



A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Existing and Proposed Broiler Chicken Rearing Houses at Oakstone Farm Poultry Unit, Oakstone Farm, Bratton Road, near West Ashton in Wiltshire

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Mr. James Whilding of Acorus Rural Property Services Ltd., on behalf of Devonshire Poultry Limited, to use computer modelling to assess the impact of ammonia emissions from the broiler chicken rearing houses at Oakstone Farm Poultry Unit, Oakstone Farm, Bratton Road, West Ashton, Trowbridge, Wiltshire. BA14 6AX.

Ammonia emission rates from the existing and proposed poultry rearing houses have been assessed and quantified based upon the Environment Agency 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 broiler rearing houses at Oakstone Farm Poultry Unit are in a rural area, approximately 1.8 km to the south-east of the village of West Ashton in Wiltshire. The surrounding land is used largely for arable farming, although there are some isolated wooded, industrial and urban areas. There are also extensive areas of unimproved chalk downland to the south. The site is at an altitude of around 73 m with the land rising gently towards higher ground to the south-east and north-west and falling gently towards the north-east and south-west. The escarpment of the Salisbury plain lies approximately 1.8 km to the south of Oakstone Farm Poultry Unit.

There are currently four poultry rearing houses at the site; these houses are used to rear up to 176,000 broiler chickens. The houses are ventilated using cowled side mounted fans. The chickens are reared from day old chicks up to around 38 days old and there are approximately 7.5 flocks per annum.

It is proposed that extensions to three of the existing broiler chicken rearing houses be constructed. Ventilation of the extended houses would be provided by cowled side mounted fans. The extensions to the poultry houses would increase the capacity of the poultry unit to 220,000 broiler chickens. The chickens would be reared from day old chicks up to around 38 days old and there would be approximately 7.5 flocks per annum.

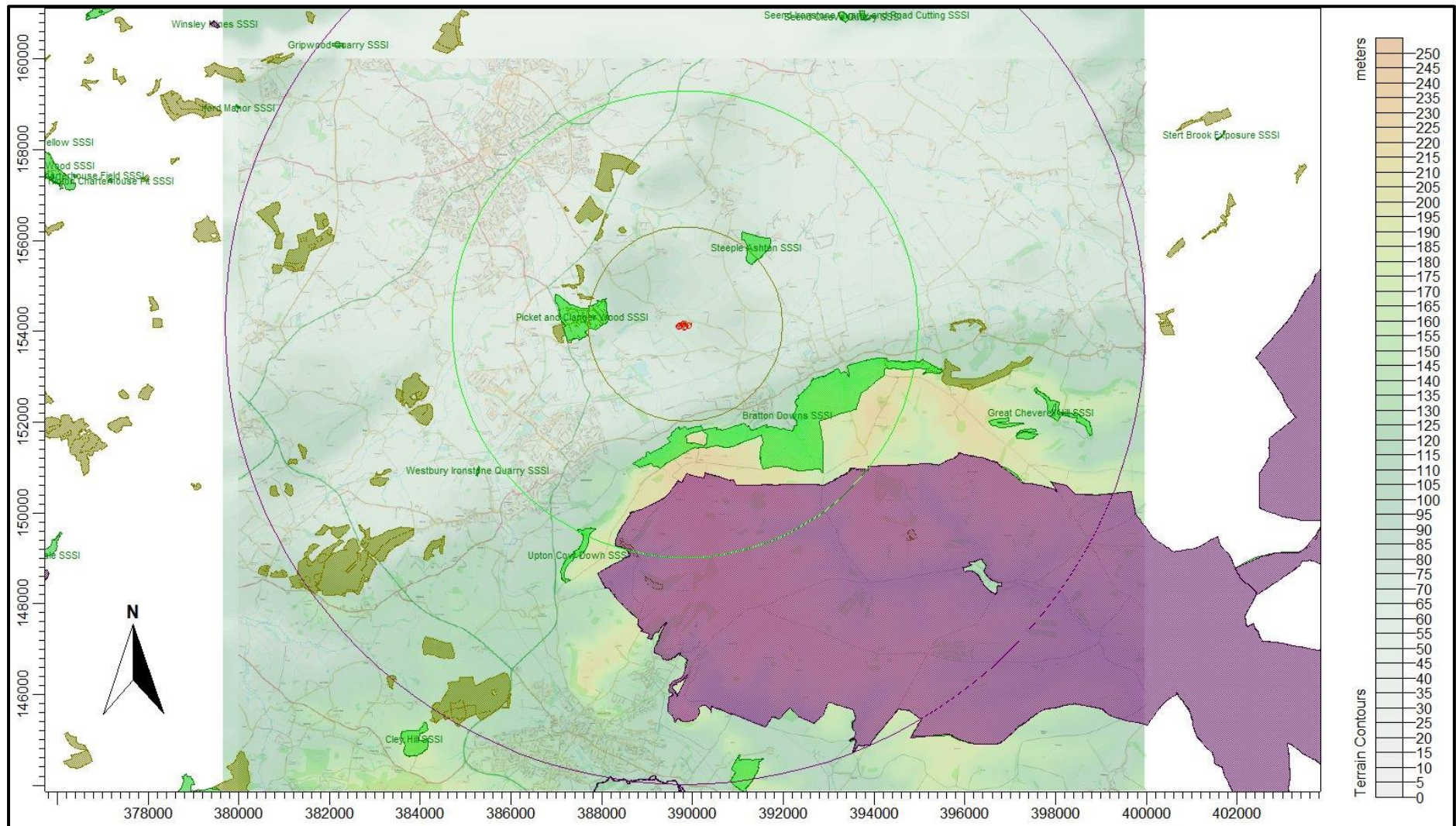
There is one area of Ancient Woodland (AW) within 2 km of the poultry houses at Oakstone Farm Poultry Unit. AS Modelling and Data have not identified any Local Wildlife Sites (LWSs) within 2 km (Wiltshire Local Plan Submission Policies Map). There are eleven SSSIs within 10 km (the screening distance for a SSSIs/internationally designated sites - Defra/Natural England, Impact Risk Zone Mapping), two of the SSSIs are also designated as Special Protection Areas (SPAs) and/or Special Areas of Conservation (SACs). Some further details of the statutory wildlife sites are provided below:

- **Picket and Clanger Wood SSSI** - Approximately 1.5 km to the west - A floristically-rich ancient woodland supporting an outstanding range of butterfly species. The site also accommodates a diversity of birds characteristic of ancient woodland in southern and western England.
- **Steeple Ashton SSSI** - Approximately 1.8 km to the north-east - Designated for geological, palaeogeographic and palaeoecological interest.
- **Bratton Downs SSSI** - Approximately 2.1 km to the south (closest point) - Biologically the site is diverse, comprising species-rich calcareous grassland and ancient broadleaved woodland. The site supports many rare and nationally uncommon species of plant and animal. The extensive area of chalk grassland has a wide range of herb species and more than twenty species of grasses. At the eastern end the steep north-facing slope supports two woods of ash and wych elm. There is a diverse assemblage of butterflies with over thirty species recorded, most of which breed on the site.
- **Upton Cow Down SSSI** - Approximately 4.7 km to the south-south-west - An area of botanically rich chalk grassland at the extreme western end of Salisbury Plain. The site supports a diverse chalk downland butterfly fauna.
- **Great Cheverell Hill SSSI** - Approximately 6.9 km to the east-south-east - An area of botanically rich chalk grassland on the northern edge of Salisbury Plain. The site supports 3 nationally restricted plant species and several uncommon butterflies. The north-facing slope of Hillier's Hole, the northern combe, is unusual for its particular abundance of the moss *Fissidens adianthoides*. Over 20 species of butterflies have been recorded.
- **Westbury Ironstone Quarry SSSI** - Approximately 5.3 km to the south-west - Designated for geological, palaeoenvironmental and palaeogeographic interest.

- **Scratchbury & Cotleigh Hills SSSI** - Approximately 9.4 km to the south - A chalk grassland site, supporting a rich flora and an outstanding associated butterfly fauna.
- **Seend Ironstone Quarry and Road Cutting SSSI** - Approximately 7.4 km to the north-east - Geological.
- **Gripwood Quarry SSSI** - Approximately 9.5 km to the north-west - Geological.
- **Salisbury Plain SSSI/SPA/SAC** - Approximately 2.2 km to the south (closest point) - The largest known expanse of unimproved chalk downland in north-west Europe, which supports: 13 species of nationally rare and scarce plants; 67 species of rare and scarce invertebrates and forms a site of international importance for birds. In addition to chalk downland, this site supports scrub and woodland habitats, temporary and permanent pools and the Nine Mile River winterbourne. A very local community characterised by a lichen-rich turf (*Cladonia* species) and the moss *Dicranum scoparium* is found in some stabilised missile-impactation craters on the central ranges. There is diverse bryophyte flora with seven nationally scarce species. es of the chalk grassland remain open with very little invasion of woody species. Of particular interest are the large stands of juniper *Juniperus communis* on Bulford Downs and Beacon Hill (note that these habitats are not present at parts of the site within 10 km of the poultry unit).
- **River Avon System SSSI/SAC** - Approximately 8.8 km to the south (closest point) - The Avon is richer and more varied than in most chalk streams with over 180 species of aquatic plant having been recorded, one of the most diverse fish faunas in Britain and a wide range of aquatic invertebrates. Adjacent and associated habitats comprise swamp, wet woodland and flood pasture habitats (note that these habitats are not present at parts of the site within 10 km of the poultry unit).

A map of the surrounding area showing the location of the poultry houses (outlined in blue), the AW (shaded in olive), the SSSIs (shaded in green) and the SSSIs/SPA/SACs (shaded in purple) is provided in Figure 1.

Figure 1. The area surrounding Oakstone Poultry Farm - concentric circles radii 2.14 km (olive), 5.14 km (green) and 10.14 km (purple)



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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 source of the background figures is the Air Pollution Information System (APIS, 4th September 2025). It should be noted that the 1 km APIS database background levels are extrapolated from 5 km modelled data. Ammonia levels may vary markedly over relatively short distances and the APIS website itself notes that, the background values should be used only to assist the user in obtaining a broad indication of the likely pollutant impact at a specific location and cannot be considered representative of any particular location within the 5 km grid square; extrapolation to a 1 km grid does not alter this.

The APIS figures for background ammonia concentration (2021) in the area around Oakstone Farm is $1.87 \mu\text{g-NH}_3/\text{m}^3$. The background nitrogen deposition rate to woodland is 29.56 kg-N/ha/y and to short vegetation is 16.10 kg-N/ha/y . The background acid deposition rate to woodland is 2.17 keq/ha/y and to short vegetation is 1.18 keq/ha/y .

The APIS background figures are subject to correction and revision and appear to change fairly frequently, the latest figures can be obtained at <https://www.apis.ac.uk/search-location>.

In most cases, the APIS background figures, which are modelled, extrapolated and statistically manipulated figures, nevertheless, are the only figures available and although it is noted that the background values should be used only to assist in obtaining a broad indication of the likely pollutant impact, it is also noted that across the majority of the UK the lower bounds of the Critical Level and Critical Load are already exceeded.

3.3 Critical Levels and 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. 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 $1.0 \mu\text{g-NH}_3/\text{m}^3$ 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.

Please note that the assessment requirement is to use the lower bound of the range of Critical Loads for habitats that are present; however, the APIS database (<https://www.apis.ac.uk/app>) may contain Critical Levels and Critical Loads for species/habitats that are not present at the site, or not present at the parts of the site under consideration.

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)
AWs	1.0 ¹	-	-
Picket and Clanger Wood SSSI	1.0 ¹	15.0 ^{2 & 3}	-
Bratton Downs SSSI; Upton Cow Down SSSI; Great Cheverell Hill SSSI and Salisbury Plain SSSI/SPA/SAC	1.0 ^{1 & 2}	10.0 ^{2 & 3}	-
River Avon System SSSI/SAC	3.0 ²	n/a ⁴	n/a ⁴
Steeple Ashton SSSI; Westbury Ironstone Quarry SSSI; Scratchbury & Cotley Hills SSSI; Seend Ironstone Quarry and Road Cutting SSSI and Gripwood Quarry SSSI	n/a ⁴	n/a ⁴	n/a ⁴

1. A precautionary figure used where no details of the ecology of the site are available, or the citation for the sites indicates that sensitive lichens and/or bryophytes are/may be present.
2. Based upon APIS (<https://www.apis.ac.uk/search-habitat-impacts>) and/or the citation for the site. Note that the APIS database may contain entries habitats/species that are not present at the site or the parts of the site under consideration.
3. The lower bound of the range of Critical Load for habitats/species present at the site (<https://www.apis.ac.uk/search-habitat-impacts>) and Review and revision of empirical critical loads of nitrogen for Europe, 2022. Note that the APIS database may contain entries habitats/species that are not present at the site or the parts of the site under consideration.
4. No critical Level/Load for designated features.

3.4 Guidance on the Significance of Ammonia Emissions

3.4.1 Environment Agency Criteria

The Environment Agency web-page titled “Intensive farming risk assessment for your environmental permit”, contains a set of criteria, with thresholds defined by percentages of the Critical Level or Critical Load, for: internationally designated wildlife sites (Special Protection Areas (SPAs), Special Areas of Conservation (SACs) and Ramsar sites); Sites of Special Scientific Interest (SSSIs) and other non-statutory wildlife sites. The lower and upper thresholds are: 1% and ‘no upper level’% for SACs, SPAs and Ramsar sites; 20% and 50% for SSSIs and 100% and 100% for non-statutory wildlife sites.

If the predicted process contributions to Critical Level or Critical Load are below the lower threshold percentage, the impact is usually deemed acceptable.

If the predicted process contributions (PCs) to Critical Level or Critical Load are in the range between the lower and upper thresholds; 1% to n/a% for SACs, SPAs and Ramsar sites; 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. In the case of LWSs and AWs, the Environment Agency do not usually consider other farms that may act in-combination and therefore a PC of up to 100% of Critical Level or Critical Load is usually deemed acceptable for permitting purposes and therefore the upper and lower thresholds are the same (100%).

It should be noted that at the detailed modelling stage there are no criteria to decide whether PCs are significant. The significance and the impact and effect of the PCs should be assessed in the context of the current background levels, the environmental standard and the site-specific circumstances.

3.4.2 Natural England advisory criterion

Natural England are a statutory consultee at planning and usually advise that, if predicted process contributions exceed 1% (in some circumstances <1%) of Critical Level or Critical Load at a SSSI, SAC, SPA or Ramsar site, then the local authority should consider whether other farming installations¹ might act in-combination or cumulatively with the farm and the sensitivities of the wildlife sites.

1. The process contribution from most farming installations is already included in the background ammonia concentrations and nitrogen and acid deposition rates. Therefore, it is normally only necessary to consider new installations and installations with extant planning permission developments when understanding the additional impact of a proposal upon nearby ecologies. However, established farms in close proximity may need to be considered given the background concentrations and deposition rates are derived as an average for a 5 km by 5 km grid.

3.4.3 Joint Nature Conservancy Committee - Guidance on Decision-making Thresholds for Air Pollution

In December 2021, the Joint Nature Conservancy Committee (JNCC) published a report titled, “Guidance on Decision-making Thresholds for Air Pollution” This report provides decision-making criteria to inform the assessment of air quality impacts on designated conservation sites. The criteria are intended to be applied to individual sources to identify those for which a decision can be taken without the need for further assessment effort.

The Decision-making thresholds (DMT) for on-site emission sources provided in the JNCC report are reproduced below:

- For lichens and bryophytes - 0.08%, 0.20%, 0.34% and 0.75% of the Critical Level for high, medium, low and very low development density areas, respectively.
- For higher plants - 0.08%, 0.20%, 0.34% and 0.75% of the Critical Level for high, medium, low and very low development density areas, respectively.
- For nitrogen deposition to woodland (Critical Load 10 kg-N/ha/y) - 0.13%, 0.34%, 0.57% and 1.30% of the Critical Level for high, medium, low and very low development density areas, respectively.
- For nitrogen deposition to grassland (Critical Load 10 kg-N/ha/y) 0.09%, 0.24%, 0.40% and 0.88% of the Critical Level for high, medium, low and very low development density areas, respectively.

Note that 'development density' is defined as, the assumed number of additional new sources below the DMT within 5 km of the proposed development over 13 years: very low density being 1 development; low 5 developments; medium 10 developments and high 30 developments.

Subject to some exceptions, where the process contribution from an on-site source is below the DMT, no further assessment is required. Where the process contribution exceeds the DMT there are two possible outcomes:

- Where site-relevant thresholds have been derived these can be applied to see if it is possible to avoid further assessment effort on the basis of site-specific circumstances.
- If site-relevant thresholds have not yet been derived, further assessment in combination with other plans and projects is required.

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 emission factors used for the poultry housing have been obtained from: <https://www.gov.uk/guidance/ammonia-emission-factors-for-pig-and-poultry-screening-modelling-and-reporting#ammonia-emission-factors-for-poultry>.

Details of the poultry numbers and types, 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)
Existing Housing	176,000	Broiler Chickens	0.024	0.133850
Proposed Housing	220,000	Broiler Chickens	0.024	0.167313

4. The Atmospheric Dispersion Modelling System (ADMS) and model parameters

The Atmospheric Dispersion Modelling System (ADMS) ADMS 6 is a new generation Gaussian plume air dispersion model, which means that the atmospheric boundary layer properties are characterised by two parameters; the boundary layer depth, and the Monin-Obukhov length rather than in terms of the single parameter Pasquill-Gifford class.

Dispersion under convective meteorological conditions uses a skewed Gaussian concentration distribution (shown by validation studies to be a better representation than a symmetrical Gaussian expression).

ADMS has a number of model options, that include: dry and wet deposition; NO_x chemistry; impacts of hills, variable roughness, buildings and coastlines; puffs; fluctuations; odours; radioactivity decay (and γ -ray dose); condensed plume visibility; time varying sources and inclusion of background concentrations.

ADMS has an in-built meteorological pre-processor that allows flexible input of meteorological data both standard and more specialist. Hourly sequential and statistical data can be processed and all input and output meteorological variables are written to a file after processing.

The user defines the pollutant, the averaging time (which may be an annual average or a shorter period), which percentiles and exceedance values to calculate, whether a rolling average is required or not and the output units. The output options are designed to be flexible to cater for the variety of air quality limits, which can vary from country to country and are subject to revision.

4.1 Meteorological data

Computer modelling of dispersion requires hourly sequential meteorological data and to provide robust statistics the record should be of a suitable length; preferably four years or longer.

The meteorological data used in this study is obtained from assimilation and short-term forecast fields of the Numerical Weather Prediction (NWP) system known as the Global Forecast System (GFS)¹.

The GFS is a discrete model. The physics/dynamics model has a resolution or had a resolution of approximately 7 km over the central UK; terrain is understood to be resolved at a resolution of approximately 2 km, with sub-7 km terrain effects parameterised. Site specific data may be extrapolated from nearby archive grid points or a most representative grid point chosen. The GFS resolution adequately captures major topographical features and the broad-scale characteristics of the weather over the UK. Smaller scale topological features may be included in the dispersion modelling by using the flow field module of ADMS (FLOWSTAR²). The use of NWP data has advantages over traditional meteorological records because:

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

A wind rose showing the distribution of wind speeds and directions in the GFS derived data is shown in Figure 2a. Wind speeds are modified by the treatment of roughness lengths (see Section 4.7) and where terrain data is included in the modelling, the raw GFS wind speeds and directions will be modified. The terrain and roughness length modified wind rose for the site is shown in Figure 2b. Please note that FLOWSTAR² 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 amended³.

1. The GFS data used is derived from the high-resolution operational GFS datasets, the data is not obtained from the lower resolution (0.5 degree) long-term archive.
2. Note that FLOWSTAR requirements are for meteorological data representative of the upwind flow over the modelling domain and that single site meteorological data (observational or from high resolution modelled data) that is representative of the application site is not generally suitable (personal correspondence: CERC 2019 and UK Met O 2015). If data are deemed representative of a particular application site, either wholly or partially, then these data cannot also be representative of the upstream flow over the modelling domain. Furthermore, it would be extremely poor practice to use such data as the boundary conditions for a flow-solver, such as FLOWSTAR.

3. When modelling complex terrain with ADMS, by default, the minimum turbulence length has 0.1 m added to the flat terrain value (calculated from the Monin-Obukhov length). Whilst this might be appropriate over hill/mountain tops in terrain with slopes $> 1:10$ (and quite possibly only in certain wind directions) in lesser terrain it introduces model behaviour that is not desirable where FLOWSTAR is simply being used to modify the upwind flow. Specifically, the parameter σ_z of the Gaussian plume model is overly constrained, which for elevated point sources emissions, may on occasion cause over prediction of ground level concentrations in stable weather conditions and light winds (Steven R. Hanna & Biswanath Chowdhury, 2013), conversely for low level emission sources, this will cause gross under prediction. Note that this becomes particularly important overnight and if calm and light wind conditions are not being ignored, as they often are when using traditional observational meteorological datasets. To reduce this behaviour, where terrain is modelled, AS Modelling & Data Ltd. have set a minimum turbulence length of 0.025 m in ADMS. This approximates the normal behaviour of ADMS with flat terrain.

Figure 2a. The wind rose. Raw GFS derived data for 51.286 N, 2.146 W, 2021-2024

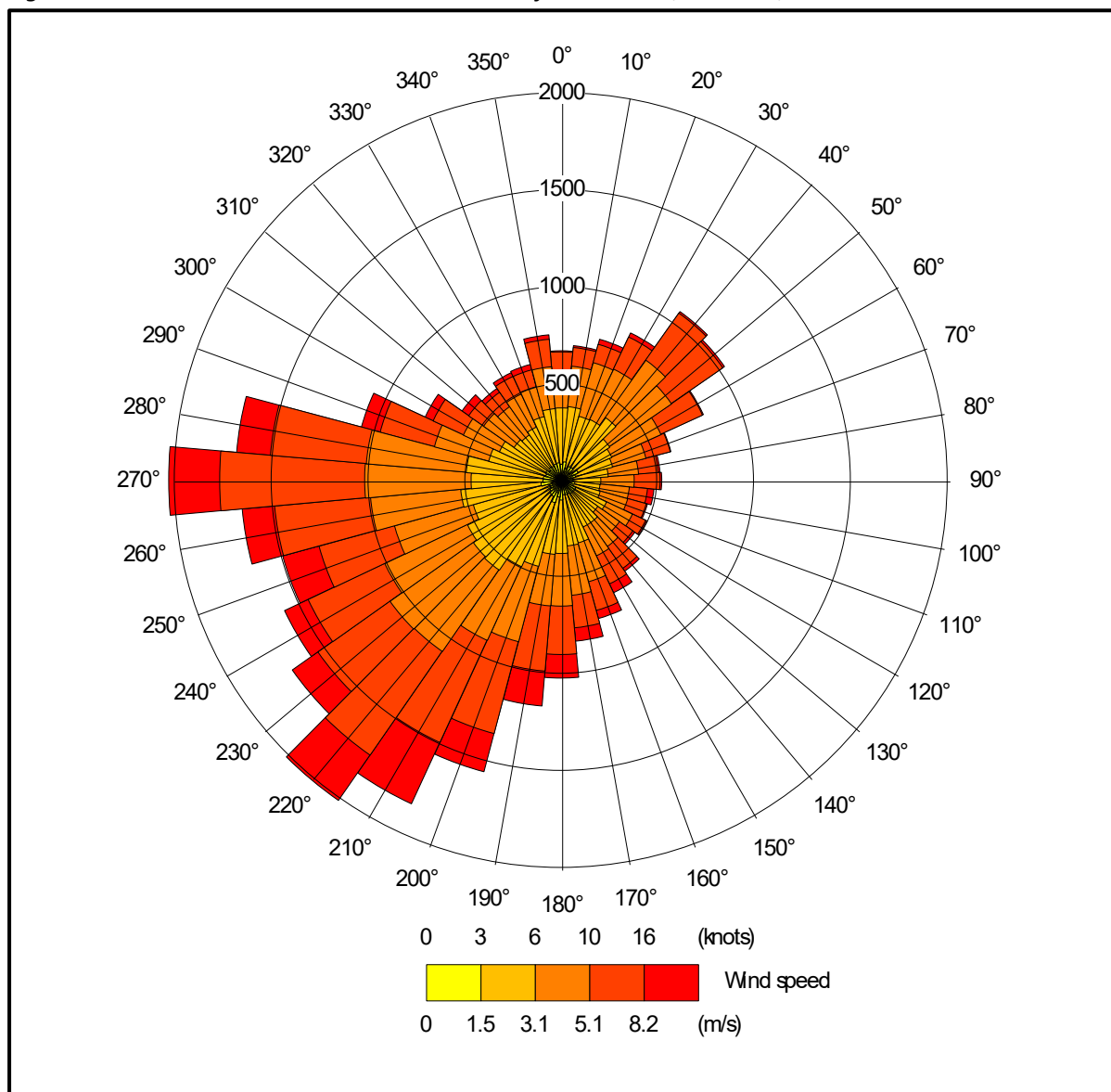
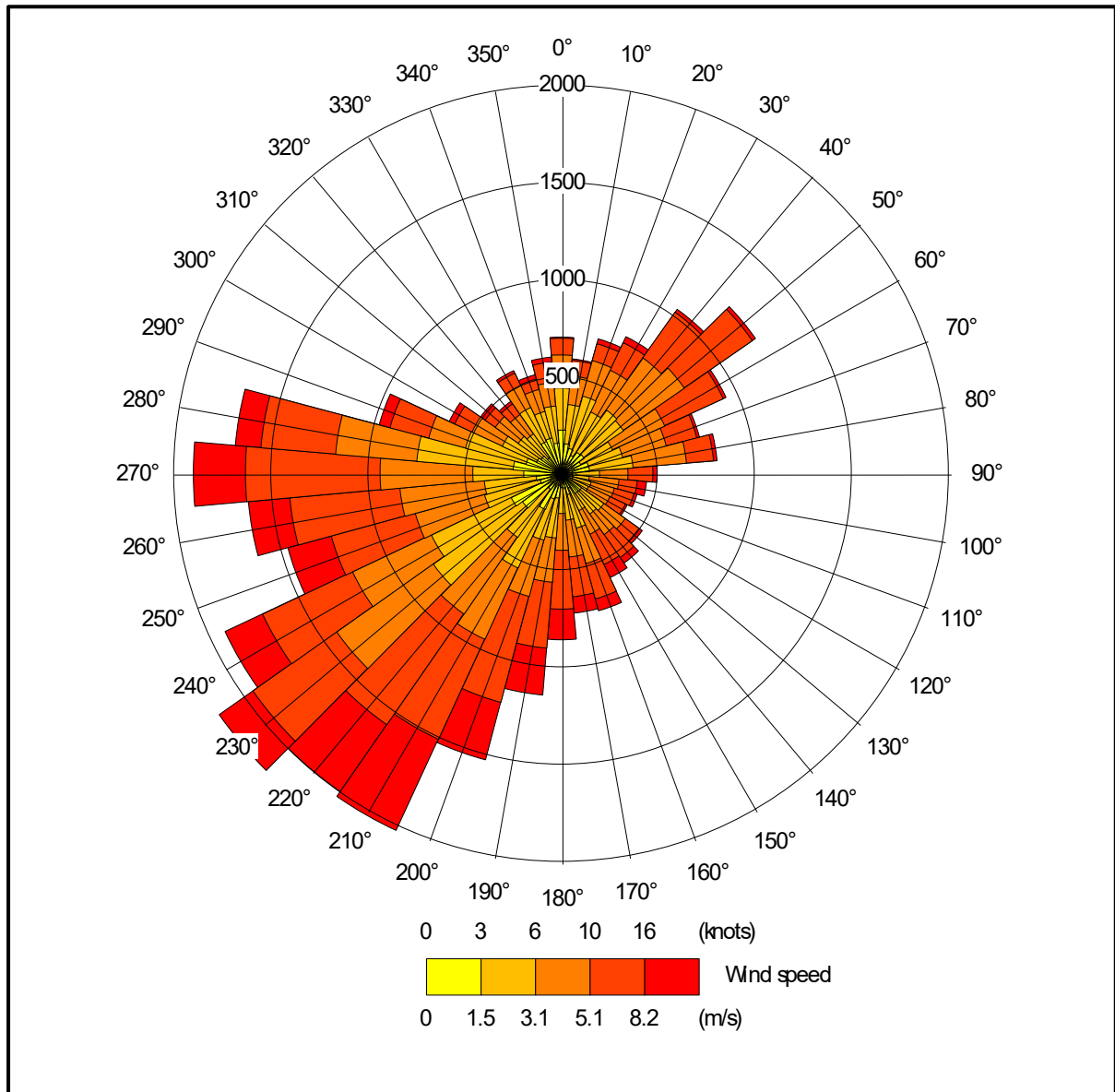


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 389800, 154150, 2021-2024



4.2 Emission sources

Emissions from the side mounted fans used to provide ventilation to the houses have been represented by volume sources within ADMS.

Details of the volume source parameters are shown in Table 3. The positions of the emission sources used are shown in Figure 3 (marked by red shaded rectangles).

Table 3. Volume source parameters

Source ID	Width (m)	Length (m)	Depth (m)	Base height (m)	Emission temperature (°C)	Baseline Emission rate per source ¹ (g/s)
EX1	30.5	61.0	3.0	0.0	Ambient	0.018825
EX2	30.5	61.0	3.0	0.0	Ambient	0.018825
EX3	25.9	73.2	3.0	0.0	Ambient	0.019201
EX4	25.9	73.2	3.0	0.0	Ambient	0.019201
PR1	30.5	71.6	3.0	0.0	Ambient	0.017102
PR2	30.5	91.4	3.0	0.0	Ambient	0.021833
PR3	25.9	73.2	3.0	0.0	Ambient	0.014846
PR4	25.9	109.7	3.0	0.0	Ambient	0.022270

1. The baseline emission rates used in the modelling assume a nominal 100,000 birds (existing and proposed) and are apportioned based upon the floor area of each house. The results obtained are scaled to the appropriate number of birds (given in Table 2), post modelling.

4.3 Modelled buildings

Not modelled.

4.4 Discrete receptors

Thirty-six discrete receptors have been defined at the nearby wildlife sites. These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figure 4 (marked by enumerated pink rectangles).

4.5 Cartesian grid

To produce the contour plots presented in Section 5 of this report and to define the spatially varying deposition velocity field, two regular Cartesian grids have been defined within ADMS. The individual grid receptors are defined at ground level within ADMS. The positions of the Cartesian grids may be seen in Figure 4 (marked by grey lines).

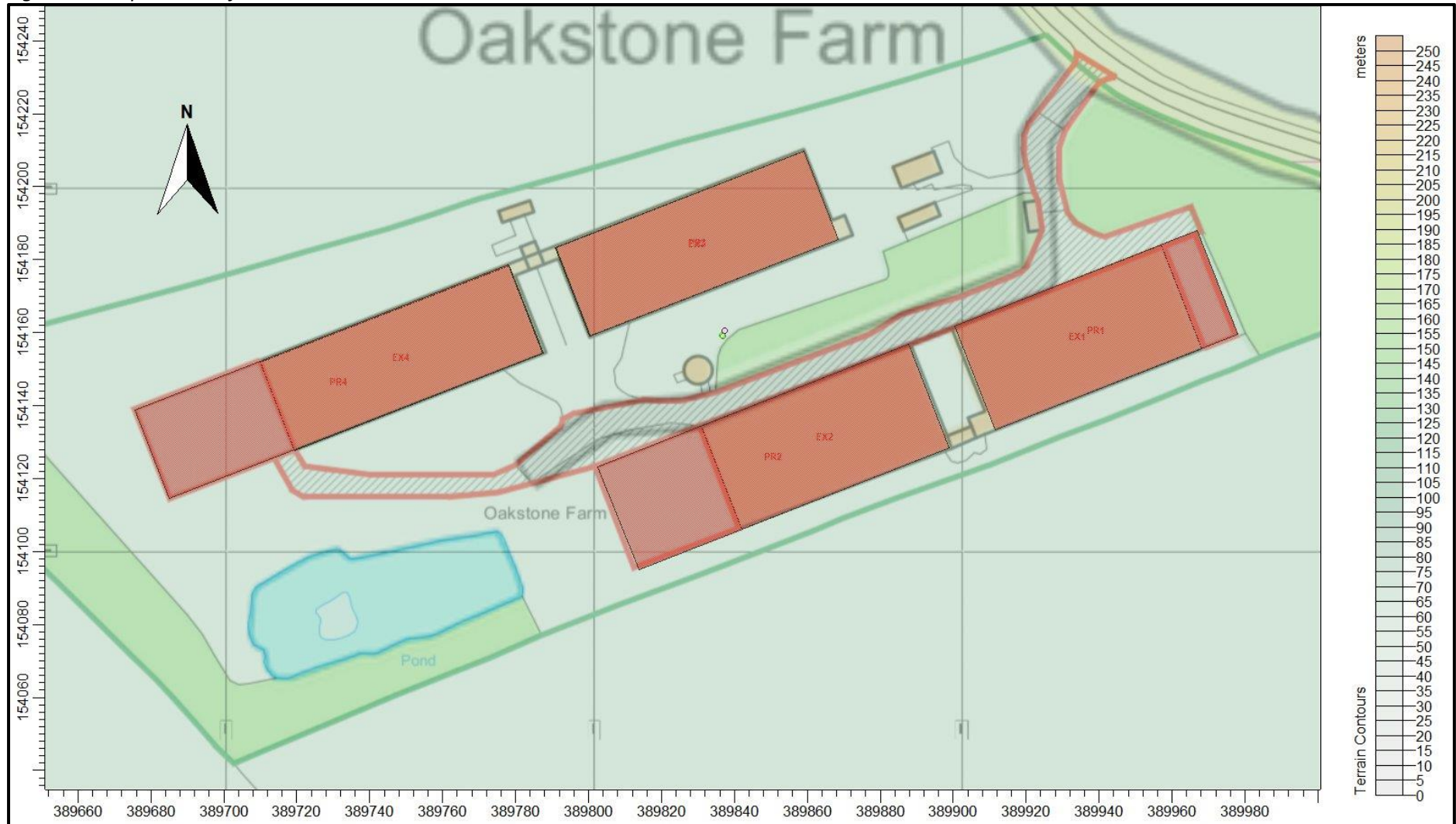
4.6 Terrain data

Terrain has been considered in the modelling. The terrain data are based upon the Ordnance Survey 50 m Digital Elevation Model. A 20.0 km by 20.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS for the modelling. The resolution of FLOWSTAR is 64 x 64 grid points; therefore, the effective resolution of the wind field for the terrain runs is approximately 300 m.

4.7 Roughness Length

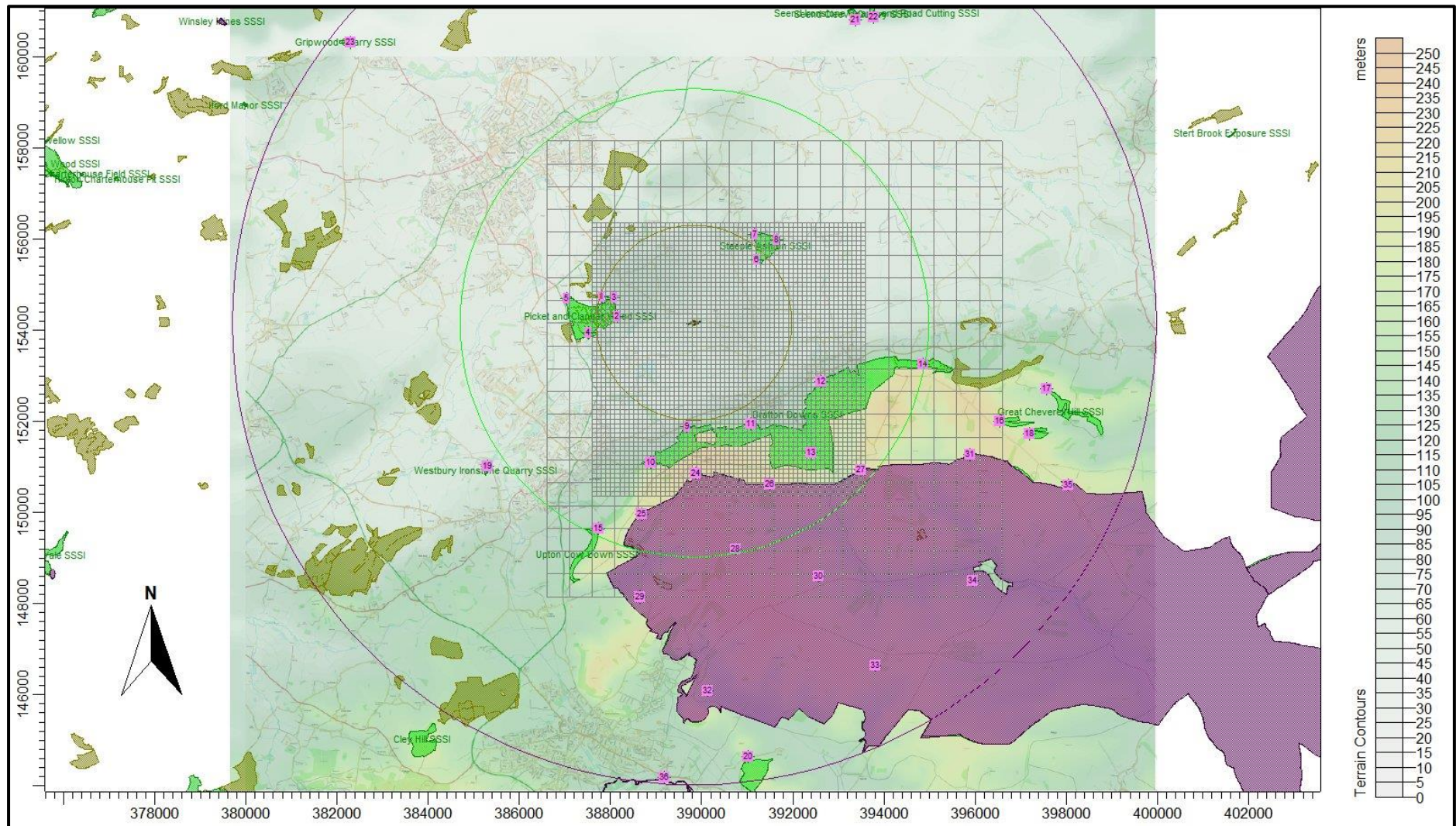
In this case, a spatially varying roughness length file has been defined, this is based upon the Defra Living Landscapes database. The GFS meteorological data is assumed to have a roughness length of 0.160 m (arithmetic average of the spatially varying roughness over the modelling domain). The sample of the central area of the spatially varying roughness length field is shown in Figure 5.

Figure 3. The positions of the modelled sources



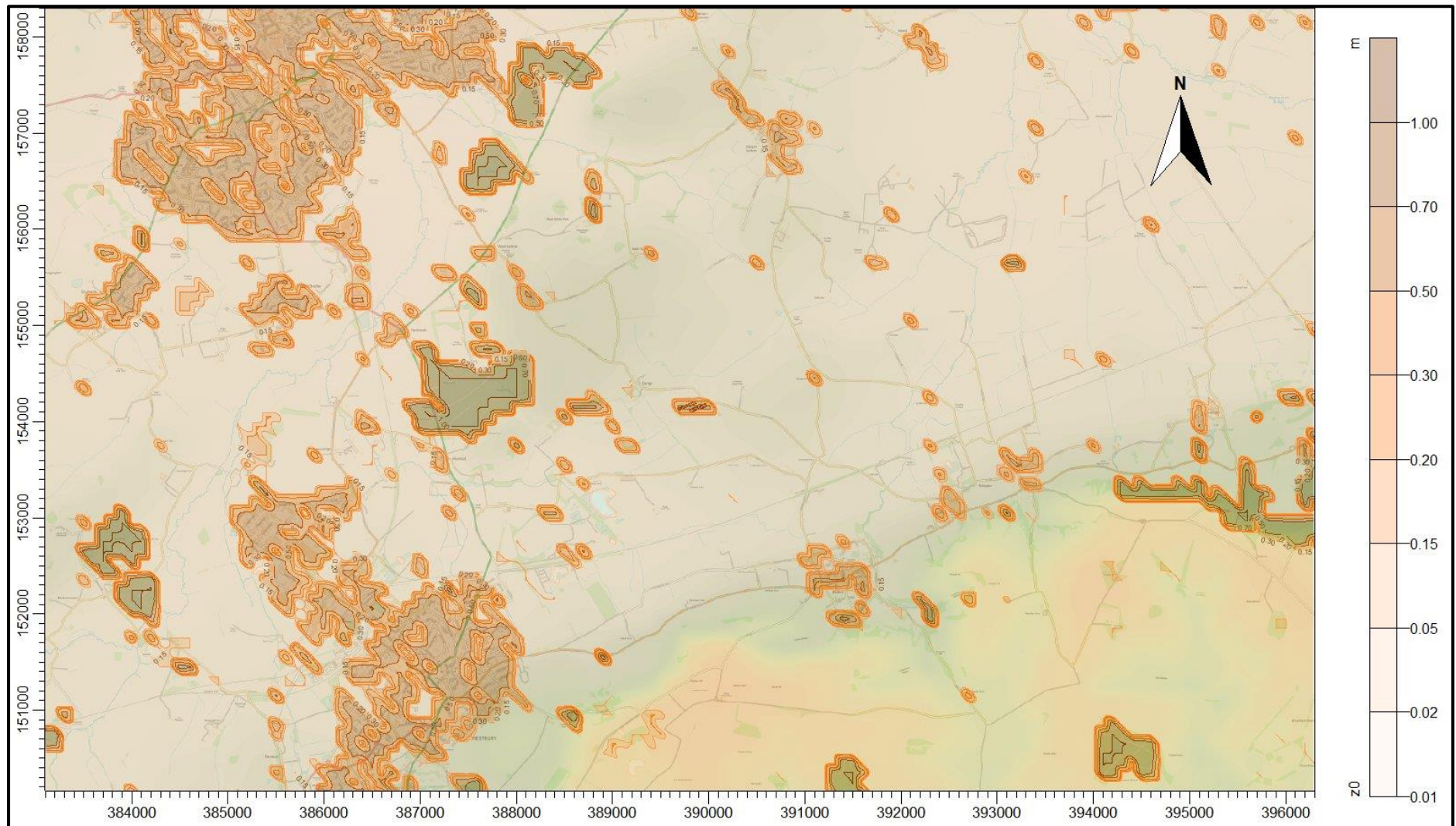
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Figure 4. The discrete receptors and regular Cartesian grids



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Figure 5. The spatially varying surface roughness field (central area)



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4.8 Deposition

The method used to model deposition of ammonia and consequent plume depletion is based primarily upon Frederik Schrader and Christian Brümmer. Land Use Specific Ammonia Deposition Velocities: a Review of Recent Studies (2004-2013). 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 0.010 m/s to 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.

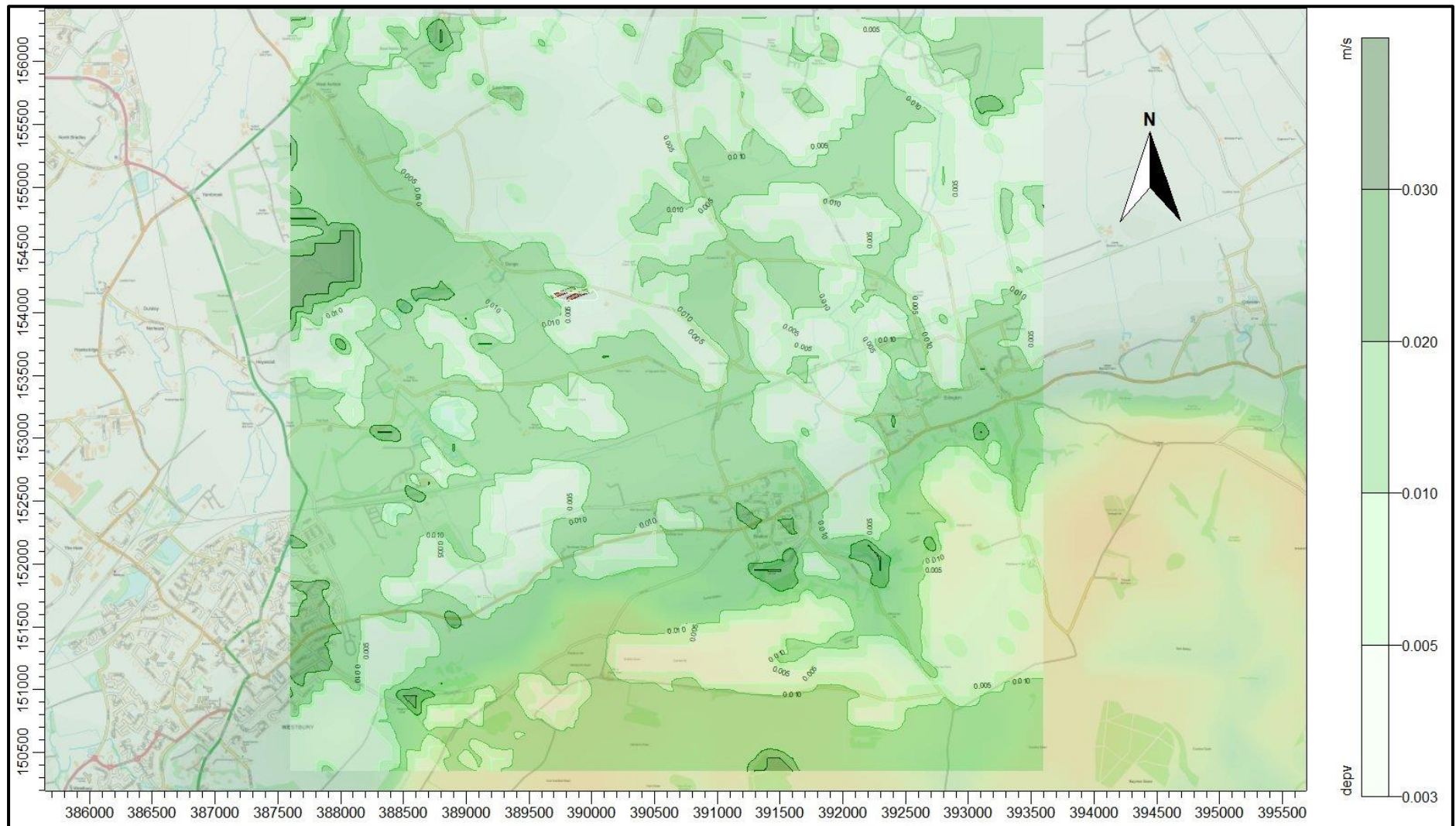
Table 4. Deposition velocities

NH ₃ 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 (0.010 to 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 fields is provided in Figure 6.

Figure 6. The spatially varying deposition field



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5. Details of the Model Runs and Results

5.1 Preliminary modelling and model sensitivity tests

ADMS was effectively run a total of eight times, once for each year of the meteorological record in the following modes:

- In basic mode without calms, or terrain – GFS data.
- With calms and without terrain – 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. The primary purpose of the preliminary modelling is to assess the effect of calms on the results at closer receptors.

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

Receptor number	X(m)	Y(m)	Name/Designation	Maximum annual mean ammonia concentration - ($\mu\text{g}/\text{m}^3$)	
				Nominal 100,000 birds	
				GFS No Calms No Terrain	GFS Calms No Terrain
1	387805	154722	AW	0.015	0.016
2	388145	154302	Picket and Clanger Wood SSSI	0.025	0.027
3	388076	154710	Picket and Clanger Wood SSSI	0.020	0.021
4	387508	153945	Picket and Clanger Wood SSSI	0.013	0.013
5	387040	154683	Picket and Clanger Wood SSSI	0.009	0.010
6	391204	155538	Steeple Ashton SSSI	0.043	0.044
7	391159	156100	Steeple Ashton SSSI	0.029	0.030
8	391652	155988	Steeple Ashton SSSI	0.025	0.025

5.2 Detailed modelling

In this case, detailed modelling has been carried out over a high resolution 6.0 km x 6.0 km domain surrounding Oakstone Farm. The primary purpose is to determine the magnitude of deposition of ammonia and consequent plume depletion close to the sources where it is of the greatest importance, but also to provide results should any LWSs be identified. Outside of the 6.0 km x 6.0 km domain a fixed deposition velocity of 0.005 m/s is assumed (with appropriate deposition velocities applied post-modelling at the discrete receptors).

The detailed deposition run was made with terrain. Calms cannot be used with terrain or spatially varying deposition; therefore, calms have not been included in the detailed modelling. However, the results of the preliminary modelling indicate that the effects of calms may be of some significance in this case; therefore an adjustment, based on the preliminary modelling results is applied to closer receptors.

The predicted maximum annual mean ground level ammonia concentrations and nitrogen deposition rates at the discrete receptors are shown in Tables 6a (Existing, 176,000 birds) and 6b (Proposed, 220,000 birds).

In the Tables, there are no predicted ammonia concentrations or nitrogen deposition rates as a percentage of the Critical Level or Critical Load that are in excess of the Environment Agency's upper threshold for the site (n/a% for an internationally designated site, 50% for a SSSI and 100% for a non-statutory site) nor any in the range between the Environment Agency's upper threshold and lower threshold of the Critical Level or Critical Load for the site (1% and n/a% for an internationally designated site, 20% and 50% for a SSSI and 100% and 100% for a non-statutory site). Process Contributions that exceed 1% of the relevant Critical Level or Critical Load at SSSIs are highlighted with bold text.

It has been noted previously that Critical Levels and Loads are almost certainly already exceeded and that available background levels are suitable only to provide a broad indication of likely pollutant impact at a specific location; therefore, PECs are not presented in the Tables.

Contour plots of the predicted ground level maximum annual mean ammonia concentration and maximum annual nitrogen deposition rates for the proposed scenario only are shown in Figures 7a and 7b.

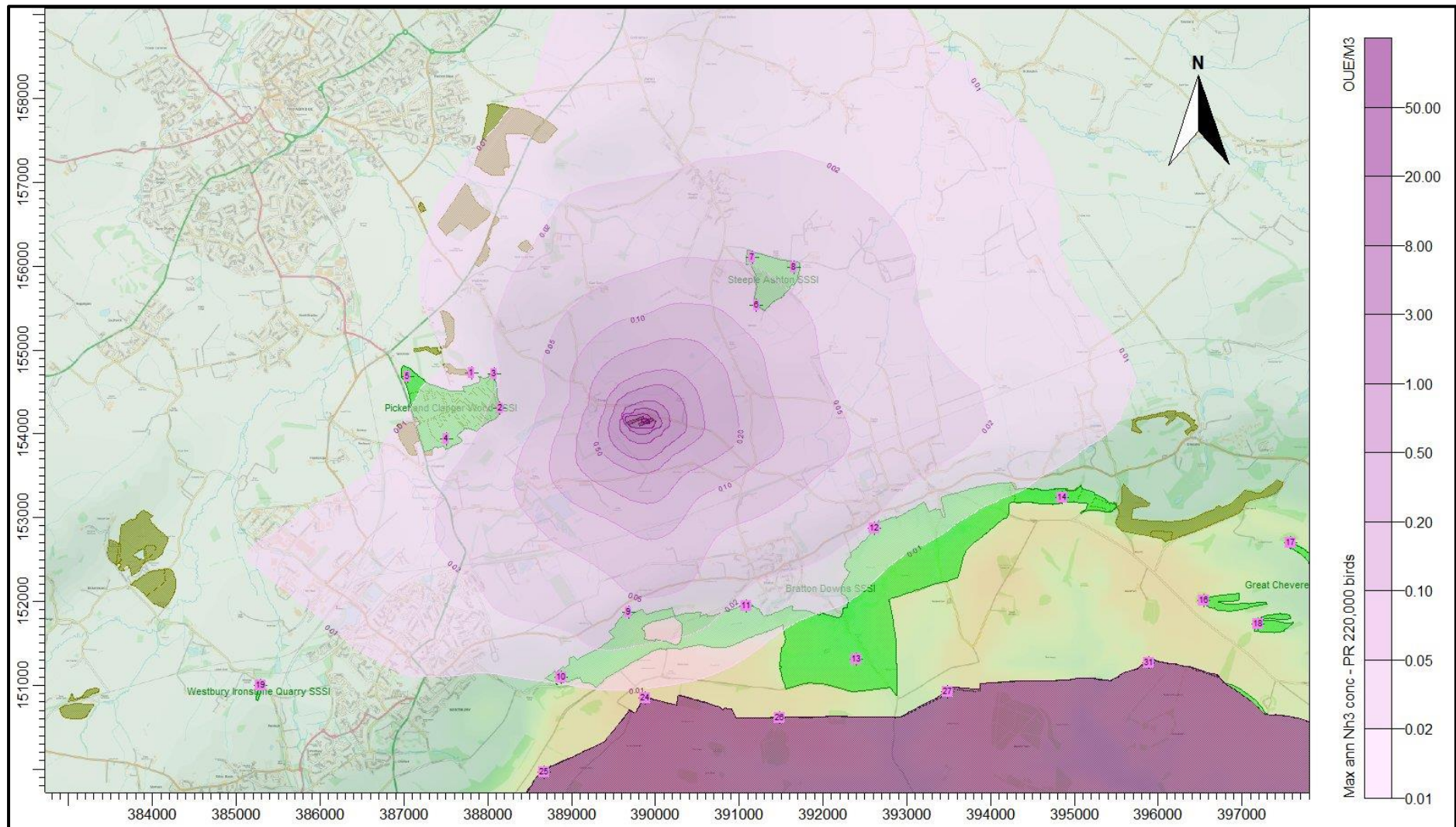
Table 6a. Predicted maximum annual mean ammonia concentrations and nitrogen deposition rates - Existing 176,000 birds

Receptor number	X(m)	Y(m)	Name	Site Parameters			Maximum annual ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level ($\mu\text{g}/\text{m}^3$)	Critical Load (kg/ha)	Process Contribution ($\mu\text{g}/\text{m}^3$)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	387805	154722	AW	0.005	1.0	10.0	0.011	1.09	0.01	-
2	388145	154302	Picket and Clanger Wood SSSI	0.03	1.0	15.0	0.021	2.10	0.16	1.09
3	388076	154710	Picket and Clanger Wood SSSI	0.03	1.0	15.0	0.015	1.52	0.12	0.79
4	387508	153945	Picket and Clanger Wood SSSI	0.03	1.0	15.0	0.012	1.23	0.10	0.64
5	387040	154683	Picket and Clanger Wood SSSI	0.03	1.0	15.0	0.007	0.74	0.06	0.38
6	391204	155538	Steeple Ashton SSSI	0.005	n/a	n/a	0.060	-	0.08	-
7	391159	156100	Steeple Ashton SSSI	0.005	n/a	n/a	0.039	-	0.05	-
8	391652	155988	Steeple Ashton SSSI	0.005	n/a	n/a	0.034	-	0.04	-
9	389679	151873	Bratton Downs SSSI	0.02	1.0	10.0	0.030	2.99	0.16	1.55
10	388878	151094	Bratton Downs SSSI	0.02	1.0	10.0	0.009	0.89	0.05	0.46
11	391079	151948	Bratton Downs SSSI	0.02	1.0	10.0	0.014	1.37	0.07	0.71
12	392614	152869	Bratton Downs SSSI	0.02	1.0	10.0	0.015	1.48	0.08	0.77
13	392397	151311	Bratton Downs SSSI	0.02	1.0	10.0	0.004	0.45	0.02	0.23
14	394853	153244	Bratton Downs SSSI	0.02	1.0	10.0	0.006	0.59	0.03	0.31
15	387728	149642	Upton Cow Down SSSI	0.02	1.0	10.0	0.003	0.34	0.02	0.18
16	396549	152009	Great Cheverell Hill SSSI	0.02	1.0	10.0	0.002	0.19	0.01	0.10
17	397575	152704	Great Cheverell Hill SSSI	0.02	1.0	10.0	0.002	0.23	0.01	0.12
18	397194	151727	Great Cheverell Hill SSSI	0.02	1.0	10.0	0.002	0.15	0.01	0.08
19	385293	151002	Westbury Ironstone Quarry SSSI	0.03	n/a	n/a	0.005	-	0.04	-
20	391011	144642	Scratchbury & Cotley Hills SSSI	0.03	n/a	n/a	0.001	-	0.01	-
21	393373	160815	Seend Ironstone Quarry and Road Cutting SSSI	0.03	n/a	n/a	0.004	-	0.03	-
22	393762	160862	Seend Ironstone Quarry and Road Cutting SSSI	0.03	n/a	n/a	0.004	-	0.03	-
23	382283	160308	Gripwood Quarry SSSI	0.03	n/a	n/a	0.001	-	0.01	-
24	389874	150847	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.007	0.70	0.04	0.36
25	388677	149963	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.004	0.36	0.02	0.19
26	391487	150613	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.003	0.31	0.02	0.16
27	393491	150925	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.002	0.23	0.01	0.12
28	390745	149195	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.002	0.23	0.01	0.12
29	388651	148141	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.002	0.18	0.01	0.10
30	392554	148596	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.001	0.13	0.01	0.07
31	395885	151264	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.002	0.15	0.01	0.08
32	390134	146085	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.001	0.10	0.01	0.05
33	393803	146645	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.001	0.08	0.00	0.04
34	395937	148505	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.001	0.08	0.00	0.04
35	398045	150600	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.001	0.10	0.01	0.05
36	389171	144185	River Avon System SSSI/SAC	0.005	3.0	n/a	0.001	0.03	0.00	-

Table 6b. Predicted maximum annual mean ammonia concentrations and nitrogen deposition rates - Proposed 220,000 birds

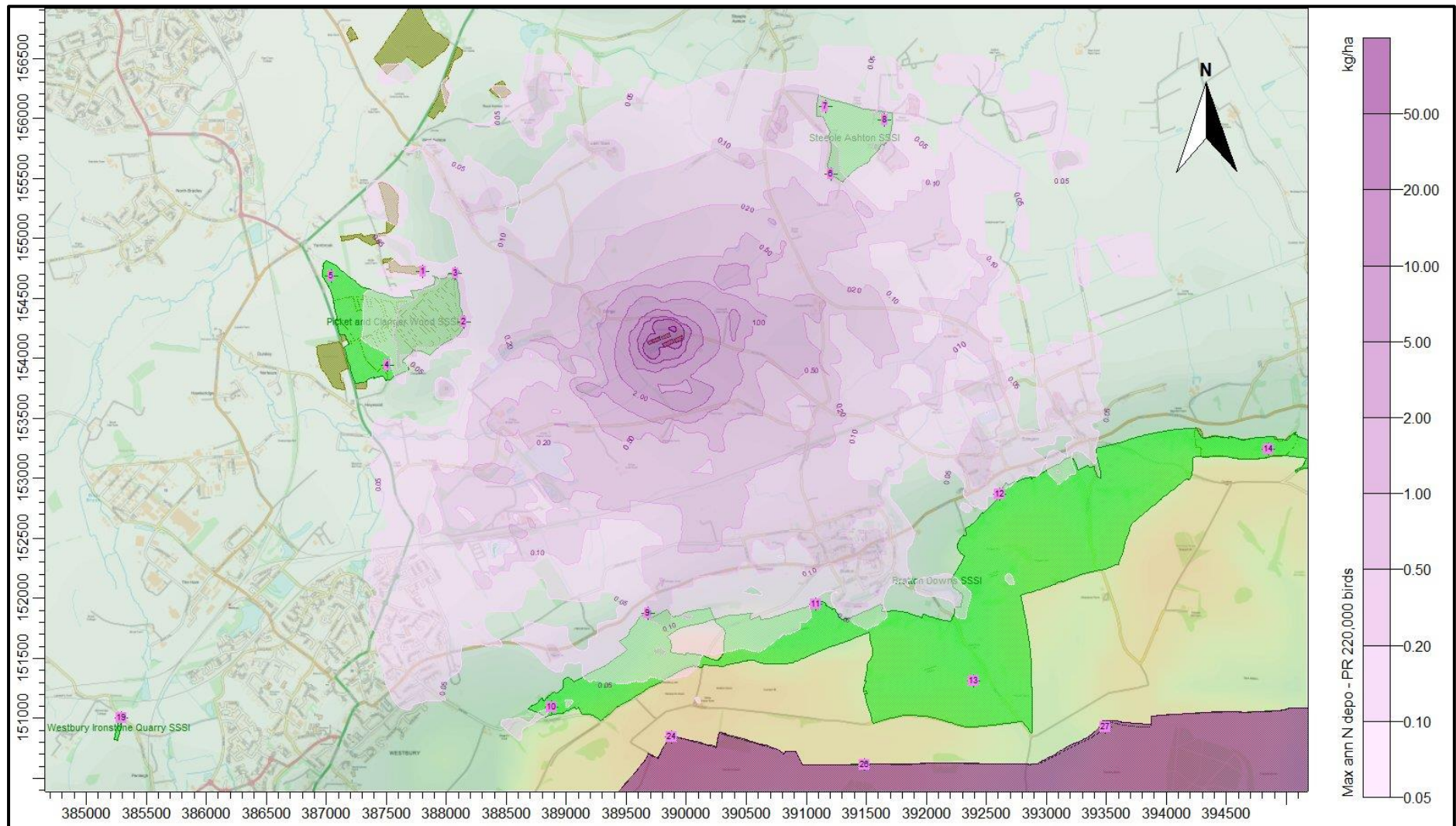
Receptor number	X(m)	Y(m)	Name	Site Parameters			Maximum annual ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level ($\mu\text{g}/\text{m}^3$)	Critical Load (kg/ha)	Process Contribution ($\mu\text{g}/\text{m}^3$)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	387805	154722	AW	0.005	1.0	10.0	0.014	1.36	0.02	-
2	388145	154302	Picket and Clanger Wood SSSI	0.03	1.0	15.0	0.026	2.63	0.20	1.36
3	388076	154710	Picket and Clanger Wood SSSI	0.03	1.0	15.0	0.019	1.89	0.15	0.98
4	387508	153945	Picket and Clanger Wood SSSI	0.03	1.0	15.0	0.015	1.54	0.12	0.80
5	387040	154683	Picket and Clanger Wood SSSI	0.03	1.0	15.0	0.009	0.92	0.07	0.48
6	391204	155538	Steeple Ashton SSSI	0.005	n/a	n/a	0.075	-	0.10	-
7	391159	156100	Steeple Ashton SSSI	0.005	n/a	n/a	0.049	-	0.06	-
8	391652	155988	Steeple Ashton SSSI	0.005	n/a	n/a	0.043	-	0.06	-
9	389679	151873	Bratton Downs SSSI	0.02	1.0	10.0	0.037	3.74	0.19	1.94
10	388878	151094	Bratton Downs SSSI	0.02	1.0	10.0	0.011	1.11	0.06	0.58
11	391079	151948	Bratton Downs SSSI	0.02	1.0	10.0	0.017	1.72	0.09	0.89
12	392614	152869	Bratton Downs SSSI	0.02	1.0	10.0	0.018	1.85	0.10	0.96
13	392397	151311	Bratton Downs SSSI	0.02	1.0	10.0	0.006	0.56	0.03	0.29
14	394853	153244	Bratton Downs SSSI	0.02	1.0	10.0	0.007	0.74	0.04	0.38
15	387728	149642	Upton Cow Down SSSI	0.02	1.0	10.0	0.004	0.43	0.02	0.22
16	396549	152009	Great Cheverell Hill SSSI	0.02	1.0	10.0	0.002	0.24	0.01	0.12
17	397575	152704	Great Cheverell Hill SSSI	0.02	1.0	10.0	0.003	0.29	0.02	0.15
18	397194	151727	Great Cheverell Hill SSSI	0.02	1.0	10.0	0.002	0.19	0.01	0.10
19	385293	151002	Westbury Ironstone Quarry SSSI	0.03	n/a	n/a	0.006	-	0.05	-
20	391011	144642	Scratchbury & Cotley Hills SSSI	0.03	n/a	n/a	0.001	-	0.01	-
21	393373	160815	Seend Ironstone Quarry and Road Cutting SSSI	0.03	n/a	n/a	0.006	-	0.04	-
22	393762	160862	Seend Ironstone Quarry and Road Cutting SSSI	0.03	n/a	n/a	0.005	-	0.04	-
23	382283	160308	Gripwood Quarry SSSI	0.03	n/a	n/a	0.002	-	0.01	-
24	389874	150847	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.009	0.88	0.05	0.45
25	388677	149963	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.005	0.45	0.02	0.24
26	391487	150613	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.004	0.39	0.02	0.20
27	393491	150925	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.003	0.28	0.01	0.15
28	390745	149195	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.003	0.29	0.01	0.15
29	388651	148141	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.002	0.23	0.01	0.12
30	392554	148596	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.002	0.17	0.01	0.09
31	395885	151264	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.002	0.19	0.01	0.10
32	390134	146085	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.001	0.13	0.01	0.07
33	393803	146645	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.001	0.10	0.00	0.05
34	395937	148505	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.001	0.10	0.01	0.05
35	398045	150600	Salisbury Plain SSSI/SPA/SAC	0.02	1.0	10.0	0.001	0.12	0.01	0.06
36	389171	144185	River Avon System SSSI/SAC	0.005	3.0	n/a	0.001	0.04	0.00	-

Figure 7a. Maximum annual mean ammonia concentration – Proposed 220,000 birds



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Figure 7b. Maximum annual nitrogen deposition rates – Proposed 220,000 birds



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6. Summary and Conclusions

Ammonia emission rates from the existing and proposed poultry rearing houses at Oakstone Farm Poultry Unit have been assessed and quantified based upon the Environment Agency 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:

- At the AW, the process contributions to annual mean ammonia concentrations and nitrogen deposition rates are currently and would be below 100% of the precautionary Critical Level and Critical Load.
- At all SSSIs, SACs and SPAs considered, process contributions would be below the Environment Agency lower threshold of the relevant Critical Level and Critical Load (20% for SSSIs and 1% for SACs/SPAs).
- There would be exceedances of 1% at Picket and Clanger Wood SSSI and parts of Bratton Downs SSSI; however, in both cases the change from the baseline of the existing 172,000 birds is less than 1% of the relevant Critical Level or Load.

7. References

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