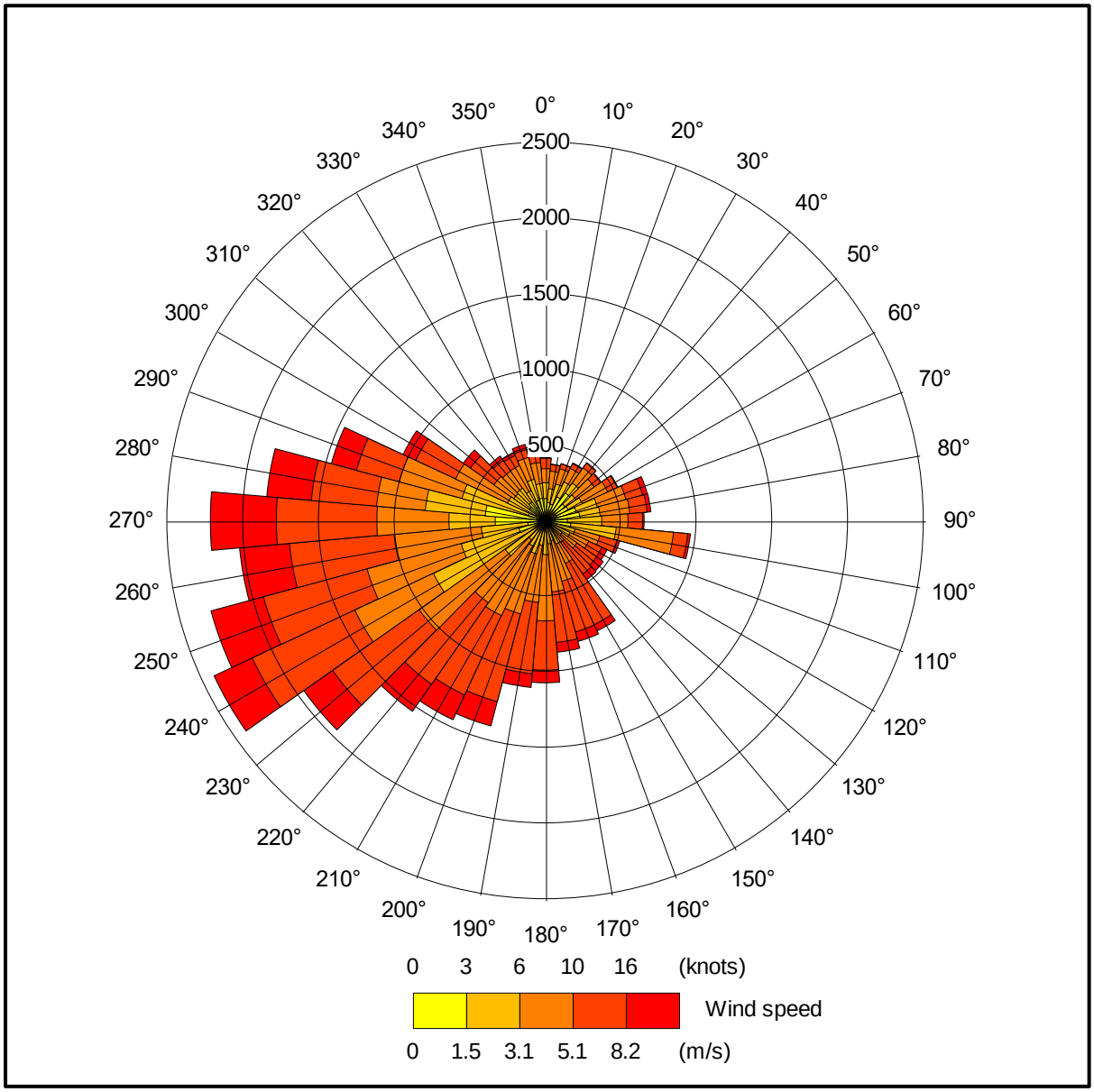


Figure 2c. The wind rose. Lake Vyrnwy, 2015 – 2018

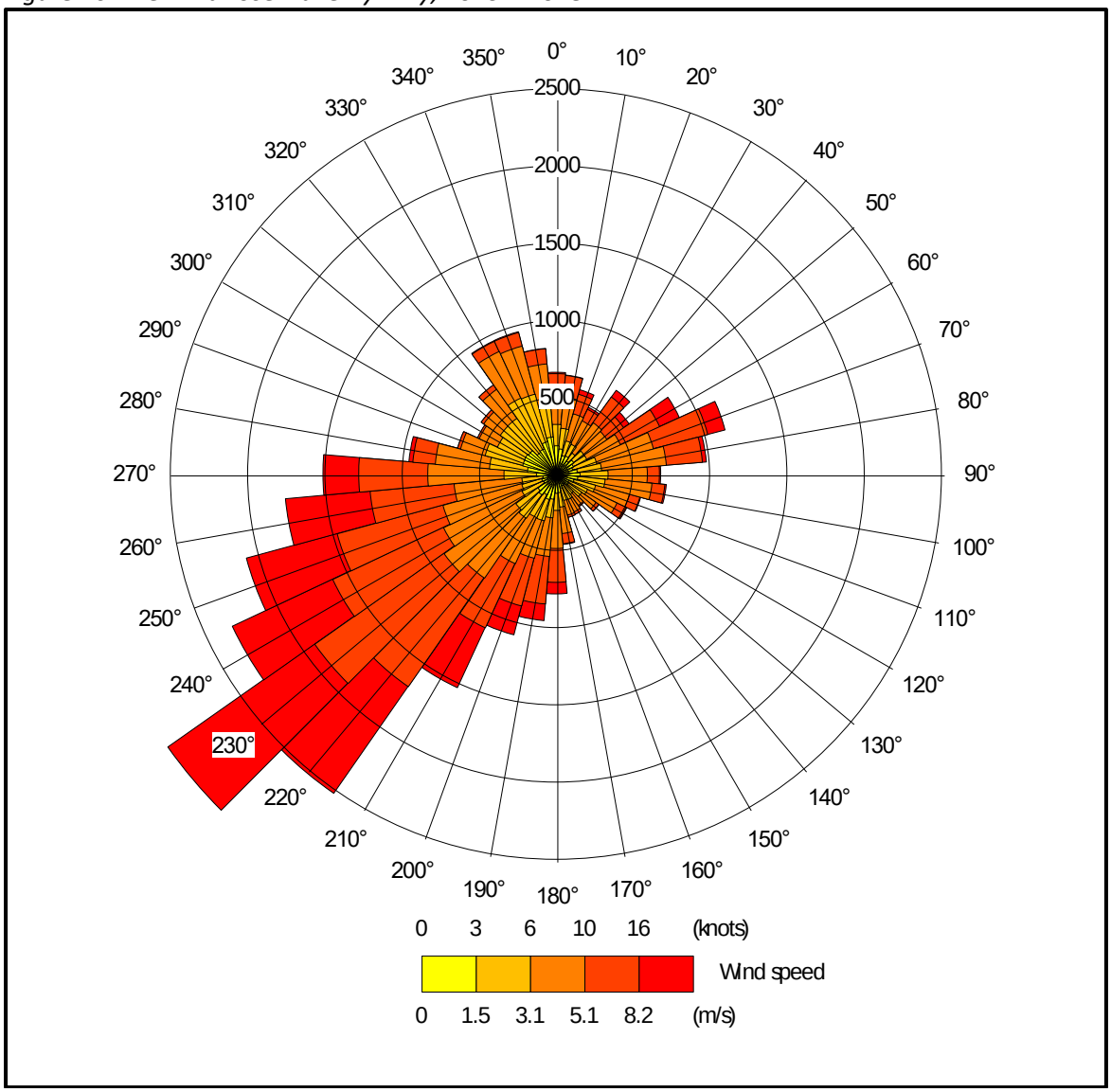
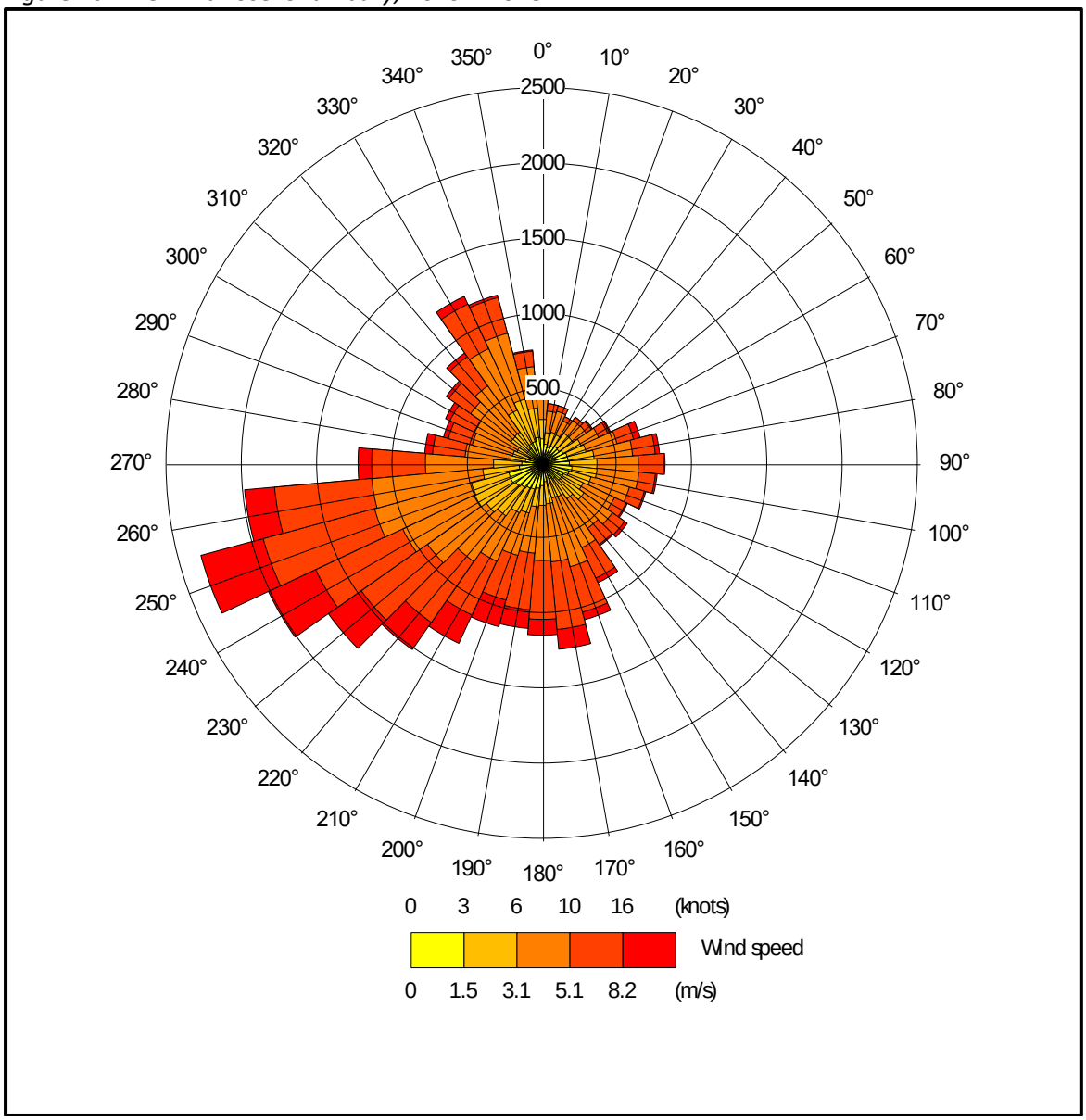


Figure 2d. The wind rose. Shawbury, 2015 – 2018



4.2 Emission sources

Emissions from the chimneys of the uncapped high speed ridge or roof fans that would be used for the ventilation of the poultry houses are represented by three point sources per house within ADMS. Details of the point source parameters are shown in Table 3 and their positions may be seen in Figure 3, where they are marked by red star symbols.

Table 3. Point source parameters

Source ID (Scenario)	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (˚C)	Emission rate per source (g-NH_3/s)
PR1 a, b & c	6.5	0.8	11.0	21.0	0.016055
PR2 a, b & c	6.5	0.8	11.0	21.0	0.016055
PR3 a, b & c	6.5	0.8	11.0	21.0	0.016055

4.3 Modelled buildings

The structure of the proposed poultry houses may affect the plumes from the point sources. Therefore, the building 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: thirty-three at the AWs (1 to 33) and six at the SSSIs (34 to 39). These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figure 4, where they are marked by enumerated pink rectangles.

4.5 Cartesian grid

To produce the contour plots presented in Section 5 of this report and to define the spatially varying deposition field used in the detailed modelling, a regular Cartesian grid has been within ADMS. The positions of the Cartesian grid receptors may be seen in Figure 4, marked by grey lines.

4.6 Terrain data

Terrain has been considered in the modelling. The terrain data are based upon the Ordnance Survey 50 m Digital Elevation Model. A 10.0 km x 10.0 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 150 m.

4.7 Roughness Length

A fixed surface roughness length of 0.3 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 stability and therefore increases predicted ground level concentrations.

Figure 3. The position of the modelled building and sources

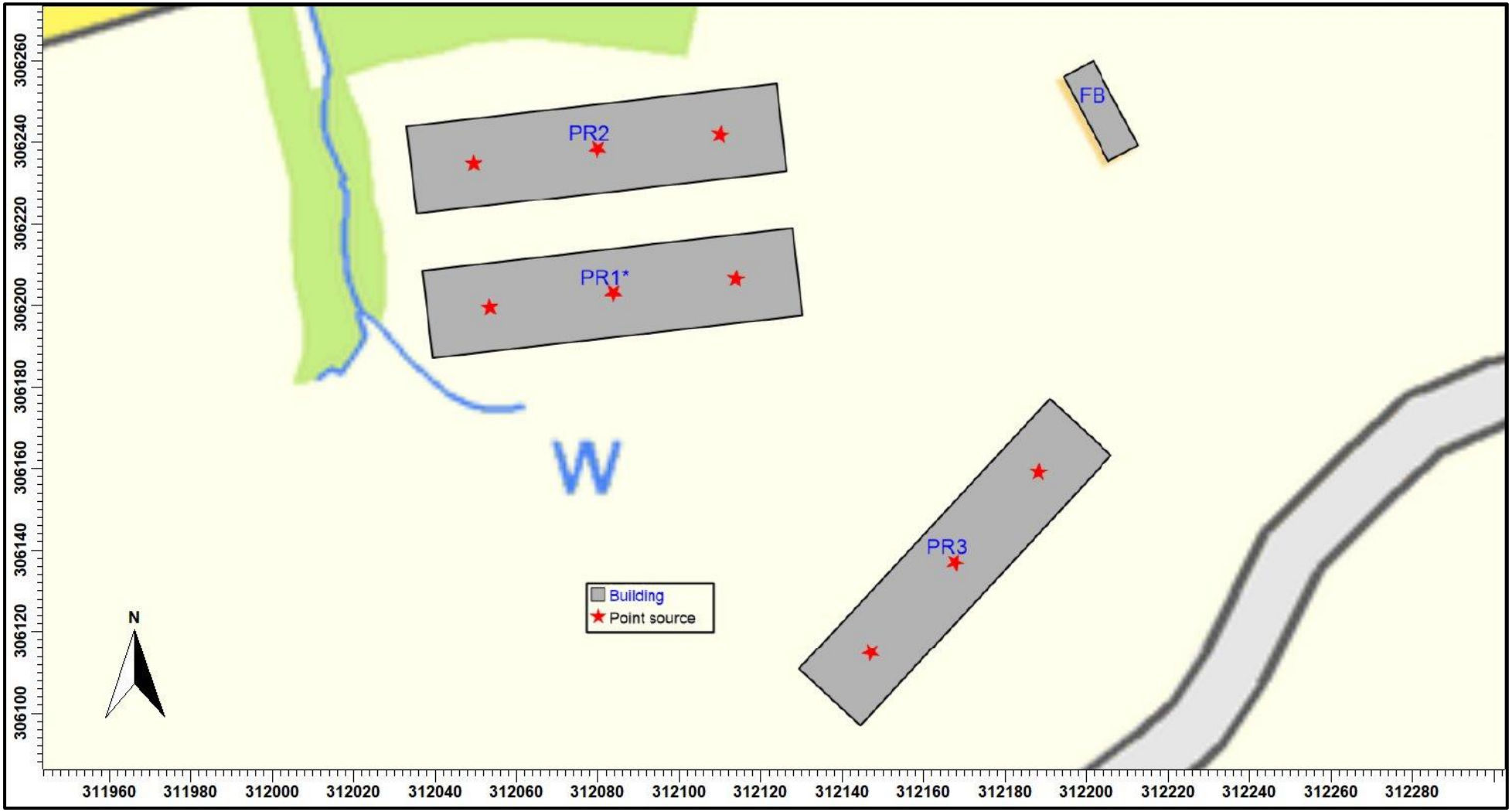
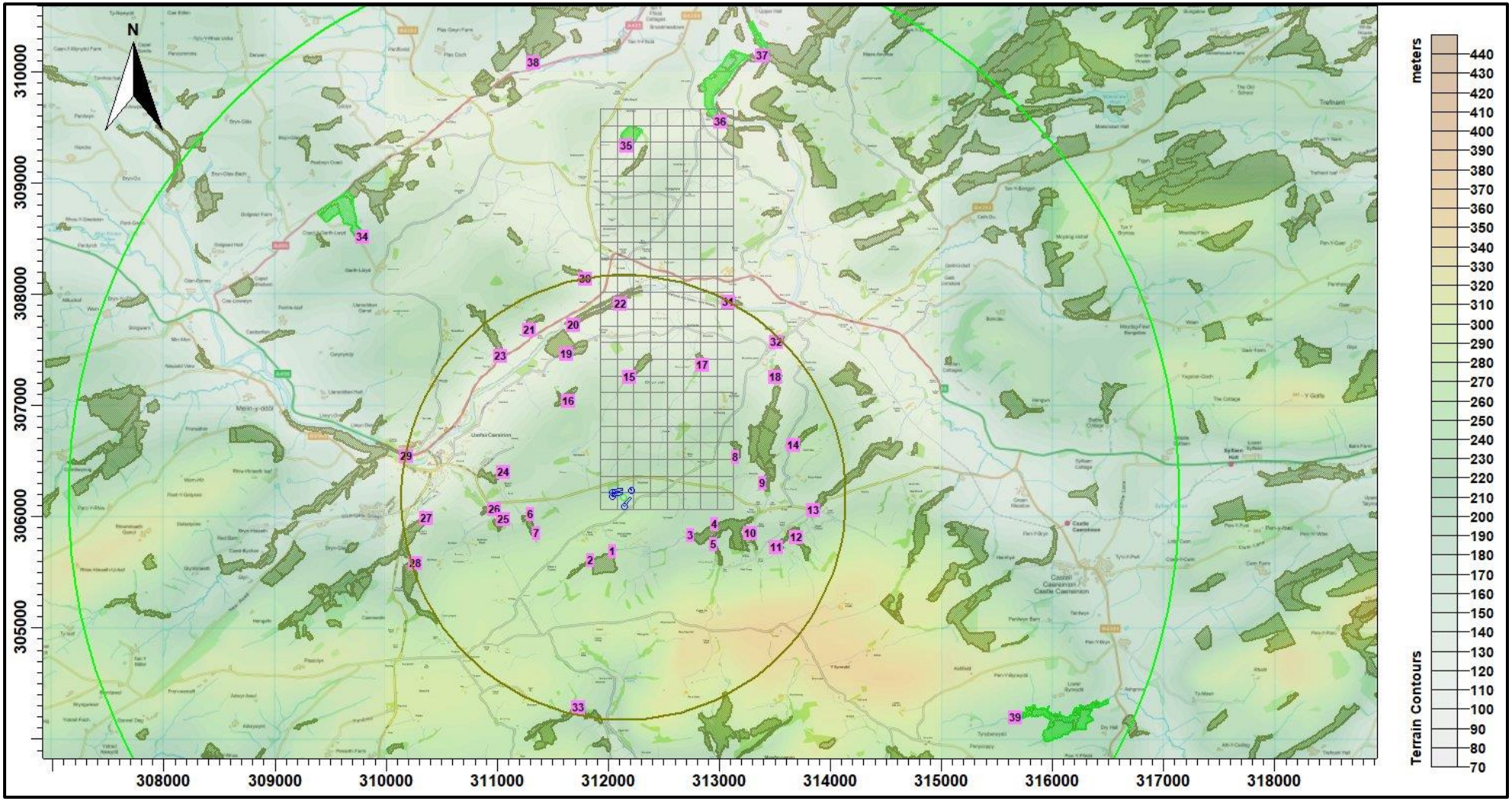


Figure 4. The discrete receptors and regular Cartesian grid



4.8 Deposition

The method used to model deposition of ammonia and consequent plume depletion is based 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. N.B deposition to water surfaces is calculated assuming a deposition velocity of 0.005 m/s.

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.

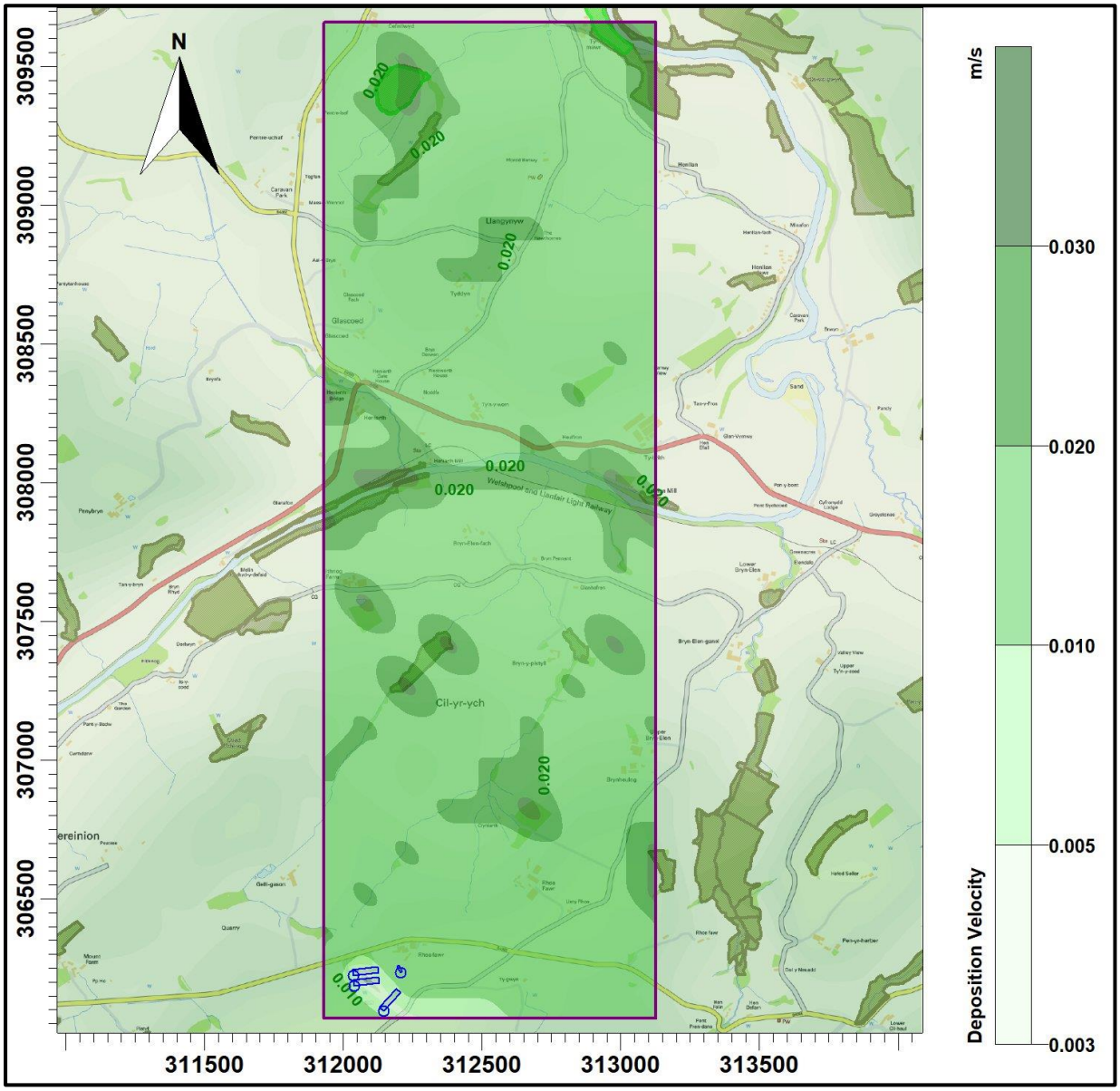
Table 4. Deposition velocities

NH_3 concentration (PC + background) ($\mu g/m^3$)	< 10	10 - 20	20 - 30	30 – 80	> 80
Deposition velocity – woodland (m/s)	0.03	0.015	0.01	0.005	0.003
Deposition velocity – short vegetation (m/s)	0.02 (0.015 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 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-eight times, once for each year in 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.
- Without calms and with terrain – GFS data with a fixed deposition at 0.003 m/s.
- In basic mode without calms, or terrain – Lake Vyrnwy data.
- In basic mode without calms, or terrain – Shawbury 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, 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 AWs are shaded olive and cells referring to the SSSI are shaded green.

Where a Critical Level of 3.0 µg-NH_3/m^3 is assumed, the Critical Load for nitrogen deposition then provides the stricter test and the following equivalences may be useful in interpreting Table 5.

- Assuming a deposition velocity of 0.03 m/s, 1% of the Critical Load of 10.0 kg-N/ha/y is equivalent to an annual mean ammonia concentration of 0.0129 µg-NH_3/m^3.

1. The pre-2016 figure has been retained

Table 4. Predicted maximum annual mean ammonia concentration 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 No Calms Terrain Fixed depo 0.003 m/s	Lake Vyrnwy No Calms No Terrain	Shawbury No Calms No Terrain
1	312036	305685	Unnamed AW	0.132	0.130	0.226	0.181	0.112	0.120
2	311837	305608	Unnamed AW	0.105	0.103	0.146	0.108	0.065	0.080
3	312738	305832	Unnamed AW	0.147	0.145	0.194	0.157	0.097	0.117
4	312954	305934	Unnamed AW	0.164	0.161	0.258	0.201	0.077	0.113
5	312945	305753	Unnamed AW	0.108	0.107	0.114	0.084	0.064	0.090
6	311299	306022	Unnamed AW	0.071	0.070	0.084	0.076	0.096	0.097
7	311350	305849	Unnamed AW	0.081	0.080	0.077	0.063	0.080	0.092
8	313143	306538	Unnamed AW	0.176	0.173	0.182	0.147	0.133	0.099
9	313384	306297	Unnamed AW	0.144	0.142	0.197	0.165	0.088	0.073
10	313277	305852	Unnamed AW	0.107	0.105	0.142	0.102	0.047	0.079
11	313515	305727	Unnamed AW	0.078	0.077	0.071	0.048	0.034	0.063
12	313693	305809	Unnamed AW	0.077	0.076	0.077	0.054	0.032	0.057
13	313849	306056	Unnamed AW	0.085	0.083	0.105	0.081	0.039	0.050
14	313666	306645	Unnamed AW	0.104	0.101	0.099	0.072	0.075	0.052
15	312190	307249	Unnamed AW	0.064	0.063	0.063	0.056	0.064	0.052
16	311645	307037	Coed Ethinog AW	0.051	0.050	0.037	0.034	0.068	0.027
17	312850	307364	Unnamed AW	0.054	0.054	0.053	0.050	0.059	0.057
18	313505	307249	Unnamed AW	0.061	0.060	0.052	0.047	0.059	0.055
19	311627	307461	Unnamed AW	0.036	0.036	0.032	0.029	0.044	0.018
20	311687	307724	Unnamed AW	0.031	0.031	0.028	0.023	0.037	0.017
21	311290	307678	Unnamed AW	0.025	0.025	0.017	0.014	0.030	0.013
22	312107	307909	Unnamed AW	0.030	0.030	0.036	0.032	0.034	0.026
23	311027	307438	Unnamed AW	0.022	0.022	0.020	0.015	0.028	0.014
24	311055	306400	Unnamed AW	0.039	0.039	0.048	0.039	0.062	0.047
25	311060	305971	Unnamed AW	0.048	0.048	0.050	0.045	0.070	0.066
26	310972	306063	Unnamed AW	0.041	0.041	0.056	0.048	0.067	0.057
27	310367	305985	Unnamed AW	0.024	0.024	0.029	0.024	0.040	0.032
28	310261	305583	Coed Y Goat AW	0.025	0.025	0.018	0.015	0.031	0.029
29	310188	306538	Coed Y Neuadd AW	0.018	0.018	0.025	0.019	0.030	0.022
30	311793	308135	Unnamed AW	0.024	0.024	0.026	0.020	0.028	0.016
31	313085	307927	Unnamed AW	0.031	0.031	0.033	0.030	0.035	0.031
32	313509	307567	Unnamed AW	0.043	0.043	0.038	0.035	0.046	0.044
33	311733	304282	Unnamed AW	0.030	0.029	0.050	0.029	0.017	0.023
34	309787	308512	Gweunydd Ger Fronhaul SSSI	0.010	0.010	0.007	0.004	**0.013**	0.007
35	312165	309334	Cors Cefn Llwyd SSSI	**0.014**	**0.014**	**0.015**	**0.013**	**0.016**	**0.013**
36	313014	309546	Coed Ty-Mawr SSSI	**0.014**	**0.014**	**0.014**	**0.012**	**0.015**	**0.014**
37	313385	310138	Afon Banwy Ger Mathrafal SSSI	**0.012**	**0.012**	0.010	0.008	**0.013**	**0.011**
38	311325	310077	Ffridd Mathrafal Track Section SSSI	**0.011**	**0.011**	0.009	0.007	**0.011**	0.007
39	315667	304195	Coed Byrwydd	**0.016**	**0.016**	0.007	0.004	0.008	**0.021**

5.2 Detailed modelling

The detailed modelling, which includes ammonia deposition and the consequent plume depletion, was carried out over a restricted domain covering the proposed poultry houses, Cors Cefn Llwyd SSSI and Coed Ty-Mawr SSSI, the area where preliminary modelling (GFS terrain and fixed deposition run) indicated that annual mean ammonia concentrations or nitrogen deposition rates would potentially exceed 1% of the (precautionary) Critical Level of 1.0 µg-NH_3/m^3.

At the other wildlife sites considered, the preliminary modelling indicated that ammonia levels (and nitrogen deposition rates) would be below Natural Resources Wales relevant lower threshold percentage of Critical Level/Load for the designation of the site.

Terrain effects are likely to be significant at some receptors; therefore, the detailed deposition runs were made with terrain. Calms cannot be used with terrain or spatially varying deposition; therefore, calms have not been included in the detailed modelling; however, the results of the preliminary modelling indicate that the effects of calms are insignificant in this case.

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 or nitrogen deposition rates that are in excess of the Natural Resources Wales upper threshold (8% of Critical Level or Load for a SSSI) are coloured red. Concentrations in the range between the Natural Resources Wales upper threshold and lower threshold (1% to 8% for a SSSI) are coloured blue.

Contour plots of the predicted ground level maximum annual mean ammonia concentration and the maximum nitrogen deposition rate are shown in Figures 6a and 6b.

Table 6. Predicted maximum annual mean ammonia concentrations and nitrogen deposition rates

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
35	312165	309334	Cors Cefn Llwyd SSSI	0.020	3.0	10.0	0.009	0.3	0.04	0.4
36	313014	309546	Coed Ty-Mawr SSSI	0.030	1.0	10.0	0.008	0.8	0.07	0.7

Figure 6a. Maximum annual ammonia concentration

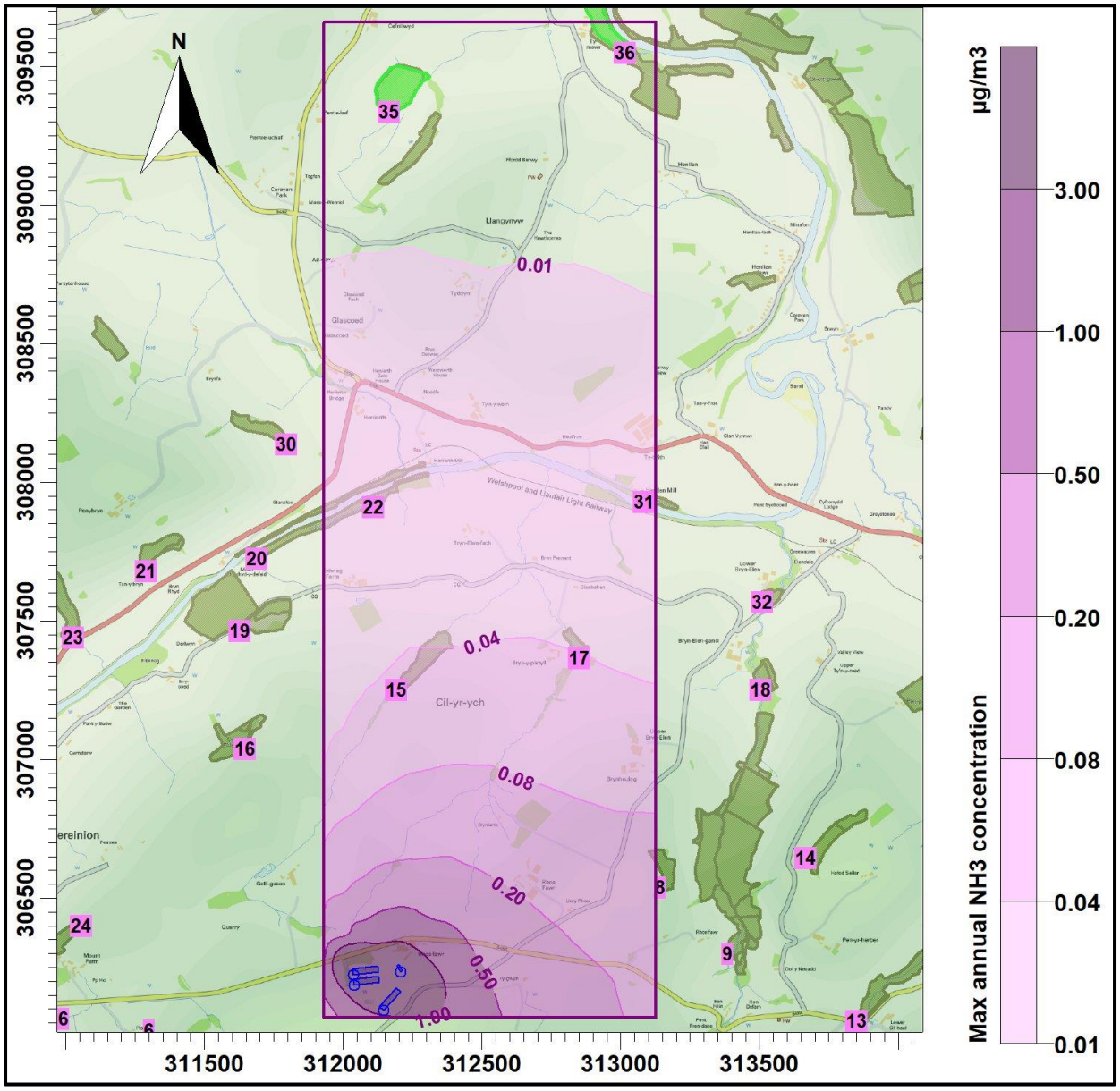
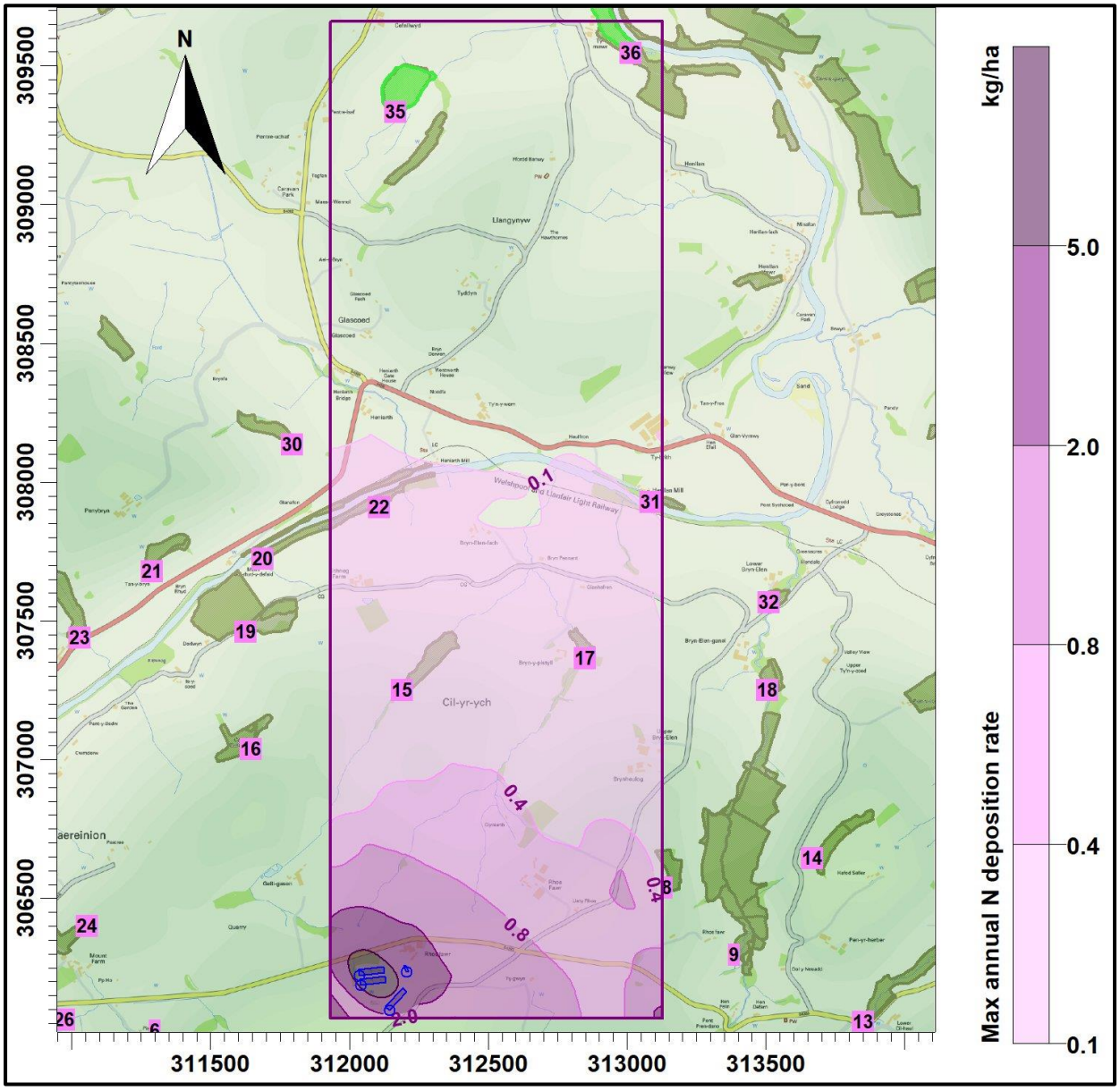


Figure 6b. Maximum annual nitrogen deposition rate



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Gail Jenkins of Roger Parry & Partners LLP, on behalf of PL & PG Bumford, to use computer modelling to assess the impact of ammonia emissions from the proposed pullet chicken rearing houses at Rhosfawr, Llanfair Caereinion, Welshpool, Powys. SY21 9HE.

Ammonia emission rates from the proposed poultry houses have been assessed and quantified based upon the Environment Agency's 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 deposition rates in the surrounding area.

At all sites considered, the modelling predicts that 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 and 100% for a non-statutory wildlife site).

7. References

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