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 Brookside Farm Poultry Unit, Watton Road, Breckles, near Great Hockham in Norfolk

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Ms. Misba Tasawar, on behalf of Amber Real Estate Investments (Agriculture) Limited, 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 Brookside Farm Poultry Unit, Watton Road, Breckles, Great Hockham, Norfolk. NR17 1ER.

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

This report is arranged in the following manner:

- Section 2 provides relevant details of the farm and potentially sensitive receptors in the area.

- Section 3 provides some general information on ammonia; details of the method used to estimate ammonia emissions; relevant guidelines and legislation on exposure limits and where relevant, details of likely background levels of ammonia.

- Section 4 provides some information about ADMS, the dispersion model used for this study and details the modelling procedure.

- Section 5 contains the results of the modelling.

- Section 6 provides a discussion of the results and conclusions.

2. Background Details

The site of the poultry rearing unit at Brookside Farm is in a rural area approximately 900 m to the north-north-west of the village of Great Hockham in Norfolk. The surrounding land is used mainly for arable farming and forestry, although there are also some extensive areas of Breckland heath to the south and east. The site is at an altitude of around 38 m in a gently rolling periglacial landscape.

There are fourteen poultry houses at the Brookside Farm Poultry Unit, which provide accommodation for up to 106,000 stag turkeys (day old chicks to 20 kg). The poultry houses are ventilated using cowled side mounted fans.

Under the proposals, the existing turkey rearing houses would be renovated and converted to broiler chicken rearing houses. As part of the renovation, ventilation would be upgraded to uncapped high speed ridge fans, each with a short chimney, with gable end fans for supplementary ventilation in hot weather. The renovated poultry houses would provide accommodation for up to 434,000 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.

There are several areas designated as Local Wildlife Sites (LWSs) within 2 km (the normal screening distance for non-statutory sites) of Brookside Farm Poultry Unit. There are no Ancient Woodlands (AWs) within 2 km of the poultry houses. There are twelve areas designated as Sites of Special Scientific Interest (SSSIs) within 10 km of the site (the normal screening distance for statutory sites). Some of the SSSIs are also designated as Special Areas of Conservation (SACs) and/or Special Protection Areas (SPAs). Some further details of the statutory sites are provided below:

- **Wretham Park Meres SSSI** - Approximately 3.7 km to the west-south-west - Four natural lakes that contrast strongly with the nearby fluctuating meres. Aquatic plants are generally sparse but there is good fringing vegetation which provides an important nesting habitat for wildfowl. The lakes also attract large populations of wintering ducks.
- **Wayland Wood, Watton SSSI** - Approximately 5.4 km to the north-north-west - One of the largest woods in South Norfolk. The structure is coppice with standards on wet calcareous boulder clay and a rare stand-type, bird cherry–alder wood is present. The diverse flora is typical of ancient woodland and includes one national rarity.
- **Scoulton Mere SSSI** - Approximately 8.1 km to the north-north-east - Of interest because of the swamp, fen and bog communities that occur on islands in the mere and around the shore. These support a diverse flora including several rare and uncommon plants.
- **Old Buckenham Fen SSSI** - Approximately 9.6 km to the east-south-east - The central part of the site consists of a species-rich, managed reedbed surrounding a small, natural mere. Around the margins of the fen basin are areas of species-rich scrub, drier fen and cattle-grazed meadows containing wet hollows and calcareous flushes. The meadows are divided by a network of dykes and are used by wading birds.
- **East Harling Common SSSI** - Approximately 7.4 km to the south-east - Of great importance for its system of periglacial ground ice depressions (pingos) retaining a relict community of aquatic beetles which, together with that of a few other Norfolk pingo systems, is unique in Britain. This includes many species which are nationally scarce or rare. Floristically rich fen, a declining habitat, has developed in and around many of the depressions, and surrounding chalk grassland supports a diversity of plants, several of which are uncommon locally.
- **Middle Harling Fen SSSI** - Approximately 9.0 km to the south-south-east - The site lies in a shallow valley and a number of springs emerge on the sloping ground. A wide range of grassland types is present including both wet and dry communities. The species-rich fen vegetation includes several plants that are now uncommon in East Anglia. An unusual feature is the unimproved calcareous grassland that occurs on dry ground surrounding the fen.

- **Breckland Forest SSSI/SPA** - Directly adjacent - The clear fell areas and young plantations within Breckland Forest SSSI provide suitable breeding habitat for woodlark *Lullula arborea* and nightjar *Caprimulgus europaeus*, which occur in internationally important numbers. The forest also supports an important assemblage of Nationally Rare and nationally scarce vascular plant species, a number of which are largely restricted to East Anglia and occupy habitats characteristic of Breckland. Breckland Forest SSSI also supports an exceptionally rich invertebrate fauna with Red Data Book and nationally scarce species across most taxonomic groups that have been studied. A mammal species associated with the conifer plantations is the red squirrel *Sciurus vulgaris*.
- **Cranberry Rough Hockham SSSI/SPA** - Approximately 630 m to the west-south-west - A basin-mire which has developed on the site of a former lake. It is now occupied by swamp woodland of Alder, Willow and Birch, tall fen, grassland and a network of ditches and pools. The high and stable water level and lack of pollution mean that the site contains an exceptionally wide range of wetland plants, butterflies and other insects. Extensive areas beneath the wetland are covered by carpets of *Sphagnum* mosses that appear to be spreading. As well as the carr there are areas of species-rich tall fen.
- **Breckland Farmland SSSI/SPA** - Approximately 2.7 km to the west-south-west (closest point) - Notified for its internationally important population of stone curlew *Burhinus oedicnemus*. The predominant land use within the SSSI is arable.
- **Thompson Water, Carr and Common SSSI/SAC** - Approximately 1.4 km to the north-west - A mosaic of habitats supporting a wide range of plant communities developed in response to variations in topography, soil type and wetness. The diversity of the grassland communities is enhanced by the presence of damp and water filled pingos, where various open-water and fen communities have developed. Scrub, woodland and an artificial lake further contribute to the site's variety, which supports an exceptional number of plant and animal species, several of them rare, and including an invertebrate fauna of considerable national importance.
- **Stanford Training Area SSSI/SAC/SPA** - Approximately 2.6 km to the west-south-west (closest point) - A very extensive area of Breckland grassland and heath. Habitats of particular nature conservation importance include the calcareous grass-heath, the heather heath, and the areas which support an intimate mosaic of acid and calcareous communities. The fluctuating meres, fed by groundwater, are internationally important. The site also includes other areas of standing water, wetlands and many springs and streams. These benefit from the large area of the SSSI because they are largely unaffected by drainage, pollution, eutrophication or water abstraction. Many of them are consequently extremely species-rich. The SSSI also contains a substantial acreage of woodland which increases the overall habitat diversity. This diversity is reflected in the great variety of bird and insect life that the area supports.
- **East Wretham Heath SSSI/SAC/SPA** - Approximately 6.0 km to the south-west - The principal scientific interest lies in the two fluctuating meres, Ringmere and Langmere and in the areas of Breckland grassland. Additional interest is provided by permanent pools, areas of mature, secondary semi-natural woodland, scrub and an artificial arable weed reserve.
- **Bridgham & Brettenham Heaths SSSI/SAC/SPA** - Approximately 6.4 km to the south-south-west - The vegetation is mainly heather and acidic grassland with considerable areas of bracken and some scrub. However, it also includes small areas of neutral and calcareous grassland to the east and associated with "patterned ground": stripes and polygons or nets formed during the last glaciation. There are several areas of woodland, mainly dominated by Silver Birch but including locally frequent Oak *Quercus robur* and Scots Pine.

Maps of the surrounding area showing the positions of Brookside Farm Poultry Unit (outlined in blue), the LWSs (shaded in yellow), the SSSIs (shaded in green), the SACs (shaded in purple) and the SPAs (shaded in orange) are provided in Figures 1a and 1b.

Figure 1a. The area surrounding Brookside Farm Poultry Unit- concentric circles radii 2.3 km (olive), 5.3 km (green) and 10.3 km (purple)

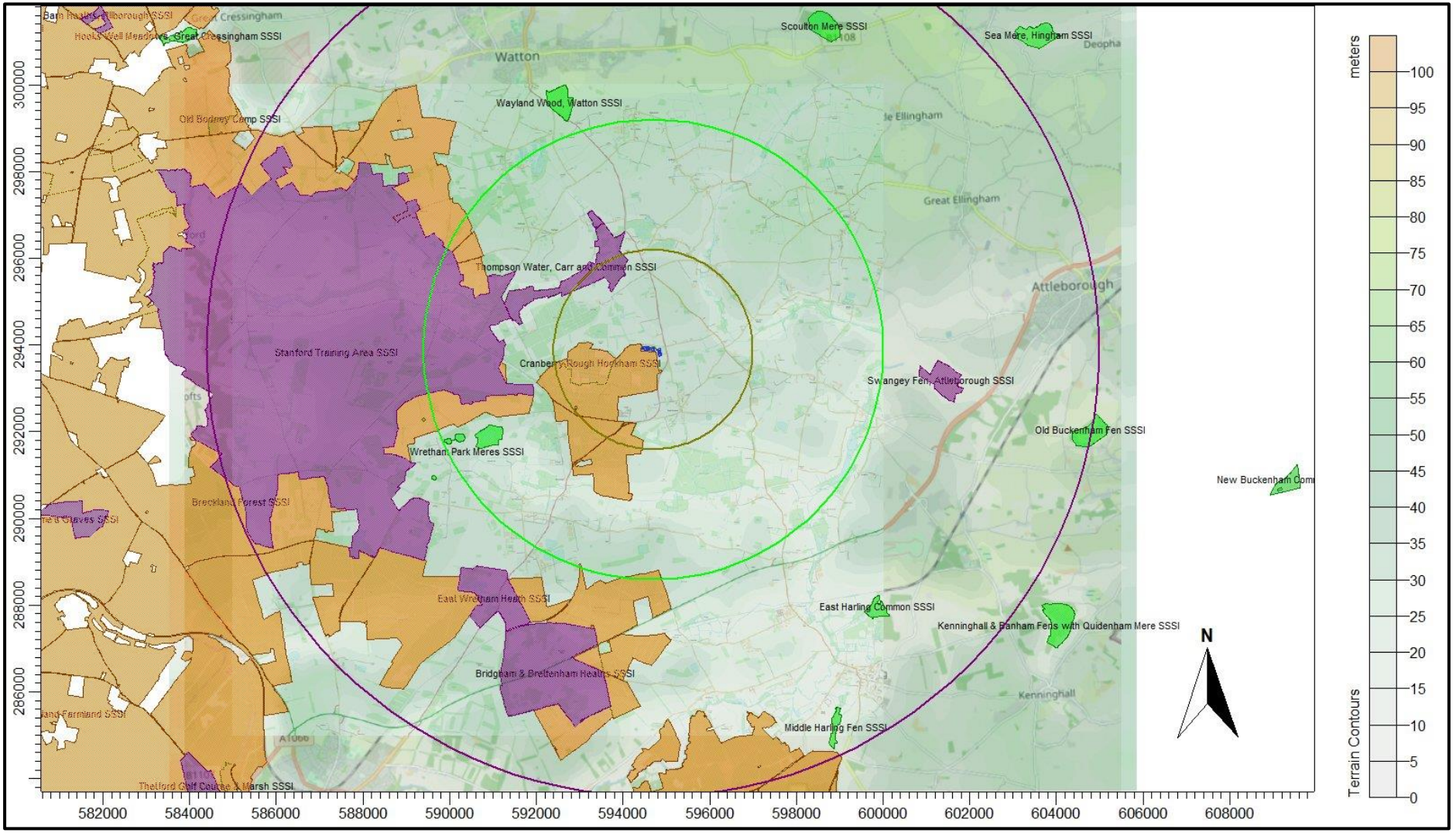
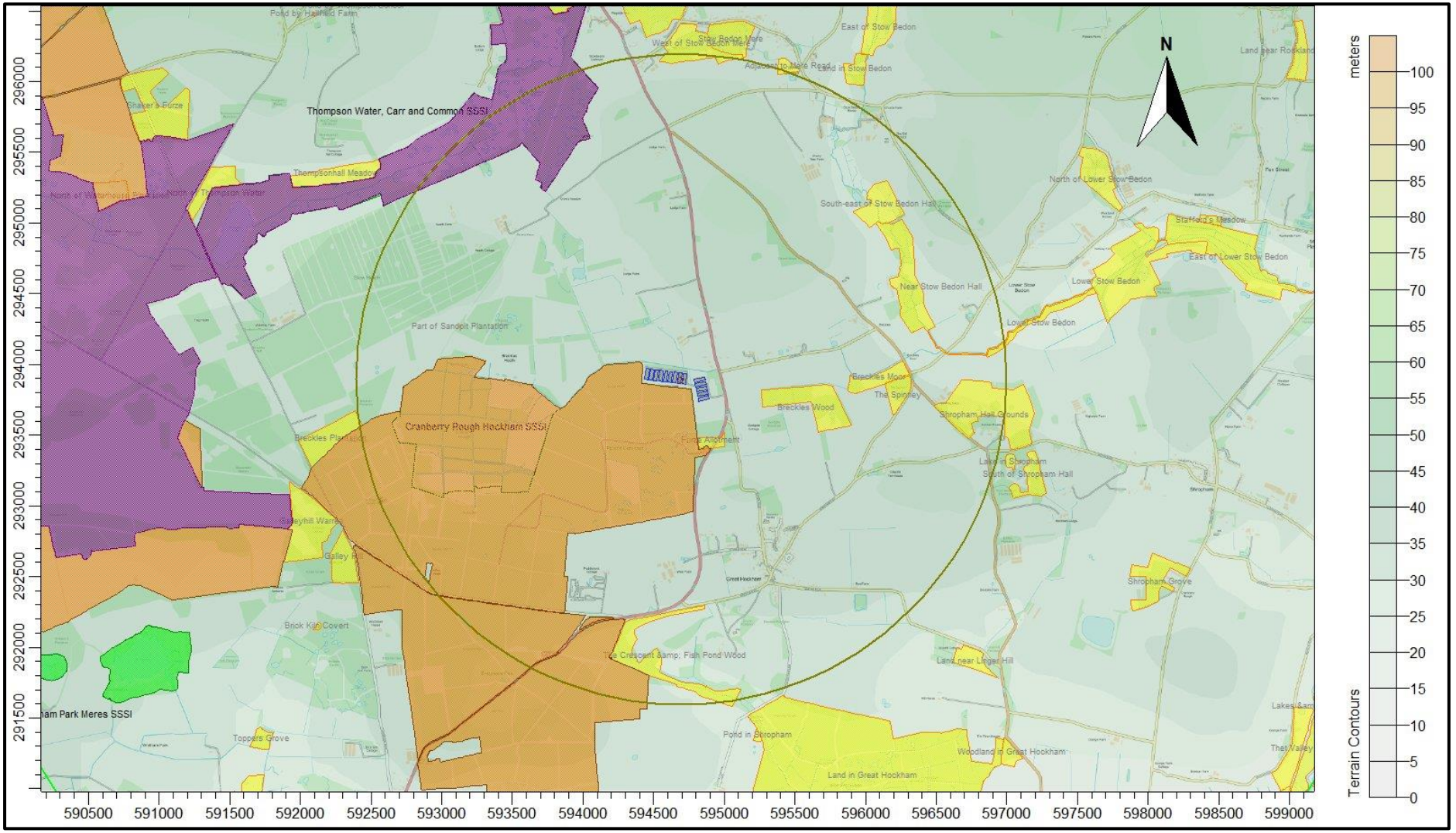


Figure 1b. The area surrounding Brookside Farm Poultry Unit – a closer view



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

3.1 Ammonia concentration and nitrogen and acid deposition

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

3.2 Background ammonia levels and nitrogen and acid deposition

The source of the background figures is the Air Pollution Information System (APIS, April 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 in the area around Brookside Farm Poultry Unit is 3.43 µg-NH_3/m^3. The background nitrogen deposition rate to woodland is 46.17 kg-N/ha/y and to short vegetation is 24.94 kg-N/ha/y. The background acid deposition rate to woodland is 3.35 keq/ha/y and to short vegetation is 1.80 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.

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	1.0 [1]	-	-
Wayland Wood, Watton SSSI	1.0 [1 & 2]	15.0 [2 & 3]	-
Scoulton Mere SSSI	3.0 [2]	15.0 [2 & 3]	-
Old Buckenham Fen SSSI; East Harling Common SSSI and Middle Harling Fen SSSI	3.0 [2]	10.0 [2 & 3]	-
Wretham Park Meres SSSI and Breckland Forest SSSI/SPA	3.0 [2]	n/a [4]	n/a [4]
Cranberry Rough Hockham SSSI/SPA; Thompson Water, Carr and Common SSSI/SAC; Stanford Training Area SSSI/SAC/SPA; East Wretham Heath SSSI/SAC/SPA and Bridgham & Brettenham Heaths SSSI/SAC/SPA	1.0 [1 & 2]	5.0 [2 & 3]	-
Breckland Farmland SSSI/SPA	n/a [4]	n/a [4]	n/a [4]

1. A precautionary figure used where details of the site are entirely unknown, or where although citations do not explicitly mention lichens or bryophytes, they are likely to be present.
2. Based upon the citation for the site (note that in some cases, the APIS database contains Critical Levels/Loads for habitats/species that are not present or not present at the site/parts of the site within 10 km).
3. The lower bound of the range of Critical Loads for habitats present at the site. (please note that in some cases, the APIS database contains Critical Loads for habitats/species that are not present at the site/parts of the site within 10 km).
4. No Critical Loads 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: 4% and 20% 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 to Critical Level or Critical Load are in the range between the lower and upper thresholds; 4% to 20% 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%).

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 installations[1] 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 and proposed 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.

3.5 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 factor used for the existing turkey rearing houses at Brookside Farm Poultry Unit is 0.138 kg-NH_3/bird-place/y; AS Modelling & Data Ltd. understands that this is a bespoke emission factor, previously agreed with the Environment Agency.

The emission factor used for the proposed broiler chicken rearing houses at Brookside Farm Poultry Unit 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 and emission factors used and calculated ammonia emission rates are provided in Table 2.

Table 2. Details of poultry numbers and ammonia emission rates

Source	Animal numbers	Type or weight	Emission factor (kg-NH_3/place/y)	Emission rate (g-NH_3/s)
Existing Housing	106,000	Stag Turkeys	0.138	0.463533
Proposed Housing	434,000	Broiler Chickens	0.024	0.330063

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 52.508 N, 0.869 E, 2021-2024

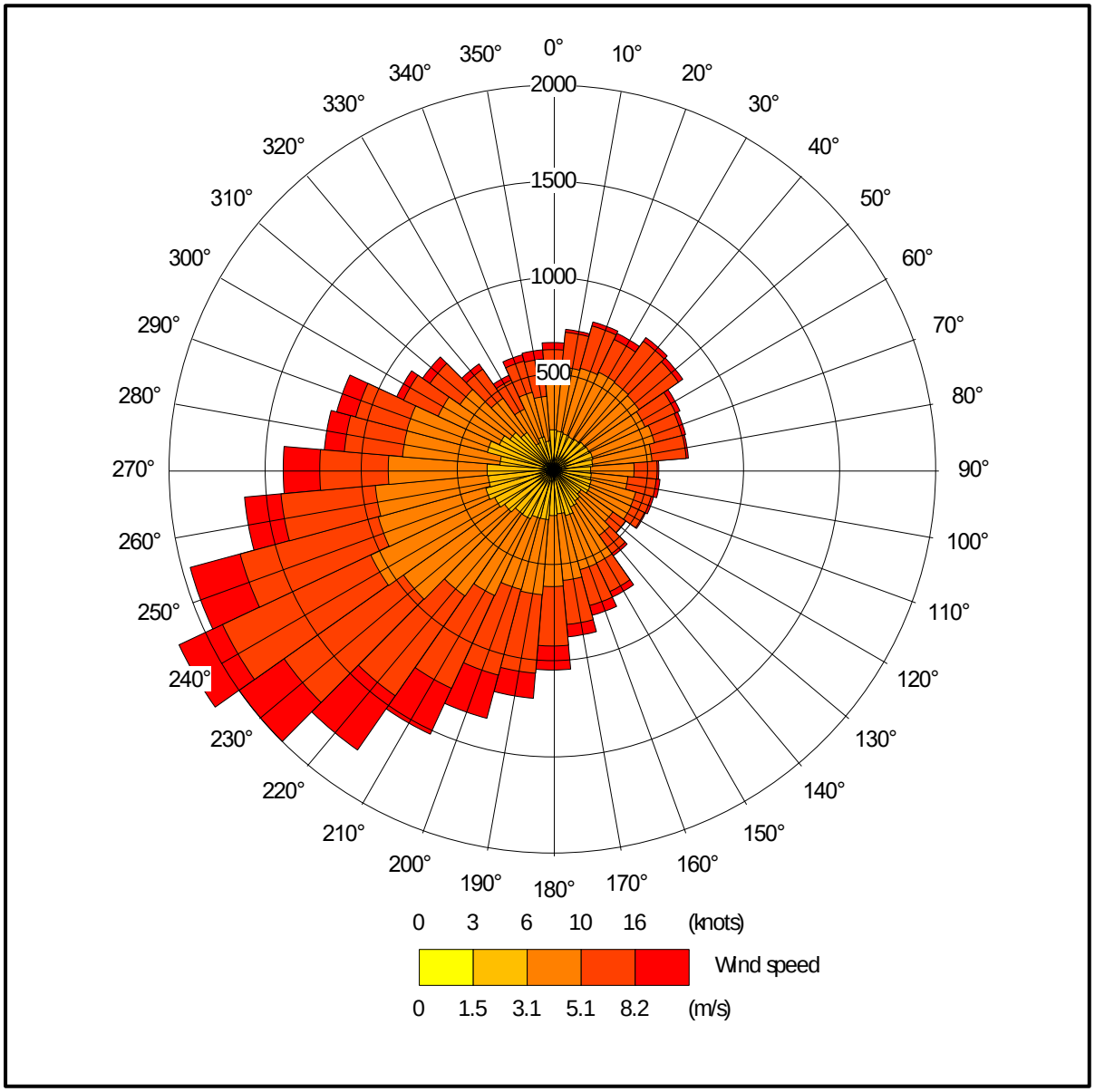
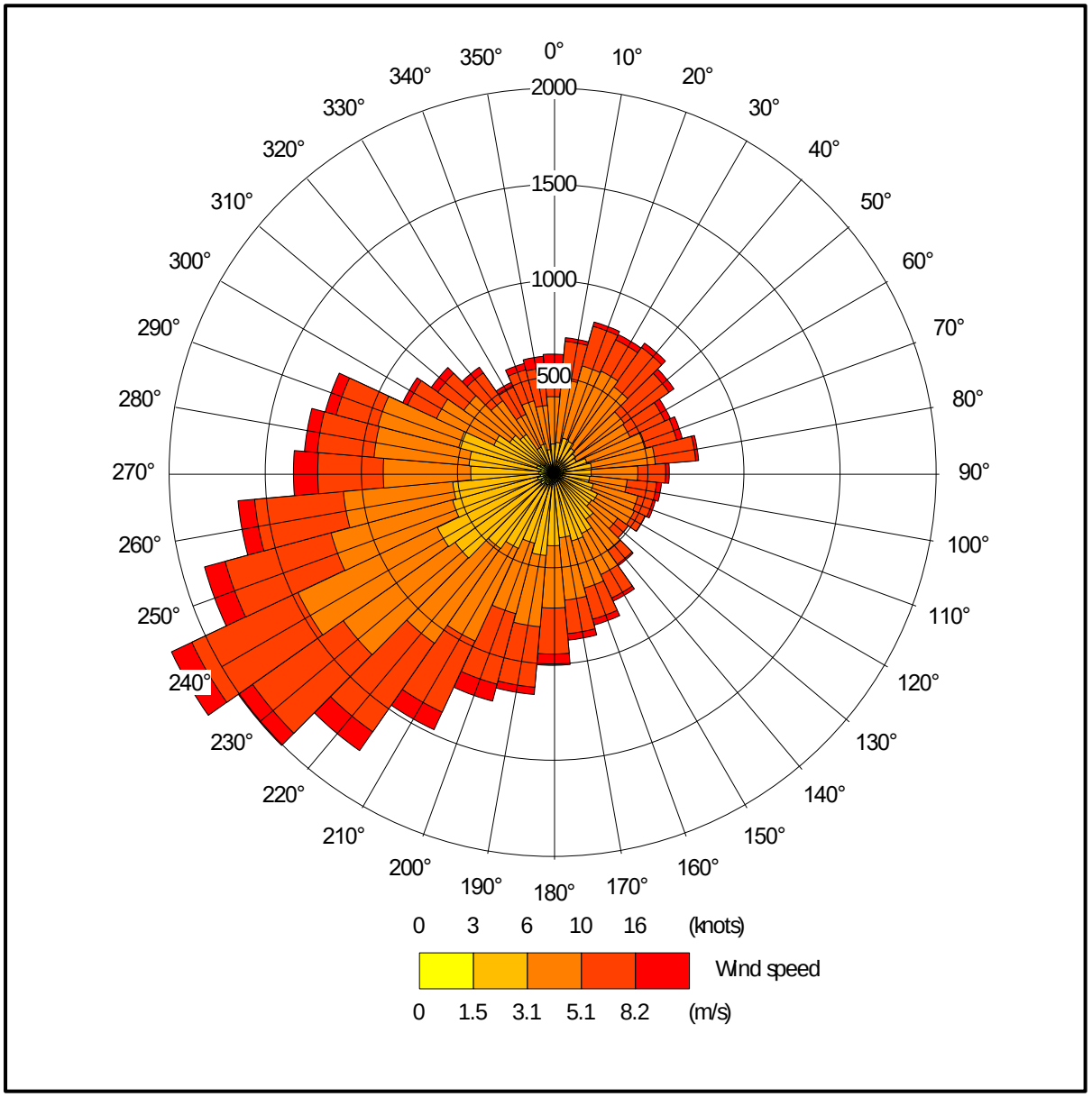


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 594650, 293900, 2021-2024



4.2 Emission sources

Emissions from the side fans of the existing houses have been represented by two volume sources within ADMS (H1TO5 and H6TO14).

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 H12; 1, 2 & 3).

Emissions from the gable end fans that would be used to supplement the primary ventilation of the proposed poultry houses have been represented by volume sources within ADMS (H1TO5_GAB and H6TO14_GAB).

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 25 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 3a and details of the volume source parameters are shown in Table 3b. The positions of the emission sources used are shown in Figures 3a and 3b (the point sources are marked by green circles and the volume sources are marked by red shaded rectangles).

Table 3a. Point source parameters

Source ID (Scenario)	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (˚C)	Emission rate per source (g/s)
H1 to H14 1, 2 & 3 (Proposed)	6.2	0.8	11.0	Variable [1]	0.007859 [1 & 2]

Table 3b. Volume source parameters

Source ID (Scenario)	Length (m)	Width (m)	Depth (m)	Base height (m)	Emission temperature (°C)	Emission rate (g/s)
H1TO5 (Existing)	160.5	76.2	3.0	0.0	Ambient	0.165548
H6TO14 (Existing)	291.0	76.2	3.0	0.0	Ambient	0.297986
H1TO5_GAB (Proposed)	160.5	10.0	3.0	0.5	Ambient	0.117880 [3]
H6TO14_GAB (Proposed)	291.0	10.0	3.0	0.5	Ambient	0.212183 [3]

1. Dependent on ambient temperature.
2. Reduced by 50% when ambient temperature equals or exceeds 25 Celsius.
3. 50% of total only emitted when ambient temperature equals or exceeds 25 Celsius.

4.3 Modelled buildings

The structure of the poultry houses and other nearby buildings may affect the plumes from the point sources in the proposed scenario. Therefore, the buildings are modelled within ADMS. The positions of the modelled buildings may be seen in Figure 3b (marked by blue rectangles).

4.4 Discrete receptors

Seventy-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 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 UK Centre for Ecology and Hydrology 25 m land use database, with permission. The GFS meteorological data is assumed to have a roughness length of 0.286 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 3a. The positions of modelled sources – Existing Scenario

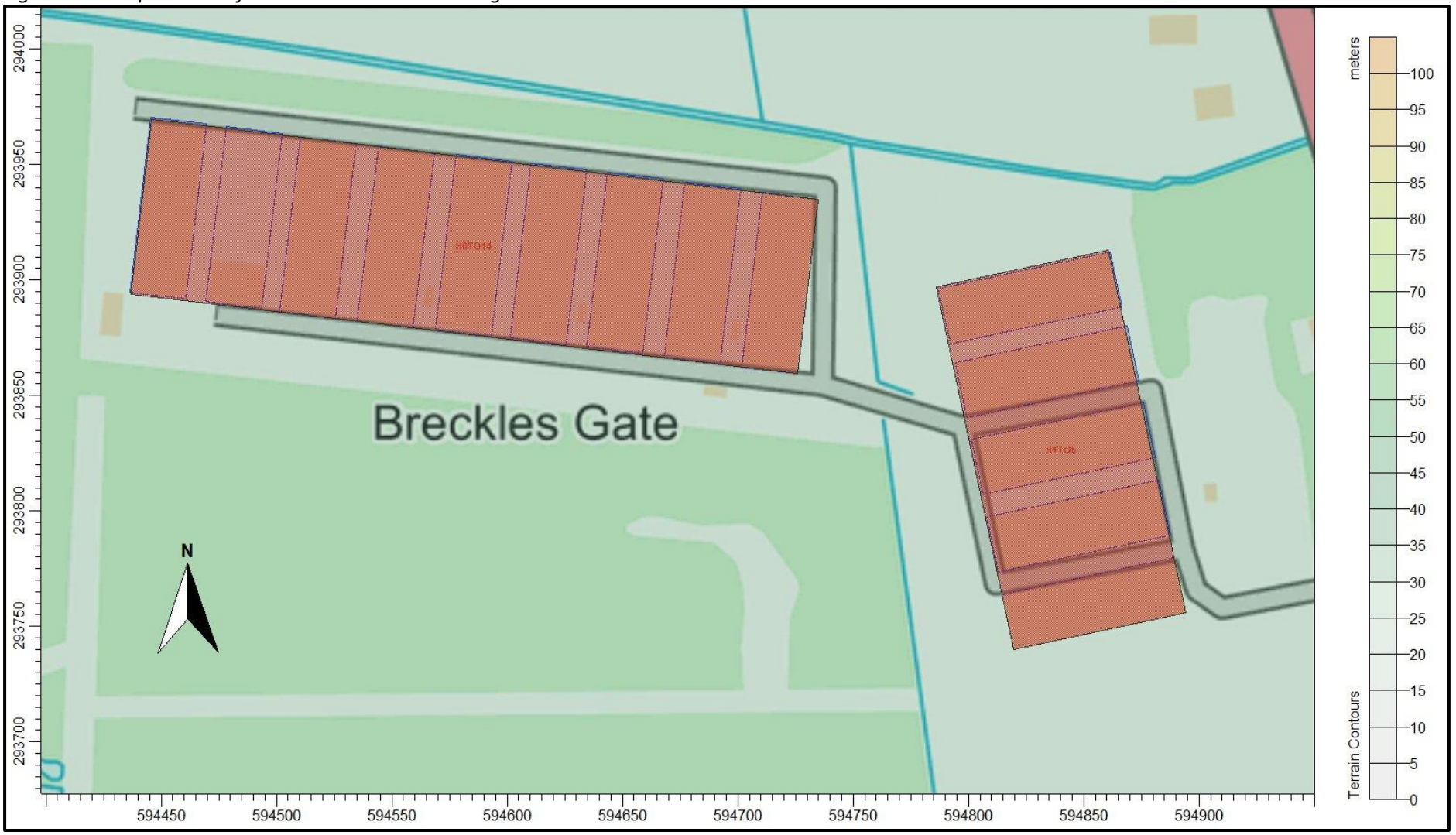


Figure 3b. The positions of modelled buildings and sources – Proposed Scenario

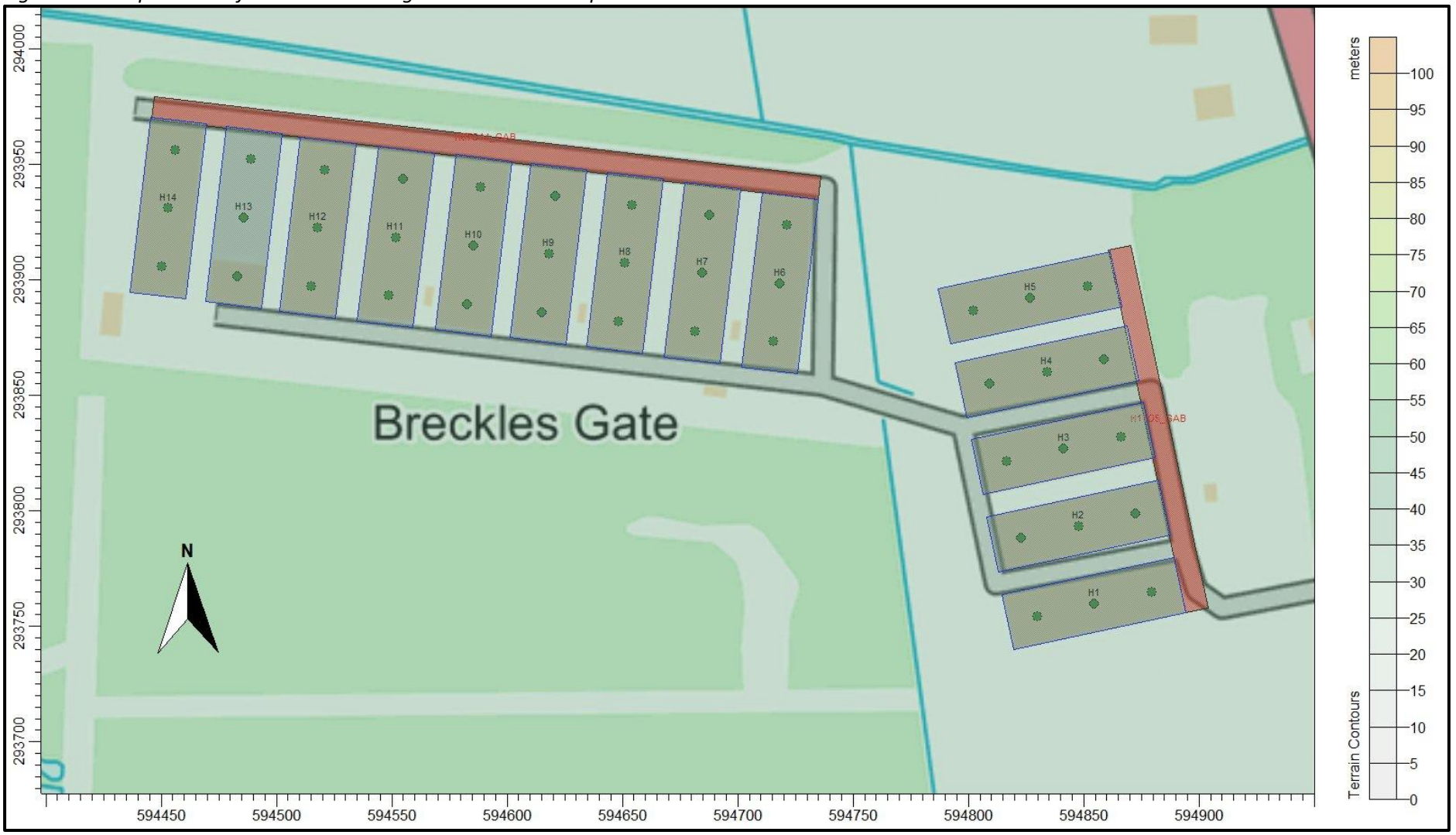


Figure 4a. The discrete receptors and regular Cartesian grids – broadscale view

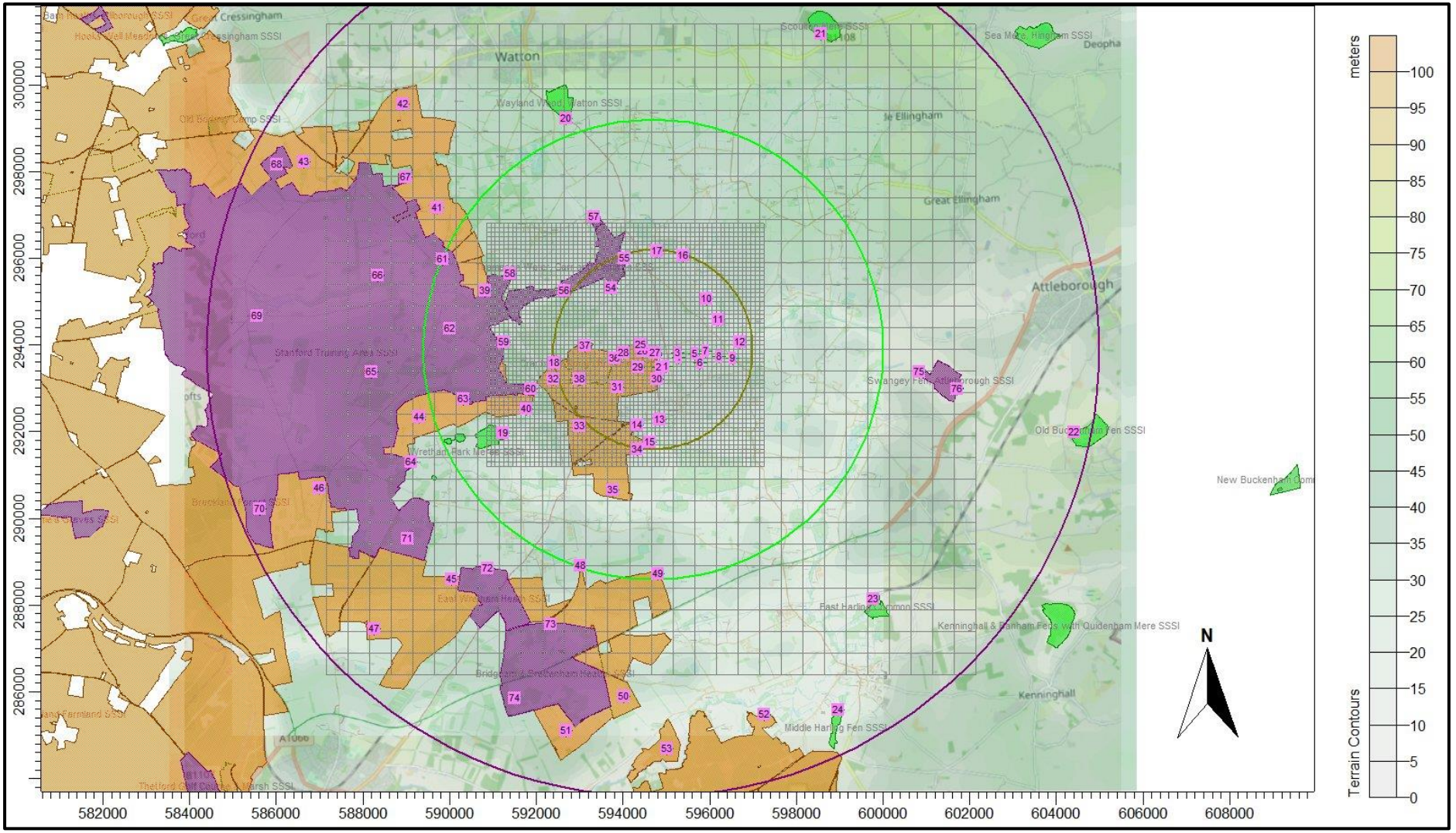


Figure 4b. The discrete receptors and regular Cartesian grids – a closer view

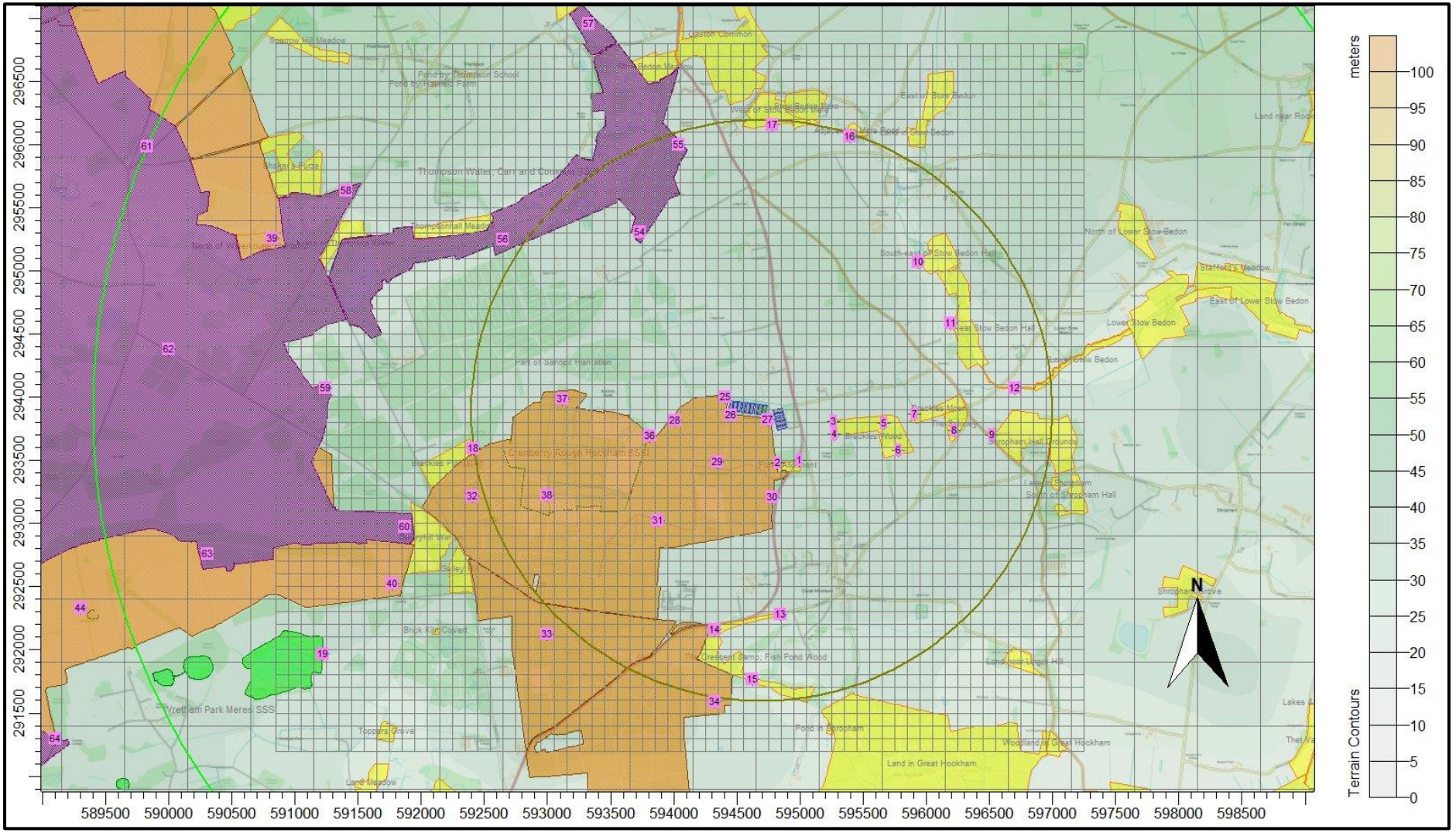
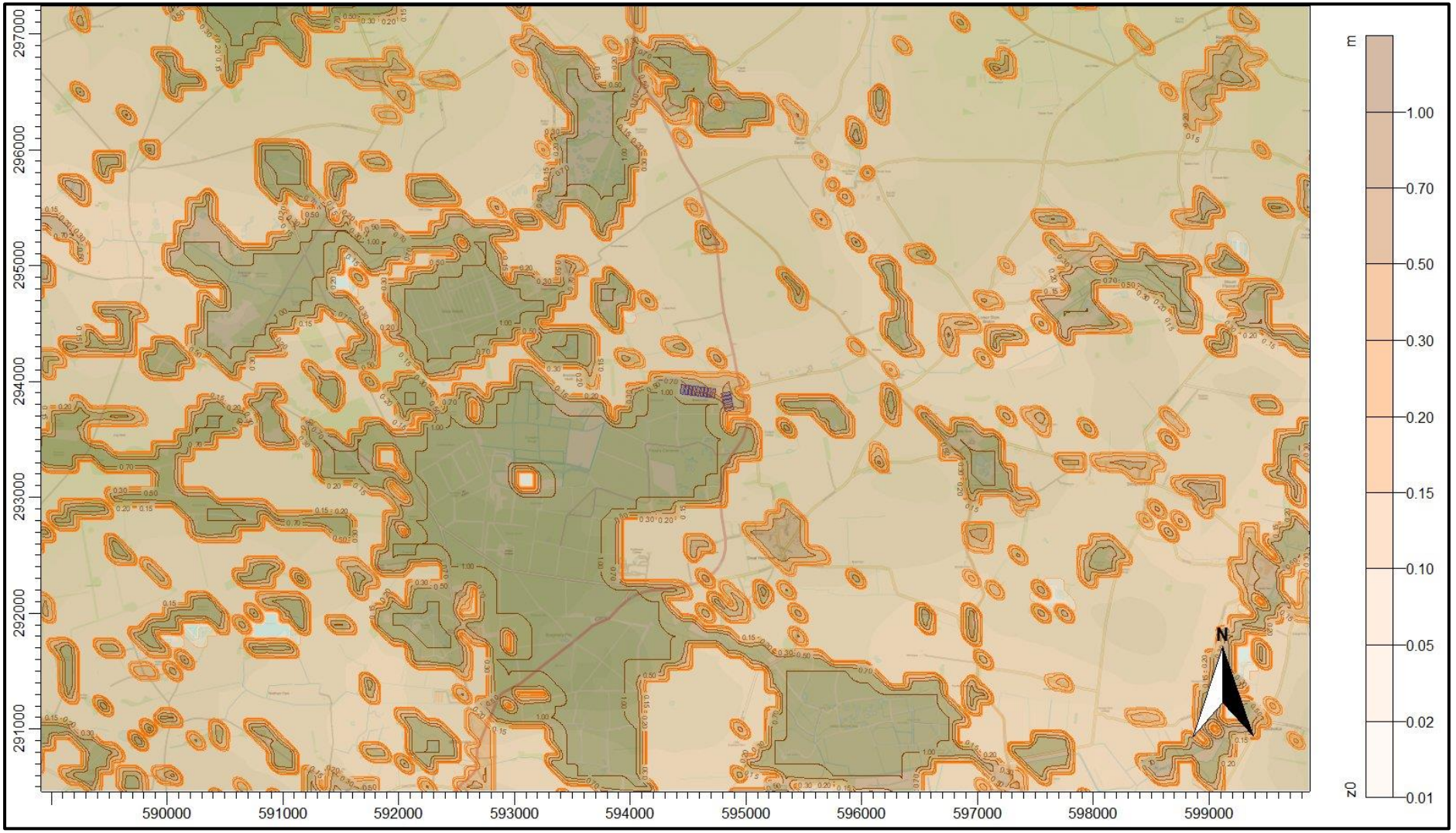


Figure 5. The spatially varying surface roughness field (central area)



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 4.

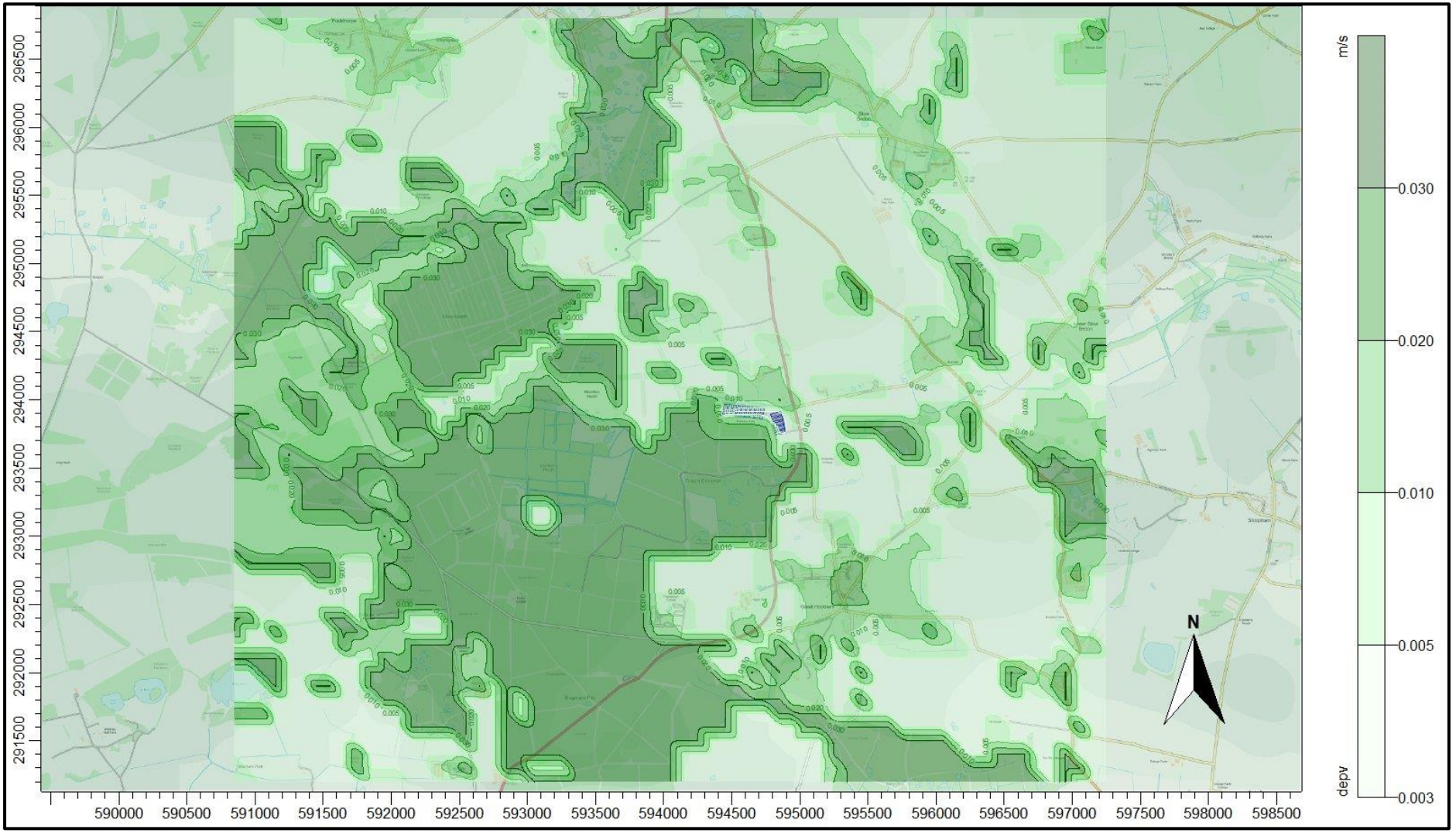
Table 4. Deposition velocities

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 5. The primary purpose of the preliminary modelling is to assess the effect of calms on the results.

Table 5. 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/m^3)			
				Existing		Proposed	
				GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms No Terrain	GFS Calms No Terrain
1	594996	293504	LWS	2.065	2.349	0.366	0.365
2	594822	293476	LWS	2.400	2.708	0.452	0.450
3	595265	293810	LWS	2.042	2.346	0.503	0.500
4	595275	293705	LWS	1.713	1.986	0.394	0.392
5	595665	293793	LWS	0.737	0.853	0.206	0.205
6	595777	293582	LWS	0.535	0.625	0.144	0.143
7	595906	293862	LWS	0.504	0.583	0.152	0.151
8	596223	293734	LWS	0.322	0.375	0.101	0.100
9	596521	293697	LWS	0.234	0.273	0.077	0.076
10	595937	295073	LWS	0.273	0.319	0.098	0.098
11	596192	294586	LWS	0.297	0.328	0.112	0.112
12	596698	294075	LWS	0.206	0.239	0.073	0.073
13	594841	292279	LWS	0.210	0.241	0.058	0.058
14	594323	292163	LWS	0.216	0.243	0.057	0.057
15	594622	291767	LWS	0.144	0.164	0.041	0.041
16	595395	296060	LWS	0.120	0.145	0.047	0.047
17	594780	296157	LWS	0.125	0.141	0.044	0.044
18	592411	293594	LWS	0.135	0.157	0.031	0.031
19	591222	291965	Wretham Park Meres SSSI	0.053	0.061	0.020	0.020
20	592685	299219	Wayland Wood, Watton SSSI	0.022	0.028	0.010	0.010
21	598557	301168	Scoulton Mere SSSI	0.016	0.019	0.008	0.008
22	604402	291991	Old Buckenham Fen SSSI	0.014	0.016	0.007	0.007
23	599771	288152	East Harling Common SSSI	0.019	0.021	0.009	0.009
24	598953	285582	Middle Harling Fen SSSI	0.010	0.012	0.005	0.005
25	594409	293999	Breckland Forest SSSI/SPA	9.156	10.259	1.300	1.294
26	594455	293856	Breckland Forest SSSI/SPA	19.078	21.243	2.051	2.040
27	594745	293819	Breckland Forest SSSI/SPA	21.786	24.596	2.554	2.543
28	594012	293814	Breckland Forest SSSI/SPA	1.271	1.462	0.194	0.194
29	594344	293487	Breckland Forest SSSI/SPA	1.732	1.962	0.359	0.357
30	594778	293210	Breckland Forest SSSI/SPA	0.991	1.124	0.218	0.218
31	593874	293021	Breckland Forest SSSI/SPA	0.390	0.449	0.097	0.097
32	592403	293219	Breckland Forest SSSI/SPA	0.139	0.161	0.035	0.035
33	592993	292126	Breckland Forest SSSI/SPA	0.108	0.125	0.035	0.035

Receptor number	X(m)	Y(m)	Name/Designation	Maximum annual mean ammonia concentration - (μg/m³)			
				Existing		Proposed	
				GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms No Terrain	GFS Calms No Terrain
34	594321	291587	Breckland Forest SSSI/SPA	0.133	0.150	0.038	0.038
35	593763	290660	Breckland Forest SSSI/SPA	0.072	0.081	0.023	0.023
36	593812	293693	Cranberry Rough Hockham SSSI/SPA	0.772	0.890	0.135	0.135
37	593117	293987	Cranberry Rough Hockham SSSI/SPA	0.230	0.268	0.053	0.053
38	592998	293221	Cranberry Rough Hockham SSSI/SPA	0.222	0.256	0.055	0.055
39	590822	295253	Breckland Farmland SSSI/SPA	0.050	0.056	0.018	0.018
40	591772	292521	Breckland Farmland SSSI/SPA	0.081	0.094	0.026	0.026
41	589705	297154	Breckland Farmland SSSI/SPA	0.022	0.026	0.010	0.010
42	588921	299553	Breckland Farmland SSSI/SPA	0.011	0.014	0.005	0.005
43	586640	298223	Breckland Farmland SSSI/SPA	0.013	0.015	0.006	0.006
44	589301	292331	Breckland Farmland SSSI/SPA	0.033	0.038	0.012	0.012
45	590038	288601	Breckland Forest SSSI/SPA	0.019	0.022	0.008	0.008
46	586997	290692	Breckland Forest SSSI/SPA	0.018	0.020	0.008	0.008
47	588257	287447	Breckland Forest SSSI/SPA	0.012	0.014	0.006	0.006
48	593007	288910	Breckland Forest SSSI/SPA	0.034	0.038	0.013	0.013
49	594813	288720	Breckland Forest SSSI/SPA	0.030	0.035	0.012	0.012
50	594005	285892	Breckland Forest SSSI/SPA	0.017	0.019	0.008	0.007
51	592675	285108	Breckland Farmland SSSI/SPA	0.014	0.016	0.007	0.007
52	597260	285489	Breckland Forest SSSI/SPA	0.012	0.014	0.006	0.006
53	595003	284681	Breckland Forest SSSI/SPA	0.012	0.013	0.006	0.006
54	593732	295304	Thompson Water, Carr and Common SSSI/SAC	0.156	0.195	0.052	0.052
55	594036	295998	Thompson Water, Carr and Common SSSI/SAC	0.108	0.134	0.038	0.037
56	592648	295246	Thompson Water, Carr and Common SSSI/SAC	0.095	0.114	0.029	0.029
57	593327	296953	Thompson Water, Carr and Common SSSI/SAC	0.053	0.067	0.020	0.020
58	591404	295637	Stanford Training Area SSSI/SAC/SPA	0.056	0.063	0.019	0.019
59	591245	294075	Stanford Training Area SSSI/SAC/SPA	0.060	0.070	0.019	0.019
60	591867	292975	Stanford Training Area SSSI/SAC/SPA	0.097	0.112	0.027	0.027
61	589827	295984	Stanford Training Area SSSI/SAC/SPA	0.033	0.037	0.013	0.013
62	590001	294378	Stanford Training Area SSSI/SAC/SPA	0.034	0.040	0.014	0.014
63	590305	292758	Stanford Training Area SSSI/SAC/SPA	0.046	0.054	0.015	0.015
64	589104	291298	Stanford Training Area SSSI/SAC/SPA	0.028	0.032	0.011	0.011
65	588193	293380	Stanford Training Area SSSI/SAC/SPA	0.023	0.027	0.009	0.009
66	588337	295593	Stanford Training Area SSSI/SAC/SPA	0.022	0.025	0.010	0.010
67	588988	297879	Stanford Training Area SSSI/SAC/SPA	0.016	0.020	0.007	0.007
68	586009	298153	Stanford Training Area SSSI/SAC/SPA	0.012	0.014	0.006	0.006
69	585546	294668	Stanford Training Area SSSI/SAC/SPA	0.012	0.014	0.006	0.006
70	585618	290213	Stanford Training Area SSSI/SAC/SPA	0.014	0.016	0.006	0.006
71	589032	289533	Stanford Training Area SSSI/SAC/SPA	0.018	0.021	0.009	0.009
72	590869	288853	Stanford Training Area SSSI/SAC/SPA	0.024	0.027	0.010	0.010
73	592329	287551	Stanford Training Area SSSI/SAC/SPA	0.022	0.025	0.009	0.009
74	591505	285859	East Wretham Heath SSSI/SAC/SPA	0.015	0.017	0.007	0.007
75	600840	293383	Bridgham & Brettenham Heaths SSSI/SAC/SPA	0.030	0.035	0.014	0.014
76	601709	292983	Bridgham & Brettenham Heaths SSSI/SAC/SPA	0.024	0.028	0.012	0.012

5.2 Detailed modelling

In this case, detailed modelling has been carried out over a high resolution 6.4 km x 5.6 km domain surrounding Brookside Farm Poultry Unit. 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 6.4 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 the existing scenario and therefore a correction, based on the preliminary modelling results has been applied to the existing scenario results.

The predicted maximum annual mean ground level ammonia concentrations and annual nitrogen deposition rates at the discrete receptors are shown in Tables 6a (Existing Scenario) and 6b (Proposed Scenario). The predicted changes are shown in Table 7.

In these 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 (20% for an internationally designated site, 50% for a SSSI and 100% for a LWS) are coloured red. 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 (4% and 20% for an internationally designated site, 20% and 50% for a SSSI and 100% and 100% for a LWS) are coloured blue. Additionally, process contributions which exceed 1% of the relevant Critical Level or Critical Load at a statutory site are highlighted with bold text.

Contour plots of the predicted ground level maximum annual mean ammonia concentration and maximum annual nitrogen deposition rates for the Proposed Scenario are shown in Figures 7a and 7b. Contour plots for other scenarios can be made available upon request.

Table 6a. Predicted maximum annual mean ammonia concentrations and annual nitrogen deposition rates – Existing Scenario

Receptor number	X(m)	Y(m)	Name	Site Parameters			Maximum annual mean ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level ($\mu g/m^3$)	Critical Load (kg/ha)	Process Contribution ($\mu g/m^3$)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	594996	293504	LWS	0.03	1.0	10.0	0.978	97.80	7.62	76.19
2	594822	293476	LWS	0.03	1.0	10.0	1.099	**109.87**	8.56	85.60
3	595265	293810	LWS	0.03	1.0	10.0	1.655	**165.51**	12.90	**128.95**
4	595275	293705	LWS	0.03	1.0	10.0	1.195	**119.52**	9.31	93.11
5	595665	293793	LWS	0.02	1.0	10.0	0.463	46.32	2.41	24.06
6	595777	293582	LWS	0.02	1.0	10.0	0.298	29.80	1.55	15.48
7	595906	293862	LWS	0.03	1.0	10.0	0.294	29.36	2.29	22.88
8	596223	293734	LWS	0.03	1.0	10.0	0.172	17.24	1.34	13.43
9	596521	293697	LWS	0.03	1.0	10.0	0.126	12.60	0.98	9.82
10	595937	295073	LWS	0.02	1.0	10.0	0.186	18.62	0.97	9.67
11	596192	294586	LWS	0.03	1.0	10.0	0.224	22.43	1.75	17.48
12	596698	294075	LWS	0.03	1.0	10.0	0.115	11.55	0.90	9.00
13	594841	292279	LWS	0.03	1.0	10.0	0.072	7.15	0.56	5.57
14	594323	292163	LWS	0.03	1.0	10.0	0.065	6.50	0.51	5.06
15	594622	291767	LWS	0.03	1.0	10.0	0.042	4.17	0.32	3.25
16	595395	296060	LWS	0.02	1.0	10.0	0.065	6.51	0.34	3.38
17	594780	296157	LWS	0.03	1.0	10.0	0.066	6.62	0.52	5.15
18	592411	293594	LWS	0.03	1.0	10.0	0.029	2.86	0.22	2.23
19	591222	291965	Wretham Park Meres SSSI	0.02	3.0	n/a	0.010	0.35	0.05	-
20	592685	299219	Wayland Wood, Watton SSSI	0.03	1.0	15.0	0.009	0.94	0.07	0.49
21	598557	301168	Scoulton Mere SSSI	0.02	3.0	15.0	0.008	0.27	0.04	0.28
22	604402	291991	Old Buckenham Fen SSSI	0.02	3.0	10.0	0.006	0.21	0.03	0.33
23	599771	288152	East Harling Common SSSI	0.02	3.0	10.0	0.006	0.21	0.03	0.33
24	598953	285582	Middle Harling Fen SSSI	0.02	3.0	10.0	0.003	0.11	0.02	0.16
25	594409	293999	Breckland Forest SSSI/SPA	0.03	3.0	n/a	5.738	**191.25**	44.70	-
26	594455	293856	Breckland Forest SSSI/SPA	0.03	3.0	n/a	11.124	**370.81**	86.67	-
27	594745	293819	Breckland Forest SSSI/SPA	0.03	3.0	n/a	14.422	**480.75**	112.37	--
28	594012	293814	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.423	**14.08**	3.29	-
29	594344	293487	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.602	**20.07**	4.69	-
30	594778	293210	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.379	**12.63**	2.95	-

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
31	593874	293021	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.100	**3.34**	0.78	-
32	592403	293219	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.025	0.84	0.20	-
33	592993	292126	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.021	0.71	0.17	-
34	594321	291587	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.037	**1.22**	0.28	-
35	593763	290660	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.023	0.75	0.18	-
36	593812	293693	Cranberry Rough Hockham SSSI/SPA	0.03	1.0	5.0	0.219	**21.90**	1.71	**34.12**
37	593117	293987	Cranberry Rough Hockham SSSI/SPA	0.03	1.0	5.0	0.064	**6.35**	0.49	**9.90**
38	592998	293221	Cranberry Rough Hockham SSSI/SPA	0.03	1.0	5.0	0.044	**4.41**	0.34	**6.86**
39	590822	295253	Breckland Farmland SSSI/SPA	0.005	n/a	n/a	0.012	-	0.02	-
40	591772	292521	Breckland Farmland SSSI/SPA	0.005	n/a	n/a	0.014	-	0.02	-
41	589705	297154	Breckland Farmland SSSI/SPA	0.005	n/a	n/a	0.006	-	0.01	-
42	588921	299553	Breckland Farmland SSSI/SPA	0.005	n/a	n/a	0.004	-	0.00	-
43	586640	298223	Breckland Farmland SSSI/SPA	0.005	n/a	n/a	0.003	-	0.00	-
44	589301	292331	Breckland Farmland SSSI/SPA	0.005	n/a	n/a	0.006	-	0.01	-
45	590038	288601	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.005	0.16	0.04	-
46	586997	290692	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.003	0.11	0.03	-
47	588257	287447	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.003	0.10	0.02	-
48	593007	288910	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.010	0.32	0.07	-
49	594813	288720	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.008	0.27	0.06	-
50	594005	285892	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.004	0.14	0.03	-
51	592675	285108	Breckland Farmland SSSI/SPA	0.005	n/a	n/a	0.004	-	0.00	-
52	597260	285489	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.004	0.13	0.03	-
53	595003	284681	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.003	0.11	0.03	-
54	593732	295304	Thompson Water, Carr and Common SSSI/SAC	0.02	1.0	5.0	0.086	**8.64**	0.45	**8.98**
55	594036	295998	Thompson Water, Carr and Common SSSI/SAC	0.02	1.0	5.0	0.055	**5.48**	0.28	**5.69**
56	592648	295246	Thompson Water, Carr and Common SSSI/SAC	0.02	1.0	5.0	0.028	**2.77**	0.14	**2.88**
57	593327	296953	Thompson Water, Carr and Common SSSI/SAC	0.02	1.0	5.0	0.025	**2.53**	0.13	**2.63**
58	591404	295637	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.012	**1.24**	0.06	**1.29**
59	591245	294075	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.012	**1.20**	0.06	**1.24**
60	591867	292975	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.016	**1.60**	0.08	**1.66**
61	589827	295984	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.008	0.85	0.04	0.88
62	590001	294378	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.009	0.90	0.05	0.93

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
63	590305	292758	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.008	0.85	0.04	0.88
64	589104	291298	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.006	0.55	0.03	0.57
65	588193	293380	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.004	0.41	0.02	0.43
66	588337	295593	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.007	0.69	0.04	0.71
67	588988	297879	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.004	0.43	0.02	0.45
68	586009	298153	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.003	0.26	0.01	0.27
69	585546	294668	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.003	0.28	0.01	0.29
70	585618	290213	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.002	0.25	0.01	0.26
71	589032	289533	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.004	0.44	0.02	0.46
72	590869	288853	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.006	0.59	0.03	0.61
73	592329	287551	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.006	0.62	0.03	0.65
74	591505	285859	East Wretham Heath SSSI/SAC/SPA	0.02	1.0	5.0	0.004	0.39	0.02	0.40
75	600840	293383	Bridgham & Brettenham Heaths SSSI/SAC/SPA	0.02	1.0	5.0	0.014	**1.41**	0.07	**1.46**
76	601709	292983	Bridgham & Brettenham Heaths SSSI/SAC/SPA	0.02	1.0	5.0	0.011	**1.12**	0.06	**1.16**

Table 6b. Predicted maximum annual mean ammonia concentrations and annual nitrogen deposition rates – Proposed Scenario

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	594996	293504	LWS	0.03	1.0	10.0	0.628	62.78	4.89	48.91
2	594822	293476	LWS	0.03	1.0	10.0	0.724	72.37	5.64	56.38
3	595265	293810	LWS	0.03	1.0	10.0	1.134	**113.40**	8.83	88.35
4	595275	293705	LWS	0.03	1.0	10.0	0.807	80.70	6.29	62.88
5	595665	293793	LWS	0.02	1.0	10.0	0.351	35.11	1.82	18.24
6	595777	293582	LWS	0.02	1.0	10.0	0.227	22.74	1.18	11.81
7	595906	293862	LWS	0.03	1.0	10.0	0.233	23.26	1.81	18.12
8	596223	293734	LWS	0.03	1.0	10.0	0.140	13.96	1.09	10.88
9	596521	293697	LWS	0.03	1.0	10.0	0.103	10.26	0.80	7.99
10	595937	295073	LWS	0.02	1.0	10.0	0.152	15.22	0.79	7.90
11	596192	294586	LWS	0.03	1.0	10.0	0.181	18.13	1.41	14.12
12	596698	294075	LWS	0.03	1.0	10.0	0.098	9.81	0.76	7.64
13	594841	292279	LWS	0.03	1.0	10.0	0.060	6.04	0.47	4.70
14	594323	292163	LWS	0.03	1.0	10.0	0.054	5.35	0.42	4.17
15	594622	291767	LWS	0.03	1.0	10.0	0.035	3.52	0.27	2.74
16	595395	296060	LWS	0.02	1.0	10.0	0.056	5.57	0.29	2.89
17	594780	296157	LWS	0.03	1.0	10.0	0.055	5.46	0.43	4.26
18	592411	293594	LWS	0.03	1.0	10.0	0.025	2.50	0.19	1.95
19	591222	291965	Wretham Park Meres SSSI	0.02	3.0	n/a	0.010	0.33	0.05	-
20	592685	299219	Wayland Wood, Watton SSSI	0.03	1.0	15.0	0.008	0.84	0.07	0.44
21	598557	301168	Scoulton Mere SSSI	0.02	3.0	15.0	0.007	0.24	0.04	0.25
22	604402	291991	Old Buckenham Fen SSSI	0.02	3.0	10.0	0.006	0.19	0.03	0.29
23	599771	288152	East Harling Common SSSI	0.02	3.0	10.0	0.006	0.19	0.03	0.30
24	598953	285582	Middle Harling Fen SSSI	0.02	3.0	10.0	0.003	0.10	0.02	0.15
25	594409	293999	Breckland Forest SSSI/SPA	0.03	3.0	n/a	4.900	**163.35**	38.18	-
26	594455	293856	Breckland Forest SSSI/SPA	0.03	3.0	n/a	9.546	**318.19**	74.37	-
27	594745	293819	Breckland Forest SSSI/SPA	0.03	3.0	n/a	9.495	**316.51**	73.98	--
28	594012	293814	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.352	**11.75**	2.75	-
29	594344	293487	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.491	**16.37**	3.83	-
30	594778	293210	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.283	**9.43**	2.20	-

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
31	593874	293021	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.085	**2.82**	0.66	-
32	592403	293219	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.022	0.74	0.17	-
33	592993	292126	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.019	0.63	0.15	-
34	594321	291587	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.031	**1.03**	0.24	-
35	593763	290660	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.020	0.66	0.15	-
36	593812	293693	Cranberry Rough Hockham SSSI/SPA	0.03	1.0	5.0	0.183	**18.35**	1.43	**28.59**
37	593117	293987	Cranberry Rough Hockham SSSI/SPA	0.03	1.0	5.0	0.055	**5.48**	0.43	**8.54**
38	592998	293221	Cranberry Rough Hockham SSSI/SPA	0.03	1.0	5.0	0.038	**3.81**	0.30	**5.93**
39	590822	295253	Breckland Farmland SSSI/SPA	0.005	n/a	n/a	0.011	-	0.01	-
40	591772	292521	Breckland Farmland SSSI/SPA	0.005	n/a	n/a	0.013	-	0.02	-
41	589705	297154	Breckland Farmland SSSI/SPA	0.005	n/a	n/a	0.005	-	0.01	-
42	588921	299553	Breckland Farmland SSSI/SPA	0.005	n/a	n/a	0.003	-	0.00	-
43	586640	298223	Breckland Farmland SSSI/SPA	0.005	n/a	n/a	0.003	-	0.00	-
44	589301	292331	Breckland Farmland SSSI/SPA	0.005	n/a	n/a	0.006	-	0.01	-
45	590038	288601	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.004	0.14	0.03	-
46	586997	290692	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.003	0.10	0.02	-
47	588257	287447	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.003	0.09	0.02	-
48	593007	288910	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.009	0.29	0.07	-
49	594813	288720	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.008	0.25	0.06	-
50	594005	285892	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.004	0.13	0.03	-
51	592675	285108	Breckland Farmland SSSI/SPA	0.005	n/a	n/a	0.003	-	0.00	-
52	597260	285489	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.003	0.12	0.03	-
53	595003	284681	Breckland Forest SSSI/SPA	0.03	3.0	n/a	0.003	0.10	0.02	-
54	593732	295304	Thompson Water, Carr and Common SSSI/SAC	0.02	1.0	5.0	0.072	**7.20**	0.37	**7.48**
55	594036	295998	Thompson Water, Carr and Common SSSI/SAC	0.02	1.0	5.0	0.046	**4.60**	0.24	**4.78**
56	592648	295246	Thompson Water, Carr and Common SSSI/SAC	0.02	1.0	5.0	0.024	**2.39**	0.12	**2.48**
57	593327	296953	Thompson Water, Carr and Common SSSI/SAC	0.02	1.0	5.0	0.022	**2.22**	0.12	**2.30**
58	591404	295637	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.011	**1.12**	0.06	**1.16**
59	591245	294075	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.011	**1.09**	0.06	**1.13**
60	591867	292975	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.015	**1.47**	0.08	**1.53**
61	589827	295984	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.008	0.78	0.04	0.81
62	590001	294378	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.008	0.83	0.04	0.86

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
63	590305	292758	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.008	0.81	0.04	0.84
64	589104	291298	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.005	0.52	0.03	0.54
65	588193	293380	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.004	0.40	0.02	0.42
66	588337	295593	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.006	0.63	0.03	0.65
67	588988	297879	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.004	0.40	0.02	0.42
68	586009	298153	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.003	0.26	0.01	0.27
69	585546	294668	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.003	0.27	0.01	0.28
70	585618	290213	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.002	0.24	0.01	0.25
71	589032	289533	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.004	0.41	0.02	0.43
72	590869	288853	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.005	0.55	0.03	0.57
73	592329	287551	Stanford Training Area SSSI/SAC/SPA	0.02	1.0	5.0	0.006	0.56	0.03	0.59
74	591505	285859	East Wretham Heath SSSI/SAC/SPA	0.02	1.0	5.0	0.004	0.36	0.02	0.37
75	600840	293383	Bridgham & Brettenham Heaths SSSI/SAC/SPA	0.02	1.0	5.0	0.013	**1.27**	0.07	**1.31**
76	601709	292983	Bridgham & Brettenham Heaths SSSI/SAC/SPA	0.02	1.0	5.0	0.010	**1.00**	0.05	**1.04**

Table 7. Predicted changes in maximum annual mean ammonia concentrations and annual nitrogen deposition rates

Receptor number	X(m)	Y(m)	Name	Maximum annual mean ammonia concentration		Maximum annual nitrogen deposition rate	
				Process Contribution ($\mu g/m^3$)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	594996	293504	LWS	-0.350	-35.02	-2.7280	-27.28
2	594822	293476	LWS	-0.375	-37.50	-2.9216	-29.22
3	595265	293810	LWS	-0.521	-52.12	-4.0603	-40.60
4	595275	293705	LWS	-0.388	-38.81	-3.0238	-30.24
5	595665	293793	LWS	-0.112	-11.20	-0.5819	-5.82
6	595777	293582	LWS	-0.071	-7.06	-0.3667	-3.67
7	595906	293862	LWS	-0.061	-6.11	-0.4759	-4.76
8	596223	293734	LWS	-0.033	-3.27	-0.2551	-2.55
9	596521	293697	LWS	-0.023	-2.35	-0.1827	-1.83
10	595937	295073	LWS	-0.034	-3.41	-0.1769	-1.77
11	596192	294586	LWS	-0.043	-4.30	-0.3351	-3.35
12	596698	294075	LWS	-0.017	-1.74	-0.1355	-1.35
13	594841	292279	LWS	-0.011	-1.12	-0.0870	-0.87
14	594323	292163	LWS	-0.011	-1.14	-0.0891	-0.89
15	594622	291767	LWS	-0.006	-0.64	-0.0502	-0.50
16	595395	296060	LWS	-0.009	-0.94	-0.0487	-0.49
17	594780	296157	LWS	-0.012	-1.15	-0.0897	-0.90
18	592411	293594	LWS	-0.004	-0.36	-0.0279	-0.28
19	591222	291965	Wretham Park Meres SSSI	0.000	-0.01	-0.0023	-
20	592685	299219	Wayland Wood, Watton SSSI	-0.001	-0.10	-0.0078	-0.05
21	598557	301168	Scoulton Mere SSSI	-0.001	-0.03	-0.0050	-0.03
22	604402	291991	Old Buckenham Fen SSSI	-0.001	-0.02	-0.0037	-0.04
23	599771	288152	East Harling Common SSSI	-0.001	-0.02	-0.0033	-0.03
24	598953	285582	Middle Harling Fen SSSI	0.000	-0.01	-0.0013	-0.01
25	594409	293999	Breckland Forest SSSI/SPA	-0.837	-27.90	-6.5221	-
26	594455	293856	Breckland Forest SSSI/SPA	-1.579	-52.62	-12.2992	-
27	594745	293819	Breckland Forest SSSI/SPA	-4.927	-164.24	-38.3882	--
28	594012	293814	Breckland Forest SSSI/SPA	-0.070	-2.335	-0.5457	-
29	594344	293487	Breckland Forest SSSI/SPA	-0.111	-3.693	-0.8632	-
30	594778	293210	Breckland Forest SSSI/SPA	-0.096	-3.200	-0.7479	-

Receptor number	X(m)	Y(m)	Name	Maximum annual mean ammonia concentration		Maximum annual nitrogen deposition rate	
				Process Contribution ($\mu g/m^3$)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
31	593874	293021	Breckland Forest SSSI/SPA	-0.015	-0.515	-0.1204	-
32	592403	293219	Breckland Forest SSSI/SPA	-0.003	-0.102	-0.0239	-
33	592993	292126	Breckland Forest SSSI/SPA	-0.002	-0.082	-0.0191	-
34	594321	291587	Breckland Forest SSSI/SPA	-0.006	-0.187	-0.0438	-
35	593763	290660	Breckland Forest SSSI/SPA	-0.003	-0.095	-0.0222	-
36	593812	293693	Cranberry Rough Hockham SSSI/SPA	-0.036	-3.552	-0.2767	-5.534
37	593117	293987	Cranberry Rough Hockham SSSI/SPA	-0.009	-0.869	-0.0677	-1.354
38	592998	293221	Cranberry Rough Hockham SSSI/SPA	-0.0060	-0.597	-0.0465	-0.930
39	590822	295253	Breckland Farmland SSSI/SPA	-0.0008	-	-0.0011	-
40	591772	292521	Breckland Farmland SSSI/SPA	-0.0006	-	-0.0007	-
41	589705	297154	Breckland Farmland SSSI/SPA	-0.0004	-	-0.0006	-
42	588921	299553	Breckland Farmland SSSI/SPA	-0.0003	-	-0.0004	-
43	586640	298223	Breckland Farmland SSSI/SPA	-0.0001	-	-0.0001	-
44	589301	292331	Breckland Farmland SSSI/SPA	-0.0002	-	-0.0003	-
45	590038	288601	Breckland Forest SSSI/SPA	-0.0004	-0.014	-0.0032	-
46	586997	290692	Breckland Forest SSSI/SPA	-0.0001	-0.004	-0.0009	-
47	588257	287447	Breckland Forest SSSI/SPA	-0.0003	-0.009	-0.0022	-
48	593007	288910	Breckland Forest SSSI/SPA	-0.0010	-0.032	-0.0075	-
49	594813	288720	Breckland Forest SSSI/SPA	-0.0006	-0.021	-0.0050	-
50	594005	285892	Breckland Forest SSSI/SPA	-0.0003	-0.009	-0.0022	-
51	592675	285108	Breckland Farmland SSSI/SPA	-0.0003	-	-0.0003	-
52	597260	285489	Breckland Forest SSSI/SPA	-0.0003	-0.010	-0.0023	-
53	595003	284681	Breckland Forest SSSI/SPA	-0.0002	-0.008	-0.0018	-
54	593732	295304	Thompson Water, Carr and Common SSSI/SAC	-0.0144	-1.441	-0.0748	-1.497
55	594036	295998	Thompson Water, Carr and Common SSSI/SAC	-0.0088	-0.881	-0.0458	-0.916
56	592648	295246	Thompson Water, Carr and Common SSSI/SAC	-0.0038	-0.379	-0.0197	-0.394
57	593327	296953	Thompson Water, Carr and Common SSSI/SAC	-0.0031	-0.315	-0.0163	-0.327
58	591404	295637	Stanford Training Area SSSI/SAC/SPA	-0.0012	-0.122	-0.0063	-0.127
59	591245	294075	Stanford Training Area SSSI/SAC/SPA	-0.0011	-0.108	-0.0056	-0.112
60	591867	292975	Stanford Training Area SSSI/SAC/SPA	-0.0013	-0.128	-0.0067	-0.133
61	589827	295984	Stanford Training Area SSSI/SAC/SPA	-0.0006	-0.064	-0.0033	-0.066
62	590001	294378	Stanford Training Area SSSI/SAC/SPA	-0.0007	-0.067	-0.0035	-0.069

Receptor number	X(m)	Y(m)	Name	Maximum annual mean ammonia concentration		Maximum annual nitrogen deposition rate	
				Process Contribution ($\mu g/m^3$)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
63	590305	292758	Stanford Training Area SSSI/SAC/SPA	-0.0004	-0.039	-0.0020	-0.040
64	589104	291298	Stanford Training Area SSSI/SAC/SPA	-0.0003	-0.028	-0.0014	-0.029
65	588193	293380	Stanford Training Area SSSI/SAC/SPA	-0.0001	-0.009	-0.0005	-0.009
66	588337	295593	Stanford Training Area SSSI/SAC/SPA	-0.0006	-0.056	-0.0029	-0.059
67	588988	297879	Stanford Training Area SSSI/SAC/SPA	-0.0003	-0.029	-0.0015	-0.030
68	586009	298153	Stanford Training Area SSSI/SAC/SPA	-0.0001	-0.006	-0.0003	-0.006
69	585546	294668	Stanford Training Area SSSI/SAC/SPA	-0.0001	-0.015	-0.0008	-0.015
70	585618	290213	Stanford Training Area SSSI/SAC/SPA	-0.0001	-0.008	-0.0004	-0.009
71	589032	289533	Stanford Training Area SSSI/SAC/SPA	-0.0003	-0.028	-0.0015	-0.029
72	590869	288853	Stanford Training Area SSSI/SAC/SPA	-0.0004	-0.042	-0.0022	-0.043
73	592329	287551	Stanford Training Area SSSI/SAC/SPA	-0.0006	-0.059	-0.0031	-0.061
74	591505	285859	East Wretham Heath SSSI/SAC/SPA	-0.0003	-0.030	-0.0015	-0.031
75	600840	293383	Bridgham & Brettenham Heaths SSSI/SAC/SPA	-0.0014	-0.141	-0.0073	-0.147
76	601709	292983	Bridgham & Brettenham Heaths SSSI/SAC/SPA	-0.0012	-0.119	-0.0062	-0.123

Figure 7a. Maximum annual mean ammonia concentration – Proposed Scenario

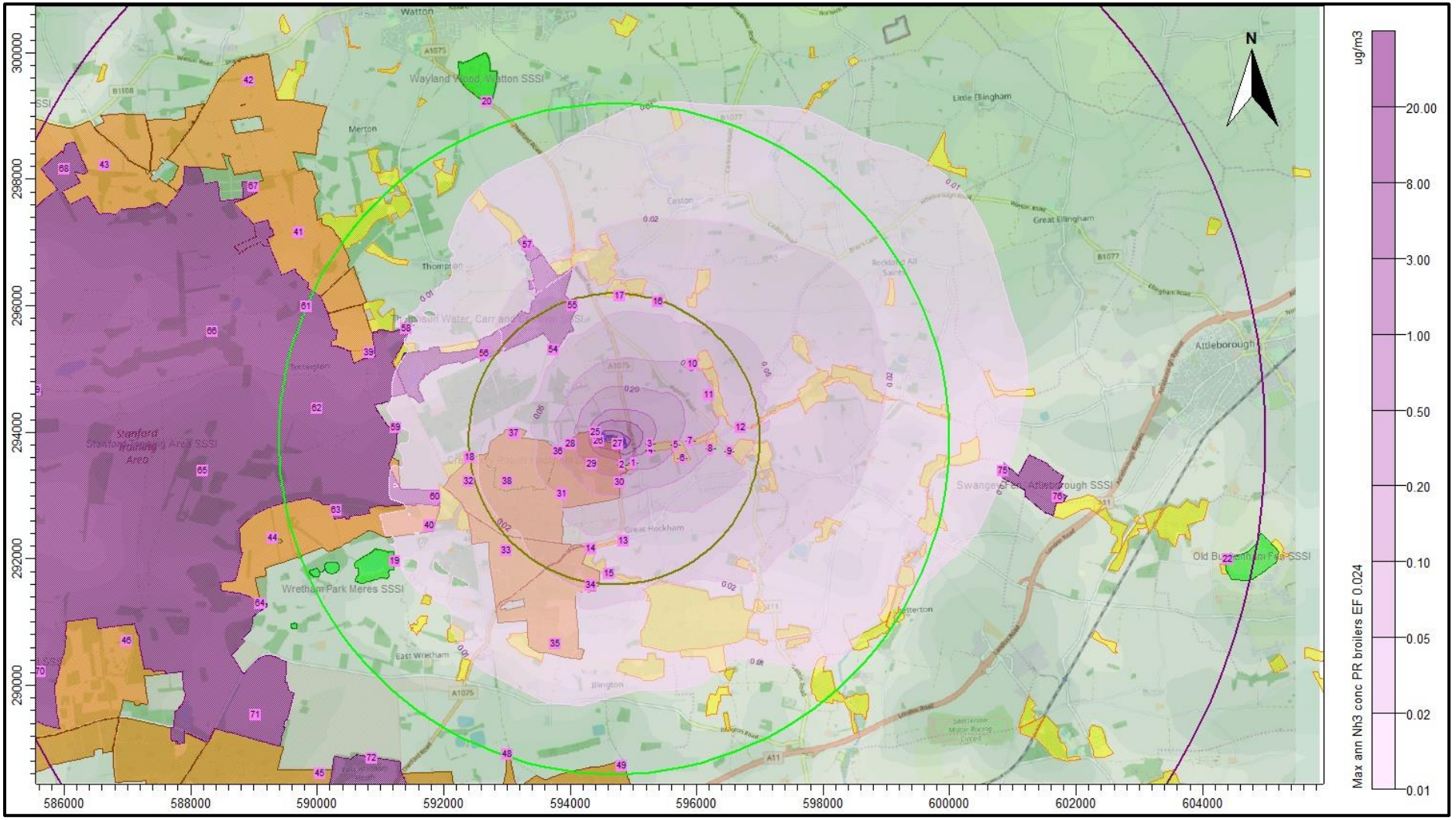
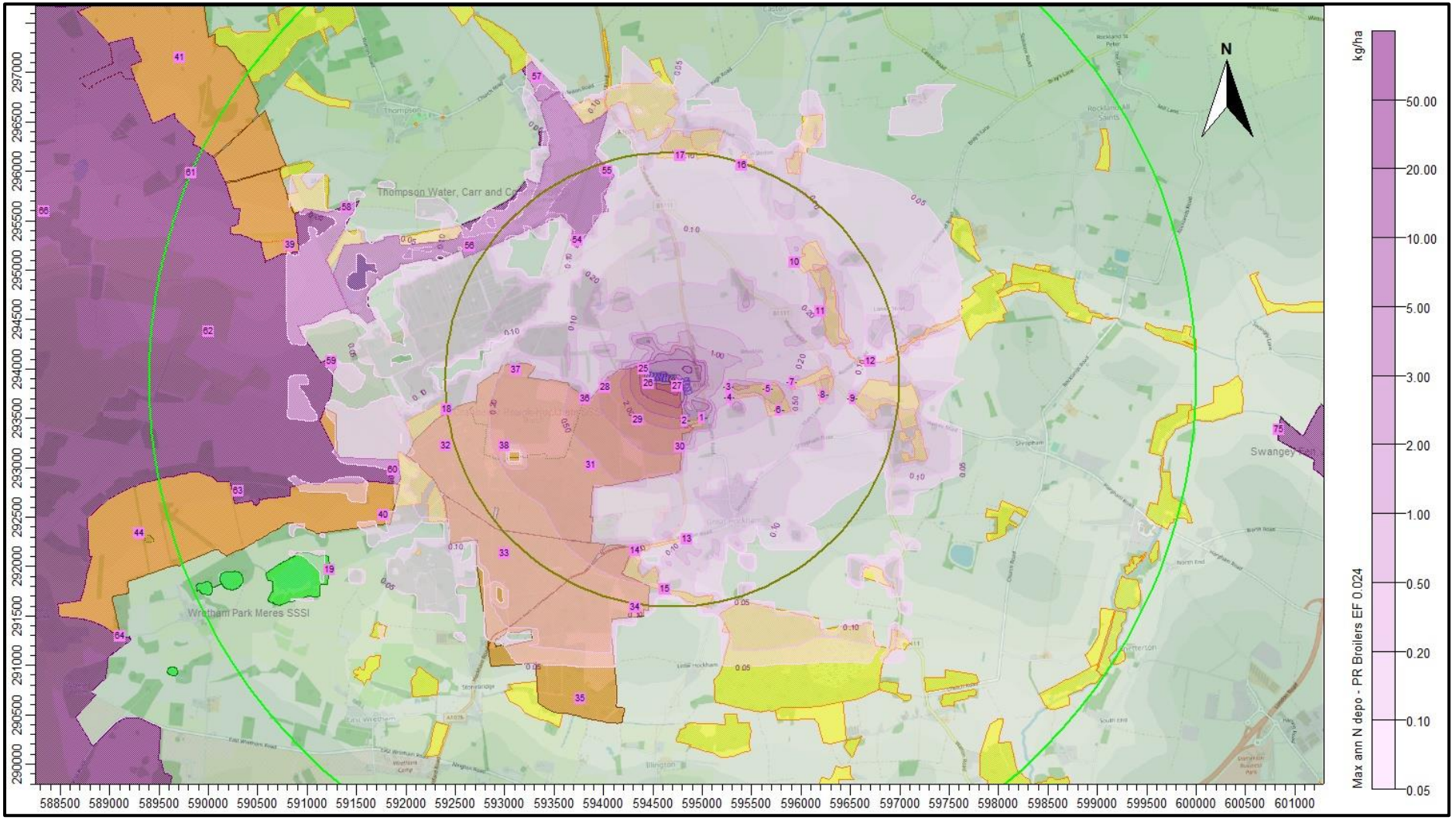


Figure 7b. Maximum annual nitrogen deposition rates – Proposed Scenario



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Ms. Misba Tasawar, on behalf of Amber Real Estate Investments (Agriculture) Limited, 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 Brookside Farm Poultry Unit, Watton Road, Breckles, Great Hockham, Norfolk. NR17 1ER.

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

Existing Scenario

The modelling predicts that the process contributions to the maximum annual mean ammonia concentration and annual nitrogen deposition rates:

- Are currently in excess of the Environment Agency lower and/or upper thresholds of the Critical Level and/or the Critical Load over parts of Breckland Forest SSSI/SPA, Cranberry Rough Hockham SSSI/SPA and Thompson Water, Carr and Common SSSI/SAC.

- Exceed 1% of the Critical Level and/or the Critical Load at Bridgham & Brettenham Heaths SSSI/SAC/SPA, Thompson Water, Carr and Common SSSI/SAC and over parts of Stanford Training Area SSSI/SAC/SPA and Breckland Forest SSSI/SPA.

- Are currently in excess of 100% of the Critical Level at the two closest areas designated as Local Wildlife Sites.

Proposed Scenario

The modelling predicts that the process contributions to the maximum annual mean ammonia concentration and annual nitrogen deposition rates:

- Would remain in excess of the lower and/or upper threshold of the Critical Level and/or the Critical Load over closer parts of Breckland Forest SSSI/SPA, Cranberry Rough Hockham SSSI/SPA and Thompson Water, Carr and Common SSSI/SAC.

- Would remain in excess of 1% of the Critical Level and/or the Critical Load at Bridgham & Brettenham Heaths SSSI/SAC/SPA, Thompson Water, Carr and Common SSSI/SAC and over parts of Stanford Training Area SSSI/SAC/SPA and Breckland Forest SSSI/SPA.

- Would be reduced to below 100% of the Critical Level at all but a small corner of one of the Local Wildlife Sites near Brookside Farm.

- Notwithstanding the status of the existing farm with Environment Agency permitting, the proposed redevelopment would offer significant reductions in ammonia levels and nitrogen (and acid) deposition rates in the surrounding area.

7. References

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