A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Existing Turkey Rearing Houses and the Proposed Broiler Chicken Rearing Houses at Beck Farm, Felthorpe Poultry Unit, Haveringland Road, near Felthorpe in Norfolk

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Mr. Andrew Irving of 2Agriculture Ltd. to use computer modelling to assess the impact of ammonia emissions from the existing turkey rearing houses and the proposed broiler chicken rearing houses at Beck Farm, Felthorpe Poultry Unit, Haveringland Road, Felthorpe, Norfolk. NR10 4BZ.

Ammonia emission rates from the poultry houses have been assessed and quantified based upon the Environment Agency standard ammonia emission factors and bespoke Environment Agency ammonia emission factors. The 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 poultry rearing unit at Beck Farm is in a rural area approximately 500 m to the north-east of the village of Felthorpe in Norfolk. The surrounding land is used mainly for arable farming, although there are some pastures, heathland and wooded areas. The site is at an altitude of around 35 m in a gentle, rolling landscape, characteristic of central Norfolk's boulder clay plateau.

There are currently twenty poultry houses at the site, which provide accommodation for up to 151,967 hen turkeys, which are reared for around 100 days from poults of around 7 weeks of age to fully grown turkeys at around 28 weeks of age. The poultry houses are ventilated using cowled side mounted fans.

It is proposed that the existing turkey rearing houses would be renovated and converted to broiler chicken rearing houses. As part of the renovation, the ventilation of the houses would be upgraded to uncapped high speed ridge fans, each with a short chimney, with gable end fans for supplementary ventilation in hot weather conditions. The renovated poultry houses would provide accommodation for up to 617,500 broiler chickens. The chickens would be reared from day old chicks for a period of around 38 days and houses would be empty for around 10 days at the end of each crop.

Two scenarios are considered in the report:

Scenario 1 – The Existing Scenario - 151,967 hen turkeys in the twenty existing poultry houses.
Scenario 2 – The Proposed Scenario - The renovated poultry houses stocked with 617,500 broiler chickens.

There are several areas designated as Local Wildlife Sites (LWSs) and two areas designated as Ancient Woodlands (AWs) within 2 km (the normal screening distance for non-statutory sites) of the poultry unit at Beck Farm. There are five areas designated as Sites of Special Scientific Interest (SSSIs) within 5 km of the site (Environment Agency and Natural England screening distance). Two of the SSSIs are also designated as Special Areas of Conservation (SACs). There are two other SACs within 10 km (Natural England screening distance), one of which is also designated as a Special Protection Area (SPA) and a Ramsar site. Some further details of the SSSIs/SACs/SPA/Ramsar site are provided below:

- **Swannington Upgate Common SSSI** - Approximately 2.0 km to the west-south-west - An unusual site supporting a wide variety of habitat types within a small area including, dry acidic heathland, wet heathland with acidic flushes, fen, birch and alder woodland, scrub, bracken, rough grassland and ponds.
- **Alderford Common SSSI** - Approximately 3.9 km to the west-south-west - The site supports a wide range of habitats. The habitats represented include scrub, woodland, bracken heath, marshy grassland and ponds. A diverse chalk flora has developed in old pits and the site forms the only remaining example of species-rich chalk grassland in East Norfolk. A bat roost and an outstanding assemblage of breeding birds provide additional interest.
- **Cawston and Marsham Heaths SSSI** - Approximately 4.0 km to the north - The largest area of Heather-dominated heathland now remaining in east Norfolk. There is a diverse flora which includes a rich assemblage of lichens. The site is also of considerable ornithological interest.
- **Buxton Heath SSSI/SAC** - Approximately 4.0 km to the north - A diverse heath-with-fen which forms one of the best examples of this rare habitat type in Norfolk. The valley mire is floristically rich and there is a rapid transition from calcareous to acidic plant communities with dry acidic heathland on higher ground. These communities have remained undisturbed for a long period of time and Round-leaved *Sundew Drosera* rotundifolia and a number of

rare relict mosses, liverworts and fungi occur on the site. Several uncommon invertebrates have also been recorded including one species new to Britain.

- **River Wensum SSSI/SAC** - Approximately 4.6 km to the south-west (closest point) - Selected as one of a national series of rivers of special interest as an example of an enriched, calcareous lowland river. With a total of over 100 species of plants, a rich invertebrate fauna and a relatively natural corridor, it is probably the best whole river of its type in nature conservation terms. Much of the adjacent land is still traditionally managed for hay crops and by grazing, giving a wide spectrum of grassland habitats. The mosaic of meadow and marsh habitats, including one of the most extensive reedbeds in the country outside the Broads, provide niches for a wide variety of specialised plants and animals.
- **Booton Common SSSI/SAC** - Approximately 6.8 km to the north-west - The principal interest of the site is associated with a mosaic of wet calcareous fen grassland and acid heath communities which have developed due to the naturally undulating ground. Areas of tall fen and a strip of valley alder woodland occupy the lower ground adjacent to a stream.
- **Crostwick Marsh SSSI/SAC/Ramsar** - Approximately 8.7 km to the east-south-east -The site forms an excellent example of unimproved valley meadow and supports a series of intergrading plant communities ranging from damp neutral grassland through species-rich fen grassland to tall fen in the valley bottom. A spring line is present on the valley slopes which provides irrigating water and calcareous flushes have developed locally at seepage points. A number of uncommon plants are present, several in great abundance and there is additional ornithological interest.

Maps of the surrounding area showing the position of the poultry unit at Beck Farm (outlined in blue), the LWSs (shaded in yellow), the SSSIs (shaded in green), the SACs/SPA/Ramsar site (shaded in purple) are provided in Figures 1a and 1b.

Figure 1a. The area surrounding Beck Farm – concentric circles radii 2.25 km (olive), 5.25 km (green) and 10.25 km (purple)

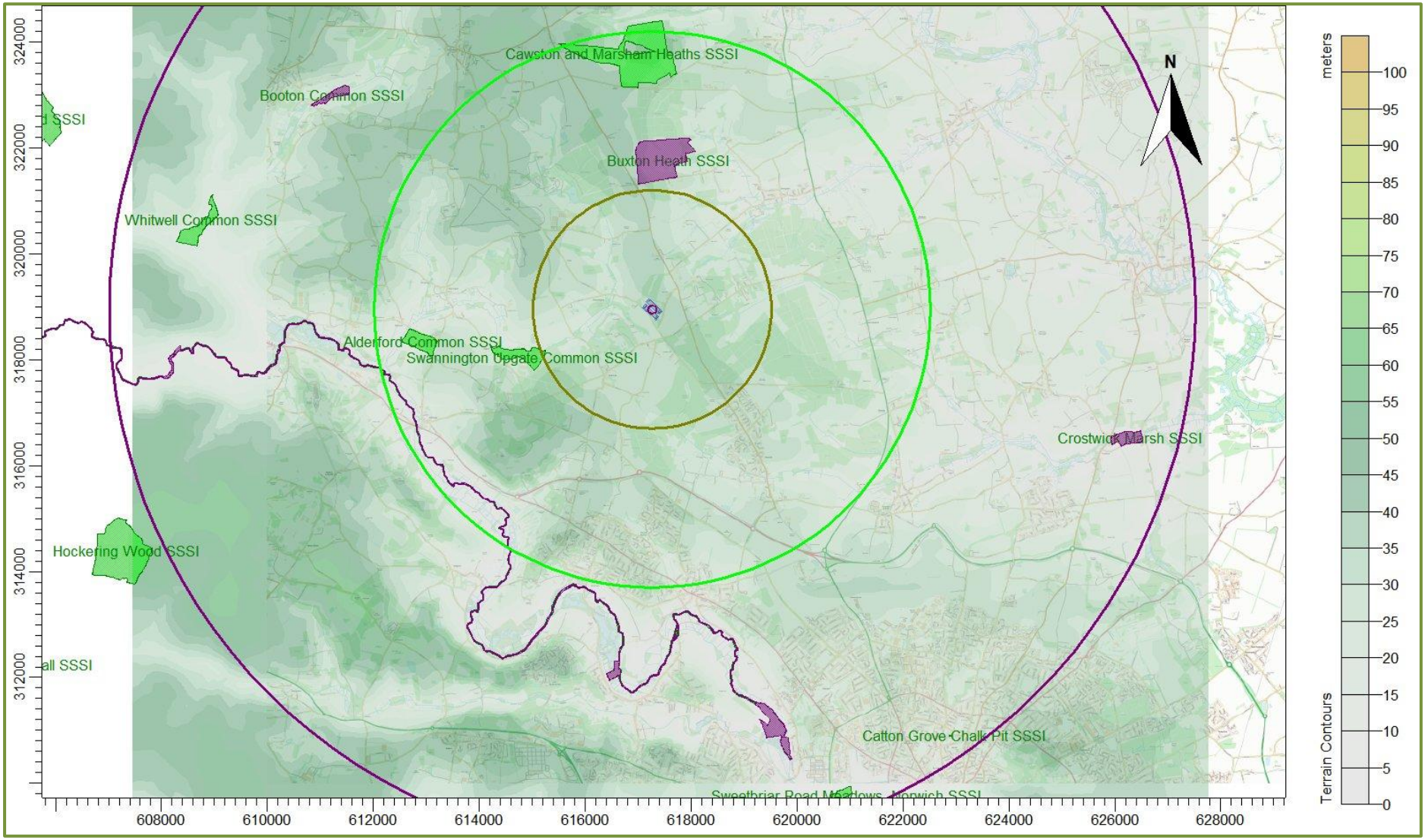
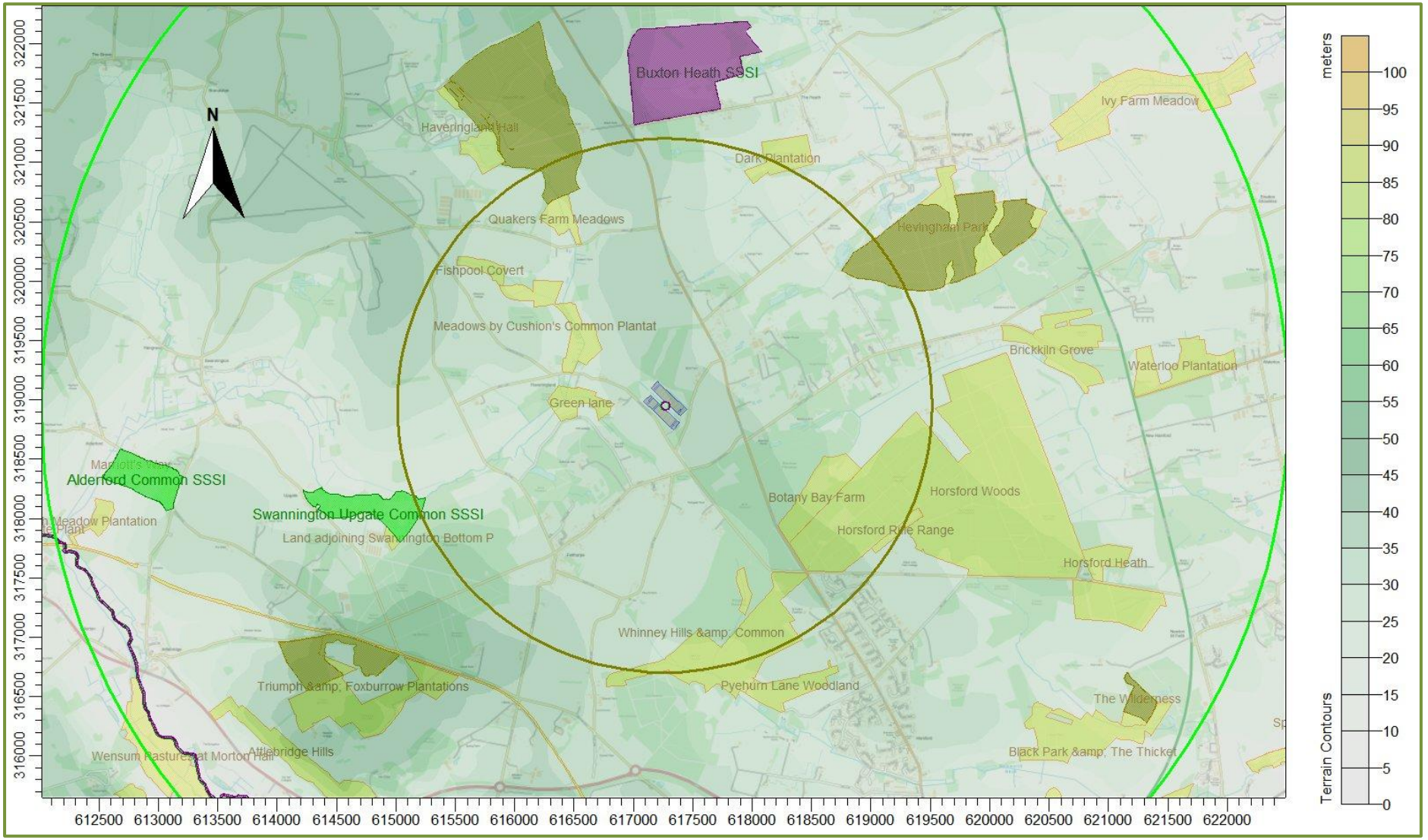


Figure 1b. The area surrounding Beck Farm – a closer view with AWs and LWSs



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 source of the background figures is the Air Pollution Information System (APIS, March 2026). 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 in the area around Beck Farm is 2.61 µg-NH_3/m^3. The background nitrogen deposition rate to woodland is 39.02 kg-N/ha/y and to short vegetation is 21.04 kg-N/ha/y. The background acid deposition rate to woodland is 2.83 keq/ha/y and to short vegetation is 1.52 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/app.

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 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. 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 Deposition (kg-N/ha/y)	Critical Load - Acid Deposition (keq/ha/y)
LWSs and AWs	1.0 [1]	-	-
Alderford Common SSSI	3.0 [2]	10.0 [2 & 3]	-
River Wensum SSSI/SAC and Crostwick Marsh SSSI/SAC/SPA/Ramsar	3.0 [2]	15.0 [2 & 3]	-
Swannington Upgate Common SSSI; Cawston and Marsham Heaths SSSI and Buxton Heath SSSI/Norfolk Valley Fens SAC	1.0 [1 & 2]	5.0 [2 & 3]	-

1. A precautionary figure used where details of the site are entirely unknown, or where although citations do not explicitly mention lichens or bryophytes, there are habitats where they are likely to be present.
2. Based upon APIS (https://www.apis.ac.uk/search-habitat-impacts) and the citation for the site. Note that the APIS database may contain entries habitats/species that are not present at the site or part 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 part of the site under consideration.

3.4 Guidance on the Significance of Ammonia Emissions

3.4.1 Environment Agency Criteria

The Environment Agency and Department for Environment, Food & Rural Affairs published guidance "Intensive farming risk assessment for your environmental permit" (last updated August 2025) applies to ammonia emitting developments requiring a permit. The Environment Agency ammonia screening thresholds for designated nature conservation sites are given in Table 2.

Table 2. Environment Agency Screening Thresholds

Nature conservation site designation	Distance from site (km)	Lower threshold %	Upper threshold %
Special Protection Areas (SPAs), Special Areas of Conservation (SACs), Ramsar sites	5	1	No upper threshold
Sites of Special Scientific Interest (SSSIs)	5	20	50
Local nature sites (National Nature Reserves, Local Nature Reserves, Local Wildlife Sites, Ancient Woodlands)	2	100	100

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 to Critical Level or Critical Load are in the range between the lower and upper thresholds, 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 Process Contribution of up to 100% of Critical Level and/or Critical Load is usually deemed acceptable for permitting purposes and therefore the upper and lower thresholds are the same (100%).

3.4.2 Natural England guidance for Local Authorities

Natural England, a statutory consultee at planning, published the "Air pollution and development: advice for local authorities" guidance document in October 2025, which is applicable to ammonia assessments of agricultural proposals in England.

For livestock and poultry units (over 500 m^2 floorspace) the screening distance for SSSIs is 5 km and for habitats sites (SPAs, SAC's and Ramsar Sites) is 10 km. It should be noted that Natural England screening distances may differ from the Environment Agency and Department for Environment, Food & Rural Affairs published guidance.

If the predicted process contributions of the proposal to the relevant Critical Level and/or Critical Load are 1% or more further assessment may be required. If a proposal does not exceed 1% of the Critical Level and/or Critical Load alone, the Local Authority should consider the proposal in-combination. It is a legal requirement to assess process contributions in-combination for habitats sites (SPAs, SACs and Ramsar sites) only. In-combination assessment would not be required where the proposal would result in a reduction in emissions or where process contributions would be below the Joint Nature Conservancy Committee Decision Making Thresholds.

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 NH_3 - 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 - 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 housing 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.

A bespoke ammonia emission rate for the hen turkeys provided by 2Agriculture Ltd, which AS Modelling & Data Ltd. understands has previously been agreed with the Environment Agency. This is the lowest emission factor available (it is lower than the pre-November 2024 emission factors for hen turkeys) and as such, according to AS Modelling & Data Ltd. correspondence with the Environment Agency, should be used for the existing baseline in a case such as this study.

The emission factors used for the proposed broiler chickens 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 factor used and calculated ammonia emission rates are provided in Table 3.

Table 3. Details of poultry numbers and ammonia emission rates

Housing	Bird numbers	Bird Type	Emission Factor ($kg\text{-}NH_3/place/y$)	Emission rate ($g\text{-}NH_3/s$)
Existing Turkey Rearing Houses	151,967	Hen Turkeys	0.138	0.664545
Proposed Broiler Chicken Houses	617,500	Broiler Chickens	0.024	0.469617

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 (FLOWSTAR[2]). 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 FLOWSTAR[2] 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 [3].

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 sigma 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 52.724 N, 1.218 E, 2022-2025

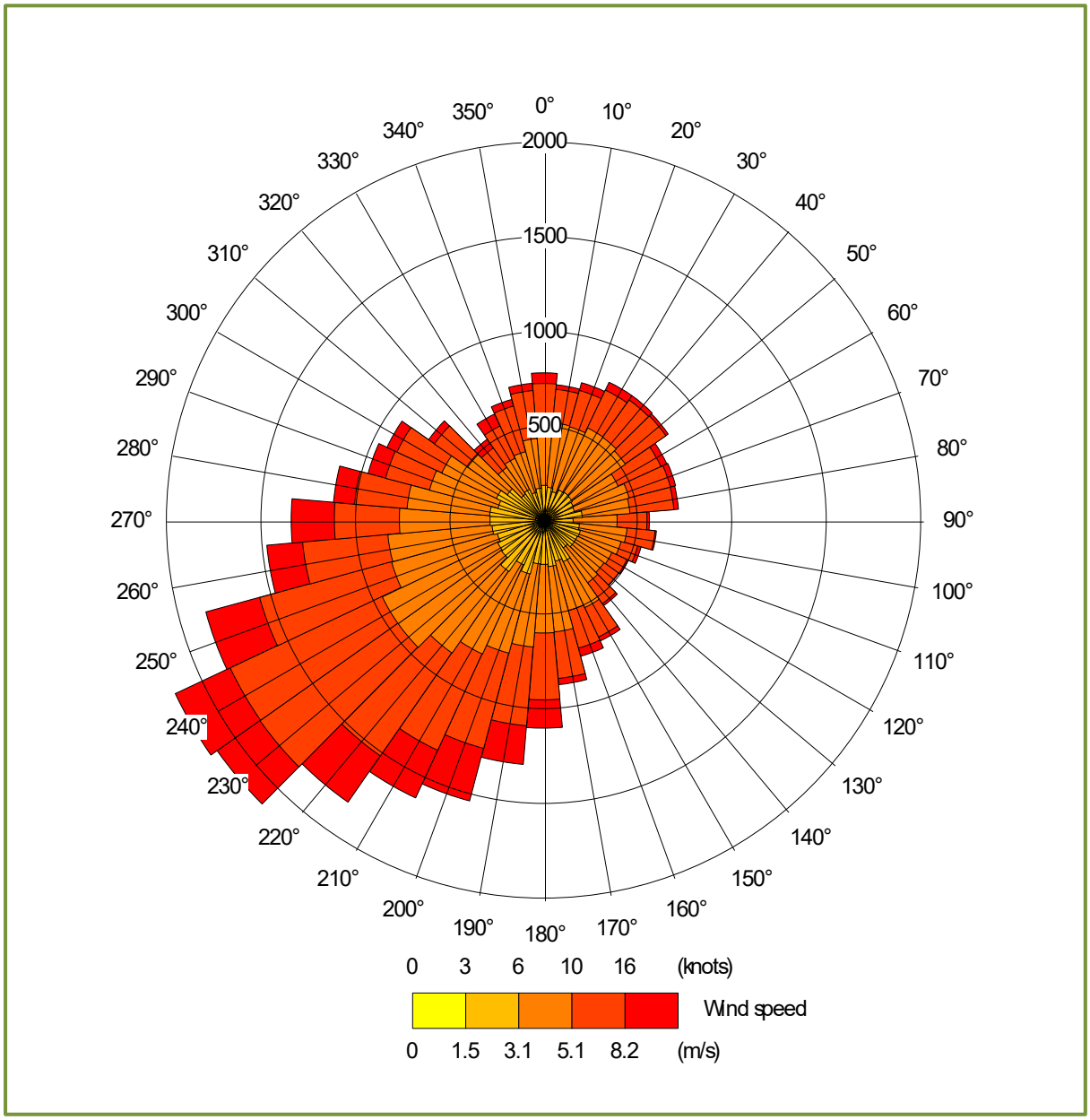
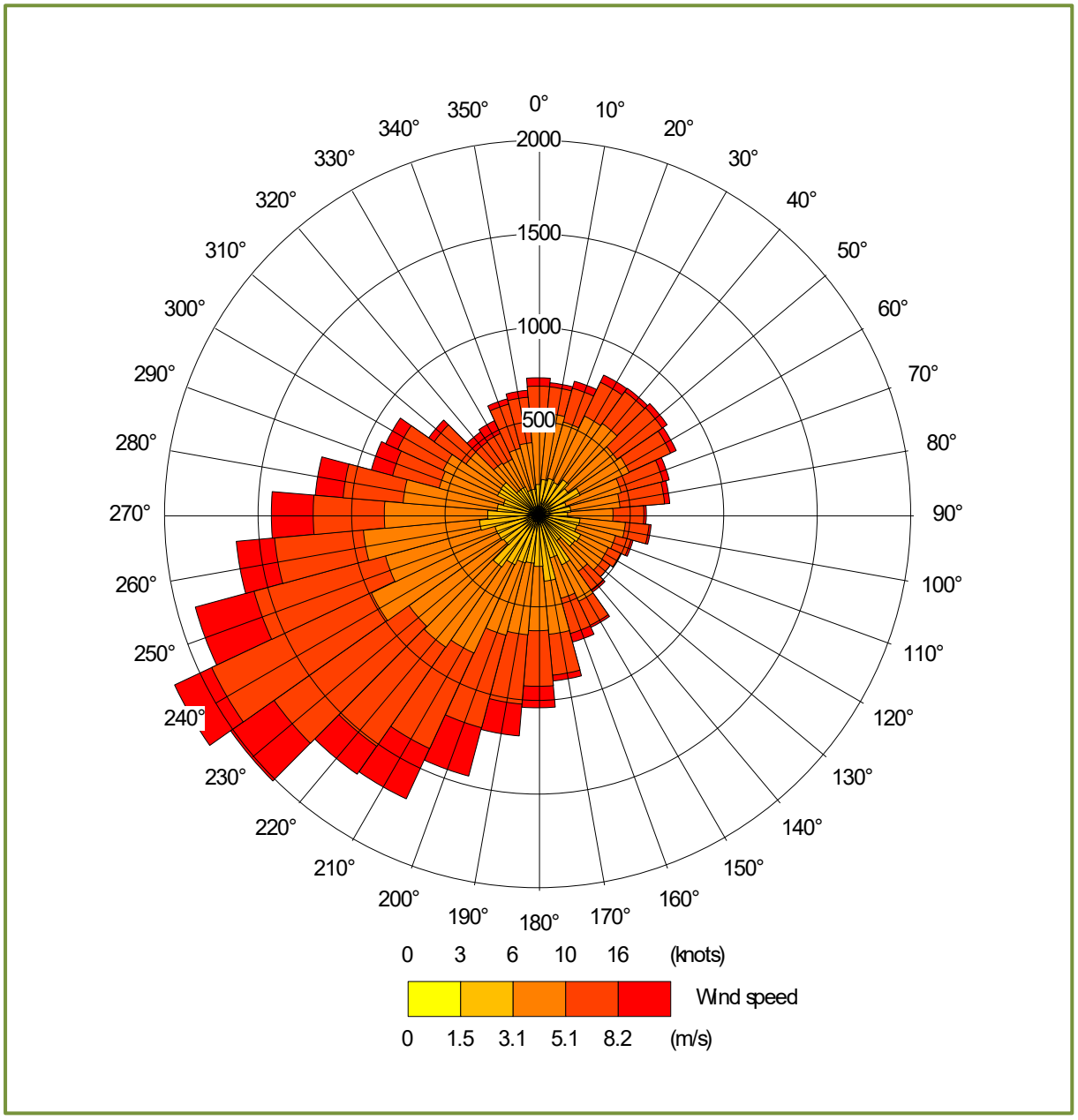


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 617250, 318900, 2022-2025



4.2 Emission sources

Emissions from the side fans that are used for the ventilation of the existing houses have been represented by two volume sources within ADMS (1TO10 and 11TO20).

Emissions from the chimneys of the uncapped high-speed ridge fans that would be used for the ventilation of the proposed poultry houses are represented by three point sources per house within ADMS (H1 to H20; 1, 2 & 3).

Emissions from the gable end fans that are/would be used for supplementary ventilation of the existing poultry houses (as proposed) are represented by volume sources within ADMS (H1_GAB, H2TO7_GAB, H8&9_GAB, H10_GAB, H11_GAB, H12TO19_GAB and H20_GAB [volume sources are arranged to facilitate multi-scenario modelling]). The emissions from the gable end fans are assumed to be zero unless the ventilation requirement within the poultry houses exceeds the capacity of the ridge fans. As a precautionary measure, it is assumed this occurs whenever the ambient temperature exceeds 23 Celsius and the proportion of emissions is 50:50 between ridge fans and gable end fans.

Details of the point source parameters are shown in Table 4a and details of the volume source parameters are shown in Table 4b. Please note that to facilitate multi-scenario modelling, the modelling was conducted assuming 10,000 birds per house with an emission factor of 1.0 kg-N/bird-place/y, with results scaled appropriately post-modelling. Details of the scaling factors are provided in Table 4c.

The positions of the emission sources used are shown in Figure 3 (the point sources are marked by green circles and the volume sources are marked by red shaded rectangles).

Table 4a. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (˚C)	Baseline emission rate per source (g/s)
H1 to H20 1, 2 & 3	6.2	0.8	11.0	Variable [1]	0.105627 [1 & 2]

1. Dependent on ambient temperature.
2. Reduced by 50% when ambient temperature exceeds 23 Celsius.

Table 4b. Volume source parameters

Source ID	Length (m)	Width (m)	Depth (m)	Base height (m)	Emission temperature (°C)	Baseline emission rate (g/s)
H1_GAB	24.4	10.0	3.0	0.5	Ambient	0.316881 [3]
H2TO7_GAB	199.6	10.0	3.0	0.5	Ambient	1.901285 [3]
H8&9_GAB	60.2	10.0	3.0	0.5	Ambient	0.633762 [3]
H10_GAB	24.4	10.0	3.0	0.5	Ambient	0.316881 [3]
H11_GAB	24.4	10.0	3.0	0.5	Ambient	0.316881 [3]
H12TO19_GAB	271.2	10.0	3.0	0.5	Ambient	2.535047 [3]
H20_GAB	24.4	10.0	3.0	0.5	Ambient	0.316881 [3]
1TO10	340.0	78.5	3.0	0.5	Ambient	3.168809
11TO20	340.0	78.5	3.0	0.5	Ambient	3.168809

3. 50% of total only emitted when ambient temperature exceeds 23 Celsius.

Table 4c. Scaling factors – calculations

Scenario	Modelled		Actual			
	Birds per house	EF	Birds per house	EF	Usage	Scaling Factor
Existing Turkeys	10,000	1.0	7,598	0.138	1	0.10486
Proposed Broilers	10,000	1.0	30,875	0.024	1	0.07410

4.3 Modelled buildings

The structure of the poultry houses and other nearby buildings may affect the plumes from the point sources. Therefore, the buildings are modelled within ADMS. Please note that buildings are arranged to facilitate multi-scenario modelling. The positions of the modelled buildings may be seen in Figure 3 (marked by blue rectangles).

4.4 Discrete receptors

Thirty-seven discrete receptors have been defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figures 4a and 4b (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 Figures 4a and 4b (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 0.256 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 modelled buildings and sources

Figure 4a. The discrete receptors and regular Cartesian grids – broadscale view

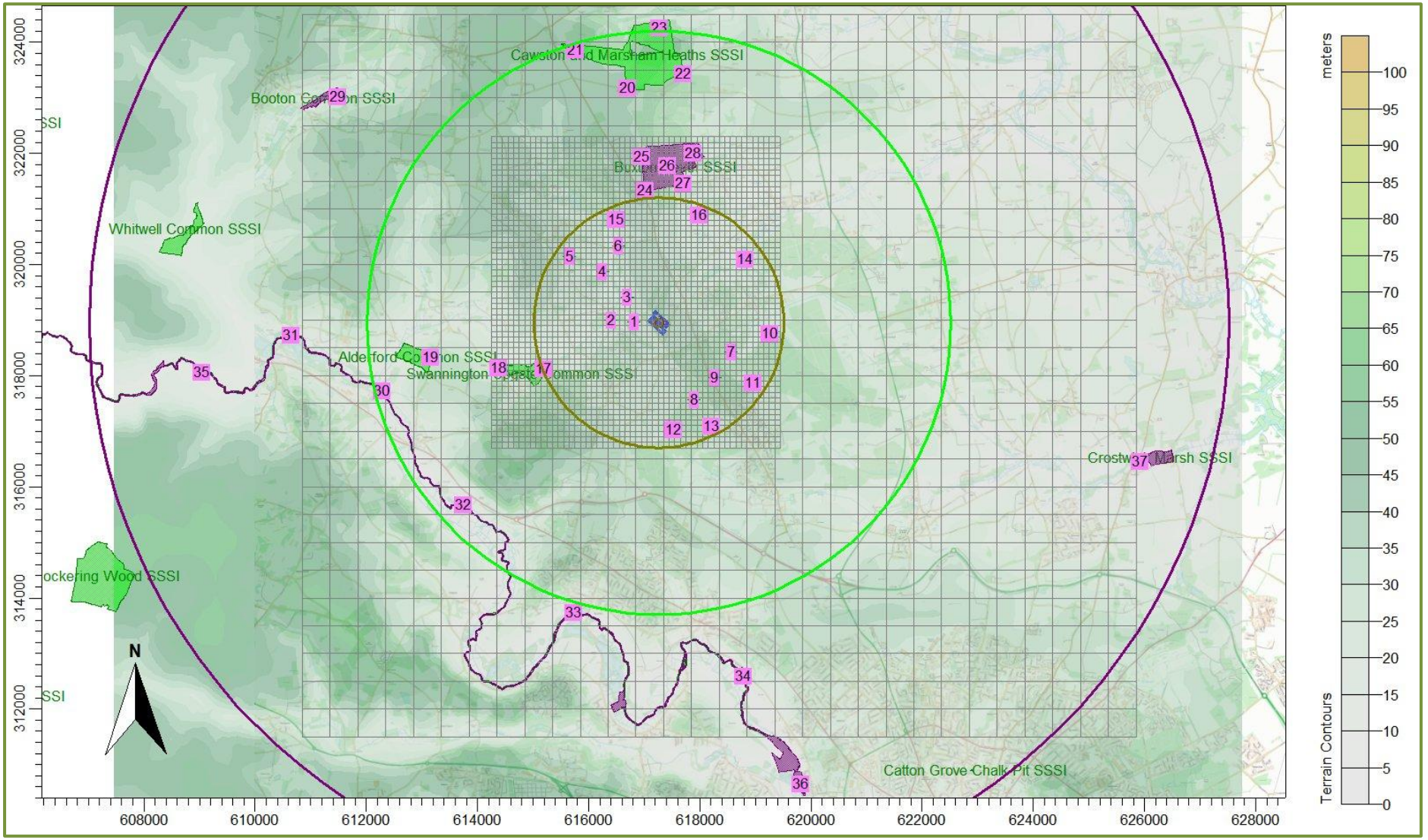


Figure 4b. The discrete receptors and regular Cartesian grids – a closer view

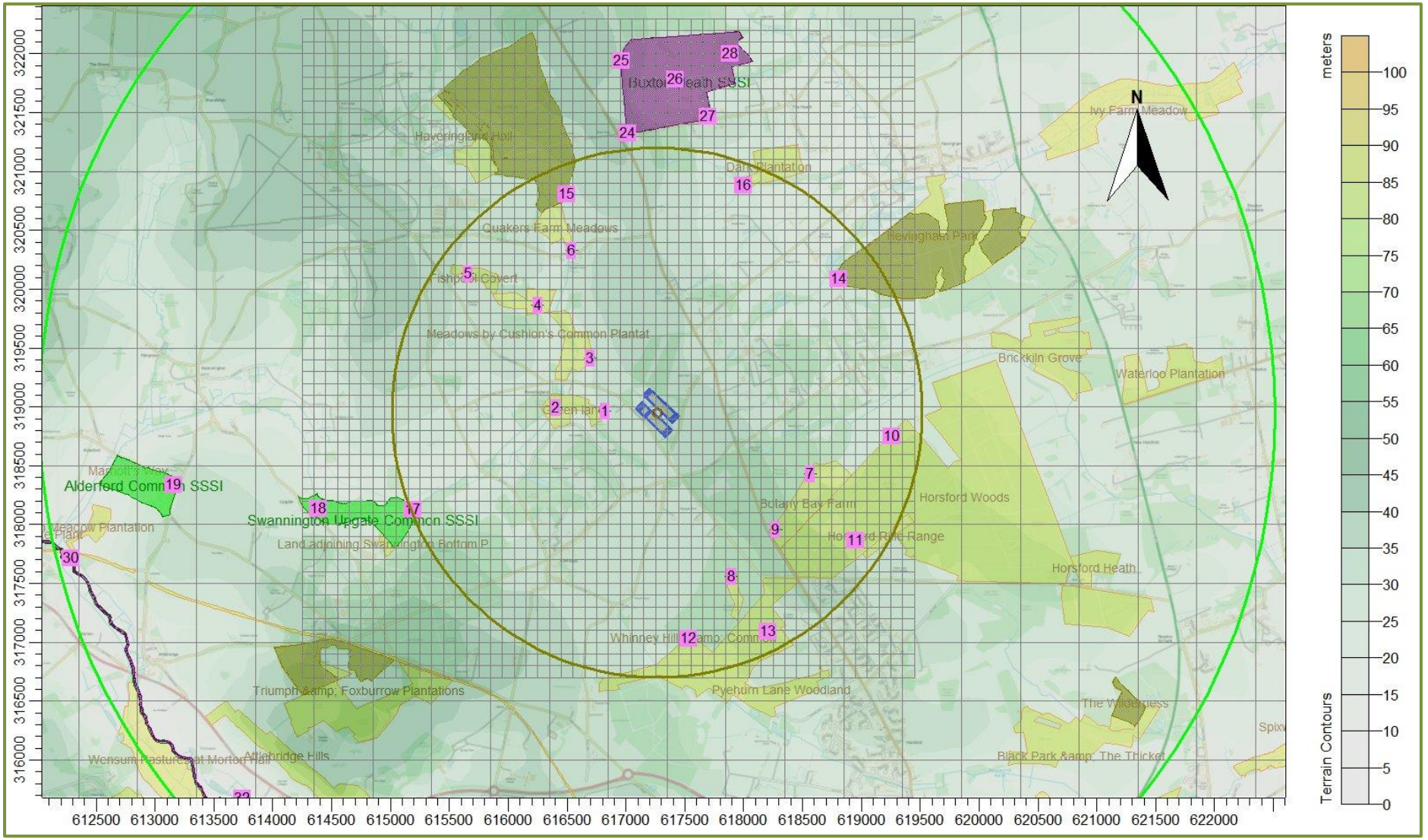
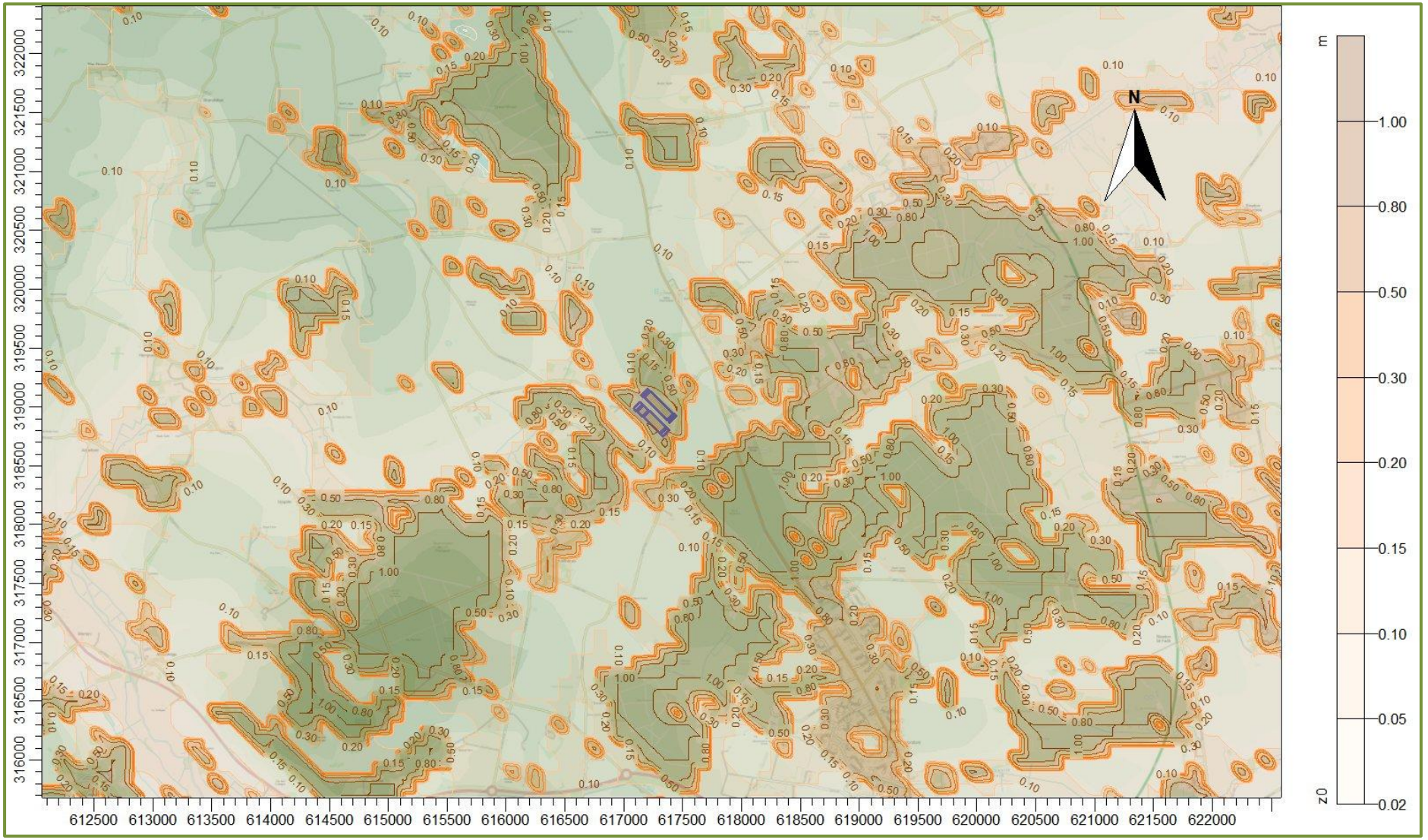


Figure 5. The spatially varying surface roughness field (central area)



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 5.

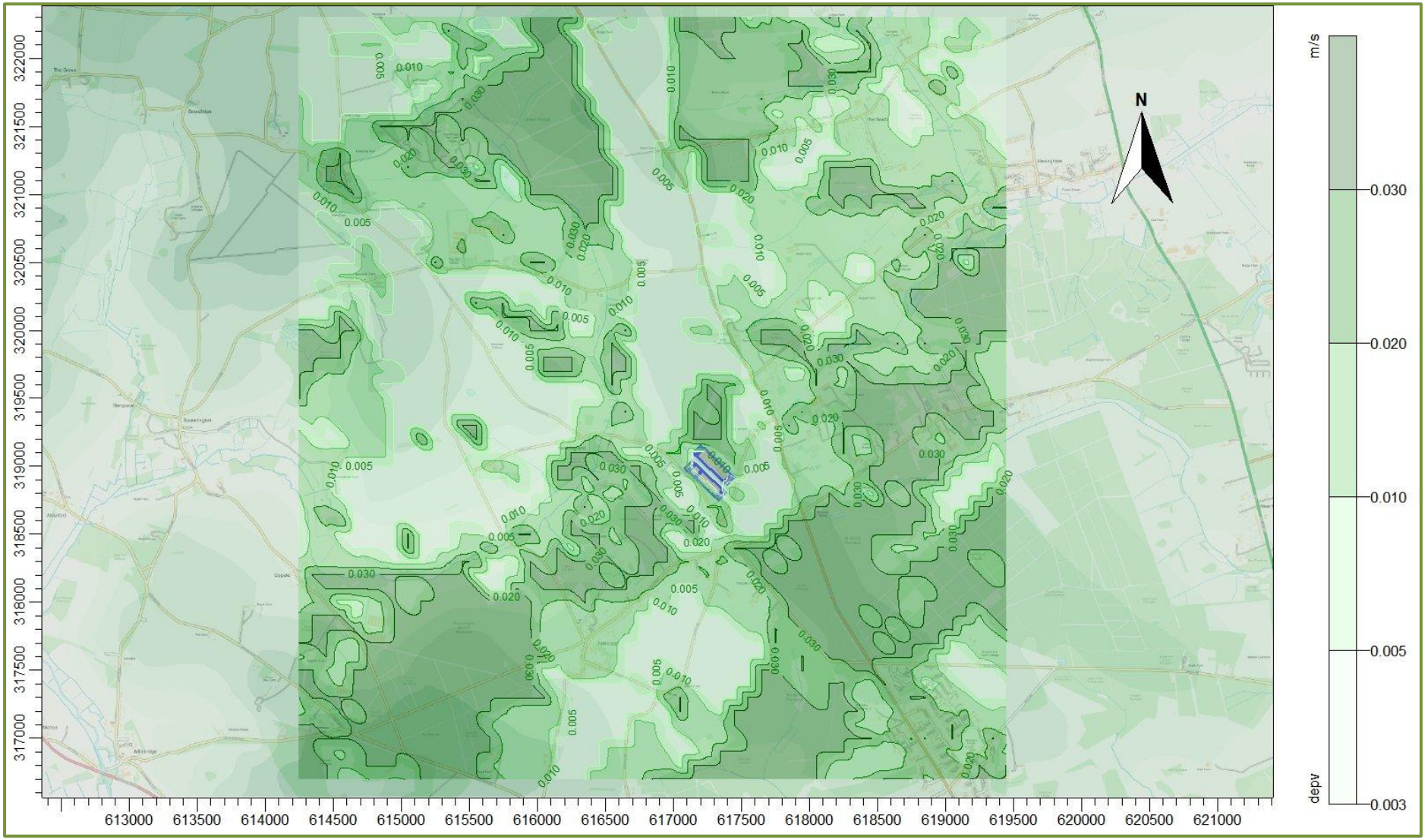
Table 5. Deposition velocities

NH_3 concentration (PC + background) ($\mu g/m^3$)	< 10	10 - 20	20 - 30	30 - 80	> 80
Deposition velocity - woodland (m/s)	0.03	0.015	0.01	0.005	0.003
Deposition velocity - short vegetation (m/s)	0.02 (0.010 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



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 6. Please note that the primary purpose of the preliminary modelling is to assess the effect of calms on the results and that the results in Table 6 are un-scaled.

Table 6. Predicted maximum annual mean ammonia concentration at the discrete receptors – preliminary modelling

Receptor number	X(m)	Y(m)	Name/Designation	Maximum annual mean ammonia concentration (µg/m³)			
				Scenario 1		Scenario 2	
				GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms No Terrain	GFS Calms No Terrain
1	616818	318966	LWS	26.177	31.611	7.731	7.764
2	616405	318995	LWS	8.427	10.016	2.690	2.702
3	616697	319412	LWS	14.109	16.138	3.104	3.093
4	616248	319866	LWS	4.468	5.152	1.179	1.174
5	615655	320137	LWS	2.482	2.831	0.772	0.767
6	616540	320331	LWS	3.291	4.093	1.354	1.350
7	618567	318428	LWS	4.872	5.843	1.795	1.788
8	617895	317562	LWS	2.940	3.905	0.938	0.942
9	618274	317959	LWS	3.400	4.303	1.293	1.289
10	619254	318755	LWS	2.619	3.284	1.188	1.179
11	618953	317871	LWS	2.453	2.866	1.016	1.013
12	617531	317033	LWS	2.385	2.966	0.770	0.773
13	618208	317099	LWS	1.666	2.242	0.601	0.603
14	618808	320091	AW/LWS	3.241	3.773	1.794	1.778
15	616495	320812	AW	2.112	2.623	0.962	0.959
16	617993	320886	LWS	2.833	3.192	1.260	1.253
17	615193	318130	Swannington Upgate Common SSSI	1.684	2.043	0.701	0.699
18	614384	318139	Swannington Upgate Common SSSI	1.023	1.242	0.461	0.460
19	613155	318338	Alderford Common SSSI	0.597	0.723	0.292	0.291
20	616705	323184	Cawston and Marsham Heaths SSSI	0.540	0.665	0.341	0.340
21	615767	323862	Cawston and Marsham Heaths SSSI	0.412	0.516	0.255	0.255
22	617695	323432	Cawston and Marsham Heaths SSSI	0.525	0.685	0.324	0.324
23	617265	324265	Cawston and Marsham Heaths SSSI	0.373	0.487	0.252	0.251
24	617011	321331	Buxton Heath SSSI/Norfolk Valley Fens SAC	1.449	1.789	0.766	0.765
25	616960	321944	Buxton Heath SSSI/Norfolk Valley Fens SAC	0.978	1.207	0.556	0.555
26	617418	321783	Buxton Heath SSSI/Norfolk Valley Fens SAC	1.105	1.453	0.628	0.627
27	617696	321470	Buxton Heath SSSI/Norfolk Valley Fens SAC	1.478	1.870	0.773	0.772
28	617882	322006	Buxton Heath SSSI/Norfolk Valley Fens SAC	1.109	1.352	0.589	0.586
29	611481	323020	Booton Common SSSI/Norfolk Valley Fens SAC	0.308	0.350	0.176	0.174
30	612282	317722	River Wensum SSSI/SAC	0.421	0.511	0.231	0.230
31	610647	318736	River Wensum SSSI/SAC	0.256	0.316	0.145	0.145
32	613738	315678	River Wensum SSSI/SAC	0.569	0.651	0.323	0.321
33	615724	313732	River Wensum SSSI/SAC	0.390	0.459	0.224	0.225
34	618790	312586	River Wensum SSSI/SAC	0.297	0.375	0.148	0.147
35	609047	318059	River Wensum SSSI/SAC	0.193	0.235	0.121	0.120
36	619823	310652	River Wensum SSSI/SAC	0.177	0.227	0.099	0.099
37	625921	316462	Crostwick Marsh SSSI/SAC/SPA/Ramsar	0.208	0.257	0.147	0.147

5.2 Detailed modelling

In this case, detailed modelling has been carried out over a high resolution 5.2 km x 5.6 km domain surrounding the poultry unit at Beck 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 further LWSs be identified. Outside of the 5.2 km x 5.6 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. The results of the preliminary modelling indicate that the effects of calms are significant in the case of Scenario 1 and therefore a correction, based on the preliminary modelling results has been applied to the Scenario 1 results only at receptors within approximately 2 km. Marked katabatic winds are unlikely in the area due to high surface roughness; however, if they did occur they would be shallow, so would only entrain low level emissions (the side fans) and would flow into the shallow valley formed by the River Wensum to the west.

The predicted maximum annual mean ground level ammonia concentrations and maximum nitrogen deposition rates at the discrete receptors are shown in Tables 7a (Scenario 1 – Existing Scenario and 7b (Scenario 2 – Proposed Scenario). The predicted change in annual mean ground level ammonia concentrations and nitrogen deposition rates (Scenario 2 minus Scenario 1) at the discrete receptors are shown in Table 8.

In the Tables, predicted ammonia concentrations and nitrogen deposition rates that are in excess of the Environment Agency's upper threshold of the relevant Critical Level or Critical Load (n/a% for a SAC/SPA/Ramsar site, 50% for a SSSI and 100% for a LWS/AW) are highlighted with bold red text. Concentrations or deposition rates that are in the range between the Environment Agency's lower and upper threshold of the relevant Critical Level or Critical Load (1% and n/a% for an SAC/SPA/Ramsar site, 20% and 50% for a SSSI and 100% and 100% for a LWS/AW) are coloured blue. Process contributions which exceed 1% of the relevant Critical Level or Critical Load at a SSSI are highlighted with bold text.

Contour plots of the predicted ground level maximum annual mean ammonia concentrations and maximum annual nitrogen deposition rates are shown in Figures 7a and 7b (Scenario 1) and Figures 8a and 8b (Scenario 2).

Table 7a. Predicted maximum annual mean ammonia concentrations and nitrogen deposition rates – Scenario 1

Receptor number	X(m)	Y(m)	Name	Site Parameters			Maximum annual mean ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level (µg/m^3)	Critical Load (kg/ha)	Process Contribution (µg/m^3)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	616818	318966	LWS	0.03	1.0	10.0	1.517	**151.68**	11.82	**118.17**
2	616405	318995	LWS	0.03	1.0	10.0	0.337	33.67	2.62	26.23
3	616697	319412	LWS	0.02	1.0	10.0	0.575	57.50	2.99	29.87
4	616248	319866	LWS	0.02	1.0	10.0	0.138	13.84	0.72	7.19
5	615655	320137	LWS	0.03	1.0	10.0	0.072	7.25	0.56	5.65
6	616540	320331	LWS	0.02	1.0	10.0	0.164	16.39	0.85	8.51
7	618567	318428	LWS	0.03	1.0	10.0	0.185	18.53	1.44	14.43
8	617895	317562	LWS	0.02	1.0	10.0	0.089	8.86	0.46	4.60
9	618274	317959	LWS	0.03	1.0	10.0	0.123	12.28	0.96	9.57
10	619254	318755	LWS	0.03	1.0	10.0	0.108	10.84	0.84	8.44
11	618953	317871	LWS	0.03	1.0	10.0	0.069	6.88	0.54	5.36
12	617531	317033	LWS	0.03	1.0	10.0	0.070	6.97	0.54	5.43
13	618208	317099	LWS	0.03	1.0	10.0	0.045	4.53	0.35	3.53
14	618808	320091	AW/LWS	0.03	1.0	10.0	0.177	17.66	1.38	13.76
15	616495	320812	AW	0.03	1.0	10.0	0.098	9.79	0.76	7.63
16	617993	320886	LWS	0.03	1.0	10.0	0.125	12.48	0.97	9.72
17	615193	318130	Swannington Upgate Common SSSI	0.02	1.0	5.0	0.059	**5.95**	0.31	**6.18**
18	614384	318139	Swannington Upgate Common SSSI	0.02	1.0	5.0	0.033	**3.28**	0.17	**3.41**
19	613155	318338	Alderford Common SSSI	0.02	3.0	10.0	0.018	0.60	0.09	0.93
20	616705	323184	Cawston and Marsham Heaths SSSI	0.02	1.0	5.0	0.022	**2.20**	0.11	**2.29**
21	615767	323862	Cawston and Marsham Heaths SSSI	0.02	1.0	5.0	0.014	**1.38**	0.07	**1.44**
22	617695	323432	Cawston and Marsham Heaths SSSI	0.02	1.0	5.0	0.024	**2.40**	0.12	**2.49**
23	617265	324265	Cawston and Marsham Heaths SSSI	0.02	1.0	5.0	0.017	**1.70**	0.09	**1.77**
24	617011	321331	Buxton Heath SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	0.060	**6.01**	0.31	**6.25**
25	616960	321944	Buxton Heath SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	0.038	**3.85**	0.20	**4.00**
26	617418	321783	Buxton Heath SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	0.049	**4.87**	0.25	**5.06**
27	617696	321470	Buxton Heath SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	0.061	**6.10**	0.32	**6.34**
28	617882	322006	Buxton Heath SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	0.041	**4.13**	0.21	**4.29**
29	611481	323020	Booton Common SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	0.006	0.60	0.03	0.62
30	612282	317722	River Wensum SSSI/SAC	0.02	3.0	15.0	0.013	0.43	0.07	0.44
31	610647	318736	River Wensum SSSI/SAC	0.02	3.0	15.0	0.009	0.30	0.05	0.31
32	613738	315678	River Wensum SSSI/SAC	0.02	3.0	15.0	0.013	0.42	0.07	0.44
33	615724	313732	River Wensum SSSI/SAC	0.02	3.0	15.0	0.014	0.46	0.07	0.48
34	618790	312586	River Wensum SSSI/SAC	0.02	3.0	15.0	0.006	0.21	0.03	0.22
35	609047	318059	River Wensum SSSI/SAC	0.02	3.0	15.0	0.007	0.23	0.04	0.24
36	619823	310652	River Wensum SSSI/SAC	0.02	3.0	15.0	0.004	0.13	0.02	0.14
37	625921	316462	Crostwick Marsh SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	0.006	0.21	0.03	0.21

Table 7b. Predicted maximum annual mean ammonia concentrations and nitrogen deposition rates – Scenario 2

Receptor number	X(m)	Y(m)	Name	Site Parameters			Maximum annual mean ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level (µg/m^3)	Critical Load (kg/ha)	Process Contribution (µg/m^3)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	616818	318966	LWS	0.03	1.0	10.0	0.475	47.47	3.70	36.98
2	616405	318995	LWS	0.03	1.0	10.0	0.152	15.22	1.19	11.86
3	616697	319412	LWS	0.02	1.0	10.0	0.176	17.58	0.91	9.13
4	616248	319866	LWS	0.02	1.0	10.0	0.066	6.56	0.34	3.41
5	615655	320137	LWS	0.03	1.0	10.0	0.043	4.34	0.34	3.38
6	616540	320331	LWS	0.02	1.0	10.0	0.082	8.22	0.43	4.27
7	618567	318428	LWS	0.03	1.0	10.0	0.085	8.50	0.66	6.62
8	617895	317562	LWS	0.02	1.0	10.0	0.044	4.44	0.23	2.30
9	618274	317959	LWS	0.03	1.0	10.0	0.058	5.76	0.45	4.49
10	619254	318755	LWS	0.03	1.0	10.0	0.066	6.60	0.51	5.14
11	618953	317871	LWS	0.03	1.0	10.0	0.040	3.99	0.31	3.11
12	617531	317033	LWS	0.03	1.0	10.0	0.035	3.54	0.28	2.76
13	618208	317099	LWS	0.03	1.0	10.0	0.025	2.52	0.20	1.97
14	618808	320091	AW/LWS	0.03	1.0	10.0	0.091	9.06	0.71	7.06
15	616495	320812	AW	0.03	1.0	10.0	0.051	5.11	0.40	3.98
16	617993	320886	LWS	0.03	1.0	10.0	0.070	7.04	0.55	5.48
17	615193	318130	Swannington Upgate Common SSSI	0.02	1.0	5.0	0.033	**3.33**	0.17	**3.46**
18	614384	318139	Swannington Upgate Common SSSI	0.02	1.0	5.0	0.020	**1.99**	0.10	**2.06**
19	613155	318338	Alderford Common SSSI	0.02	3.0	10.0	0.014	0.47	0.07	0.74
20	616705	323184	Cawston and Marsham Heaths SSSI	0.02	1.0	5.0	0.018	**1.80**	0.09	**1.87**
21	615767	323862	Cawston and Marsham Heaths SSSI	0.02	1.0	5.0	0.013	**1.25**	0.07	**1.30**
22	617695	323432	Cawston and Marsham Heaths SSSI	0.02	1.0	5.0	0.018	**1.78**	0.09	**1.85**
23	617265	324265	Cawston and Marsham Heaths SSSI	0.02	1.0	5.0	0.013	**1.32**	0.07	**1.37**
24	617011	321331	Buxton Heath SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	0.043	**4.33**	0.23	**4.50**
25	616960	321944	Buxton Heath SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	0.034	**3.36**	0.17	**3.49**
26	617418	321783	Buxton Heath SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	0.034	**3.43**	0.18	**3.56**
27	617696	321470	Buxton Heath SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	0.042	**4.17**	0.22	**4.33**
28	617882	322006	Buxton Heath SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	0.030	**2.96**	0.15	**3.07**
29	611481	323020	Booton Common SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	0.006	0.63	0.03	0.66
30	612282	317722	River Wensum SSSI/SAC	0.02	3.0	15.0	0.010	0.34	0.05	0.35
31	610647	318736	River Wensum SSSI/SAC	0.02	3.0	15.0	0.007	0.22	0.03	0.23
32	613738	315678	River Wensum SSSI/SAC	0.02	3.0	15.0	0.013	0.43	0.07	0.45
33	615724	313732	River Wensum SSSI/SAC	0.02	3.0	15.0	0.011	0.37	0.06	0.38
34	618790	312586	River Wensum SSSI/SAC	0.02	3.0	15.0	0.005	0.18	0.03	0.18
35	609047	318059	River Wensum SSSI/SAC	0.02	3.0	15.0	0.005	0.16	0.03	0.17
36	619823	310652	River Wensum SSSI/SAC	0.02	3.0	15.0	0.003	0.10	0.02	0.11
37	625921	316462	Crostwick Marsh SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	0.006	0.19	0.03	0.19

Table 8. Predicted changes in maximum annual mean ammonia concentrations and nitrogen deposition rates – Scenario 2 minus Scenario 1

Receptor number	X(m)	Y(m)	Name	Site Parameters			Maximum annual mean ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level (µg/m^3)	Critical Load (kg/ha)	Process Contribution (µg/m^3)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	616818	318966	LWS	0.03	1.0	10.0	-1.042	-104.21	-8.12	-81.19
2	616405	318995	LWS	0.03	1.0	10.0	-0.184	-18.45	-1.44	-14.37
3	616697	319412	LWS	0.02	1.0	10.0	-0.399	-39.93	-2.07	-20.74
4	616248	319866	LWS	0.02	1.0	10.0	-0.073	-7.28	-0.38	-3.78
5	615655	320137	LWS	0.03	1.0	10.0	-0.029	-2.91	-0.23	-2.27
6	616540	320331	LWS	0.02	1.0	10.0	-0.082	-8.17	-0.42	-4.24
7	618567	318428	LWS	0.03	1.0	10.0	-0.100	-10.03	-0.78	-7.81
8	617895	317562	LWS	0.02	1.0	10.0	-0.044	-4.43	-0.23	-2.30
9	618274	317959	LWS	0.03	1.0	10.0	-0.065	-6.53	-0.51	-5.09
10	619254	318755	LWS	0.03	1.0	10.0	-0.042	-4.24	-0.33	-3.31
11	618953	317871	LWS	0.03	1.0	10.0	-0.029	-2.89	-0.23	-2.25
12	617531	317033	LWS	0.03	1.0	10.0	-0.034	-3.43	-0.27	-2.67
13	618208	317099	LWS	0.03	1.0	10.0	-0.020	-2.00	-0.16	-1.56
14	618808	320091	AW/LWS	0.03	1.0	10.0	-0.086	-8.60	-0.67	-6.70
15	616495	320812	AW	0.03	1.0	10.0	-0.047	-4.68	-0.36	-3.64
16	617993	320886	LWS	0.03	1.0	10.0	-0.054	-5.44	-0.42	-4.24
17	615193	318130	Swannington Upgate Common SSSI	0.02	1.0	5.0	-0.026	-2.62	-0.14	-2.72
18	614384	318139	Swannington Upgate Common SSSI	0.02	1.0	5.0	-0.013	-1.30	-0.07	-1.35
19	613155	318338	Alderford Common SSSI	0.02	3.0	10.0	-0.004	-0.13	-0.02	-0.20
20	616705	323184	Cawston and Marsham Heaths SSSI	0.02	1.0	5.0	-0.004	-0.40	-0.02	-0.42
21	615767	323862	Cawston and Marsham Heaths SSSI	0.02	1.0	5.0	-0.001	-0.13	-0.01	-0.14
22	617695	323432	Cawston and Marsham Heaths SSSI	0.02	1.0	5.0	-0.006	-0.61	-0.03	-0.64
23	617265	324265	Cawston and Marsham Heaths SSSI	0.02	1.0	5.0	-0.004	-0.38	-0.02	-0.40
24	617011	321331	Buxton Heath SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	-0.017	-1.68	-0.09	-1.75
25	616960	321944	Buxton Heath SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	-0.005	-0.49	-0.03	-0.51
26	617418	321783	Buxton Heath SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	-0.014	-1.45	-0.08	-1.50
27	617696	321470	Buxton Heath SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	-0.019	-1.93	-0.10	-2.01
28	617882	322006	Buxton Heath SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	-0.012	-1.18	-0.06	-1.22
29	611481	323020	Booton Common SSSI/Norfolk Valley Fens SAC	0.02	1.0	5.0	0.000	0.04	0.00	0.04
30	612282	317722	River Wensum SSSI/SAC	0.02	3.0	15.0	-0.003	-0.09	-0.01	-0.09
31	610647	318736	River Wensum SSSI/SAC	0.02	3.0	15.0	-0.002	-0.08	-0.01	-0.09
32	613738	315678	River Wensum SSSI/SAC	0.02	3.0	15.0	0.000	0.01	0.00	0.01
33	615724	313732	River Wensum SSSI/SAC	0.02	3.0	15.0	-0.003	-0.09	-0.01	-0.10
34	618790	312586	River Wensum SSSI/SAC	0.02	3.0	15.0	-0.001	-0.04	-0.01	-0.04
35	609047	318059	River Wensum SSSI/SAC	0.02	3.0	15.0	-0.002	-0.07	-0.01	-0.07
36	619823	310652	River Wensum SSSI/SAC	0.02	3.0	15.0	-0.001	-0.03	0.00	-0.03
37	625921	316462	Crostwick Marsh SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	-0.001	-0.02	0.00	-0.02

Figure 7a. Maximum annual ammonia concentration – Scenario 1

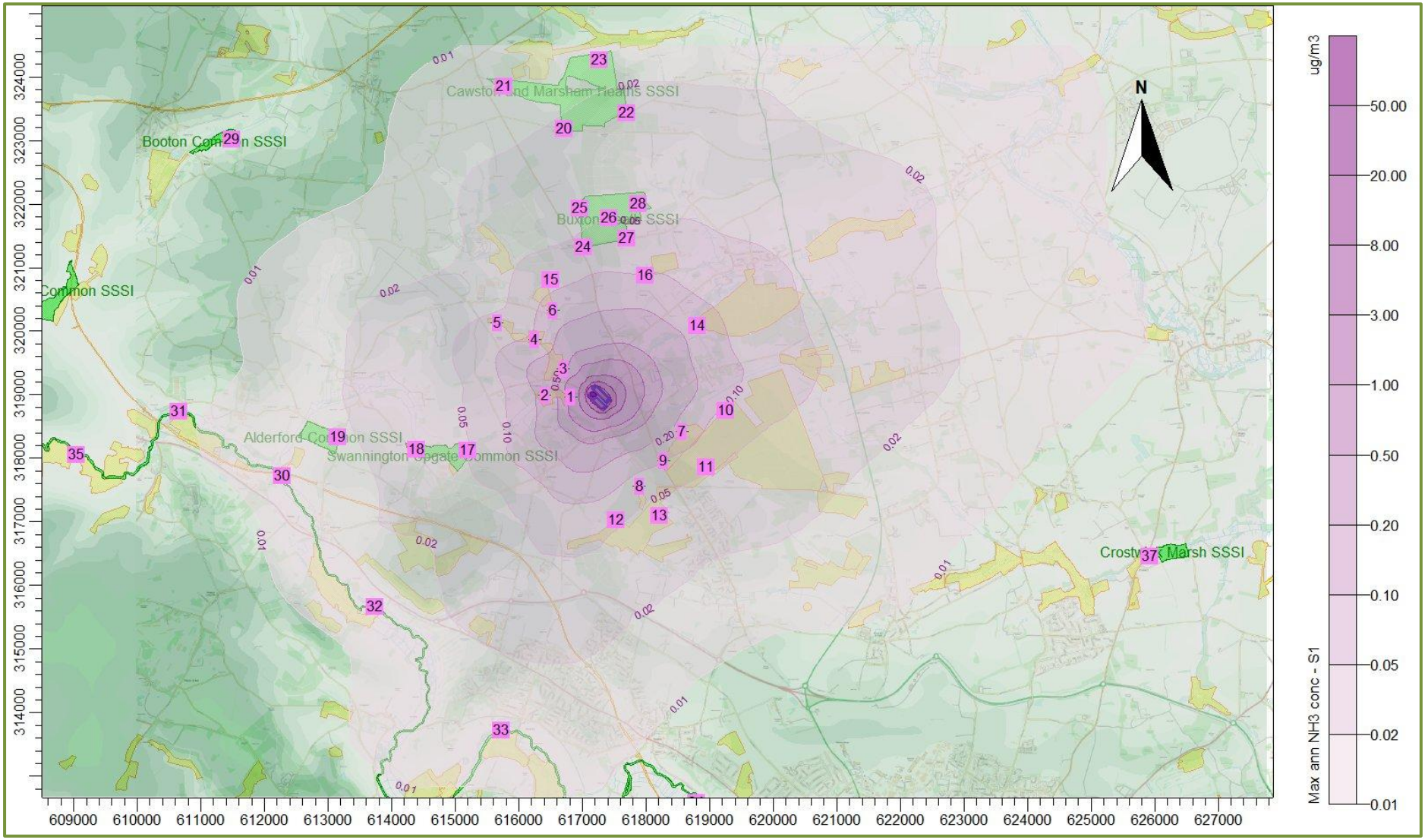


Figure 7b. Maximum annual nitrogen deposition rates – Scenario 1

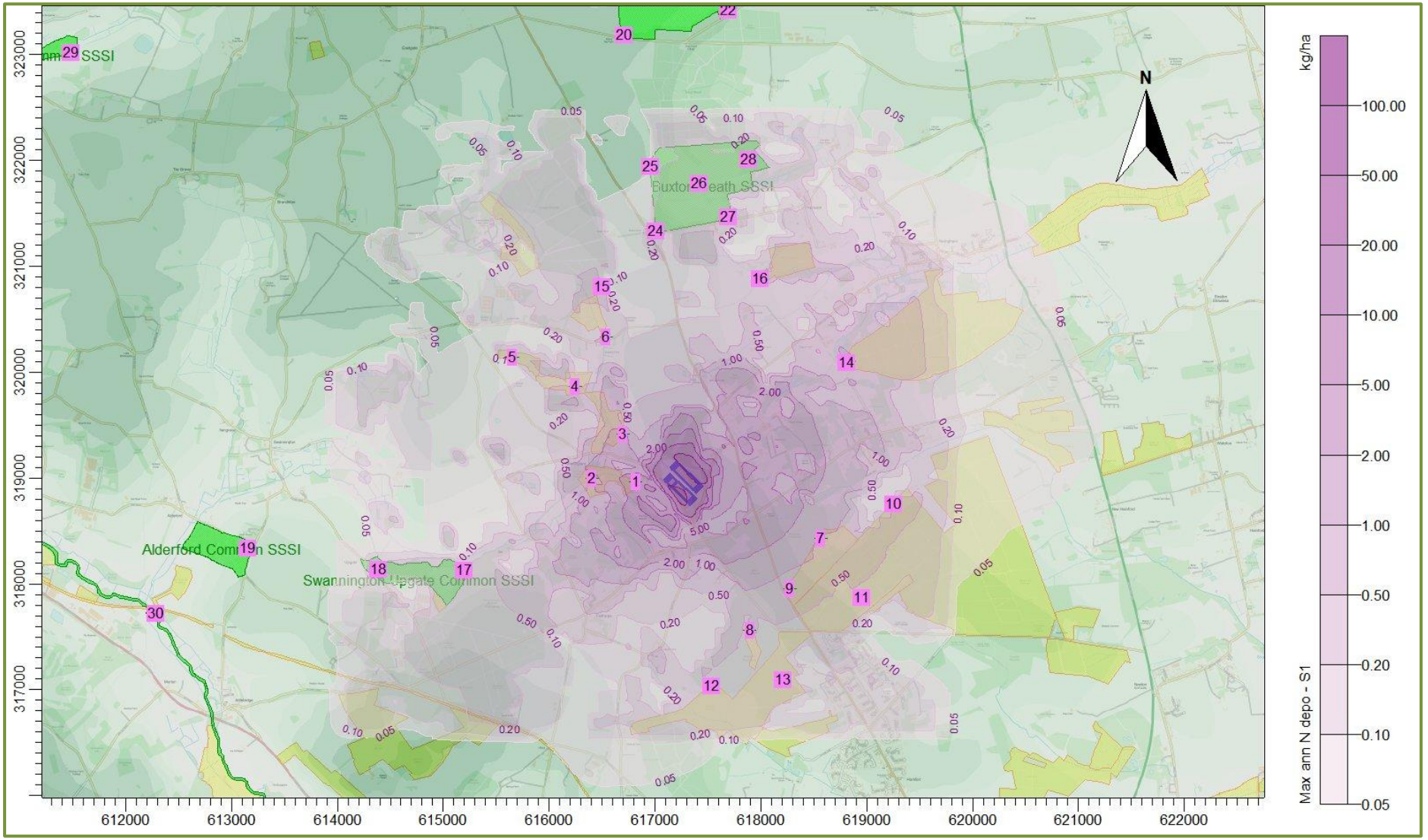


Figure 8a. Maximum annual ammonia concentration – Scenario 2

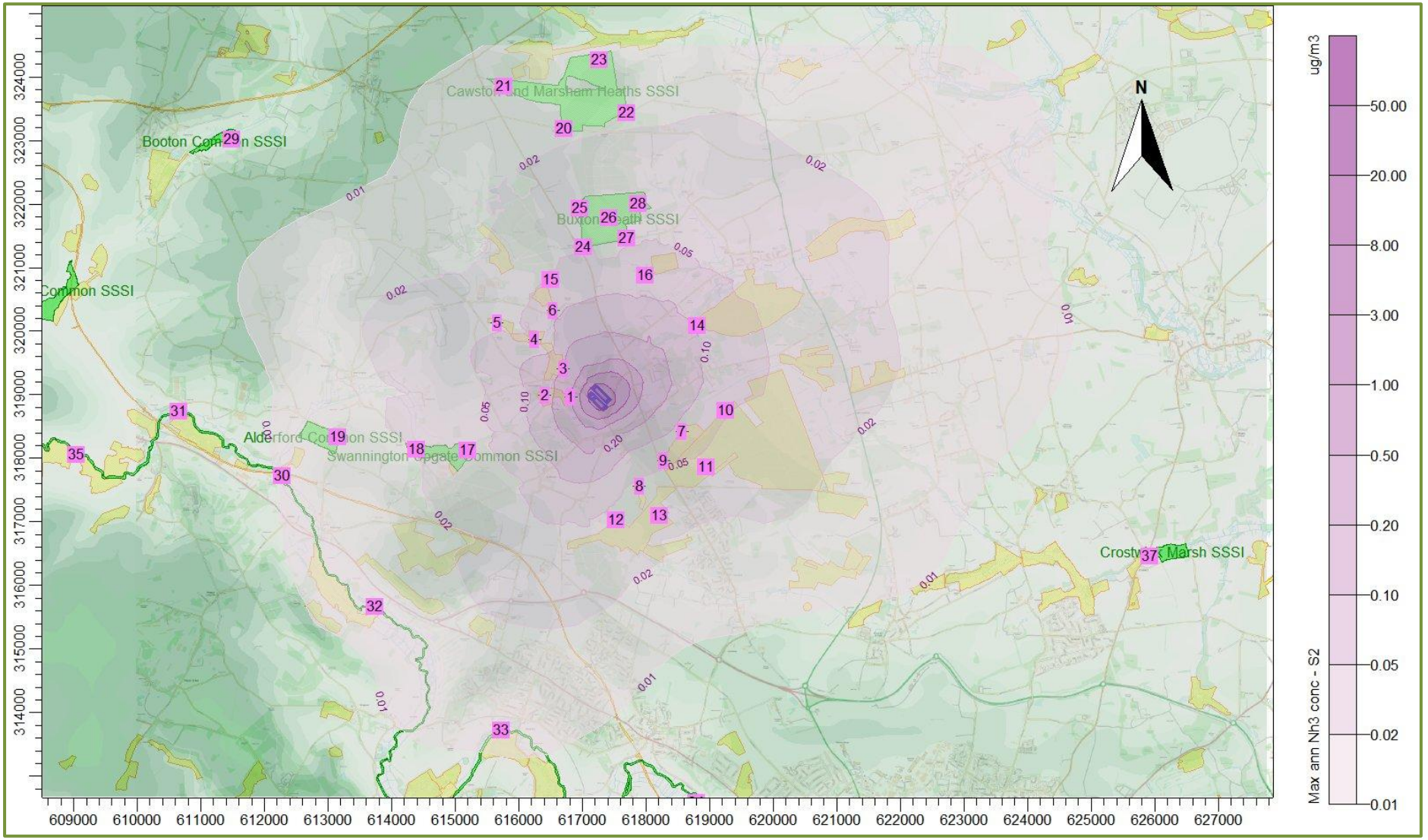
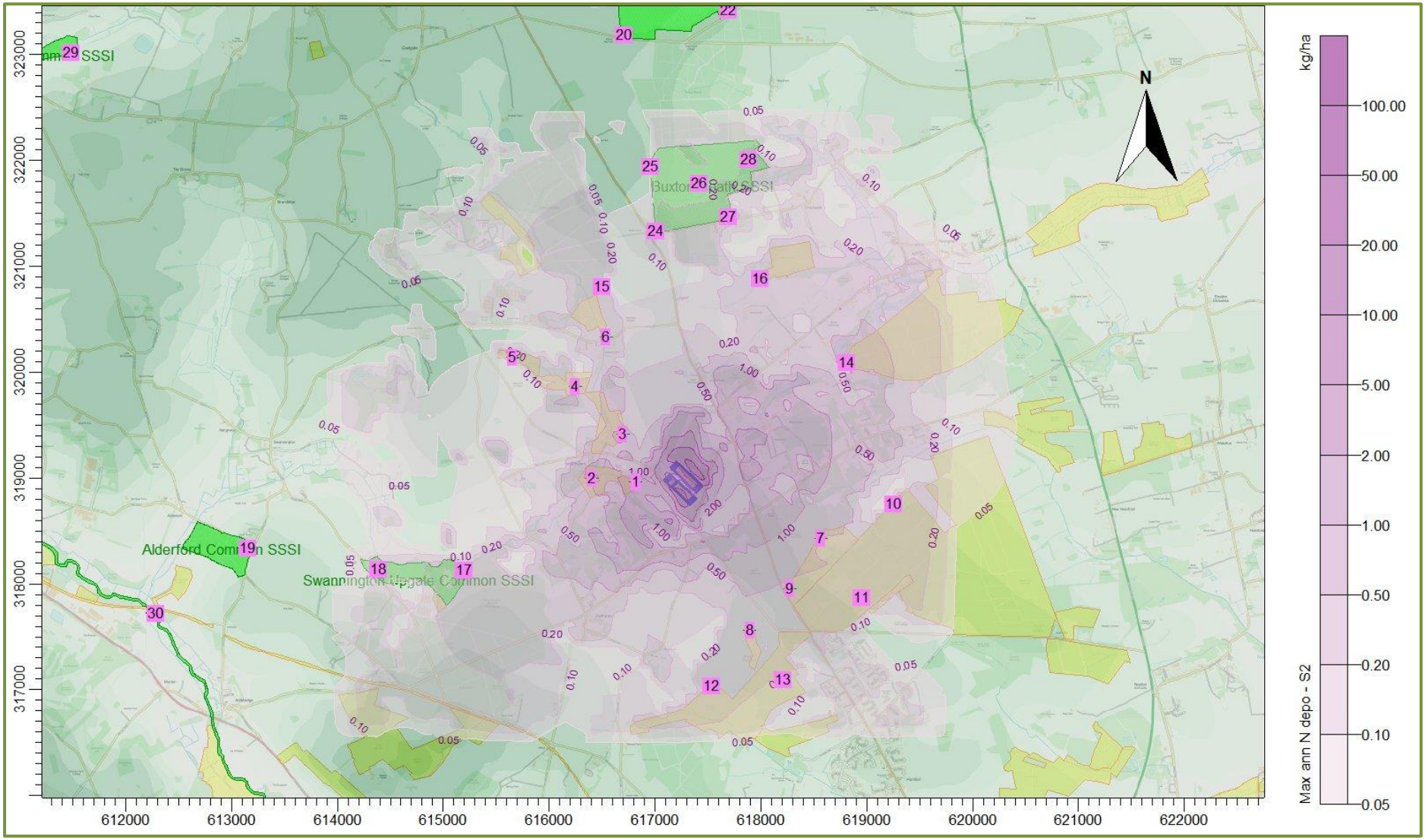


Figure 8b. Maximum annual nitrogen deposition rates – Scenario 2



6. Summary and Conclusions

Ammonia emission rates from the poultry houses have been assessed and quantified based upon the Environment Agency standard ammonia emission factors and bespoke Environment Agency ammonia emission factors. The 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.

Two scenarios are considered in the report:

Scenario 1 – The Existing Scenario - 151,967 hen turkeys in the twenty existing poultry houses.
Scenario 2 – The Proposed Scenario - The renovated poultry houses stocked with 617,500 broiler chickens.

Scenario 1 - Existing

The modelling predicts that:

- Process contributions to ammonia concentrations and nitrogen deposition rates currently exceed the Environment Agency lower threshold percentage of the precautionary or relevant Critical Level or Critical Load (1% for a SACs/SPA/Ramsar site, 20% for a SSSI and 100% for a non-statutory sites) at Buxton Heath SSSI/SAC and closer parts of Green Lane LWS.
- Process contributions exceed 1% of the relevant Critical Level or Critical Load at Swannington Upgate Common SSSI and Cawston and Marsham Heaths SSSI.

Scenario 2 - Proposed

The modelling predicts that:

- Process contributions to ammonia concentrations and nitrogen deposition rates would be reduced, significantly in many cases; however, they would still exceed the Environment Agency lower threshold percentage of the relevant Critical Level or Critical Load at Buxton Heath SSSI/SAC.
- Process contributions would continue to exceed 1% of the relevant Critical Level or Critical Load at Swannington Upgate Common SSSI and Cawston and Marsham Heaths SSSI; however, there would be significant reductions in ammonia levels and nitrogen deposition rates particularly at Swannington Upgate Common SSSI.

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7. References

Cambridge Environmental Research Consultants (CERC) (website).

Chapman, C. and Kite, B. Joint Nature Conservation Committee. Guidance on Decision-making Thresholds for Air Pollution.

Environment Agency and Department for Environment, Food & Rural Affairs "Intensive farming risk assessment for your environmental permit", last updated August 2025 (website).

Natural England, "Air pollution and development: advice for local authorities", October 2025 (website).

Steven R Hanna, & Biswanath Chowdhury. Minimum turbulence assumptions and u* and L estimation for dispersion models during low-wind stable conditions.

M. A. Sutton *et al*. Measurement and modelling of ammonia exchange over arable croplands.

Frederik Schrader and Christian Brümmer. Land Use Specific Ammonia Deposition Velocities: a Review of Recent Studies (2004-2013).

United Nations Economic Commission for Europe (UNECE) (website).

UK Air Pollution Information System (APIS) (website).