A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Proposed Pullet Chicken Rearing Houses at Garn Farm, near Llanbadarn Fynydd in Powys

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Rosina Bloor of Richard Parry & Partners LLP, on behalf of the applicant V. E. Lewis & Son, to use computer modelling to assess the impact of ammonia emissions from the proposed pullet chicken rearing houses at Garn Farm, Llanbadarn Fynydd, Llandrindod Wells, Powys. LD1 6YE.

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 Garn Farm is in an isolated rural area, approximately 3.5 km to the north of the village of Llanbadarn Fynydd in Powys. The surrounding land is used largely for livestock farming, although there are some isolated wooded areas and extensive areas of upland heath on the mountains to the north-east. The site is within a col at an altitude of around 441 m, with land rising towards hill/mountain tops to the north-east and south-west and falling towards the River Ithon Valley to the north-west and the valley formed by the Cwm Nant-ddu to the south-east.

It is proposed that two new poultry houses be constructed. The houses would provide accommodation for up to 38,000 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 three unnamed remnant Ancient Woodlands (AWs) within 2 km of Garn Farm. There are four Sites of Special Scientific Interest (SSSIs); namely the River Ithon SSSI, the Gweunydd Esgairdraenllwyn SSSI, the Gweunydd Camnant SSSI, the Llymwynnt Brook Pastures SSSI and the River Teme SSSI. The River Ithon SSSI and parts of the Gweunydd Esgairdraenllwyn SSSI and the Llymwynnt Brook Pastures SSSI are also designated as the River Wye Special Area of Conservation (SAC). There are no other internationally designated sites within 5 km of the farm.

A broad scale view map of the surrounding area showing the positions of the proposed poultry houses and the nearby wildlife sites are provided in Figure 1a and a closer view of the AWs is provided in Figure 1b. In these figures, the AWs are shaded in olive, the SSSIs are shaded green, the SAC is shaded purple and the site of the proposed poultry houses is outlined in blue.

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

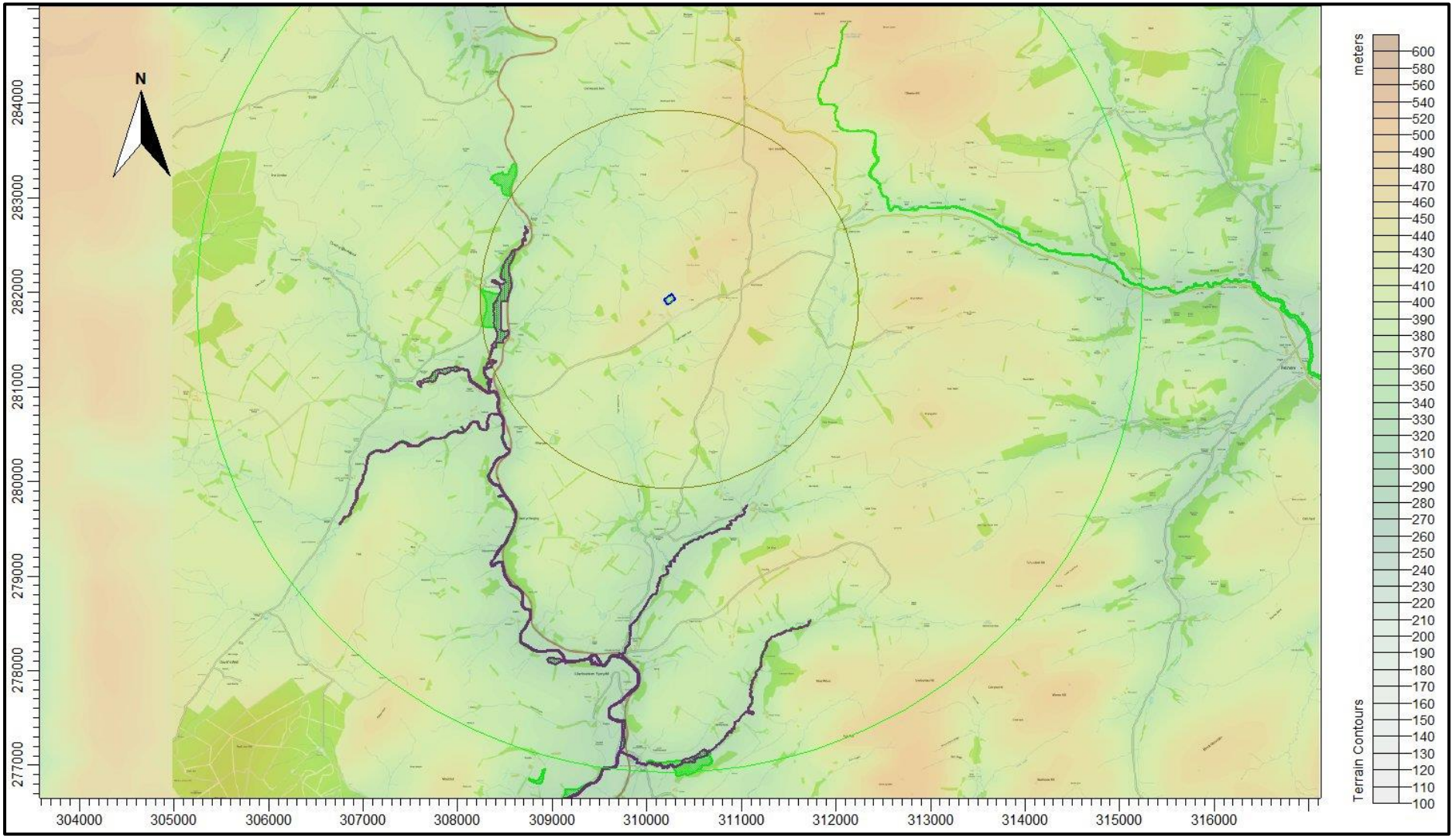
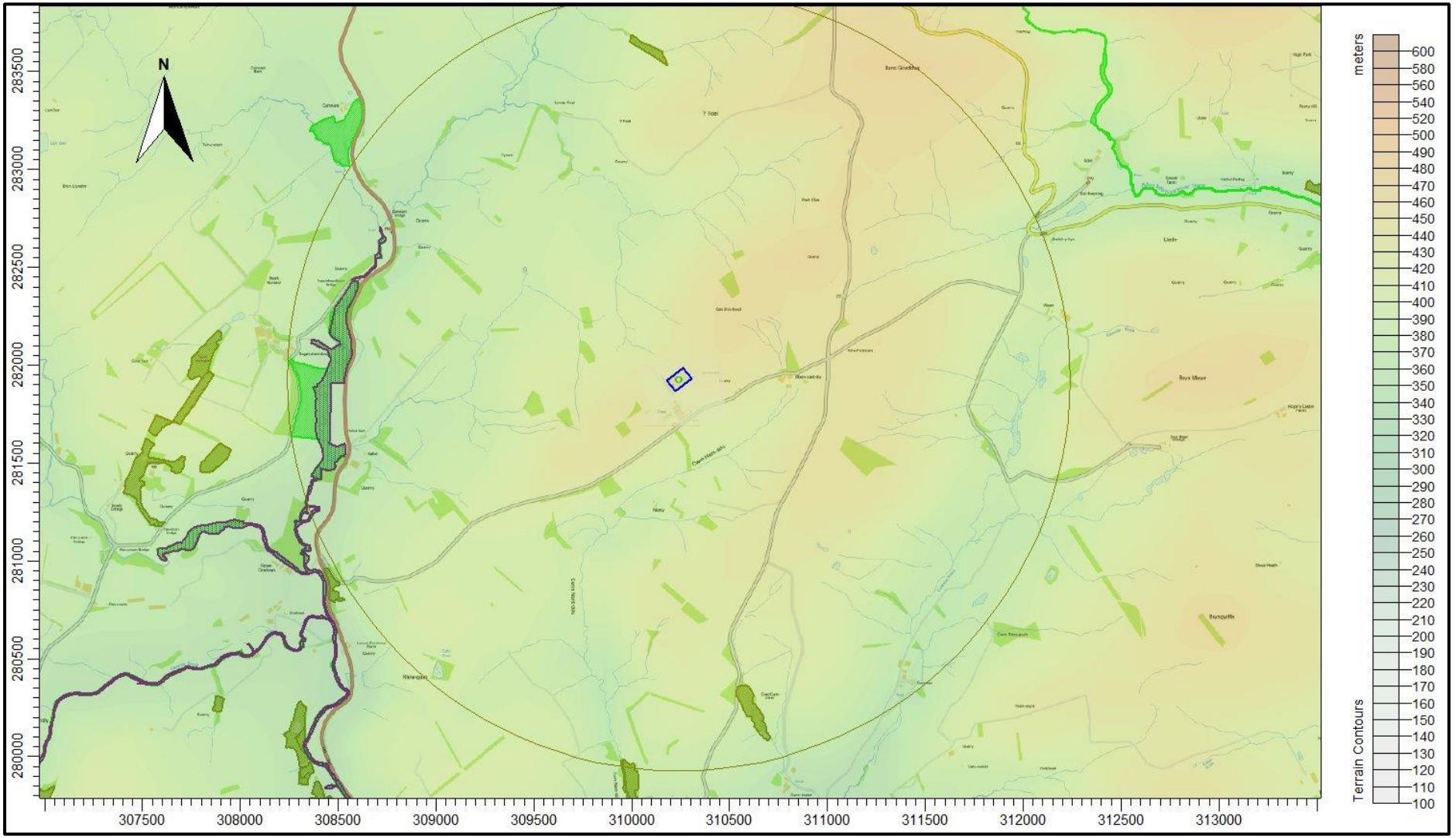


Figure 1b. The area surrounding the site, a closer view



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

3.1 Ammonia concentration and nitrogen and acid deposition

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

3.2 Background ammonia levels and nitrogen and acid deposition

The background ammonia concentration (annual mean) in the area around Garn Farm and the wildlife sites is 0.86 µg-NH_3/m^3. The background nitrogen deposition rate to woodland is 30.10 kg-N/ha/y and to short vegetation is 17.78 kg-N/ha/y. The background acid deposition rate to woodland is 2.30 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 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)
Unnamed AWs	1.0 [1]	-	-
SSSIs	1.0 [1]	-	-
River Wye SAC	1.0 [1]	-	-

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.

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.

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 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 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	76,000	Pullet Rearing	0.04	0.0963318

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). Results obtained using observational data from the meteorological recording stations at Sennybridge and Trawscoed have also been considered, primarily as a cross-check on the response of ADMS to the use of the NWP data.

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

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

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

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

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

Wind speeds are modified by the treatment of roughness lengths (see Section 4.7) and where terrain data is included in the modelling, the raw GFS wind speeds and directions will be modified. The terrain and roughness length modified wind rose for the location of the proposed poultry houses at Garn Farm is shown in Figure 2b. The resolution of the wind field in terrain runs is approximately 300 m in the preliminary and detailed modelling runs.

Figure 2a. The wind rose. Raw GFS derived data for 52.151 N, 3.538 W, 2013-2016

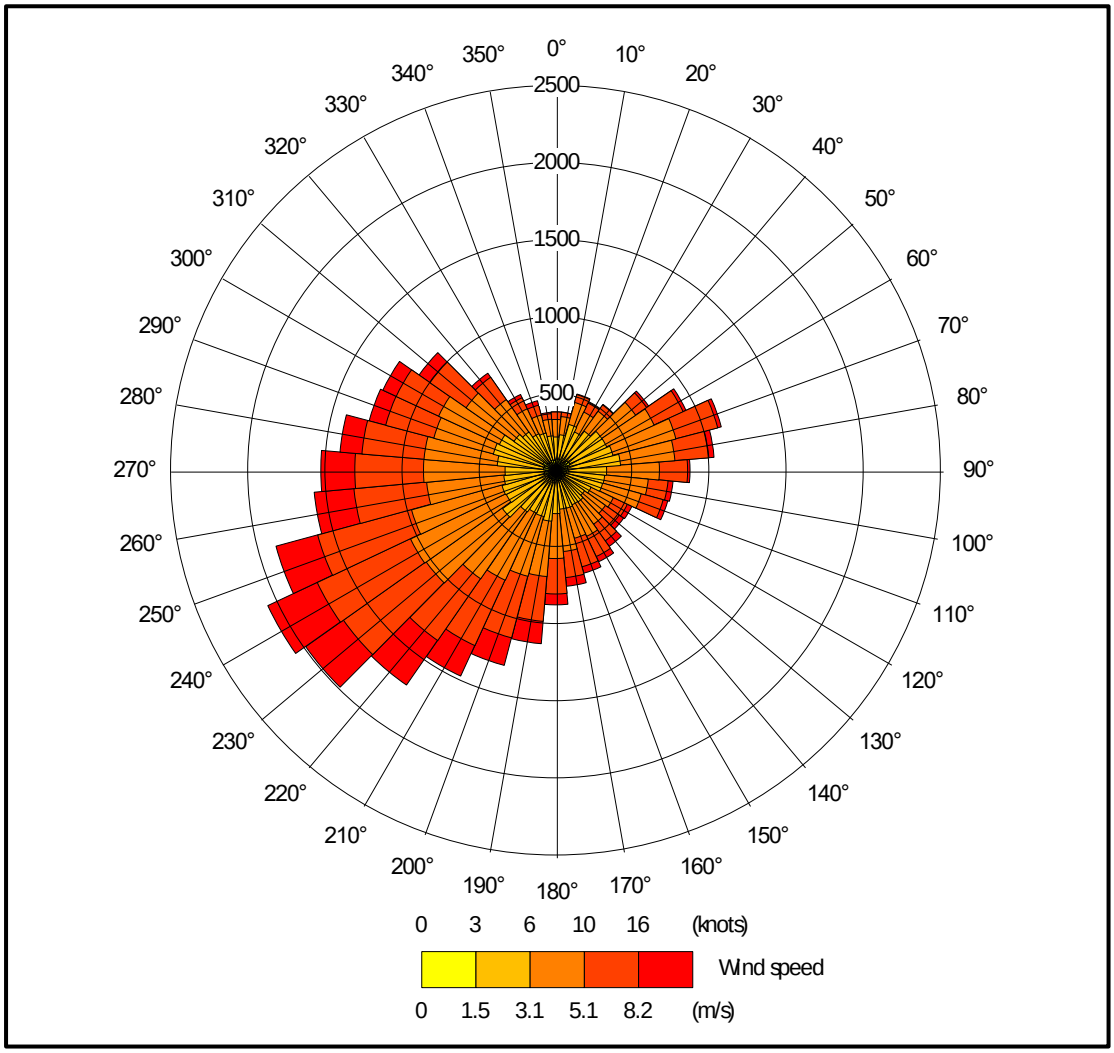
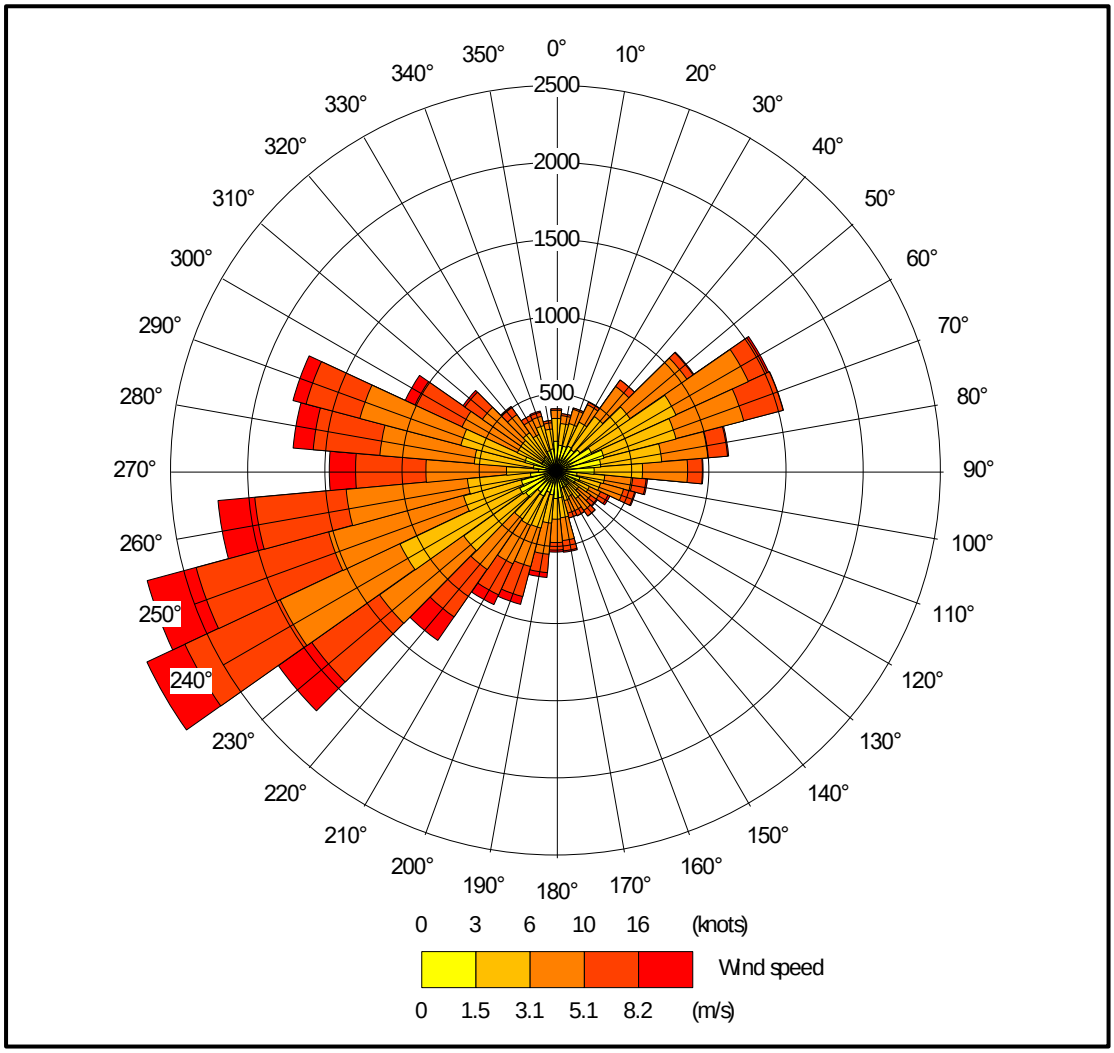


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 294800, 251500



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 (PR1 and PR2 a, b & c). 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 stars.

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

4.3 Modelled buildings

The structure of the proposed 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

Twenty-seven discrete receptors have been defined: three at the AWs (1 to 3), nine at the SSSIs (4 to 12) and fifteen at the SAC/SSSIs (13 to 27). 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 defined within ADMS. A nested grid has also been used to improve contouring of the results. The grid receptors are defined at ground level within ADMS. The positions of the Cartesian grids may be seen in Figure 4, where they are marked by grey lines.

4.6 Terrain data

Terrain has been considered in the modelling. The terrain data are based upon the Ordnance Survey 50 m Digital Elevation Model. A 12.0 km x 12.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS. N.B. The resolution of FLOWSTAR is 64 x 64 grid points; therefore, the effective resolution of the wind field is approximately 180 m.

4.7 Roughness Length

A fixed surface roughness length of 0.2 has been applied over the entire modelling domain. As a precautionary measure, the GFS meteorological data is assumed to have a roughness length of 0.175 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

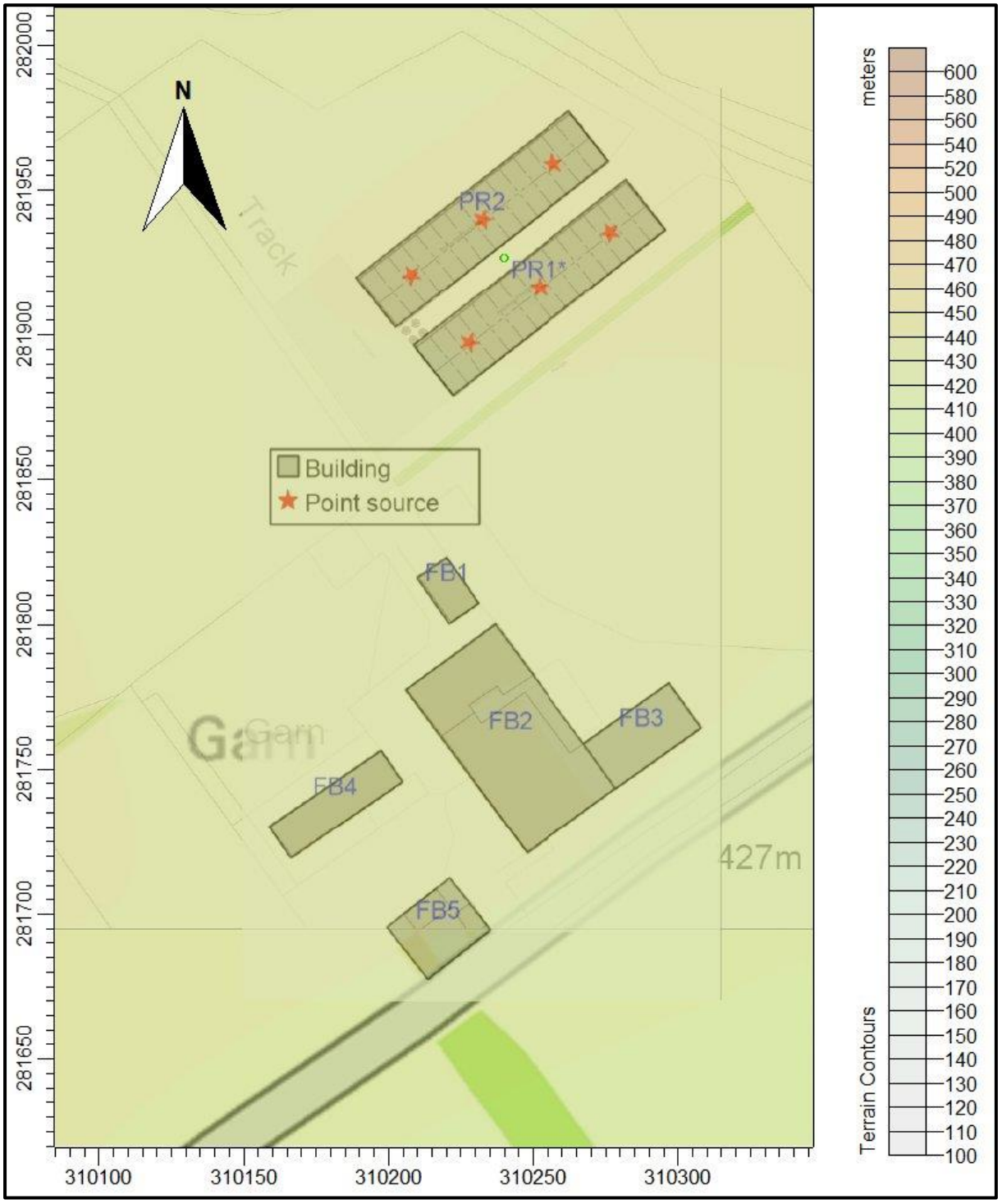
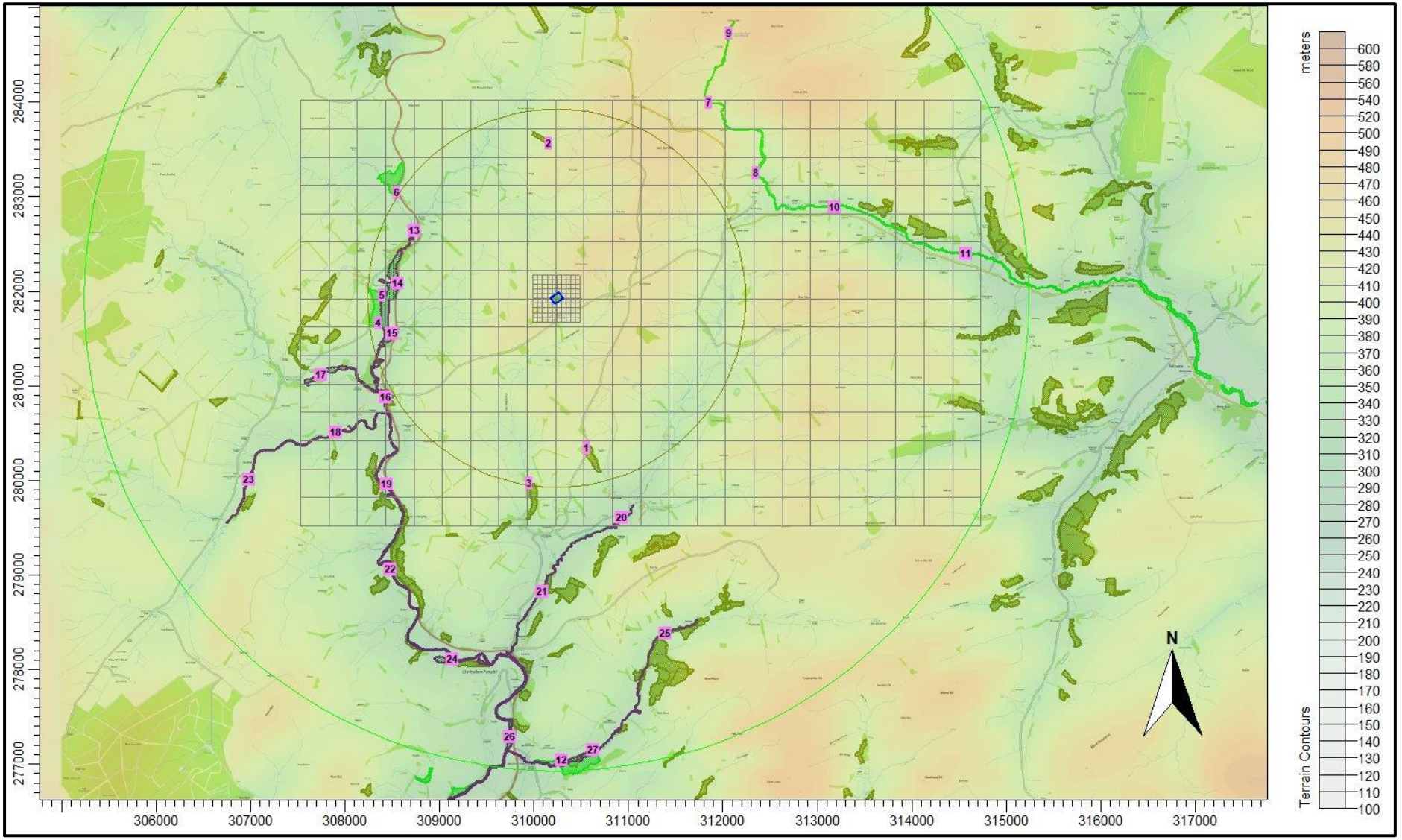


Figure 4. The discrete receptors and Cartesian grid, a broad scale view



4.8 Deposition

The method used to model deposition of ammonia and consequent plume depletion is based on a document titled "Guidance on modelling the concentration and deposition of ammonia emitted from intensive farming" from the Environment Agency's Air Quality Modelling and Assessment Unit, 22 November 2010. N.B. AS Modelling & Data Ltd. has restricted deposition over arable farmland and heavily grazed and fertilised pasture; this is to compensate for possible saturation effects due to fertilizer application and to allow for periods when fields are clear of crops (Sutton), the deposition is also restricted over areas with little or no vegetation and the deposition velocity is set to 0.002 m/s where grid points are over the poultry housing and 0.015 m/s over heavily grazed grassland. Where deposition over water surfaces is calculated, a deposition velocity of 0.005 m/s is used.

In summary, the method is as follows:

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

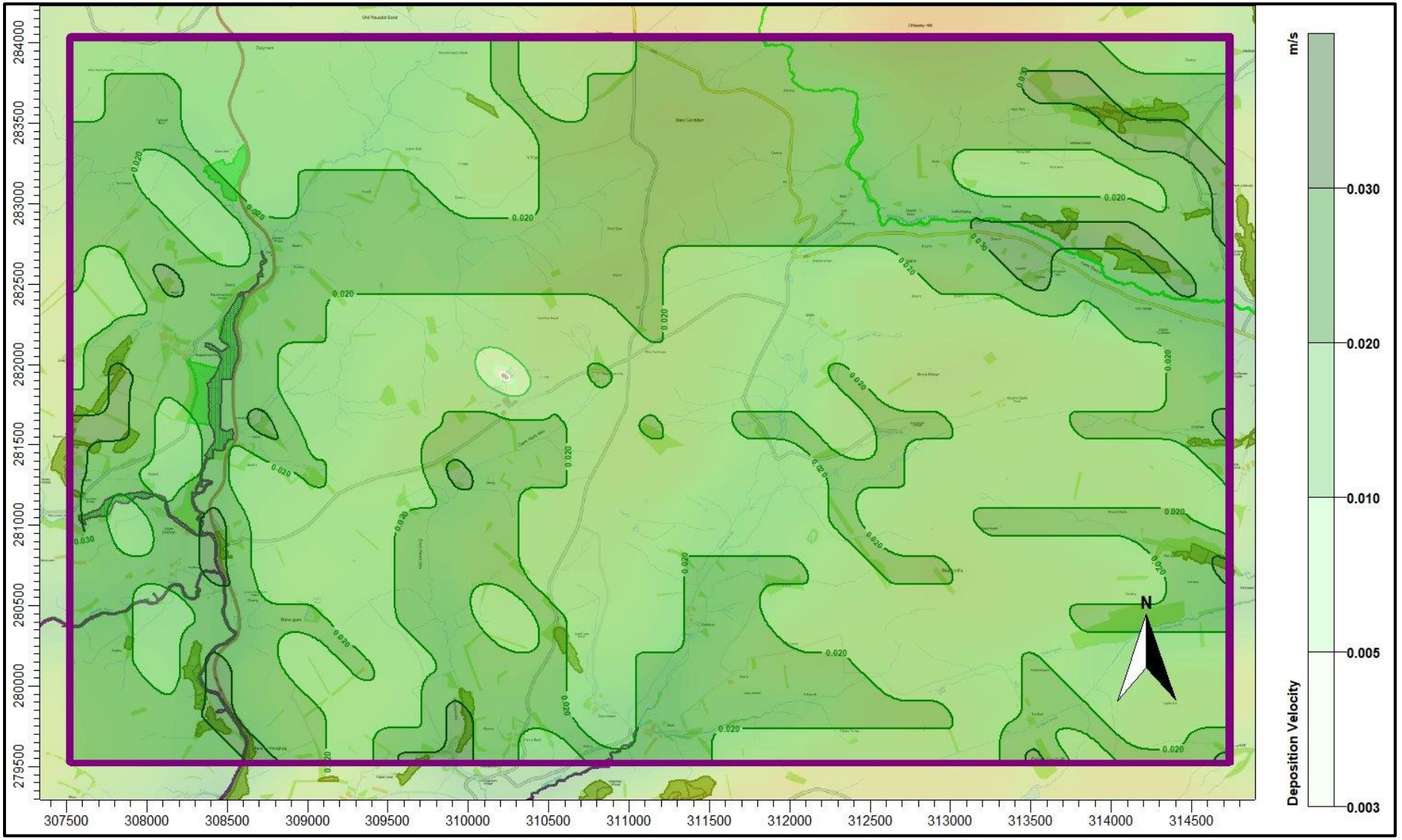
Table 4. Deposition velocities

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

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

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

ADMS was run a total of twelve times; once for each year of the meteorological record and in the following six modes:

- In basic mode without calms or terrain – GFS data.
- With calms and without terrain – GFS data.
- Without calms and with terrain – GFS data.
- Without calms, with terrain and with a fixed deposition velocity of 0.003 m/s – GFS data.
- In basic mode without calms or terrain – Sennybridge data.
- In basic mode without calms or terrain – Trawscoed data.

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

Details of the predicted annual mean ammonia concentrations at each receptor are provided in Table 5. In the Table, predicted ammonia concentrations (or concentrations equivalent to deposition rates) that are in excess of the Natural Resources Wales upper threshold (8% of Critical Level/Load for a SAC/SSSI and 50%[1] of Critical Level/Load for a non-statutory wildlife site) are coloured red. Concentrations in the range between the Natural Resources Wales lower and upper thresholds (1% and 8% for a SAC/SSSI 50%[1] and 100% for a non-statutory wildlife site) are coloured blue.

1. The pre-February 2016 value is used.

Table 5. Predicted maximum annual mean ammonia concentration at the discrete receptors

Receptor number	X(m)	Y(m)	Site	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.	Sennybridge No Calms No terrain	Trawscoed No Calms No terrain
1	310556	280344	Unnamed AW	0.013	0.013	0.021	0.013	0.014	0.009
2	310151	283563	Unnamed AW	0.025	0.024	0.038	0.030	0.045	0.065
3	309952	279966	Unnamed AW	0.016	0.016	0.020	0.013	0.028	0.005
4	308353	281665	Gweunydd Esgairdraenllwyn	**0.026**	**0.026**	**0.028**	**0.021**	**0.013**	**0.015**
5	308393	281957	Gweunydd Esgairdraenllwyn	**0.025**	**0.024**	**0.021**	**0.016**	**0.010**	**0.017**
6	308545	283045	Gweunydd Camnant	**0.015**	**0.015**	**0.012**	**0.010**	0.007	**0.024**
7	311845	283997	River Teme	**0.017**	**0.017**	**0.016**	**0.012**	**0.027**	**0.013**
8	312350	283254	River Teme	**0.025**	**0.025**	**0.025**	**0.021**	**0.030**	**0.015**
9	312066	284729	River Teme	**0.012**	**0.012**	0.009	0.006	**0.021**	**0.011**
10	313178	282890	River Teme	**0.020**	**0.020**	**0.025**	**0.020**	**0.019**	**0.013**
11	314574	282400	River Teme	**0.014**	**0.014**	**0.016**	**0.011**	**0.012**	**0.010**
12	310296	277037	Llymwynnt Brook Pastures	0.004	0.005	0.005	0.003	**0.011**	0.003
13	308732	282644	River Ithon SSSI/River Wye SAC	**0.021**	**0.021**	**0.020**	**0.016**	0.009	**0.026**
14	308556	282088	River Ithon SSSI/River Wye SAC	**0.026**	**0.025**	**0.023**	**0.017**	**0.011**	**0.020**
15	308503	281555	River Ithon SSSI/River Wye SAC	**0.028**	**0.028**	**0.034**	**0.026**	**0.015**	**0.015**
16	308435	280877	River Ithon SSSI/River Wye SAC	**0.016**	**0.016**	**0.018**	**0.015**	**0.018**	0.009
17	307742	281117	River Ithon SSSI/River Wye SAC	**0.016**	**0.016**	**0.016**	**0.011**	0.010	0.009
18	307906	280507	River Ithon SSSI/River Wye SAC	**0.012**	**0.011**	**0.012**	0.009	**0.013**	0.006
19	308438	279960	River Ithon SSSI/River Wye SAC	**0.012**	**0.012**	**0.015**	0.009	**0.017**	0.003
20	310932	279603	River Ithon SSSI/River Wye SAC	0.010	0.010	**0.030**	**0.016**	**0.011**	0.007
21	310086	278822	River Ithon SSSI/River Wye SAC	0.008	0.008	**0.012**	0.007	**0.017**	0.004
22	308482	279056	River Ithon SSSI/River Wye SAC	**0.012**	**0.012**	**0.010**	0.006	**0.018**	0.002
23	306980	280004	River Ithon SSSI/River Wye SAC	0.008	0.008	0.008	0.006	0.009	0.005
24	309138	278108	River Ithon SSSI/River Wye SAC	0.010	0.010	**0.011**	0.006	**0.018**	0.003
25	311385	278377	River Ithon SSSI/River Wye SAC	0.006	0.006	**0.021**	0.009	0.009	0.005
26	309744	277283	River Ithon SSSI/River Wye SAC	0.006	0.006	0.007	0.004	**0.014**	0.003
27	310626	277145	River Ithon SSSI/River Wye SAC	0.004	0.004	0.005	0.003	0.010	0.003

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 (or concentrations equivalent to nitrogen deposition rates) could potentially exceed the relevant upper and lower threshold percentage of the Critical Level or Critical Load. The domain covers the proposed poultry houses at Garn Farm, the Gweunydd Esgairdraenllwyn SSSI and closer parts of the River Wye SAC and River Teme SSSI. 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 within the detailed modelling domain is 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 for a SAC/SSSI and 100% of Critical Level for a non-statutory wildlife site) are coloured red. Concentrations in the range between the Natural Resources Wales lower and upper thresholds (1% and 8% for a SAC/SSSI and 50%[1] and 100% for a non-statutory wildlife site) are coloured blue.

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

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
4	308353	281665	Gweunydd Esgairdraenllwyn	0.030	1.0	10.0	0.016	**1.6**	0.12	**1.2**
5	308393	281957	Gweunydd Esgairdraenllwyn	0.030	1.0	10.0	0.013	**1.3**	0.10	1.0
6	308545	283045	Gweunydd Camnant	0.030	1.0	10.0	0.007	0.7	0.06	0.6
7	311845	283997	River Teme	0.030	1.0	10.0	0.008	0.8	0.06	0.6
8	312350	283254	River Teme	0.030	1.0	10.0	0.014	**1.4**	0.11	**1.1**
10	313178	282890	River Teme	0.030	1.0	10.0	0.015	**1.5**	0.12	**1.2**
11	314574	282400	River Teme	0.030	1.0	10.0	0.008	0.8	0.06	0.6
13	308732	282644	River Ithon SSSI/River Wye SAC	0.030	1.0	10.0	0.011	**1.1**	0.09	0.9
14	308556	282088	River Ithon SSSI/River Wye SAC	0.030	1.0	10.0	0.014	**1.4**	0.11	**1.1**
15	308503	281555	River Ithon SSSI/River Wye SAC	0.030	1.0	10.0	0.019	**1.9**	0.15	**1.5**
16	308435	280877	River Ithon SSSI/River Wye SAC	0.030	1.0	10.0	0.012	**1.2**	0.09	0.9
17	307742	281117	River Ithon SSSI/River Wye SAC	0.030	1.0	10.0	0.008	0.8	0.06	0.6
18	307906	280507	River Ithon SSSI/River Wye SAC	0.030	1.0	10.0	0.007	0.7	0.06	0.6
19	308438	279960	River Ithon SSSI/River Wye SAC	0.030	1.0	10.0	0.006	0.6	0.04	0.4
20	310932	279603	River Ithon SSSI/River Wye SAC	0.030	1.0	10.0	0.008	0.8	0.07	0.7

Figure 6a. Maximum annual ammonia concentration

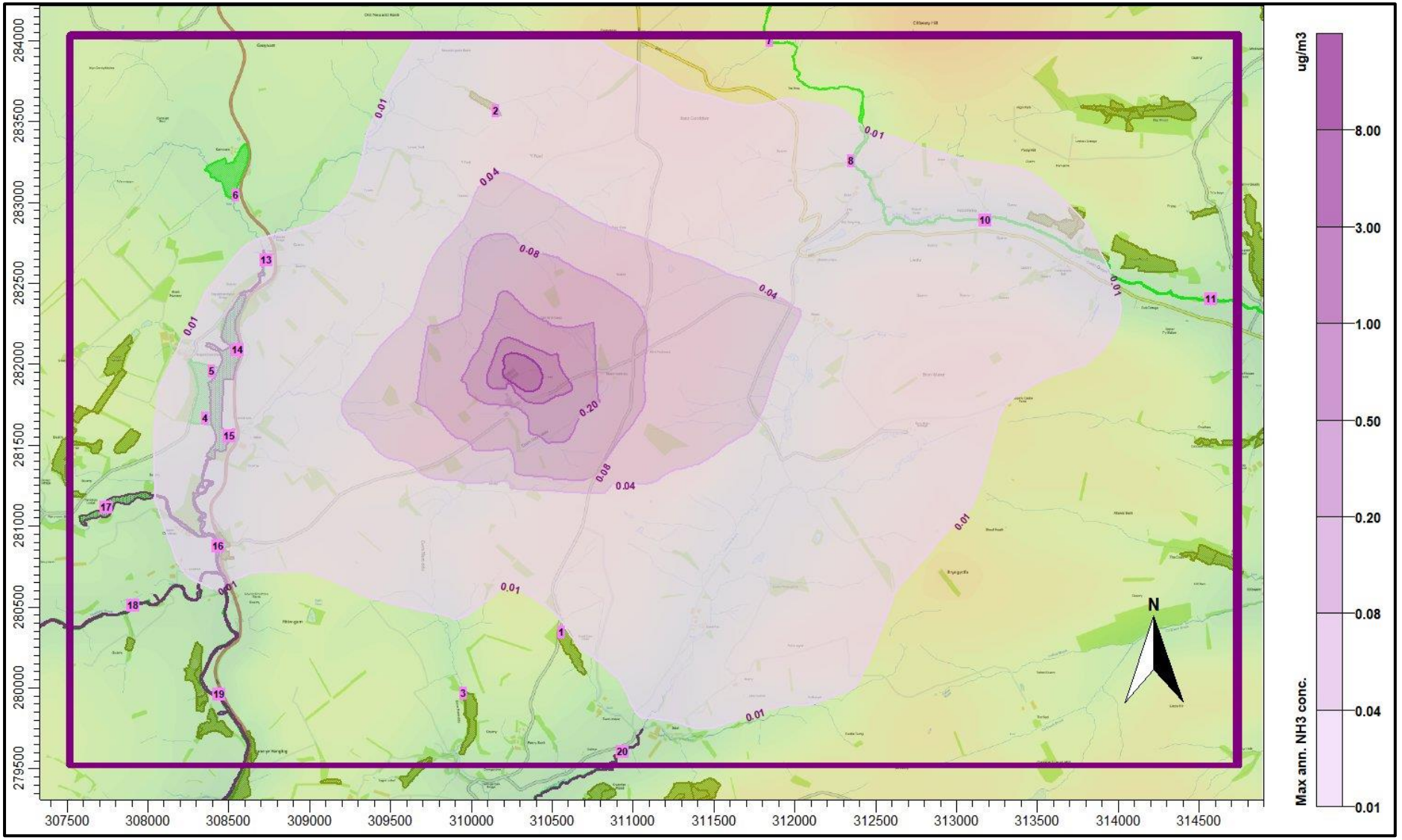
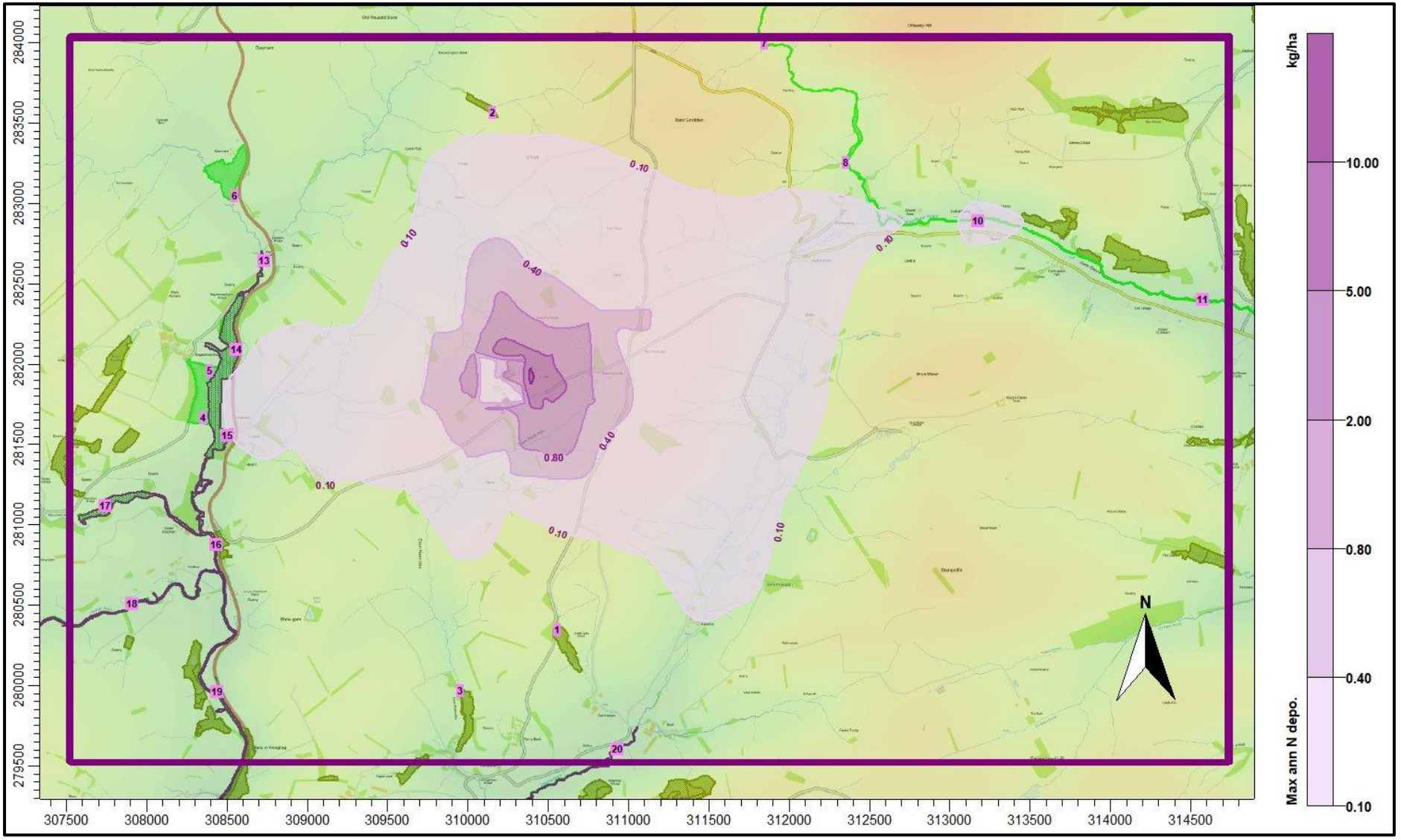


Figure 6b. Maximum annual nitrogen deposition rates



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Rosina Bloor of Richard Parry & Partners LLP, on behalf of the applicant V. E. Lewis & Son, to use computer modelling to assess the impact of ammonia emissions from the proposed pullet chicken rearing houses at Garn Farm, Llanbadarn Fynydd, Llandrindod Wells, Powys. LD1 6YE.

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.

Preliminary modelling

The preliminary modelling predicts that the process contribution to ammonia concentrations and nitrogen deposition rates would potentially exceed the Natural Resources Wale lower threshold percentage (1%) of the Critical Level of 1.0 µg-NH_3/m^3 at the Gweunydd Esgairdraenllwyn SSSI to the west, closer parts of the River Wye SAC to the west and south and at the River Teme SSSI to the east-north-east.

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 the Natural Resources Wales lower threshold percentage of Critical Level for the site (1% for a SAC/SSSI and 100% for a non-statutory wildlife site).

Detailed deposition modelling

In all cases, the Critical Level of 1.0 µg-NH_3/m^3, provides the strictest assessment criteria. The detailed modelling predicts that:

- At the Gweunydd Esgairdraenllwyn SSSI the process contribution to ammonia concentration would exceed the Natural Resources Wales lower threshold (1% for a SSSI) of the Critical Level of 1.0 µg-NH_3/m^3.

- The process contribution to ammonia concentration would exceed the Natural Resources Wales lower threshold (1% for a SSSI) of the Critical Level of 1.0 µg-NH_3/m^3 along approximately 2.2 km of the River Teme SSSI. It should be noted that the Critical Level of 1.0 µg-NH_3/m^3 and the Critical Load of 10.0 kg-N/ha/y may not be applicable to all parts of the river affected and that purely riverine sections of the SSSI may be relatively insensitive to air-borne ammonia and nitrogen deposition.

- At the River Ithon SSSI/River Wye SAC, exceedances of the lower threshold (1% for a SSSI/SAC) of the Critical Level of 1.0 µg-NH_3/m^3 along approximately 3 km of the river to the west. It should be noted that the Critical Level of 1.0 µg-NH_3/m^3 and the Critical Load of

10.0 kg-N/ha/y may not be applicable to all parts of the river affected and that purely riverine sections of the SSSI/SAC may be relatively insensitive to air-borne ammonia and nitrogen deposition.

Where exceedances of the lower threshold percentage of Critical Level or Critical Load at a SSSI/SAC are predicted, further assessment may be required. This assessment should take into account background levels of ammonia and nitrogen deposition, the sensitivity of the parts of the site in question and if it is deemed necessary, also the presence, or not, of other developments in the area that may act in combination with the proposed development.

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