A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Proposed Pullet Rearing House at Old Impton Farm, near Norton in Powys

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Geraint Davies of Roger Parry & Partners LLP, on behalf of the applicant Mr. Richard Wilding, to use computer modelling to assess the impact of ammonia emissions from the proposed pullet rearing house at Old Impton Farm, Norton, Powys. LD8 2EG.

Ammonia emission rates from the proposed poultry house 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 pullet rearing house at Old Impton Farm is in a rural area, approximately 1 km to the west of Norton in Powys. The surrounding land is used predominantly for livestock and arable farming, although there are some wooded areas. The site is at an altitude of around 297 m with the land rising to Hawthorn Hill to the north-north-west and falling towards the River Lugg Valley to the south-south-east.

It is proposed that one pullet chicken rearing house be constructed at Old Impton Farm. The proposed poultry house would provide accommodation for up to 37,000 pullets. The pullets would be reared from day old chicks up to approximately 16 weeks old, prior to being transferred to egg laying units elsewhere. The poultry house would be ventilated using uncapped high velocity ridge or roof fans with side inlets and spent litter and manure would be removed from the house at the end of each flock cycle.

There are several areas of Ancient Woodlands (AWs) within 2 km of the site of the proposed poultry houses at Old Impton Farm. There are two Sites of Special Scientific Interest (SSSIs), within 5 km of the site. Some further details of the SSSIs are provided below:

- River Lugg SSSI - closest point, approximately 1.6 km to the south.
- Gwernaffel Dingle SSSI - approximately 3.6 km to the north-north-west.

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

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

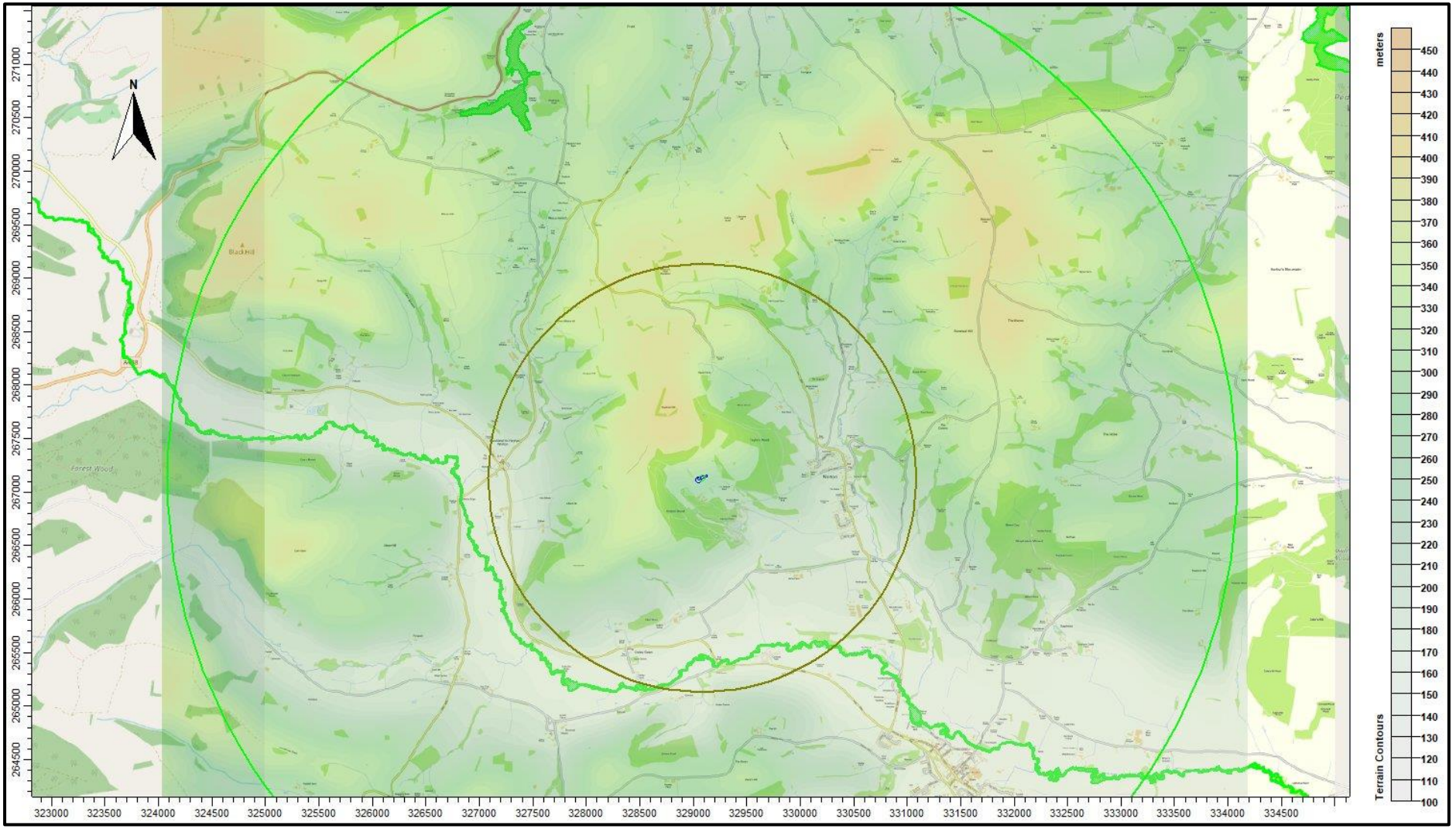
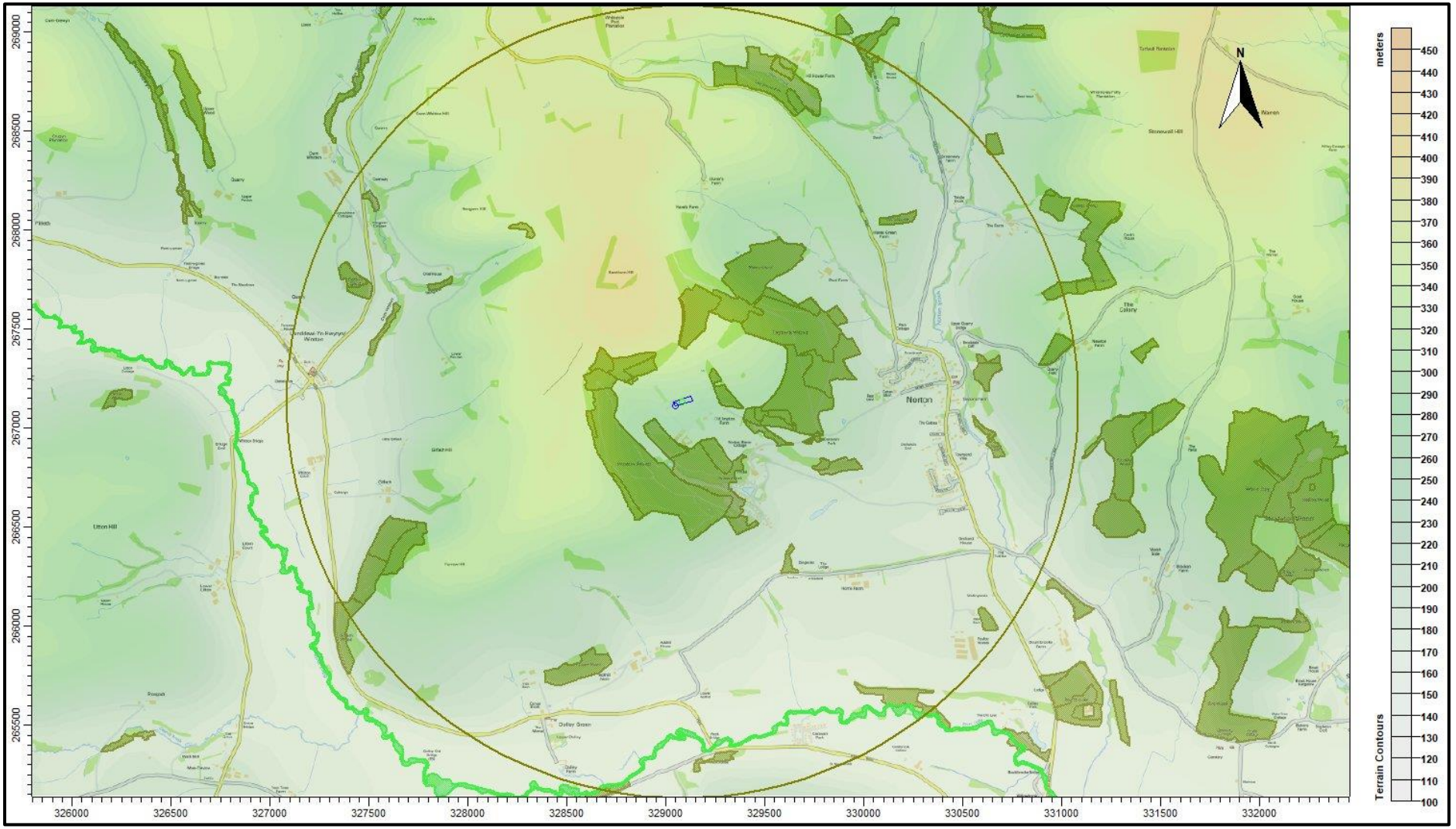


Figure 1b. The area surrounding the site – a closer view showing the AWs



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

3.1 Ammonia concentration and nitrogen and acid deposition

When assessing potential impact on ecological receptors, ammonia concentration is usually expressed in terms of micrograms of ammonia per metre cubed of air (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 the site of the proposed poultry unit and the wildlife sites is 1.58 µg-NH_3/m^3. The background nitrogen deposition rate to woodland is 31.08 kg-N/ha/y and to short vegetation is 19.32 kg-N/ha/y. The background acid deposition rate to woodland is 2.33 keq/ha/y and to short vegetation is 1.48 keq/ha/y. The source of these background figures is the Air Pollution Information System (APIS, May 2018).

3.3 Critical Levels & Critical Loads

Critical Levels and Critical Loads are a benchmark for assessing the risk of air pollution impacts to ecosystems. It is important to distinguish between a Critical Level and a Critical Load. The Critical Level is the gaseous concentration of a pollutant in the air, whereas the Critical Load relates to the quantity of pollutant deposited from air to the ground.

Critical Levels are defined as, "concentrations of pollutants in the atmosphere above which direct adverse effects on receptors, such as human beings, plants, ecosystems or materials, may occur according to present knowledge" (UNECE).

Critical Loads are defined as, "a quantitative estimate of exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge" (UNECE).

For ammonia concentration in air, the Critical Level for higher plants is 3.0 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]	-	-
River Lugg SSSI	1.0 [1 & 2]	10.0 [2]	-
Gwernaffel Dingle SSSI	1.0 [1 & 2]	10.0 [2]	-

1. A precautionary figure used where no details of the ecology of the site are available, or the citation for the site contains reference to sensitive lichens and/or bryophytes.
2. Based on the citation for the site and information obtained from the APIS website (May 2018).

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 8% of the designated site Critical Level or Load it is necessary to consider background concentrations and whether the designated site Critical Level or Load is breached and whether additional controls may be necessary. The application will then be determined based on whether there will be significant environmental effect/adverse effect/damage to scientific interest.

For Local Nature Reserves (LNRs), Local Wildlife Sites (LWSs) and Ancient Woodlands (AWs), the current assessment procedure usually applied is based on the Environment Agency's horizontal guidance, H1 Environmental Risks Assessment, H1 Annex B - Intensive Farming. The following are taken from this document.

"An emission is insignificant where Process Contribution (PC) is <50% for local and national nature reserves (LNRs & NNRs), ancient woodland and local wildlife sites." And "Where modelling predicts a process contribution >100% at a NNR, LNR, ancient woodland or local wildlife site, your proposal may not be considered acceptable. In such cases, your assessment should include proposals to reduce ammonia emissions."

This document was withdrawn February 1st 2016 and replaced with a web-page titled "Intensive farming risk assessment for your environmental permit", which contains essentially the same criteria. It is assumed that the upper threshold and lower threshold on the web-page refers to the levels that were previously referred to as levels of insignificance and acceptability in Annex B– Intensive Farming.

Within the range between the lower and upper thresholds, whether or not the impact is deemed acceptable is at the discretion of the Environment Agency. N.B. In the case of LWSs and AWs, the Environment Agency do not usually consider other farms that may act in-combination and therefore a PC of up to 100% of Critical Level or Critical Load is usually deemed acceptable for permitting purposes and therefore the upper and lower thresholds are the same (100%).

3.4.2 Environment Agency criteria

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." And, "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.

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%).

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

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

3.6 Quantification of ammonia emissions

Ammonia emission rates from poultry houses, ranging areas and manure spreading depend on many factors and are likely to be highly variable. However, the benchmarks for assessing impacts of ammonia and nitrogen deposition are framed in terms of an annual mean ammonia concentration and annual nitrogen deposition rates. To obtain relatively robust figures for these statistics it is not necessary to model short term temporal variations and a steady continuous emission rate can be assumed. In fact, modelling short term temporal variations might introduce rather more uncertainty than modelling continuous emissions.

The Environment Agency provides an Intensive Farming guidance note which lists standard ammonia emission factors for a variety of livestock, including poultry. For rearing pullet chickens, the Environment Agency figure is 0.06 kg-NH_3/bird place/year. Details of the poultry numbers and types, the emission factors used and the 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)
Housing	37,000	Pullets (rearing)	0.06	0.070348

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). There are no nearby traditional observation meteorological datasets that could be considered representative of the area around Old Impton Farm, or that could be considered as suitable for use as driving data for modelling terrain flow.

The GFS is a spectral model and data are archived at a horizontal resolution of 0.25 degrees, which is approximately 25 km over the UK (formerly 0.5 degrees, or approximately 50 km). The GFS resolution adequately captures major topographical features and the broad-scale characteristics of the weather over the UK. Smaller scale topological features may be included in the dispersion modelling by using the flow field module of ADMS (FLOWSTAR). The use of NWP data has advantages over traditional meteorological records because:

- Calm periods in traditional observational records may be over represented, this is because the instrumentation used may not record wind speeds below approximately 0.5 m/s and start up wind speeds may be greater than 1.0 m/s. In NWP data, the wind speed is continuous down to 0.0 m/s, allowing the calms module of ADMS to function correctly.

- Traditional records may include very local deviations from the broad-scale wind flow that would not necessarily be representative of the site being modelled; these deviations are difficult to identify and remove from a meteorological record. Conversely, local effects at the site being modelled are relatively easy to impose on the broad-scale flow and provided horizontal resolution is not too great, the meteorological records from NWP data may be expected to represent well the broad-scale flow.

- Information on the state of the atmosphere above ground level which would otherwise be estimated by the meteorological pre-processor may be included explicitly.

The wind rose for the raw GFS data is shown in Figure 2a.

Wind speeds are modified by the treatment of roughness lengths (see Section 4.7) and where terrain data is included in the modelling, the raw GFS wind speeds and directions will be modified. The terrain and roughness length modified wind rose for the location at the proposed poultry house at Old Impton Farm is shown in Figure 2b. It should be noted elsewhere in the modelling domain, the modified wind roses may differ markedly, reflecting the local flow in that part of the domain. The resolution of the wind field in terrain runs is approximately 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.

Figure 2a. The wind rose. Raw GFS derived data, for 52.297 N, 3.040 W, 2014-2017

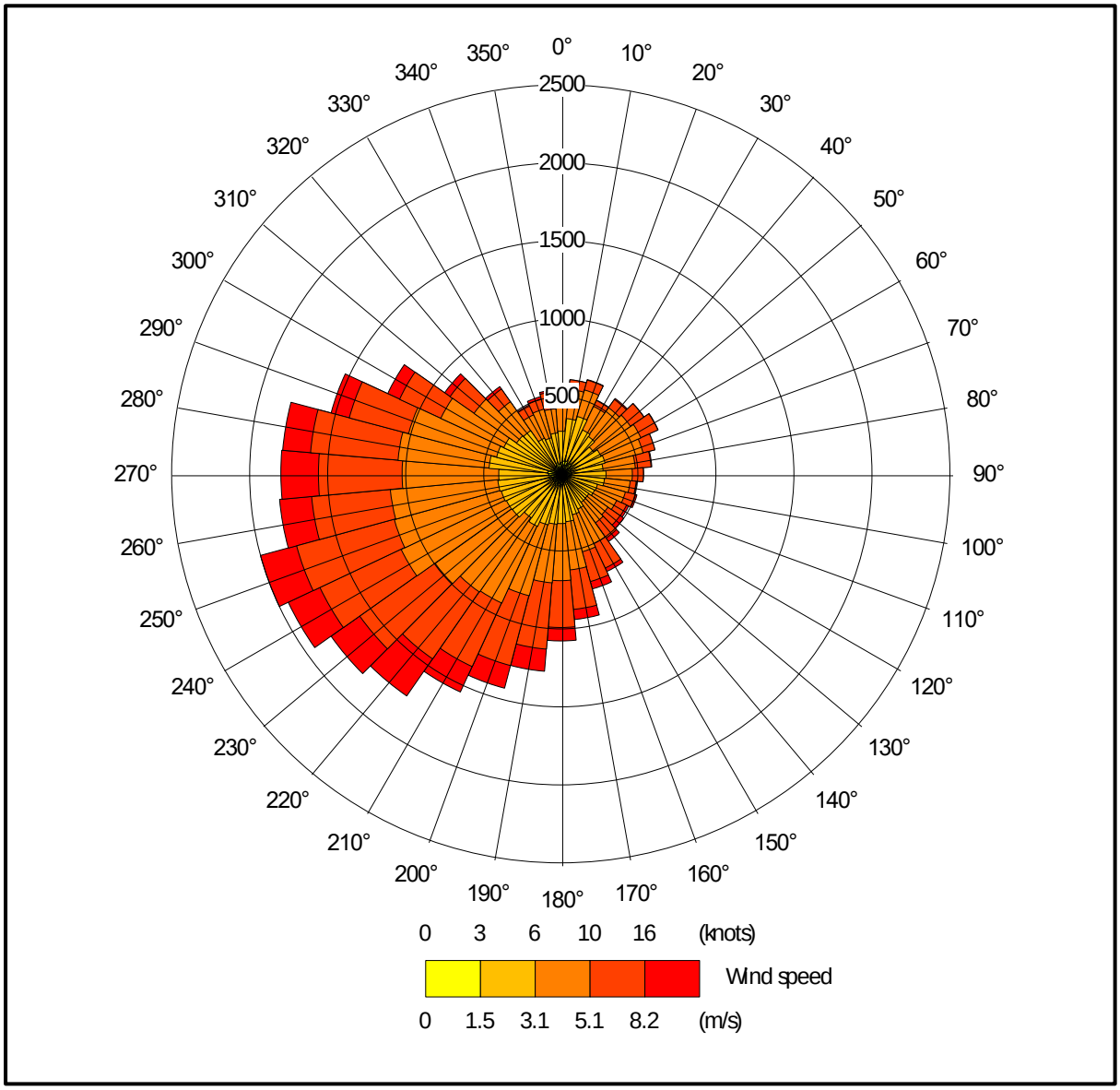
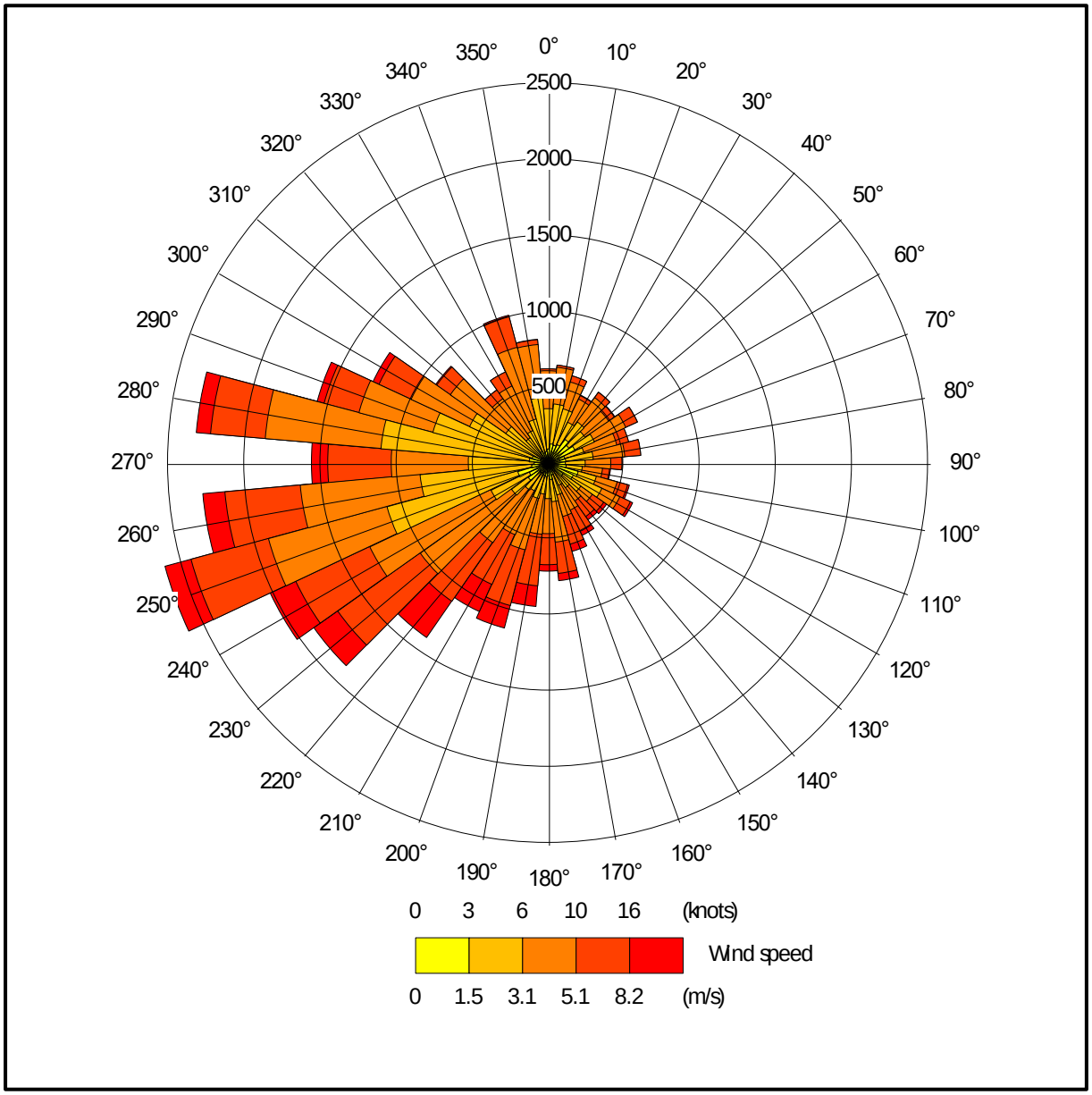


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 329050, 267150



4.2 Emission sources

Emissions from the high speed ridge/roof fans that would be used to ventilate the proposed poultry house are represented by three point sources within ADMS (PR1 a, b & c). Details of the point source parameters are shown in Table 3. The positions of the point sources may be seen in Figure 3, where they are indicated by red star symbols.

Table 3. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (˚C)	Emission rate per source (g-NH_3/s)
PR1 a, b & c	6.5	0.8	11.0	21.0	0.023449

4.3 Modelled buildings

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

4.4 Discrete receptors

Seventy-four discrete receptors have been defined: sixty at the AWs (1 to 60) and fourteen at the SSSIs (61 to 74). 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. In this case, for the closer AWS, twenty-four receptors have also been defined at canopy level (7.5m); these receptors are at the same locations as receptors 1 to 24 and are referred to as receptors 1_C to 24_C.

4.5 Cartesian grids

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 defined at ground level within ADMS. The positions of the Cartesian grid may be seen in Figure 4, where it is marked by grey lines.

4.6 Terrain data

Terrain has been considered in the modelling. The terrain data are based upon the Ordnance Survey 50 m Digital Elevation Model. A 10.0 km x 10.0 km domain has been resampled at 100 m horizontal resolution for use within. 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 0.5 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 0.3 m. The effect of the difference in roughness length is precautionary as it increases the frequency of low wind speeds and stability and therefore increases predicted ground level concentrations.

Figure 3. The positions of the modelled building and sources

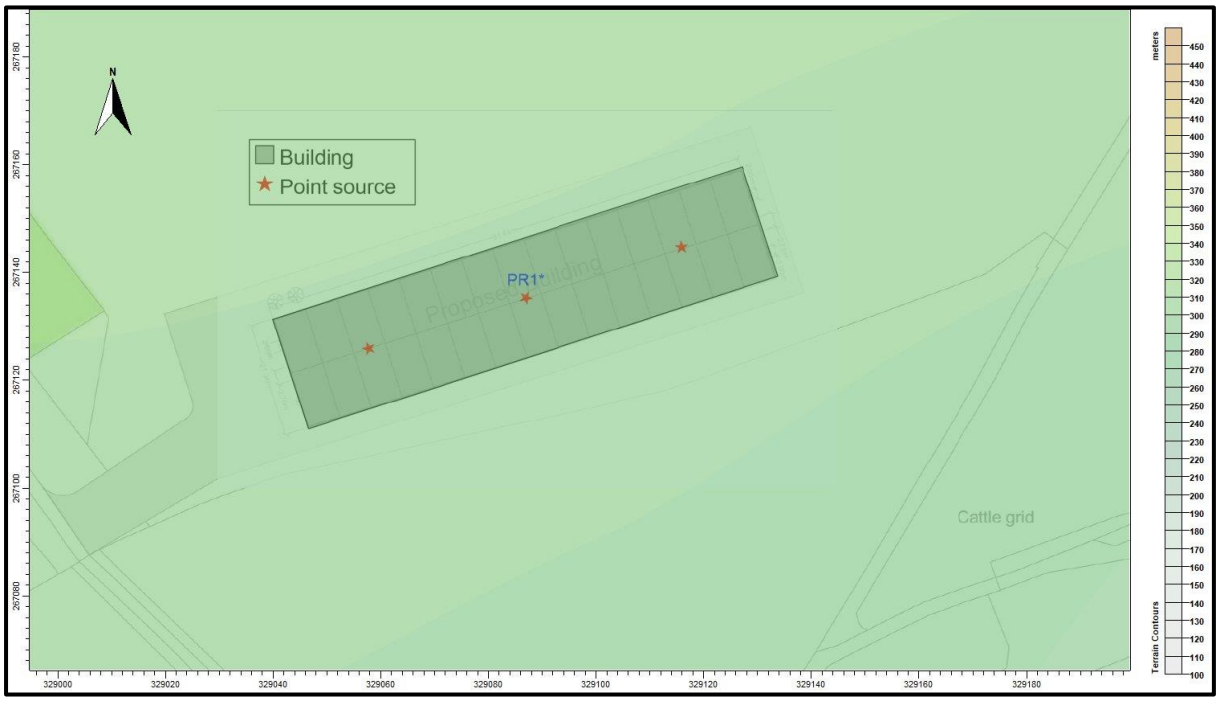


Figure 4a. The discrete receptors – a broad-scale view

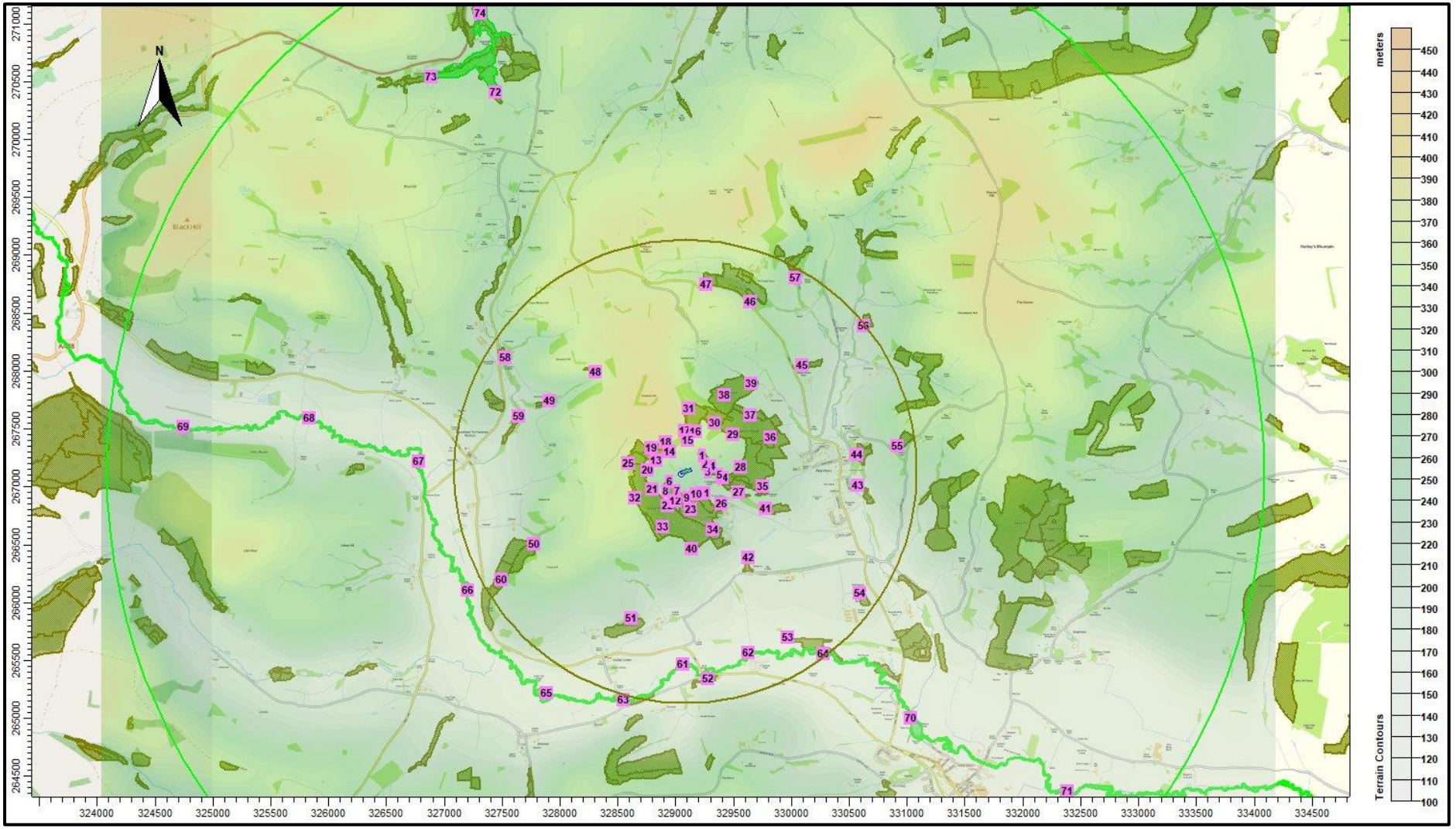
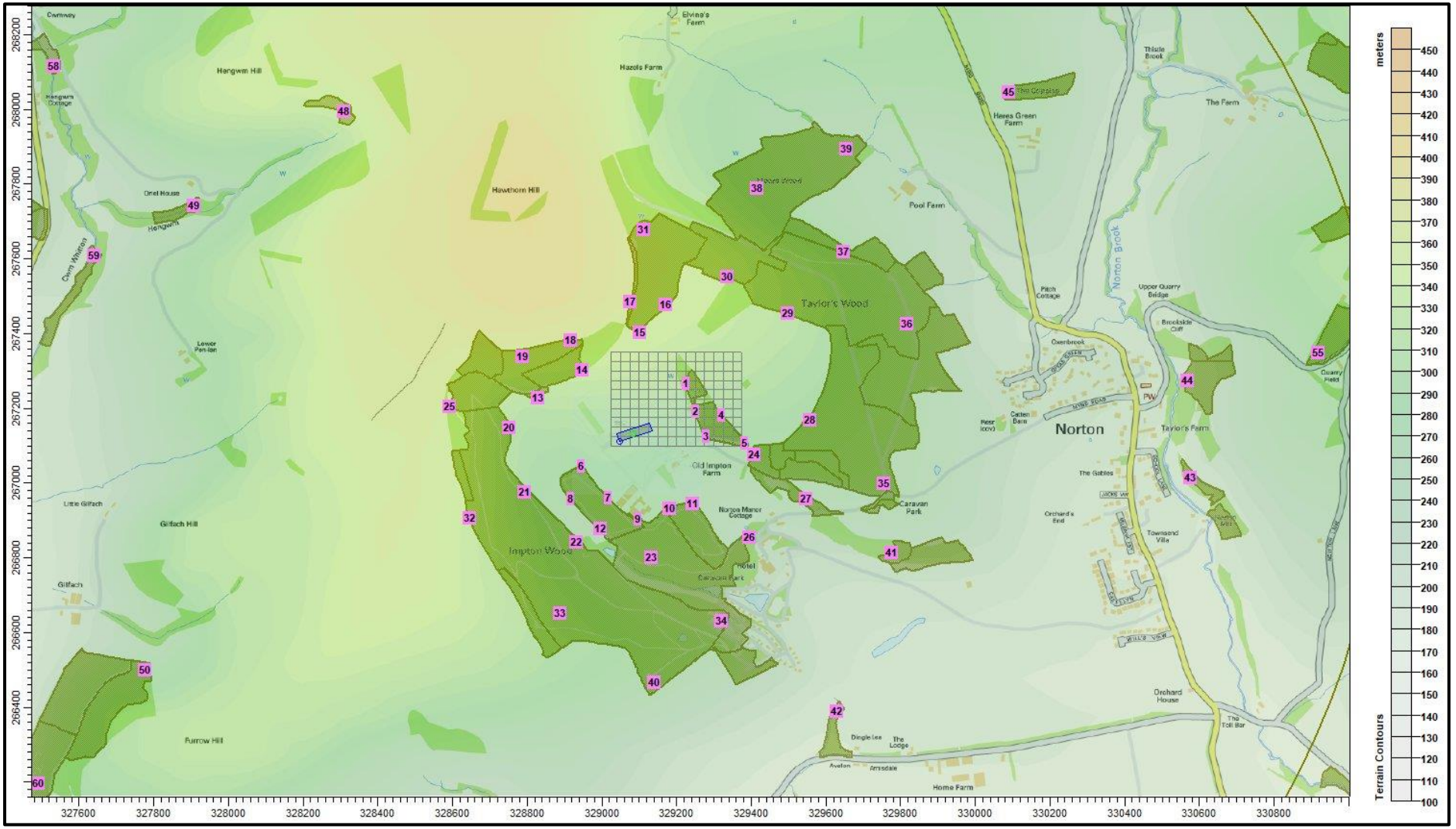


Figure 4b. The discrete receptors and regular Cartesian grid



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. Where deposition over water surfaces is calculated, a deposition velocity of 0.005 m/s is used.

In summary, the method is as follows:

- A preliminary run of the model without deposition is used to provide an ammonia concentration field.
- The preliminary ammonia concentration field, along with land usage, has been used to define a deposition velocity field. The deposition velocities used are provided in Table 4.

Table 4. Deposition velocities

NH3 concentration (PC + background) (µg/m^3)	< 10	10 - 20	20 - 30	30 – 80	> 80
Deposition velocity – woodland (m/s)	0.03	0.015	0.01	0.005	0.003
Deposition velocity – short vegetation (m/s)	0.02 (0.015 over heavily grazed grassland)	0.015	0.01	0.005	0.003
Deposition velocity – arable farmland/rye grass (m/s)	0.005	0.005	0.005	0.005	0.003

- The model is then rerun with the spatially varying deposition module.

A contour plot of the spatially varying deposition field is provided in Figure 5.

In this case, in order to constrain the size of the detailed deposition modelling domain, preliminary runs with a fixed deposition velocity of 0.003 m/s have been made. It should be noted that these results will always be precautionary compared to results obtained if full spatially varying deposition were modelled, especially so at more distant receptors.

Figure 5. The spatially varying deposition field

5. Details of the Model Runs and Results

5.1 Preliminary modelling

ADMS was run a total of sixteen times; once for each year of the meteorological record and in the following four 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 with a fixed deposition velocity of 0.003 m/s – GFS data.

For each mode, statistics for the maximum annual mean ammonia concentration at each receptor were compiled.

Details of the predicted annual mean ammonia concentrations at each receptor are provided in Table 5. In the Table, predicted ammonia concentrations, 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 SPA/SAC/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 SPA/SAC/SSSI and 50%[1] to 100% for an AW) are coloured blue. For convenience, cells referring to the SACs are shaded purple, cells referring to the SSSIs are shaded green and cells referring to the AWs are shaded olive.

1. The Pre-February 2016 figure is retained.

Table 5. 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
1	329226	267267	AW	**0.723**	**0.710**	**0.684**	**0.673**
2	329252	267192	AW	**1.078**	**1.063**	**1.002**	**0.979**
3	329278	267124	AW	**0.886**	**0.874**	**0.691**	**0.674**
4	329320	267180	AW	**0.660**	**0.651**	**0.529**	**0.516**
5	329381	267106	AW	0.440	0.434	0.331	0.319
6	328943	267045	AW	0.434	0.427	0.307	0.299
7	329016	266959	AW	0.270	0.268	0.192	0.187
8	328917	266958	AW	0.227	0.224	0.138	0.132
9	329096	266903	AW	0.178	0.176	0.142	0.137
10	329182	266933	AW	0.190	0.189	0.179	0.174
11	329243	266945	AW	0.238	0.236	0.193	0.187
12	328997	266878	AW	0.169	0.168	0.109	0.104
13	328828	267227	AW	0.149	0.148	0.176	0.161
14	328947	267301	AW	0.235	0.232	0.193	0.185
15	329101	267403	AW	0.329	0.323	0.228	0.222
16	329170	267477	AW	0.244	0.239	0.195	0.189
17	329076	267484	AW	0.199	0.196	0.139	0.134
18	328917	267382	AW	0.147	0.146	0.103	0.099
19	328787	267339	AW	0.103	0.102	0.107	0.096
20	328752	267147	AW	0.118	0.116	0.112	0.107
21	328794	266975	AW	0.147	0.145	0.101	0.098
22	328931	266840	AW	0.123	0.122	0.077	0.073
23	329131	266801	AW	0.097	0.096	0.082	0.079
24	329407	267077	AW	0.372	0.368	0.293	0.280
1_C	329226	267267	AW	**0.711**	**0.701**	**0.662**	**0.653**
2_C	329252	267192	AW	**1.048**	**1.034**	**1.014**	**0.997**
3_C	329278	267124	AW	**0.869**	**0.858**	**0.690**	**0.676**
4_C	329320	267180	AW	**0.649**	**0.640**	**0.528**	**0.517**
5_C	329381	267106	AW	0.444	0.438	0.340	0.329
6_C	328943	267045	AW	0.427	0.421	0.307	0.300
7_C	329016	266959	AW	0.289	0.286	0.196	0.191
8_C	328917	266958	AW	0.228	0.225	0.148	0.141
9_C	329096	266903	AW	0.186	0.184	0.150	0.145
10_C	329182	266933	AW	0.196	0.194	0.192	0.187
11_C	329243	266945	AW	0.247	0.245	0.203	0.197
12_C	328997	266878	AW	0.187	0.185	0.111	0.108
13_C	328828	267227	AW	0.162	0.160	0.190	0.174
14_C	328947	267301	AW	0.239	0.236	0.191	0.184
15_C	329101	267403	AW	0.327	0.321	0.221	0.216
16_C	329170	267477	AW	0.246	0.241	0.190	0.185
17_C	329076	267484	AW	0.201	0.197	0.136	0.132
18_C	328917	267382	AW	0.150	0.148	0.102	0.098
19_C	328787	267339	AW	0.111	0.110	0.113	0.102
20_C	328752	267147	AW	0.134	0.132	0.122	0.114
21_C	328794	266975	AW	0.156	0.154	0.104	0.100
22_C	328931	266840	AW	0.134	0.133	0.083	0.078
23_C	329131	266801	AW	0.105	0.104	0.088	0.085
24_C	329407	267077	AW	0.379	0.375	0.307	0.295

Table 5. (continued)

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
25	328592	267205	AW	0.064	0.064	0.066	0.058
26	329394	266853	AW	0.139	0.137	0.102	0.098
27	329546	266956	AW	0.179	0.177	0.152	0.140
28	329558	267167	AW	0.212	0.210	0.143	0.137
29	329499	267453	AW	0.161	0.159	0.206	0.197
30	329335	267551	AW	0.154	0.151	0.175	0.169
31	329113	267677	AW	0.105	0.104	0.090	0.087
32	328647	266907	AW	0.083	0.082	0.047	0.042
33	328888	266650	AW	0.070	0.070	0.035	0.032
34	329320	266631	AW	0.046	0.046	0.046	0.043
35	329754	266999	AW	0.117	0.116	0.114	0.102
36	329816	267426	AW	0.096	0.094	0.124	0.118
37	329646	267619	AW	0.088	0.087	0.134	0.127
38	329417	267789	AW	0.079	0.077	0.121	0.116
39	329654	267895	AW	0.052	0.051	0.060	0.056
40	329141	266465	AW	0.036	0.036	0.031	0.028
41	329775	266814	AW	0.088	0.087	0.078	0.070
42	329630	266388	AW	0.029	0.029	0.021	0.019
43	330576	267013	AW	0.035	0.034	0.044	0.036
44	330568	267273	AW	0.034	0.034	0.025	0.023
45	330090	268046	AW	0.034	0.033	0.030	0.027
46	329643	268598	AW	0.024	0.023	0.014	0.013
47	329261	268745	AW	0.019	0.019	0.012	0.011
48	328310	267994	AW	0.018	0.018	0.018	0.014
49	327906	267742	AW	0.016	0.016	0.042	0.031
50	327776	266501	AW	0.020	0.019	0.015	0.012
51	328618	265867	AW	0.022	0.022	0.013	0.011
52	329277	265343	AW	0.010	0.010	0.007	0.006
53	329968	265702	AW	0.012	0.012	0.008	0.008
54	330593	266078	AW	0.020	0.020	0.016	0.014
55	330917	267348	AW	0.025	0.024	0.012	0.010
56	330627	268392	AW	0.020	0.019	0.026	0.023
57	330031	268805	AW	0.017	0.017	0.013	0.012
58	327531	268116	AW	0.011	0.011	0.019	0.013
59	327639	267609	AW	0.014	0.014	0.032	0.024
60	327492	266196	AW	0.014	0.013	0.011	0.009
61	329065	265467	River Lugg SSSI	**0.012**	**0.012**	**0.010**	0.009
62	329624	265562	River Lugg SSSI	**0.011**	**0.011**	0.007	0.006
63	328545	265156	River Lugg SSSI	**0.014**	**0.014**	0.008	0.007
64	330278	265555	River Lugg SSSI	**0.010**	**0.010**	0.007	0.006
65	327883	265216	River Lugg SSSI	0.009	0.009	0.008	0.007
66	327204	266107	River Lugg SSSI	**0.012**	**0.012**	**0.010**	0.008
67	326780	267222	River Lugg SSSI	**0.011**	**0.010**	0.009	0.007
68	325832	267589	River Lugg SSSI	0.007	0.007	0.006	0.004
69	324741	267517	River Lugg SSSI	0.005	0.005	0.003	0.002
70	331030	265002	River Lugg SSSI	0.007	0.007	0.005	0.004
71	332383	264373	River Lugg SSSI	0.005	0.005	0.004	0.003
72	327448	270406	Gwernaffel Dingle SSSI	0.005	0.005	0.004	0.003
73	326891	270542	Gwernaffel Dingle SSSI	0.004	0.004	0.004	0.002
74	327312	271091	Gwernaffel Dingle SSSI	0.004	0.004	0.004	0.002

5.2 Detailed deposition modelling

The detailed modelling was carried out over a restricted domain where the preliminary modelling indicated that annual mean ammonia concentrations would potentially exceed, or be close to exceeding, the relevant lower threshold percentage of the relevant Critical Level or Critical Load for the site. The domain covers the site of the proposed poultry house and an area of un-named AW to the east. At all other receptors considered, the preliminary modelling indicated that ammonia levels (and nitrogen and acid deposition rates) would be below the Natural Resources Wales lower threshold percentage of Critical Level/Load for the designation of the site.

The predicted maximum annual mean ground level ammonia concentrations and nitrogen deposition rates at the discrete receptors are shown in Table 6. In this table, predicted ammonia concentrations or nitrogen deposition rates that are in excess of the Natural Resources Wales upper threshold (100% of Critical Level or Load for an AW) are coloured red. Concentrations that are in the range between the Natural Resources Wales lower and upper thresholds (50%[1] to 100% for an AW) are coloured blue.

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

1. The Pre-February 2016 figure is retained.

Table 6. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors

Receptor number	X(m)	Y(m)	Name	Site Parameters			Maximum annual ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level (µg/m³)	Critical Load (kg/ha)	Process Contribution (µg/m³)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	329225.91	267267.38	AW	0.020	1.0	10.0	0.596	**59.6**	3.10	**31.0**
2	329251.91	267192.09	AW	0.030	1.0	10.0	0.851	**85.1**	6.63	**66.3**
3	329277.94	267124.25	AW	0.030	1.0	10.0	0.579	**57.9**	4.51	**45.1**
4	329319.75	267180.03	AW	0.030	1.0	10.0	0.434	**43.4**	3.38	**33.8**
1_C	329225.91	267267.38	AW	0.030	1.0	10.0	0.596	**59.6**	4.65	**46.5**
2_C	329251.91	267192.09	AW	0.030	1.0	10.0	0.910	**91.0**	7.09	**70.9**
3_C	329277.94	267124.25	AW	0.030	1.0	10.0	0.612	**61.2**	4.77	**47.7**
4_C	329319.75	267180.03	AW	0.030	1.0	10.0	0.460	**46.0**	3.59	**35.9**

Figure 6a. Maximum annual ammonia concentration

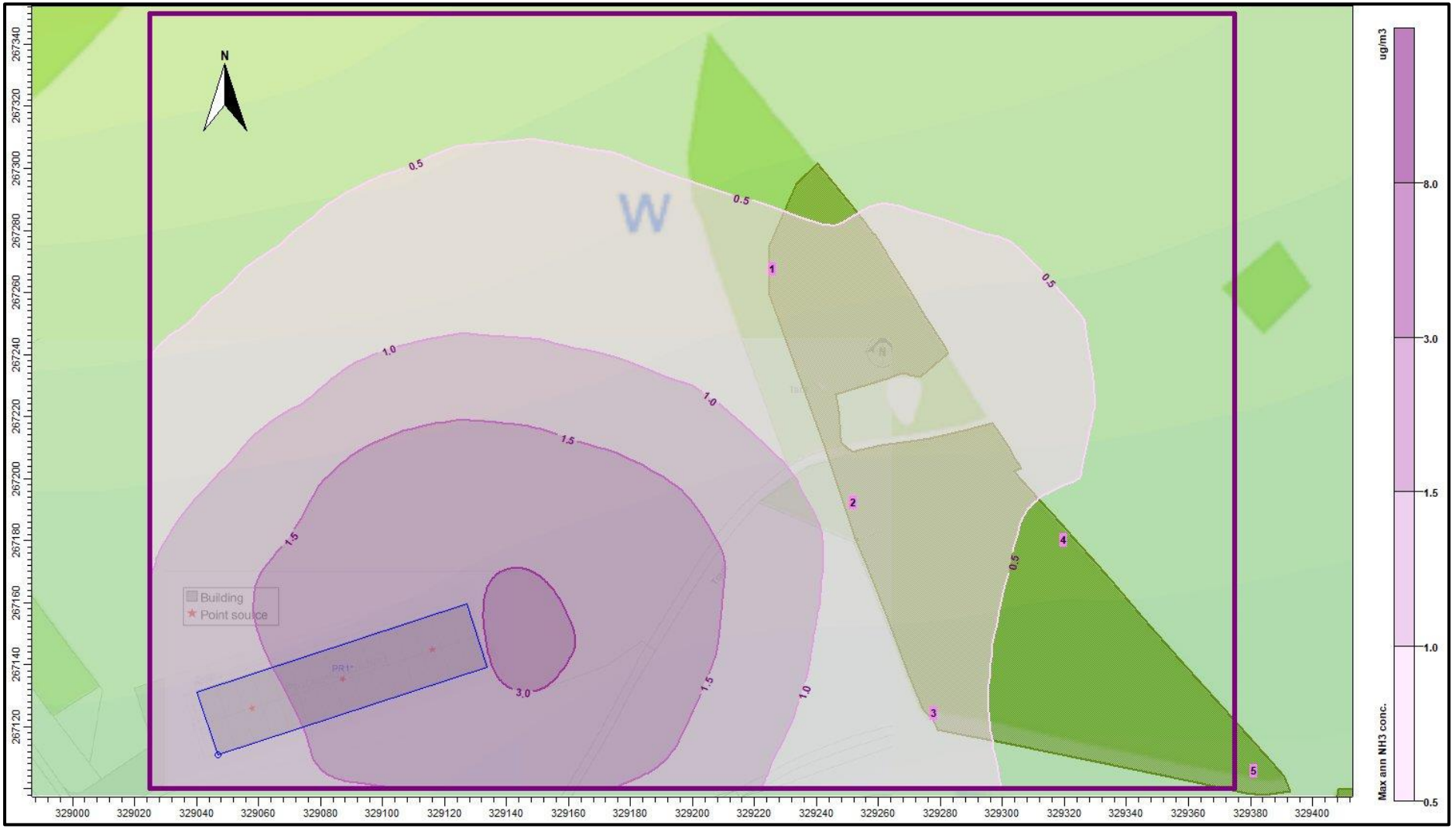
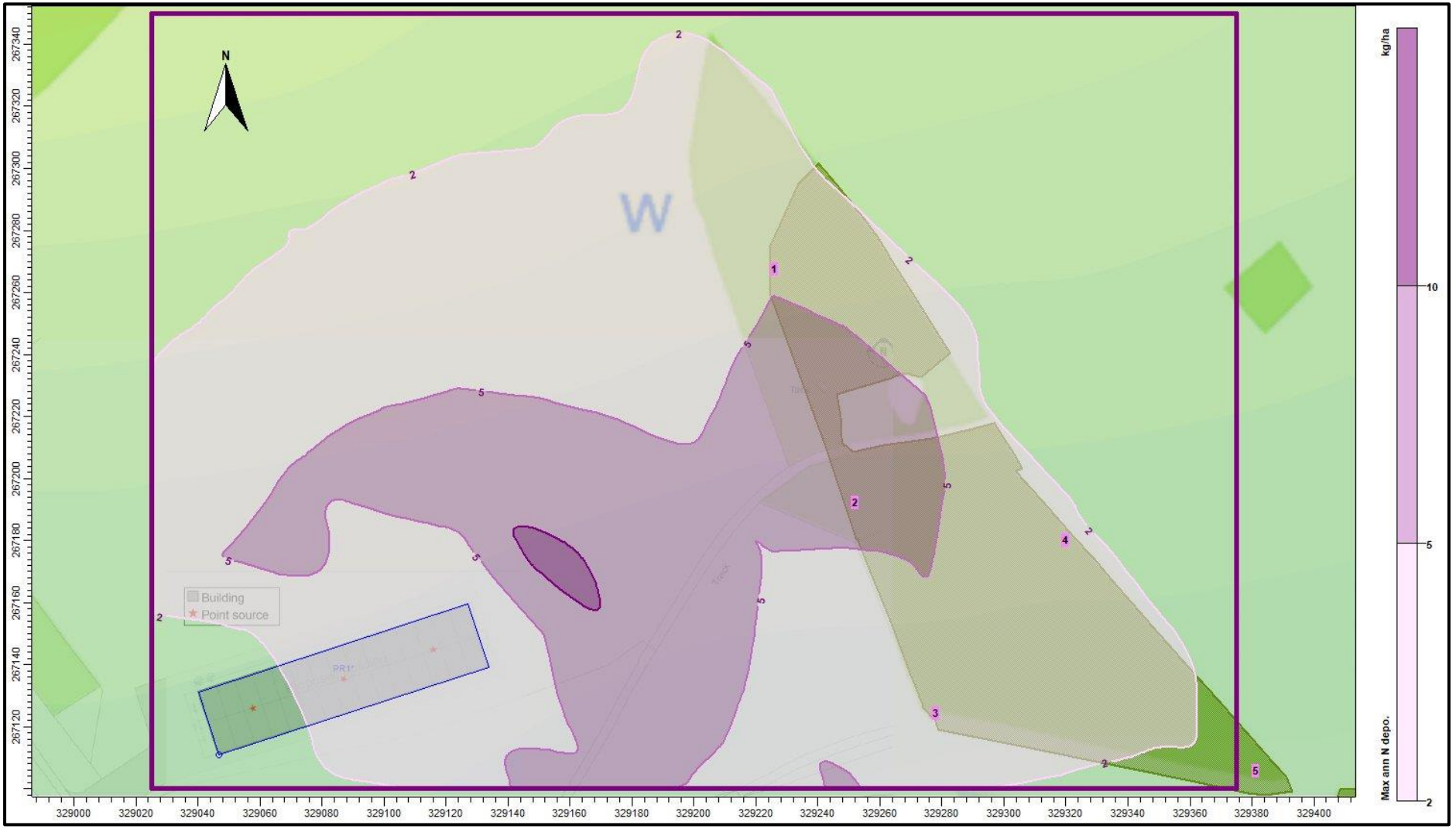


Figure 6b. Maximum annual nitrogen deposition rates



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Gerallt Davies of Roger Parry & Partners LLP, on behalf of the applicant Mr. Richard Wilding, to use computer modelling to assess the impact of ammonia emissions from the proposed pullet rearing house at Old Impton Farm, Norton, Powys. LD8 2EG.

Ammonia emission rates from the proposed poultry house have been assessed and quantified based upon the Environment Agency's standard ammonia emission factors. The ammonia emission rates have then been used as inputs to an atmospheric dispersion and deposition model which calculates ammonia exposure levels and nitrogen and acid deposition rates in the surrounding area.

Preliminary modelling

The preliminary modelling predicts that:

- At the AW to the east of the site of the proposed poultry house, the process contribution to the annual nitrogen deposition rate would potentially exceed the Natural Resources Wales lower threshold (100% for an AW) of the precautionary Critical Level of 1.0 µg-NH_3/m^3. However, the preliminary fixed deposition runs suggest that when deposition processes and consequent plume depletion are considered, the process contribution would probably be below 100% of the Critical Level.

- At all other sites considered, the preliminary modelling predicts that the process contribution to the annual ammonia concentration and the nitrogen deposition rate would be below Natural Resources Wales lower threshold percentage of Critical Level and Load for the site (1% for a SSSI and 100% for non-statutory sites).

Detailed deposition modelling

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

- At the AW to the east of the site of the proposed poultry house, the process contribution to the annual ammonia concentration would be below the Natural Resources Wales lower threshold (100% for an AW) of the precautionary Critical Level of 1.0 µg-NH_3/m^3.

7. References

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