

**A Report on the Modelling of the Dispersion and Deposition of
Ammonia from the Proposed Broiler Rearing Unit at Coombe Farm,
Llanvair Discoed, near Chepstow in Monmouthshire**

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Gareth Adams to use computer modelling to assess the impact of ammonia emissions from the proposed broiler rearing unit at Coombe Farm, Llanvair Discoed, near Chepstow in Monmouthshire. NP16 6LN.

Ammonia emission rates from the proposed poultry unit 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

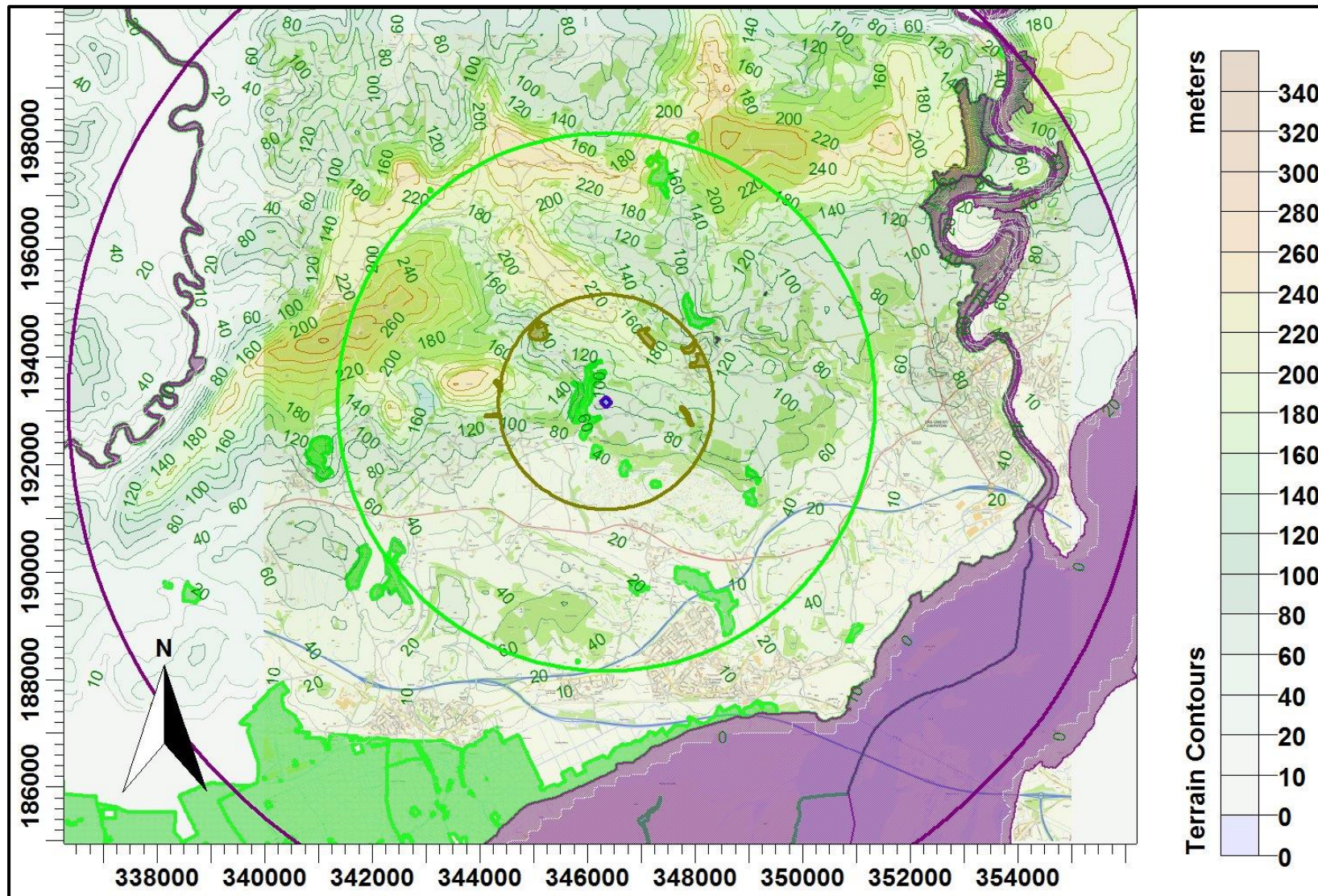
The site of the proposed broiler rearing unit at Coombe Farm is in an isolated rural area approximately 1.5 km to the north-east of the village of Llanvair Discoed in Monmouthshire. The surrounding land is used primarily for arable and livestock farming, although there are some semi-natural wooded areas. The site is at an altitude of around 105 m with the land rising towards hills and mountains to the north and falling towards the coastal plain of the River Severn Estuary to the south.

It is proposed that four poultry rearing houses be constructed on land to the north-east of the existing farm buildings at Coombe Farm. The new poultry houses would be used to provide accommodation for up to 200,000 broiler chickens. The chickens would be raised from day old chicks to up to around 42 days old and there would be approximately 7 flocks per year. The poultry houses would be ventilated primarily by high speed ridge mounted fans, each with a short chimney, but there would also be gable end fans to provide supplementary ventilation in hot weather conditions.

There are several areas of Ancient Woodland (AWs) and Local Wildlife Sites (LWSs) within 2 km of the poultry houses at Coombe Farm, some of which are also designated as Sites of Special Scientific Interest (SSSIs). The Combe Valley Woodlands SSSI, is approximately 200 m from the site of the proposed poultry houses and Stoneycroft Wood AW is approximately 220m from the site of the poultry houses. There are other SSSIs within 5 km of the farm and also two sites designated as Special Areas of Conservation (SACs); the SACs within 5 km of the farm are designated for mammalian features. There are some SACs which are designated for their flora within 10 km of Coombe Farm.

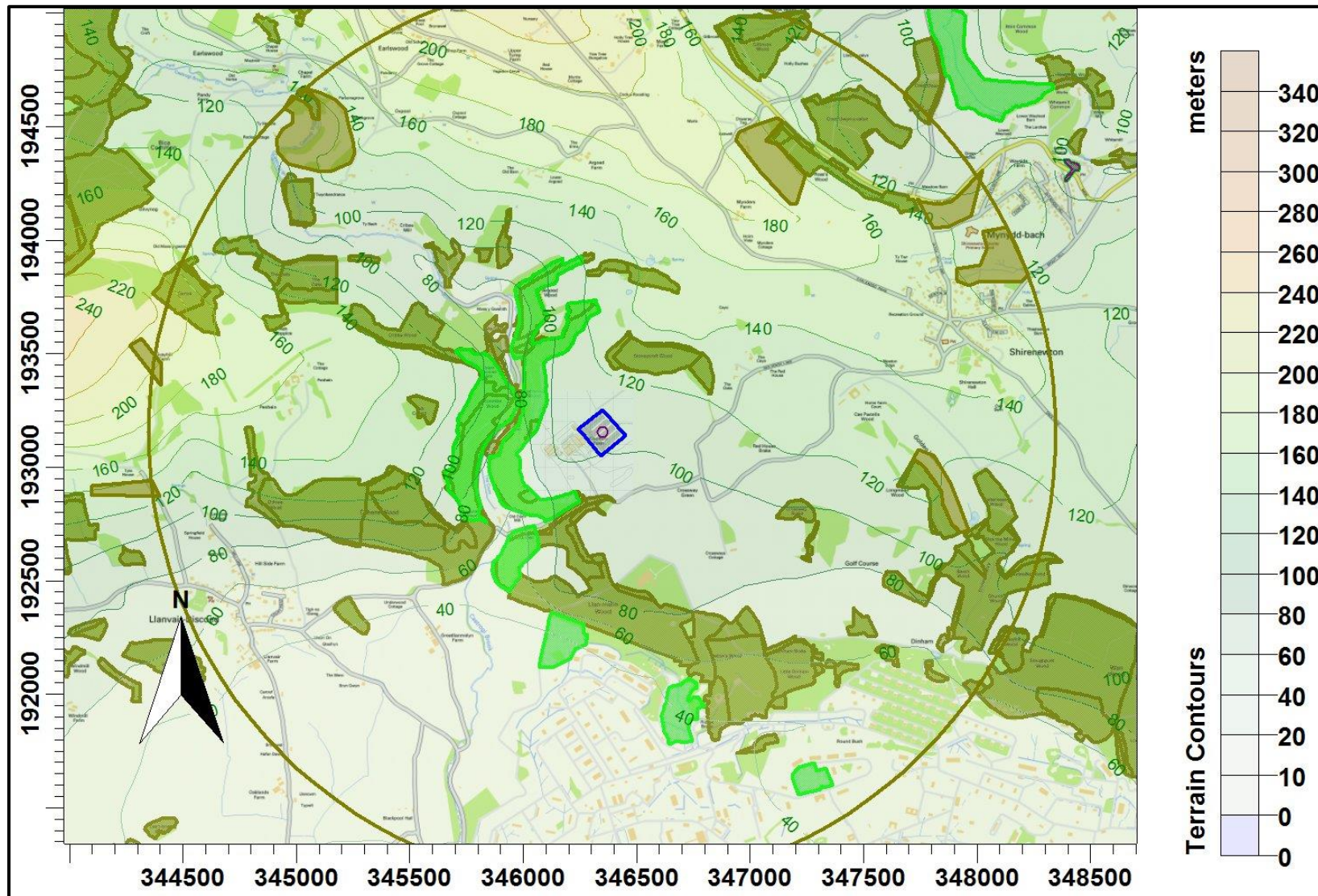
Maps of the surrounding area showing the positions of the poultry unit, the AWs, LWSs, SSSIs and SACs are provided in Figures 1a and 1b. In these figures, LWSs and AWs are shaded in olive, SSSIs are shaded in green, SACs are shaded in purple and the site of the proposed poultry unit is outlined in blue.

Figure 1a. The area surrounding Coombe Farm – a broad-scale view, with concentric circle radii 2 km (olive), 5km (green) and 10 km (purple)



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Figure 1b. The area surrounding Coombe Farm – a closer view



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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 ($\mu\text{g-NH}_3/\text{m}^3$) 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 Coombe Farm and the wildlife sites is $1.92 \mu\text{g-NH}_3/\text{m}^3$. The background nitrogen deposition rate to woodland is 32.76 kg-N/ha/y and to short vegetation is 18.48 kg-N/ha/y . The background acid deposition rate to woodland is 2.38 keq/ha/y and to short vegetation is 1.37 keq/ha/y . The source of these background figures is the Air Pollution Information System (APIS).

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 $3.0 \mu\text{g-NH}_3/\text{m}^3$ as an annual mean and for sites where there are sensitive lichens and bryophytes present, or lichens and bryophytes are an integral part of the ecosystem, the Critical Level is $1.0 \mu\text{g-NH}_3/\text{m}^3$ 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 $1.0 \mu\text{g-NH}_3/\text{m}^3$ 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 ($\mu\text{g-NH}_3/\text{m}^3$)	Critical Load - Nitrogen Deposition (kg-N/ha/y)	Critical Load - Acid Deposition (keq/ha/y)
Combe Valley Woodlands SSSI	3.0 ¹	10 ²	1.781 ³
AWs and LWSs	3.0 ³	10 ²	1.781 ³
Other SSSI and SACs designated for flora	1.0 ⁴	-	-

1. Based upon the citation for the site.
2. The lower bound of the range of Critical Loads for broad-leaved woodlands obtained from APIS. (N.B. as the soils in the area are calcareous, a higher Critical Load may be more appropriate) .
3. Obtained from APIS. (N.B. as the soils in the area are calcareous, a higher Critical Load may be more appropriate).
4. A precautionary figure, used where details of the site are unavailable, or citations indicate that sensitive lichens and bryophytes may be present.

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."

Within the range between what is considered insignificant and what may not be considered acceptable; 4% to 20% for SACs, SPAs and Ramsars; 20% to 50% for SSSIs and 50% 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 application site and the sensitivities of the wildlife sites. N.B. In the case of LWSs and AWs, the Environment Agency do not consider other farms that may act in combination, therefore a PC of up to 100% of Critical Level or Critical Load is usually deemed acceptable.

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 provided an Intensive farming guidance note which lists standard ammonia emission factors for a variety of livestock, including broiler chickens. The emission factor for broiler chickens is 0.034 kg-NH₃/bird place/y; this figure is used to calculate the emissions from the proposed poultry unit.

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

Source	Animal numbers	Type or weight	Emission factor (kg-NH ₃ /place/y)	Emission rate (g-NH ₃ /s)
Proposed Housing	200,000	Broiler Chickens	0.034	0.215479

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) and data from the meteorological recording station at Filton, several kilometres to the south-east of Coombe Farm.

The GFS is a spectral model and data are archived at a horizontal resolution of 0.5 degrees (approximately 50 km over the UK). The GFS resolution adequately captures major topographical features and the broad-scale characteristics of the weather over the UK. Smaller scale topological features may be included in the dispersion modelling by using the flow field module of ADMS (FLOWSTAR). The use of NWP data has advantages over traditional meteorological records because:

- Calm periods in traditional records may be over represented, this is because the instrumentation used may not record wind speed below approximately 0.5 m/s and start up wind speeds may be greater than 1.0 m/s. In NWP data, the wind speed is continuous down to 0.0 m/s, allowing the calms module of ADMS to function correctly.
- Traditional records may include very local deviations from the broad-scale wind flow that would not necessarily be representative of the site being modelled; these deviations are difficult to identify and remove from a meteorological record. Conversely, local effects at the site being modelled are relatively easy to impose on the broad-scale flow and provided horizontal resolution is not too great, the meteorological records from NWP data may be expected to represent well the broad-scale flow.
- Information on the state of the atmosphere above ground level which would otherwise be estimated by the meteorological pre-processor may be included explicitly.

The meteorological recording station at Filton is a considerable distance from Combe Farm and is on the opposite side of the Severn Estuary, as such, it is rather unlikely to be fully representative of the weather conditions around Coombe Farm. However, there are no observational meteorological stations that fully record the variables required for dispersion modelling nearby and other alternatives are in coastal or mountainous areas and are even less likely to be representative of the weather conditions around Coombe Farm. The results of the modelling using meteorological data from Filton are included solely to demonstrate that the use of GFS data does not lead to results that would be greatly different from those that would be obtained were a representative traditional observational data set available.

Therefore, it should be noted that the frequency of winds from a particular direction in the Filton data are likely to be high or low in comparison to what might occur at Coombe Farm, which means mean concentrations downwind may be either over or under predicted. The GFS data provides a more rounded dataset, in which local effects are not included, but can be included using terrain data and FLOWSTAR. Therefore, it is the opinion of AS Modelling & Data Ltd. that the results obtained using the GFS data will provide results less likely to have gross errors due to inclusion of local effect at the meteorological recording site which are not present at the application site and that they should be given more weight when interpreting the results of the modelling.

Wind roses for Filton and the raw GFS data at the site of the proposed poultry unit at Coombe Farm are shown in Figures 3a and 3b.

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 Coombe Farm is shown in Figure 3c. Note that elsewhere in the modelling domain, modified wind roses may differ markedly and that the resolution of the wind field in terrain runs is approximately 600 m.

The wind rose for the FLOWSTAR modified GFS data at the site of the proposed poultry unit at Black Rock Farm is shown in Figure 3c.

Figure 3a. The wind rose. Filton data, 2011 – 2014

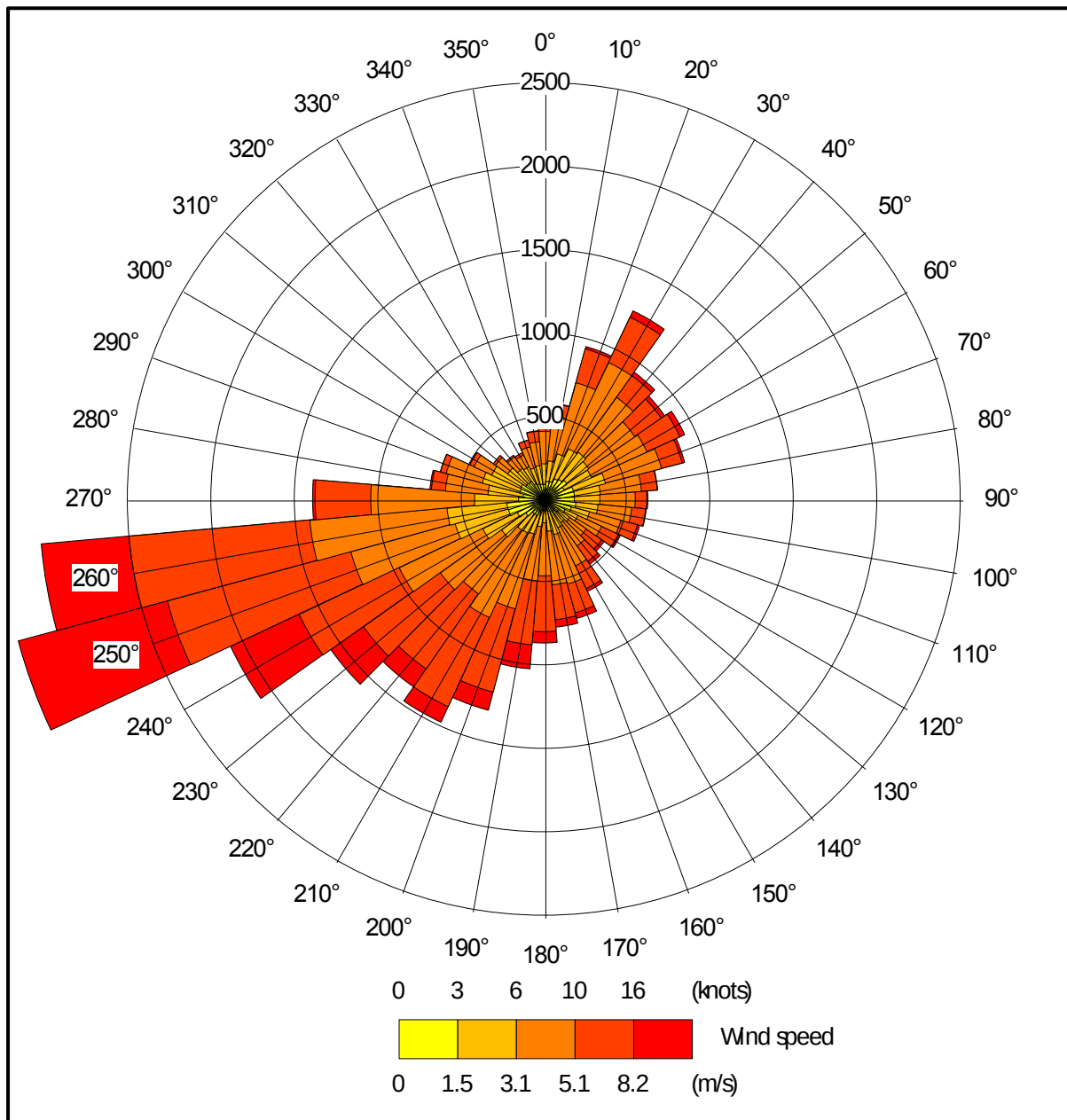


Figure 3b. The wind rose. Raw GFS derived data, for 51.634 N, 2.775 W, 2011 – 2014

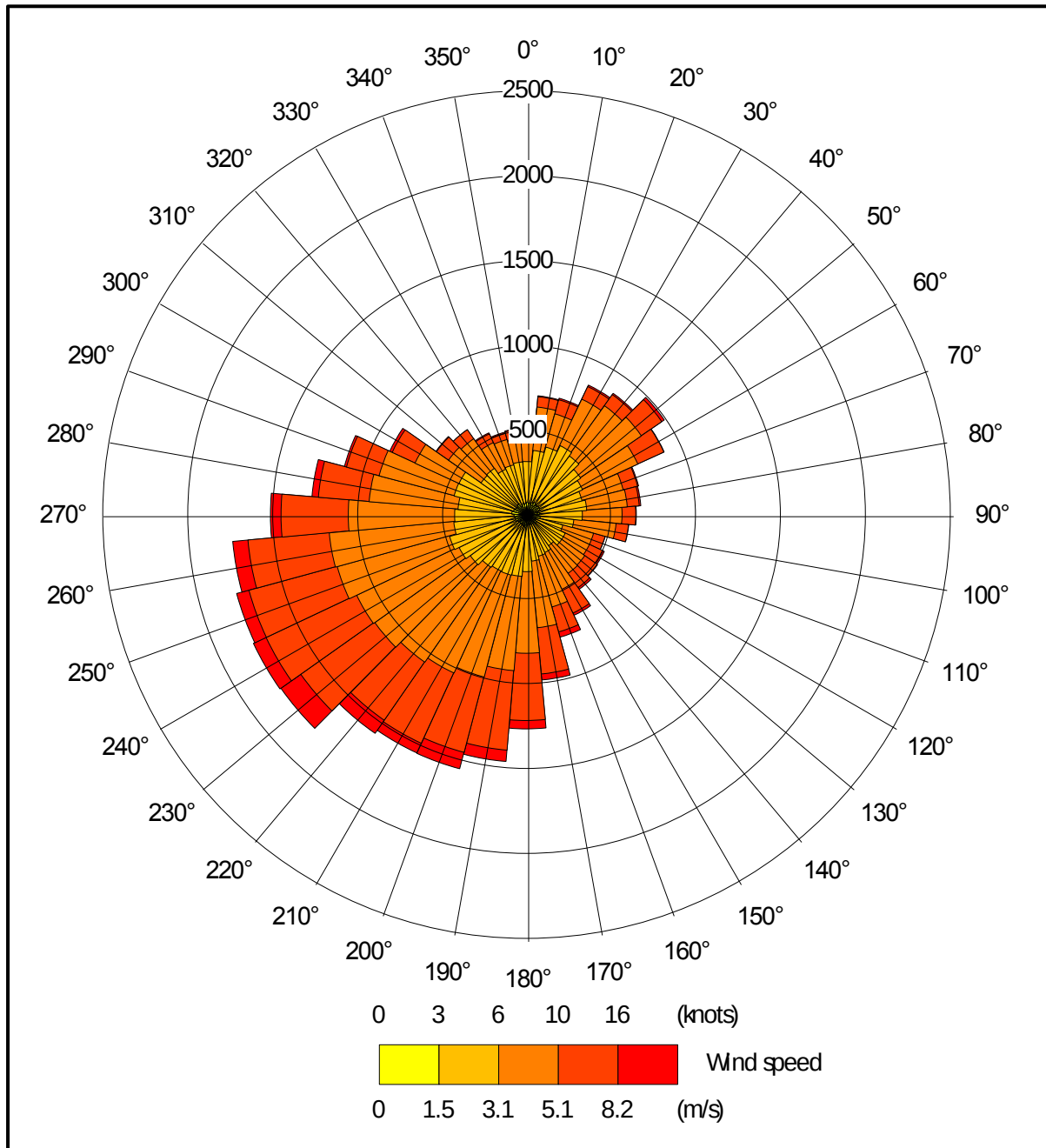
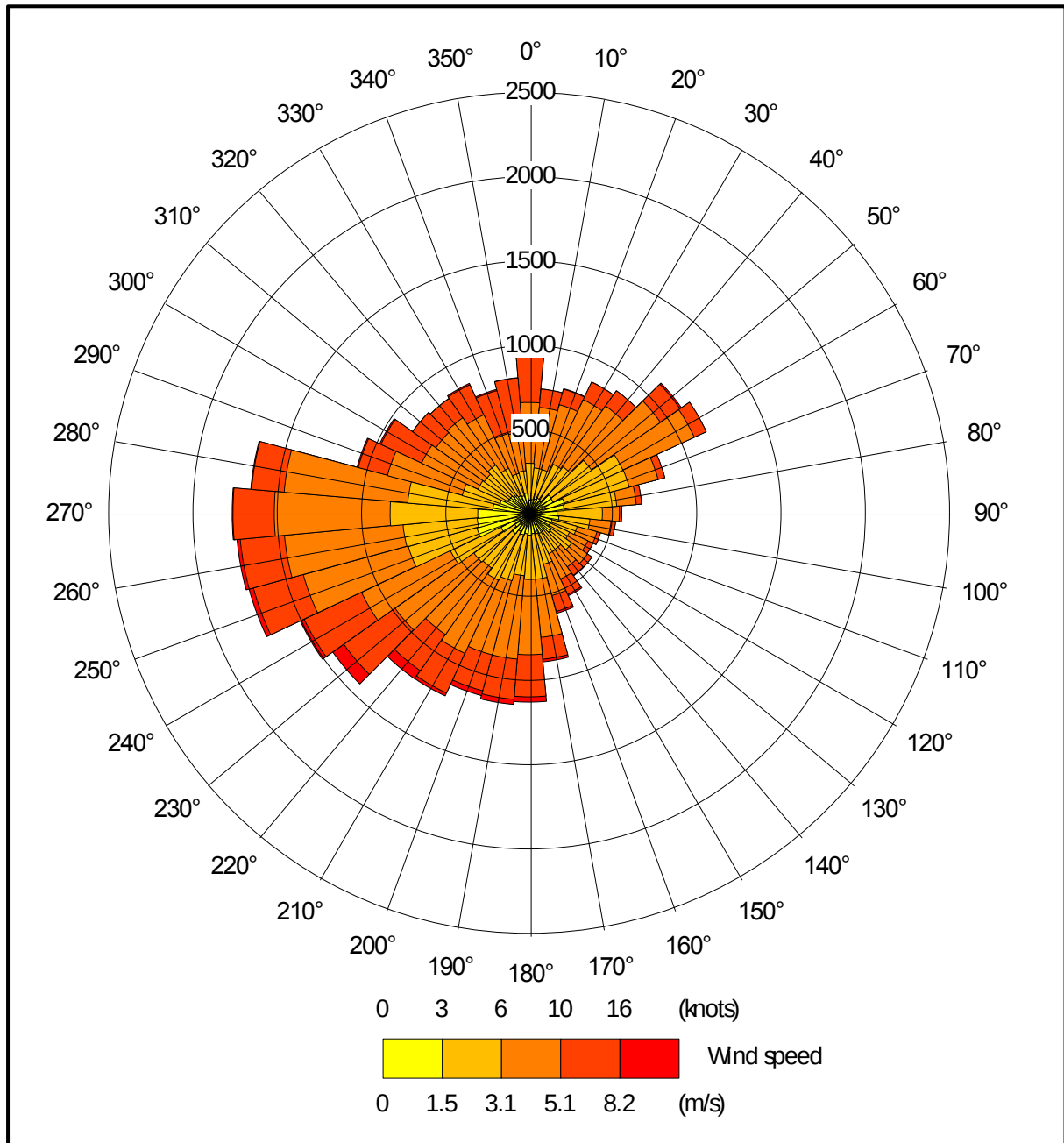


Figure 3c. The wind rose. FLOWSTAR modified GFS derived data, for 51.634 N, 2.775 W, 2011 – 2014



4.2 Emission sources

Emissions from the chimneys of the uncapped high speed ridge fans that would be used to ventilate the poultry houses 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 where they are marked by red star symbols.

The poultry houses at Coombe Farm would also be fitted with gable end fans which would be used to provide supplementary ventilation in hot weather. Emissions from the gable end fans are represented by a single volume source per house within ADMS. The volume sources are assumed to emit 50% of the total emission only when the ambient temperature equals, or exceeds, 21 Celsius. When the volume sources are emitting, the emissions from the point sources are reduced by 50%. Details of the volume source parameters are shown in Table 3b. The position of these volume sources may also 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)
PR1 to PR4 a, b & c	6.8	0.8	11.3	Variable ¹	0.017957 ²

1. Dependant on ambient temperature.
2. Reduced by 50% when ambient temperature equals or exceeds 20 Celsius.

Table 3b. 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)
PR1_gab to PR4_gab	25.0	5.0	3.0	0.0	Ambient	0.026935 ³

3. 50% of total emission only emitted when ambient temperature equals or exceeds 20 Celsius.

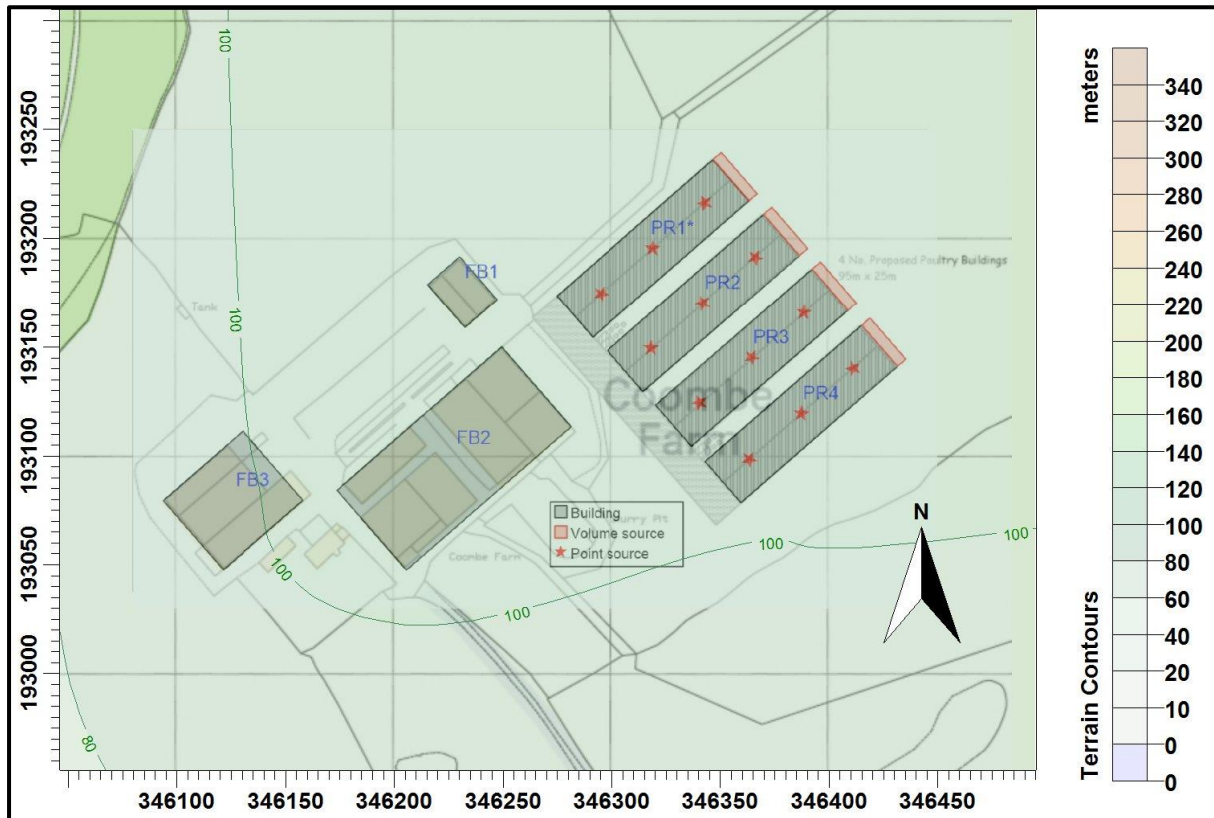
4.3 Modelled buildings

The structure of the poultry houses and other farm buildings 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

Sixty-nine discrete receptors have been defined: thirty-two at the AWs/LWSs (1 to 32); twenty-four at the SSSIs (33 to 56) and thirteen at the SACs (57 to 69). 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.

Figure 3. The positions of modelled buildings & sources



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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.

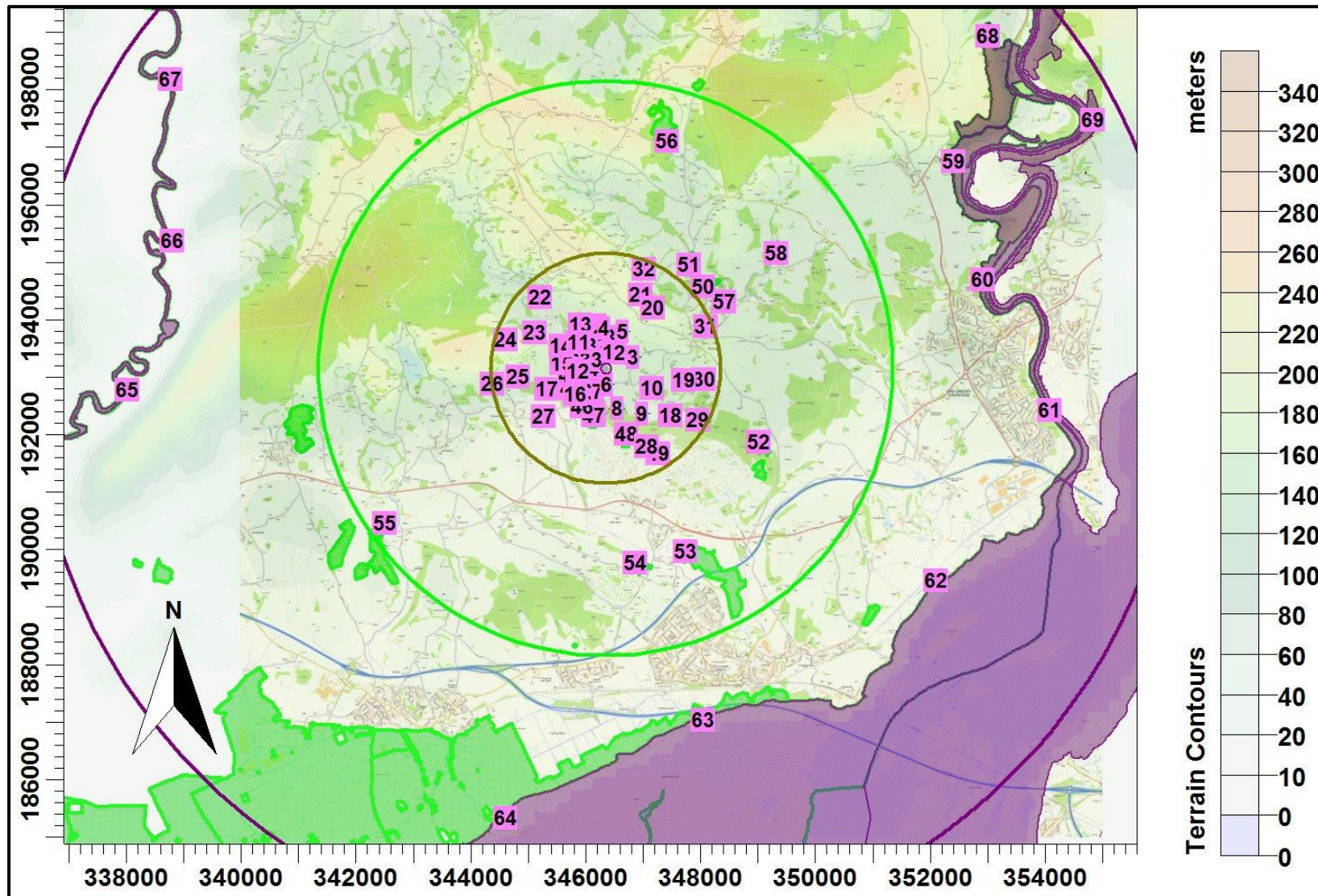
4.6 Terrain data

Terrain has been considered in the modelling. The terrain data are based upon the Ordnance Survey 50 m Digital Elevation Model. A 20 km x 20 km domain has been resampled at 100 m horizontal resolution for use within ADMS. 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

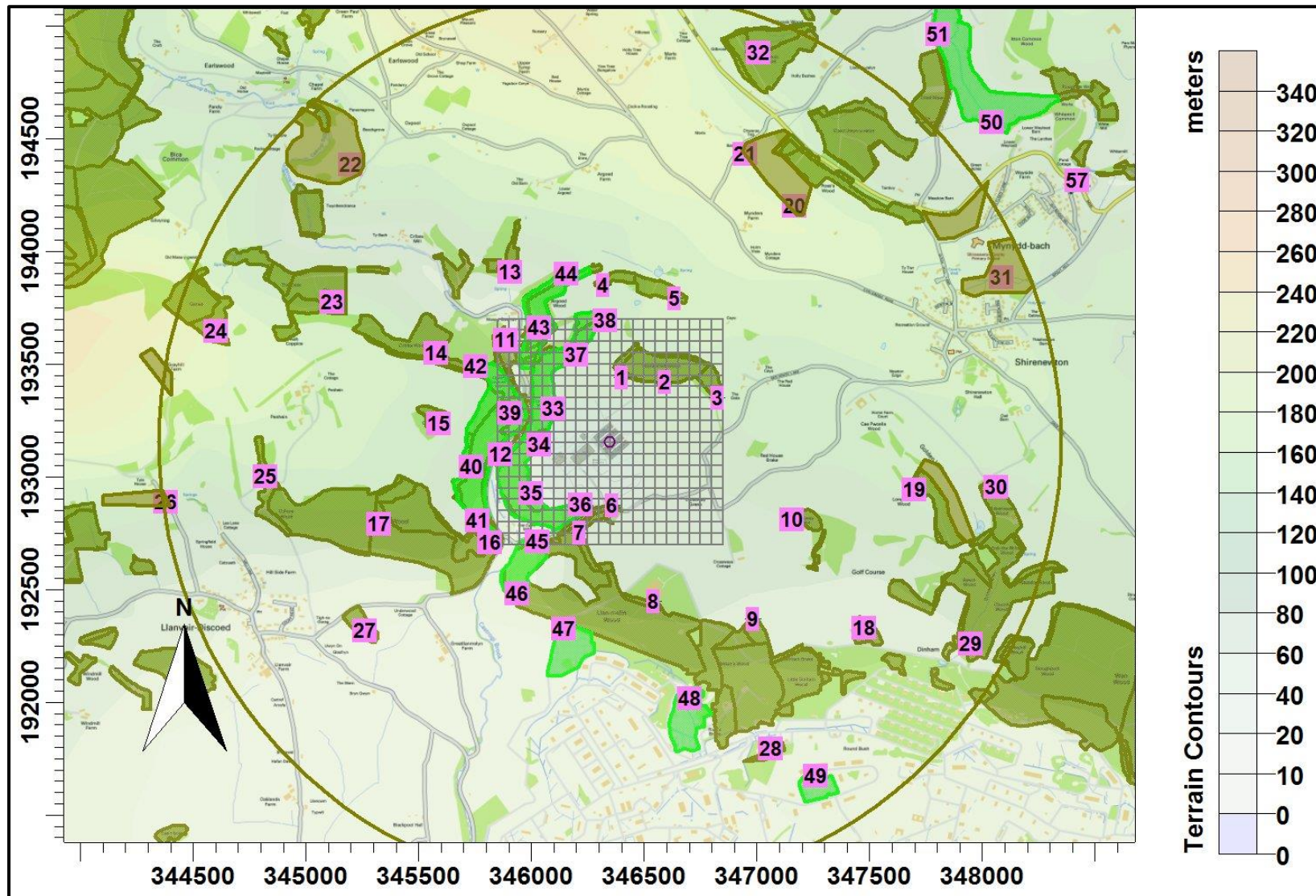
A fixed surface roughness length of 0.5 m has been applied over the entire modelling domain. As a precautionary measure, the GFS meteorological data is assumed to have a roughness length of 0.25 m. The effect of the difference in roughness length is precautionary as it increases the frequency of low wind speeds and the stability and therefore increases predicted ground level concentrations.

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



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Figure 4b. The closer discrete receptors and regular Cartesian grid



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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 to compensate for possible saturation effects due to fertilizer/manure application and to allow for periods when fields are clear of crops (Sutton *et al*). The deposition velocity is also set to 0.002 m/s where grid points are over the poultry houses.

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.

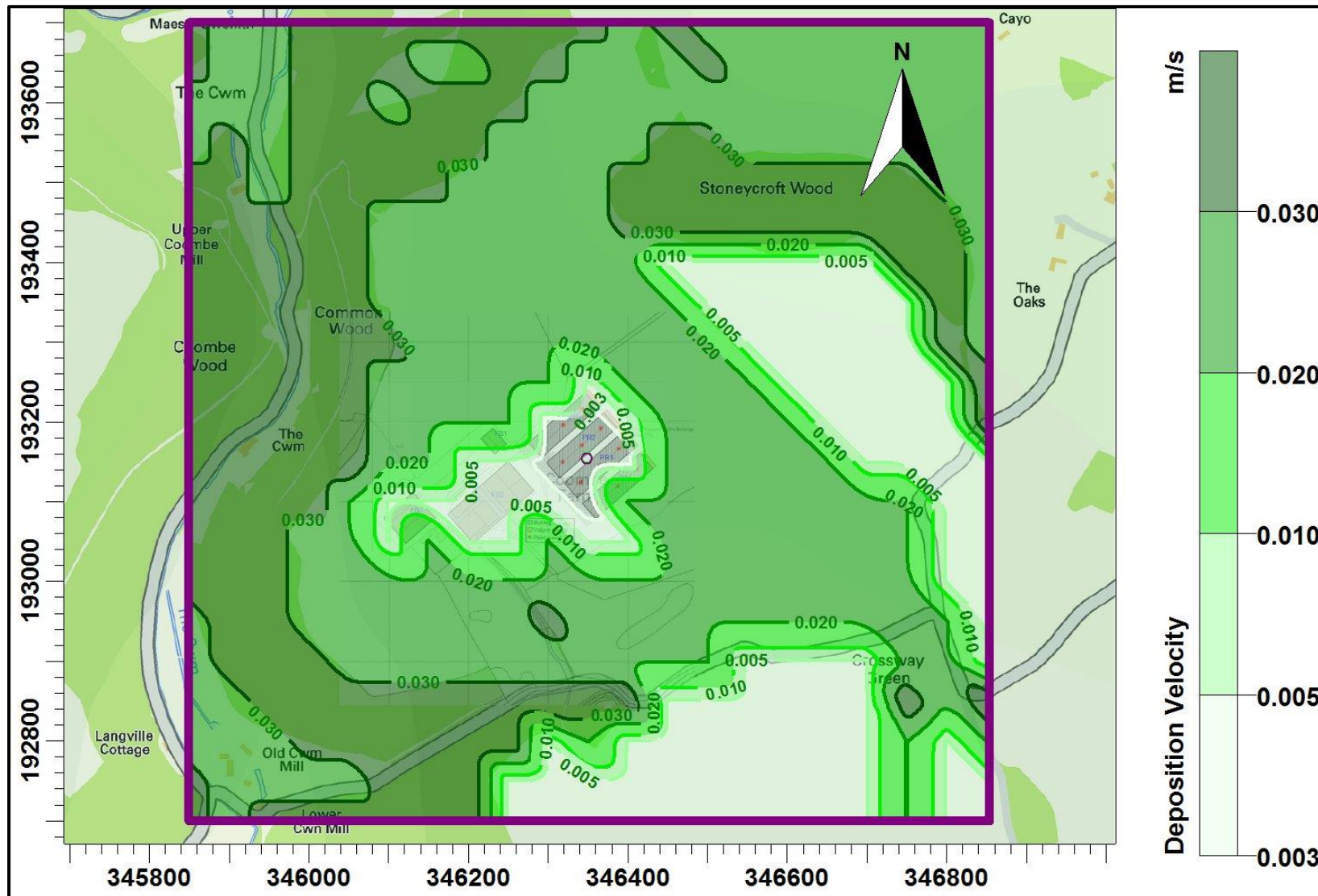
Table 4. Deposition velocities

NH3 concentration (PC + background) ($\mu\text{g}/\text{m}^3$)	< 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 (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



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5. Details of the Model Runs and Results

5.1 Preliminary modelling

ADMS was run a total of twenty times, once for each year of the meteorological record in five 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 velocity of 0.03 m/s – GFS data.
- In basic mode without calms, or terrain – Filton 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 6. In the Table, predicted ammonia concentrations, or concentrations that equate to nitrogen deposition rates that are in excess of that which may not be considered acceptable (20% of Critical Level or Load for a SAC, 50% 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 that equate to deposition rates in the range between what is considered insignificant and what may not be considered acceptable (4% to 20% of Critical Level or Load for a SAC, 20% to 50% for a SSSI and 50% to 100% for other non-statutory wildlife sites) are coloured blue. For convenience, cells referring to AWs/LWSs are shaded in olive, those referring to SSSIs are shaded in green and those referring to SACs are shaded purple. A table showing equivalent ammonia concentrations is shown in Table 5 below.

Table 5. Equivalent ammonia concentrations

Deposition Velocity (m/s)	Concentration equivalent to X % of Critical Load of 10 kg/ha ($\mu\text{g}/\text{m}^3$)			
	100%	50%	20%	4%
0.03	1.284	0.642	0.257	0.051
0.02	1.925	0.963	0.385	0.077

Table 6. Predicted maximum annual mean ammonia concentration rate at the discrete receptors

Receptor number	X(m)	Y(m)	Maximum annual mean ammonia concentration ($\mu\text{g}/\text{m}^3$)				
			GFS No Calms No terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS No Calms Terrain Fixed Depo	Filton No Calms No Terrain
1	346400	193440	1.092	1.079	0.851	0.808	0.828
2	346589	193420	0.877	0.866	0.786	0.750	0.809
3	346824	193350	0.517	0.508	0.587	0.545	0.639
4	346319	193849	0.220	0.218	0.163	0.150	0.157
5	346635	193791	0.279	0.276	0.185	0.166	0.220
6	346358	192872	0.642	0.638	0.563	0.541	0.463
7	346213	192751	0.339	0.337	0.262	0.251	0.352
8	346540	192447	0.137	0.137	0.119	0.112	0.099
9	346982	192369	0.088	0.088	0.100	0.090	0.066
10	347154	192808	0.145	0.143	0.118	0.108	0.126
11	345885	193605	0.131	0.131	0.141	0.130	0.112
12	345862	193099	0.252	0.248	0.192	0.176	0.245
13	345906	193909	0.096	0.096	0.087	0.078	0.095
14	345578	193548	0.073	0.072	0.076	0.067	0.069
15	345588	193237	0.113	0.112	0.090	0.075	0.103
16	345814	192707	0.197	0.195	0.197	0.185	0.188
17	345325	192791	0.089	0.088	0.062	0.055	0.098
18	347475	192329	0.065	0.064	0.071	0.060	0.055
19	347698	192943	0.088	0.086	0.067	0.059	0.083
20	347166	194199	0.101	0.100	0.080	0.070	0.086
21	346946	194429	0.093	0.092	0.067	0.056	0.073
22	345199	194384	0.030	0.030	0.033	0.028	0.029
23	345116	193776	0.039	0.039	0.039	0.030	0.038
24	344599	193647	0.032	0.032	0.016	0.012	0.033
25	344819	193002	0.054	0.053	0.021	0.018	0.046
26	344379	192888	0.039	0.039	0.014	0.012	0.035
27	345260	192318	0.078	0.076	0.070	0.064	0.074
28	347060	191794	0.047	0.047	0.057	0.051	0.044
29	347949	192257	0.050	0.049	0.038	0.033	0.051
30	348062	192956	0.064	0.063	0.046	0.039	0.067
31	348085	193883	0.065	0.064	0.087	0.074	0.093
32	347007	194878	0.062	0.061	0.050	0.041	0.046

Table 6. (continued)

Receptor number	X(m)	Y(m)	Maximum annual mean ammonia concentration ($\mu\text{g}/\text{m}^3$)				
			GFS No Calms No terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS No Calms Terrain Fixed Depo	Filton No Calms No Terrain
33	346098	193300	0.427	0.424	0.476	0.450	0.363
34	346034	193141	0.448	0.446	0.405	0.382	0.452
35	345999	192925	0.412	0.408	0.419	0.395	0.422
36	346218	192875	0.571	0.566	0.448	0.433	0.601
37	346199	193539	0.412	0.408	0.359	0.339	0.351
38	346326	193691	0.343	0.339	0.262	0.245	0.250
39	345907	193281	0.201	0.202	0.200	0.181	0.193
40	345732	193043	0.184	0.181	0.130	0.118	0.181
41	345761	192805	0.190	0.188	0.194	0.179	0.198
42	345751	193488	0.106	0.105	0.114	0.103	0.095
43	346034	193659	0.179	0.179	0.172	0.160	0.167
44	346155	193898	0.158	0.157	0.124	0.112	0.135
45	346028	192712	0.264	0.259	0.229	0.219	0.271
46	345936	192480	0.150	0.148	0.123	0.116	0.161
47	346144	192324	0.118	0.117	0.108	0.101	0.109
48	346702	192016	0.067	0.067	0.062	0.057	0.054
49	347260	191673	0.040	0.039	0.051	0.045	0.038
50	348039	194569	0.052	0.052	0.064	0.052	0.049
51	347803	194963	0.043	0.042	0.046	0.037	0.038
52	349010	191875	0.028	0.027	0.019	0.015	0.033
53	347739	189961	0.015	0.016	0.016	0.013	0.018
54	346854	189768	0.017	0.017	0.018	0.015	0.015
55	342494	190459	0.015	0.015	0.011	0.009	0.016
56	347417	197104	0.019	0.019	0.013	0.010	0.013
57	348419	194312	0.048	0.048	0.069	0.056	0.059
58	349316	195162	0.027	0.026	0.033	0.023	0.029
59	352402	196754	0.010	0.010	0.012	0.008	0.013
60	352910	194691	0.010	0.010	0.012	0.009	0.019
61	354076	192419	0.008	0.008	0.007	0.005	0.011
62	352103	189460	0.008	0.008	0.008	0.005	0.011
63	348038	187038	0.007	0.007	0.007	0.005	0.008
64	344600	185334	0.005	0.005	0.005	0.004	0.006
65	338023	192778	0.006	0.006	0.004	0.002	0.007
66	338800	195379	0.005	0.005	0.002	0.002	0.007
67	338770	198189	0.004	0.004	0.002	0.001	0.005
68	353000	198937	0.007	0.007	0.004	0.003	0.007
69	354824	197472	0.007	0.007	0.008	0.005	0.010

5.2 Detailed deposition modelling

The detailed deposition modelling was carried out over a domain covering the poultry units and closer parts of Coombe Valley Woodland SSSI and Stoneycroft Wood AW, where the preliminary modelling indicated that annual mean ammonia concentrations (or concentrations equivalent to nitrogen deposition rates) would potentially exceed 20% (SSSIs) and 50% (AWs) of the relevant Critical Level or Critical Load. At all other receptors annual mean ammonia concentrations, or concentrations equivalent to nitrogen deposition rates, were predicted to be at levels that would be deemed insignificant for permitting purposes in the preliminary modelling. N.B. Receptors 57 and 58 are at SAC sites designated for features other than flora.

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.

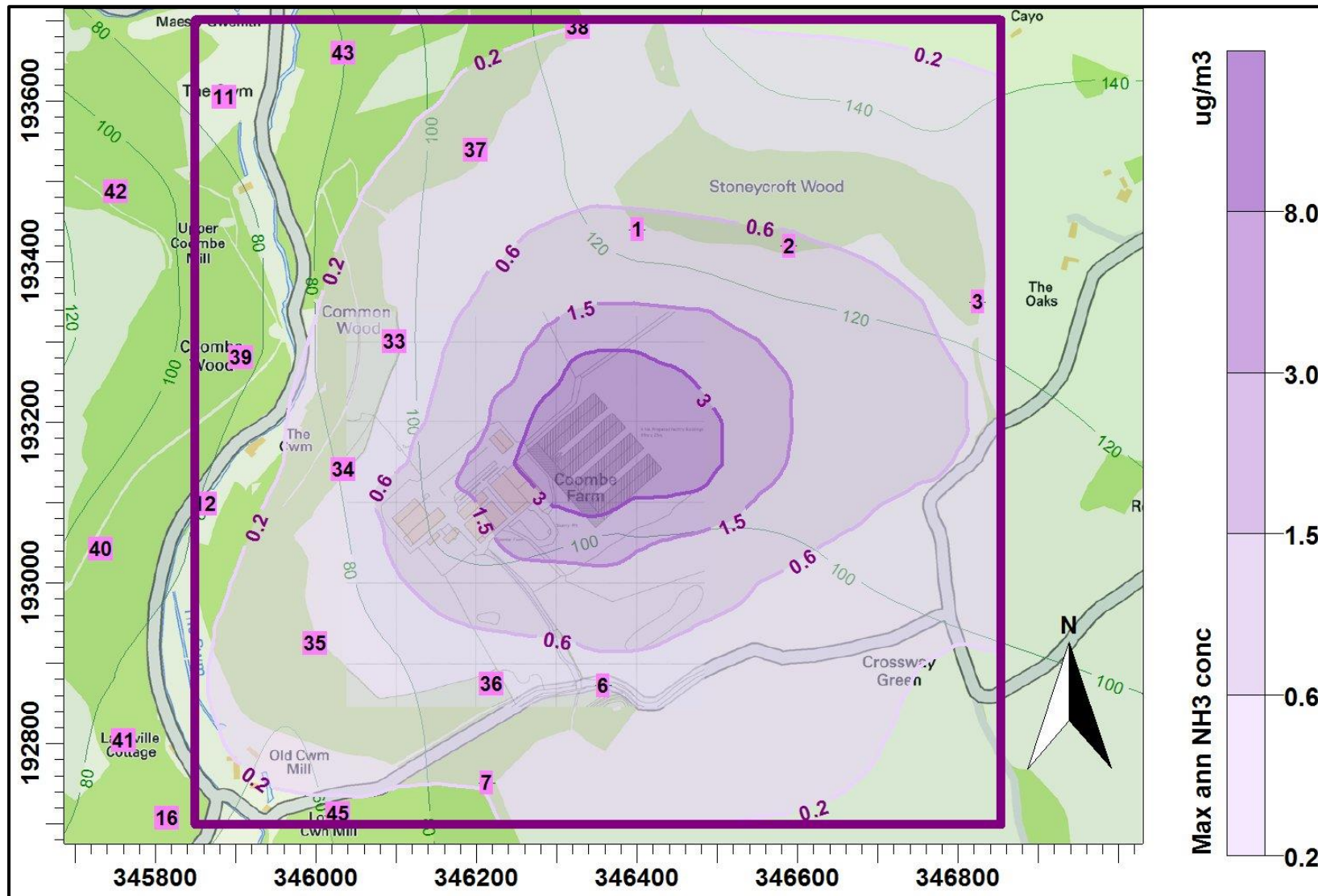
The results of the detailed deposition modelling are shown in Table 7. In this Table, predicted ammonia concentrations and nitrogen deposition rates that are in excess of that which may not be considered acceptable (50% of Critical Level or Load for a SSSI and 100% of Critical Level or Load for a non-statutory wildlife site) are coloured red. Concentrations in the range between what is considered insignificant and what may not be considered acceptable (20% to 50% of Critical Level or Load for a SSSI and 50% to 100% for a non-statutory wildlife site) are coloured blue. The abbreviations PC, Cle and Clo, used in the table, mean Process Contribution, Critical Level and Critical Load, respectively.

Contour plots of the predicted maximum annual ammonia concentrations and nitrogen deposition rates are shown in Figures 6a and 6b.

Table 7. Annual ammonia concentration and nitrogen deposition rate at the discrete receptors

Receptor number	X (m)	Y (m)	Ammonia Concentration			Nitrogen Deposition				Acid Deposition		
			Maximum annual PC ($\mu\text{g}/\text{m}^3$)	Cle ($\mu\text{g}/\text{m}^3$)	%age of Cle	Maximum annual PC (kg/ha)	Deposition Velocity (m/s)	Clo (kg/ha/y)	%age of Clo	Maximum annual PC (keq/ha)	Clo (keq/ha/y)	%age of Clo
1	346400	193440	0.697	3.0	23.2	5.430	0.03	10.0	54.3	0.388	1.781	21.8
2	346589	193420	0.698	3.0	23.3	5.442	0.03	10.0	54.4	0.389	1.781	21.8
3	346824	193350	0.439	3.0	14.6	3.421	0.03	10.0	34.2	0.244	1.781	13.7
7	346213	192751	0.206	3.0	6.9	1.607	0.03	10.0	16.1	0.115	1.781	6.4
11	345885	193605	0.100	3.0	3.3	0.782	0.03	10.0	7.8	0.056	1.781	3.1
12	345862	193099	0.137	3.0	4.6	1.066	0.03	10.0	10.7	0.076	1.781	4.3
33	346098	193300	0.360	3.0	12.0	2.808	0.03	10.0	28.1	0.201	1.781	11.3
34	346034	193141	0.312	3.0	10.4	2.434	0.03	10.0	24.3	0.174	1.781	9.8
35	345999	192925	0.335	3.0	11.2	2.607	0.03	10.0	26.1	0.186	1.781	10.5
36	346218	192875	0.367	3.0	12.2	2.858	0.03	10.0	28.6	0.204	1.781	11.5
37	346199	193539	0.282	3.0	9.4	2.194	0.03	10.0	21.9	0.157	1.781	8.8
38	346326	193691	0.200	3.0	6.7	1.556	0.03	10.0	15.6	0.111	1.781	6.2
39	345907	193281	0.141	3.0	4.7	1.098	0.03	10.0	11.0	0.078	1.781	4.4
43	346034	193659	0.122	3.0	4.1	0.952	0.03	10.0	9.5	0.068	1.781	3.8
45	346028	192712	0.179	3.0	6.0	1.398	0.03	10.0	14.0	0.100	1.781	5.6

Figure 6a. Maximum annual mean ammonia concentration



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The map displays the predicted maximum annual nitrogen deposition (kg/ha) around Coombe Farm. The color scale ranges from 1.0 kg/ha (lightest purple) to 20.0 kg/ha (darkest purple). The highest deposition is concentrated around Coombe Farm, reaching up to 20 kg/ha. The map also shows surrounding features like Stoneycroft Wood, The Oaks, and various roads and paths. The map is overlaid with a grid of coordinates, with the x-axis ranging from 345800 to 346800 and the y-axis ranging from 192800 to 193600.

6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Gareth Adams to use computer modelling to assess the impact of ammonia emissions from the proposed broiler rearing unit at Coombe Farm, Llanvair Discoed, near Chepstow in Monmouthshire. NP16 6LN.

Ammonia emission rates from the proposed poultry unit 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 the process contribution maximum annual mean ammonia concentrations and acid deposition rates would be at levels usually deemed insignificant for permitting purposes at all receptors considered.

If the Critical Load is taken to be 10 kg/ha, then nitrogen deposition rates are predicted to be in excess of 20% of the Critical Load over a small part of Coombe Valley Woodlands SSSI (approximately 3.8 ha) and 50% of the Critical Load over a small part of Stoneycroft Wood AW (approximately 0.2 ha). Note that the area has calcareous soils and therefore higher Critical Loads may be applicable; if this were the case, then the process contributions to nitrogen deposition rates may be below 20% of the Critical Load at the SSSI and 50% of the Critical Load at the AW. The nitrogen deposition rates are predicted to be at levels usually deemed insignificant for permitting purposes at all other receptors considered.

7. References

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