A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Existing and Proposed Free Range Egg Laying Chicken Houses at High Emmotland Farm, Howes Lane, Emmotland, near Driffield in East Riding of Yorkshire

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Mr. Steve Raasch, on behalf of Mr. Tim Warkup, to use computer modelling to assess the impact of ammonia emissions from the existing and proposed free range egg laying chicken houses at High Emmotland Farm, Howes Lane, Emmotland, Driffield, East Riding of Yorkshire. YO25 8JS.

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

This report is arranged in the following manner:

- Section 2 provides relevant details of the farm and potentially sensitive receptors in the area.
- Section 3 provides some general information on ammonia; details of the method used to estimate ammonia emissions, relevant guidelines and legislation on exposure limits and where relevant, details of likely background levels of ammonia.
- Section 4 provides some information about ADMS, the dispersion model used for this study and details the modelling procedure.
- Section 5 contains the results of the modelling.
- Section 6 provides a discussion of the results and conclusions.

2. Background Details

High Emmotland Farm is in a rural area, approximately 1.5 km to the south-west of the village of North Frodingham in East Riding of Yorkshire . The site is at an elevation of approximately 3 m on level drained fenland and the surrounding land is used almost exclusively for arable farming, although there are some other poultry rearing units nearby.

There are currently three poultry houses at High Emmotland Farm:

- House 1 - A naturally ventilated, flat-deck/deep litter, free range chicken house with capacity for 4,000 birds.
- House 2 - A 16,000 bird free range chicken house with belt removal of droppings and gable end fans for ventilation.
- House 4 - A naturally ventilated flat-deck/deep litter, free range chicken house with capacity for 16,000 birds.

It is proposed that the following changes are made at the farm:

- House 1 – Would be decommissioned.
- House 2 – Would remain unchanged.
- House 4 - Would be converted to an aviary system with belt removal of droppings and with capacity for 32,000 birds. Ventilation would be unchanged.

There are several areas that have been designated as Local Wildlife Sites (LWSs) within 2 km (the normal screening distance for non-statutory sites) of High Emmotland Farm. There are eight Sites of Special Scientific Interest (SSSIs) within 10 km of the farm, one of which is also designated as a Special Protection Area (SPA). Some details of these SSSIs/SPA are provided below:

- **River Hull Headwaters SSSI** - Approximately 300 m from the poultry houses at its closest point - Nationally important as the most northerly chalk stream system in Britain. Also of interest within the site are areas of riverside grassland, woodland and fen; remnants of habitats formerly more widespread but now limited in distribution due to agricultural and urban development.
- **Tophill Low SSSI** - Approximately 2.1 km to the south-south-east - Two artificial storage reservoirs. The site is important as one of few inland standing open water bodies suitable for wintering wildfowl in North Humberside.
- **Leven Canal SSSI** - Following drainage of surrounding marshland the canal provided a refuge for wetland plants and now supports an important remnant of this once much more widespread vegetation.
- **Pulfin Bog SSSI** - Approximately 6.5 km to the south - One of the last remnants of a fenland reed-swamp community in the Hull Valley. It is valued both for its botanical interest, and for the reedbed habitat it provides for breeding birds.
- **Bryan Mills Field SSSI** - Approximately 8.8 km to the south-west - This low-lying central area of the field is wet and apparently spring-fed. The fen area has developed over a complex of spring heads which create small areas of surface water.
- **Skipsea Bail Mere SSSI** - Approximately 8.1 km to the east-north-east - Geological.
- **Withow Gap, Skipsea SSSI** - Approximately 9.7 km to the east-north-east - Geological.
- **Hornsea Mere SSSI/SPA** - Approximately 9.8 km to the south-east - A site of national ornithological importance. It consists of a large shallow eutrophic lake of about 120 hectares (300 acres), together with its associated habitats of reed-swamp, fen and carr woodland, representing a relic of the once-extensive marshes and lakes of Holderness.

Maps of the surrounding area showing the location of the poultry houses at High Emmotland Farm and the LWSs, the SSSIs and the SPA is provided in Figures 1a and 1b. In the figures: the LWSs are shaded in yellow; SSSIs are shaded in green; the SPA is shaded in orange and the site of the poultry houses at High Emmotland Farm are outlined in blue.

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

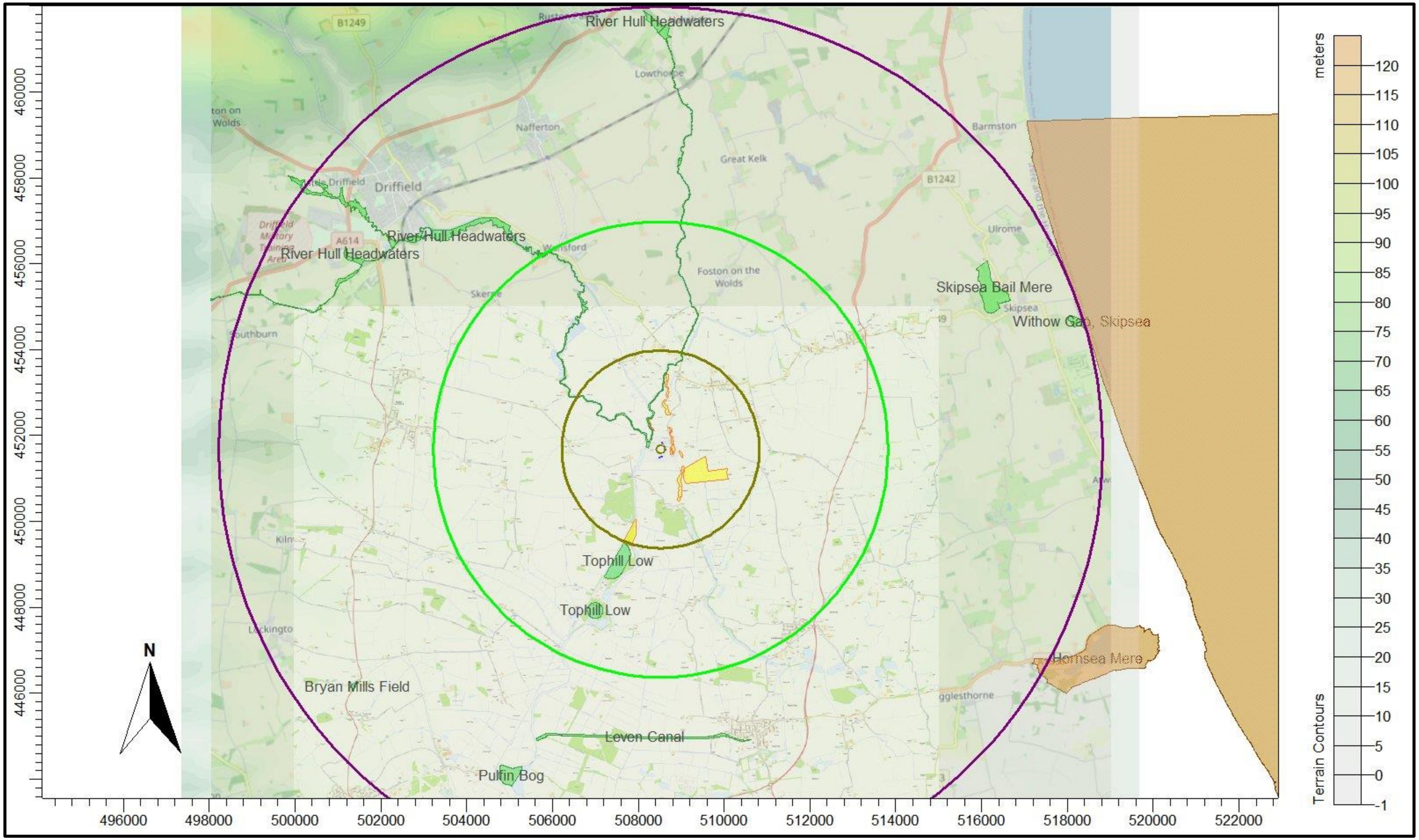
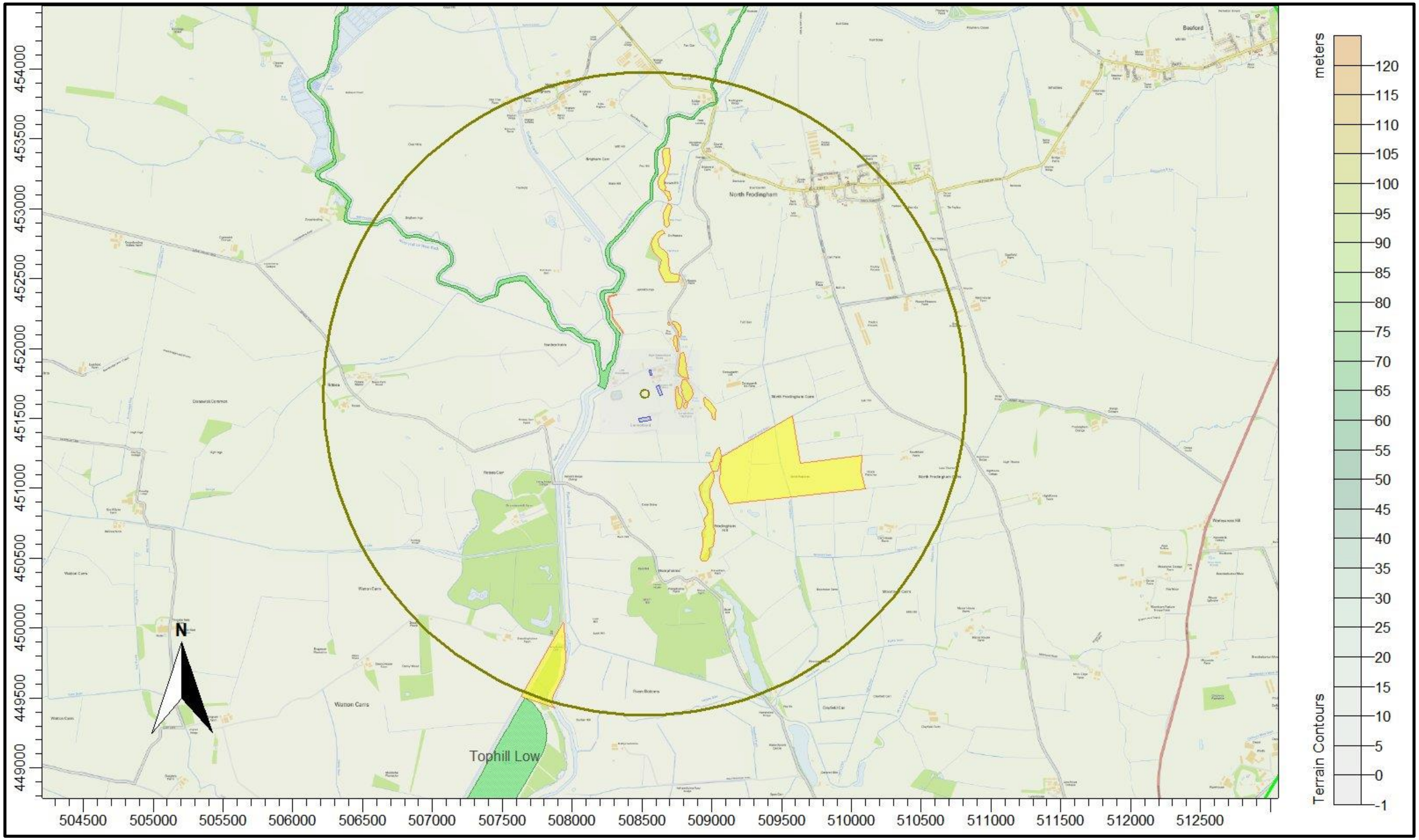


Figure 1b. The area surrounding High Emmotland Farm - a closer view



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 ($\mu g\text{-}NH_3/m^3$) 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, January 2023). 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 High Emmotland Farm is 2.34 $\mu g\text{-}NH_3/m^3$. The background nitrogen deposition rate to woodland is 33.01 kg-N/ha/y and to short vegetation is 19.27 kg-N/ha/y. The background acid deposition rate to woodland is 2.34 keq/ha/y and to short vegetation is 1.35 keq/ha/y.

The APIS background figures are subject to 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 & Critical Loads

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

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

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

For ammonia concentration in air, the Critical Level for higher plants is 3.0 $\mu g\text{-}NH_3/m^3$ 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 $\mu g\text{-}NH_3/m^3$ 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. Where the Critical Level of 1.0 $\mu g\text{-}NH_3/m^3$ is assumed, it is usually unnecessary to consider the Critical Load as the Critical Level provides the stricter test. However, it may be necessary to consider nitrogen deposition should a Critical Load of 5.0 kg-N/ha/y be appropriate. Normally, the Critical Load for nitrogen deposition provides a stricter test than the Critical Load for acid deposition.

Table 1. Critical Levels and Critical Loads at the wildlife sites

Site	Critical Level ($\mu g\text{-}NH_3/m^3$)	Critical Load - Nitrogen Deposition (kg-N/ha/y)	Critical Load - Acid Deposition (keq/ha/y)
LWSs (with terrestrial habitat)	3.0 [1]	10.0 [2]	-
LWSs (aquatic only)	3.0 [1]	n/a	n/a
River Hull Headwaters SSSI (upper reaches)	1.0 [2]	10.0 [3 & 4]	-
River Hull Headwaters SSSI (lower reaches)	3.0 [2]	15.0 [3 & 4]	-
Tophill Low SSSI and Leven Canal SSSI	3.0 [2]	n/a	n/a
Pulfin Bog SSSI and Bryan Mills Field SSSI	3.0 [2]	10.0 [3 & 4]	-
Skipsea Bail Mere SSSI and Withow Gap, Skipsea SSSI	n/a	n/a	n/a
Hornsea Mere SSSI/SPA	1.0 [2]	10.0 [3 & 4]	-

1. Assumed based on surrounding land usage.
2. A precautionary figure, used where details of the site are unavailable, or citations/APIS indicate that sensitive lichens and bryophytes may be present.
3. Based upon the citation for the site.
4. The lower bound of the range of Critical Loads.

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 criteria

Natural England are a statutory consultee at planning and usually advise that, if predicted process contributions exceed 1% (or lower in some circumstances) 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 are derived from an average for a 5 km by 5 km grid.

3.4.3 Environment Agency and Natural England May 2022 Air Quality Risk Assessment Interim Guidance

Although it seems important to include a reference to this document, it appears to be primarily a discussion document about internal Environment Agency screening models and the SCAIL model and AS Modelling & Data Ltd. have been unable to draw any conclusions from the document as to what thresholds may or may not apply, nor in what circumstances the threshold may or may not apply.

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

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

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

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

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

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

3.5 Quantification of ammonia emissions

Ammonia emission rates from poultry houses and ranging areas depend on many factors and are likely to be rather 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.

3.5.1 Ammonia emissions from the existing and proposed poultry houses

For egg laying chickens, in an aviary system, where manure is removed frequently using a belt system, the Environment Agency standard emission factor is 0.08 kg-NH_3/bird place/y, for housing with deep litter/pit, the Environment Agency standard emission factor is 0.29 kg-NH_3/bird place/y. However, the web-page titled Guidance Intensive farming: pollution inventory reporting, under the heading "Emission factors you might need", gives an emission factor is 0.21 kg-NH_3/bird place/y for housing with deep litter/pit, with no explanation for the change from the standard emission factor of 0.29 kg-NH_3/bird place/y.

Previously, it has been customary to reduce housing emissions by a factor based upon the proportion of droppings estimated to occur during ranging. This practice is not followed in this case for two reasons: firstly, ammonia emissions are most probably more dependent on surface area than they are on the absolute amount of excreta and secondly, the emission factors used for aviary type housing are already at the lower end of the range of likely emission rates for this type of housing. Additionally, if an erroneously high ranging usage figure were assumed, then reducing housing emissions by a factor based upon the proportion of droppings estimated to occur during ranging, would favour housing systems with higher emission factors rates.

3.5.2 Ammonia emissions from ranging areas

As the birds in the multi-tier free range egg laying houses have access to outdoor ranging areas, some of the birds' droppings, which is the source of the ammonia, would be deposited on these ranging areas. The Environment Agency provide an emission factor or 0.225 kg-NH_3/bird place/y (we assume this figure is based upon National Ammonia Emission Inventory figures for total N excreted, proportion of ammoniacal N and proportion of ammoniacal N released as ammonia and is for theoretical birds ranging 100% of the time). The Environment Agency also provide an estimate of 20% of birds ranging and 80% in the housing (we assume that this is an average figure when ranging is available and would note that this figure is at the high end of the range of observed range usage figures for large flocks). Assuming average daily range availability of 8 hours per day[A] the ammonia emission factors for the ranging are calculated to be 0.015 kg-NH_3/bird place/y.

A. Ranging availability may be longer in the summer and shorter in winter. The unavailability of ranging due to inclement weather or disease control for example is not considered.

The report titled "A data review – ammonia emission factors for permitted pig and poultry operations in the UK" prepared by ADAS and Rothamsted Research, January 2024 (on behalf of the Environment Agency), proposes a slightly higher baseline emission factor of 0.239 kg-NH_3/bird place/y; however the report also formally acknowledges that the 20% ranging figure refers to times when ranging is available, rather than being overall range usage, as erroneously assumed by the Environment Agency. ADAS further propose a ranging availability of 50%; however, in most cases this would be a rather high figure and is unlikely to be achieved, particularly if range closure due to inclement weather and disease prevention/control; measures are considered.

A series of other peer reviewed scientific papers have also been considered. The findings from these papers are summarised below. It should be noted that the Aarnink provides direct measurements of ammonia emissions from ranging areas and is in accord with the calculated figure (for larger flocks):

1. **Larsen, H., Cronin, G.M., Gebhardt-Henrich, S., Smith, C.L. Hemsworth, P.H. and Rault, J-L. (2017) - Individual ranging behaviour patterns in commercial free-range layers as observed through RFID tracking. Animals, 7 (21).**

   This paper is from Australian studies and given the very different climate regimes in the UK and Australia, there can be no expectation that bird behaviour would be similar. This aside:
   The Simple Summary appears to indicate high range usage (68.6% in Flock A, and 82.2% in Flock B). However, it should be noted that these percentages are the percentages of hens that used the ranging at some point in time, they are not overall range usage figures, which is the number we need to determine.
   At page 6 it is stated "Flock A spent a mean of 46 +/- 1.1 h ranging between a total duration of 34 s and 83 h outside over the 13 days, and hens in Flock B spent a mean of 30 +/- 0.7 h ranging between a total duration of 50 min and 57 h outside over the 10 days."

   So for Flock A the average range usage is - 68.6% x 46h/(24h x 13d) = **10.1%**.
   And for Flock B the average range usage is - 82.2% x 30h/(24h x 10d) = **10.3%**.

   It should also be noted that these figures do not account for days where ranging for any reason may not be available (disease control, inclement weather etc.).

2. **Campbell, D.L.M., Hinch, G.N., Dyall, T.R., Warin, L., Little, B.A. and Lee, C (2016) - Outdoor stocking density in free-range laying hens: radio-frequency identification of impacts on range use. Animal: 1 - 10.**

   This paper is from New Zealand studies and given the potentially very different climate regimes in the UK and Australia, there can be no expectation that bird behaviour would be similar. This aside:
   The abstract states the following "On average, 38% to 48% of hens were seen on the range simultaneously and used all available areas of all ranges". However, these are the figures for when ranging is available.
   On page 4, the range availability is given as from 0900 h (pop hole opening) to 1630 h (pop hole closing).

   Therefore, range usage is between 38% x 6.5h / 24 h = **10.3 %** and 48% x 6.5h / 24 h = **13.0 %**.

   It should also be noted that these figures do not account for days where ranging for any reason may not be available (disease control, inclement weather etc.).

3. **Pettersson, I.C., Freire, R. and Nicol, C.J. (2016) - Factors affecting ranging behaviour in commercial free-range hens. World Poultry Science Journal, 72.**

   This is a review of other papers.

   It is not stated explicitly whether the figures from all papers are for range usage when ranging is available; however, since it appears to be common practice to express ranging use this way, we have assumed this is the case for all figures reported, except where it is stated otherwise.
   It should be noted that the figures with the exception of one (Whay figures) from this report are all from smaller flocks. Figures from small flocks are included, but it should be fully acknowledged that ranging usage in smaller flocks may be higher than for large flocks.
   Farmers estimates are excluded and measured figures only are used below.
   Range availability is not stated (this may be available in source papers), but assumed to be 8 hours per day, this is likely to be a high figure.

The highest reported ranging usage figure is 57% (count from very small flock), which assuming 8h per day ranging gives an overall figure of **19%**.

The lowest reported ranging usage is 11% (lowest figure from 1000-16000 bird flocks) and the lowest, which assuming 8h per day ranging gives an overall figure of **3.7%**.

The highest lowest reported ranging usage from 1000-16000 bird flocks is >25%, which assuming 8h per day ranging gives an overall figure of **>8.33%**.

It should also be noted that these figures do not account for days where ranging for any reason may not be available (disease control, inclement weather etc.).

4. **L. Hegelund , J.T. Sørensen , J.B. Kjær & I.S. Kristensen b. Use of the range area in organic egg production systems: effect of climatic factors, flock size, age and artificial cover.**

This is a Danish study, but climate and housing/ranging systems are similar to the UK. This is an older study (late 90s) and the flocks were small (513 to 6000 individuals/flock). However, this is still a useful paper.
The paper stated that average range usage was 9% (11% for flocks with artificial cover on ranges).

These figures are range usage when ranging is available. Range availability is not stated, but if it is assumed to be 8 hours per day then the range usage is: 9% x 8h/24h = **3%** and for birds with cover on ranges 11% x 8h/24h = **3.67%**.

5. **Leonard Ikenna Chielo *, Tom Pike and Jonathan Cooper Ranging Behaviour of Commercial Free-Range Laying Hens.**

This is a UK study with large flocks and typical housing/ranging systems, so should carry some weight.
The paper stated that average range usage was 12.5%.

These figures are range usage when ranging is available. Range availability is stated as 7-9h. If it is assumed to be an average 8 hours per day then the range usage is: 12.5 % x 8h/24h = **4.17%**.

It should also be noted that these figures do not account for days where ranging for any reason may not be available (disease control, inclement weather etc.).

6. **Pettersson paper 2. I. C. Pettersson, C. A. Weeks, K. I. Norman, T. G. Knowles & C. J. Nicol. Internal roosting location is associated with differential use of the outdoor range by free-range Laying.**

This is a UK study with typical 16,000 bird flocks and typical housing/ranging systems, so should carry some weight. The paper states that on average, across all flocks and observations 7.34% of the whole flock (both marked and unmarked birds) were seen out on the range at a time.

Range availability is not stated, but if it is assumed to be an average 8 hours per day then the range usage is: 7.34 % x 8h/24h = **2.45%**.

It should also be noted that these figures do not account for days where ranging for any reason may not be available (disease control, inclement weather etc.).

7. **A.J.A. Aarnink*, J.M.G. Hoi and A.G.C. Beurskens. Ammonia emission and nutrient load in outdoor runs of laying hens.**

This paper provides direct measurement of ammonia emissions from ranging areas. The key figure presented is the average ammonia emission rate, this is 2.0 mg-NH_3/hen/h. This equates to an emission factor of **0.017 kg-NH_3/hen/y**.

Details of the poultry numbers and types, emission factors used and calculated ammonia emission rates used in the modelling are provided in Table 2a. Note that results obtained using these figures are scaled to actual bird numbers actual Emission Factor and range usage/availability to provide the final results. Details of the scaling factors used are provided in Tables 2b (realistic ranging emissions) and 2b (erroneous Environment Agency mandated ranging emissions method).

Table 2a. Details of modelled poultry numbers, emission factors and baseline ammonia emission rates modelled

Source	Number of Birds	Housing Emission Factor (kg-NH_3/bird/y)	Baseline Housing Emission Rate (g-NH_3/s)	Ranging Emission Factor (kg-NH_3/bird/y)	Baseline Ranging Emission Rate (g-NH_3/s)
House 1	1,000	1.0	0.031688	0.225 [1]	0.007130
House 2	1,000	1.0	0.031688	0.225 [1]	0.007130
House 4	1,000	1.0	0.031688	0.225 [1]	0.007130

1. Assumed to be for 100% ranging.

Table 2b. Details of scaling factors applied to result, post-modelling - AS Modelling & Data realistic figures)

EXISTING										
Source	Modelled Bird numbers	Modelled housing EF	Actual Bird numbers	Actual Housing EF	Housing Scaling Factor	Modelled Ranging EF	Actual Ranging EF	Ranging Use	Ranging Availability	Ranging Scaling Factor
H1	1000	1	4000	0.29	1.16	0.225	0.225	0.4 [1]	0.333333	0.5333328
H2	1000	1	16000	0.08	1.28	0.225	0.225	0.2	0.333333	1.0666656
H4	1000	1	16000	0.29	4.64	0.225	0.225	0.2	0.333333	1.0666656
PROPOSED										
Source	Modelled Bird numbers	Modelled housing EF	Actual Bird numbers	Actual Housing EF	Housing Scaling Factor	Modelled Ranging EF	Actual Ranging EF	Ranging Use	Ranging Availability	Ranging Scaling Factor
H1	1000	1	0	0.29	0	0.225	0.225	0.4 [1]	0.333333	0
H2	1000	1	16000	0.08	1.28	0.225	0.225	0.2	0.333333	1.0666656
H4	1000	1	32000	0.08	2.56	0.225	0.225	0.2	0.333333	2.1333312

2. Higher ranging uses is assumed because scratch/dusting areas within the house are more limited than in modern housing.

Table 2c. Details of scaling factors applied to result, post-modelling – Erroneous Environment Agency mandated figures)

EXISTING										
Source	Modelled Bird numbers	Modelled housing EF	Actual Bird numbers	Actual Housing EF [3]	Housing Scaling Factor	Modelled Ranging EF	Actual Ranging EF	Ranging Use	Ranging Availability	Ranging Scaling Factor
H1	1000	1	4000	0.21	0.672	0.225	0.225	0.2	1	0.8
H2	1000	1	16000	0.08	1.024	0.225	0.225	0.2	1	3.2
H4	1000	1	16000	0.21	2.688	0.225	0.225	0.2	1	3.2
PROPOSED										
Source	Modelled Bird numbers	Modelled housing EF	Actual Bird numbers	Actual Housing EF [3]	Housing Scaling Factor	Modelled Ranging EF	Actual Ranging EF	Ranging Use	Ranging Availability	Ranging Scaling Factor
H1	1000	1	0	0.21	0	0.225	0.225	0.2	1	0
H2	1000	1	16000	0.08	1.024	0.225	0.225	0.2	1	3.2
H4	1000	1	32000	0.08	2.048	0.225	0.225	0.2	1	6.4

3. Reduced to account for ranging usage of 20%.

4. The Atmospheric Dispersion Modelling System (ADMS) and Model Parameters

The Atmospheric Dispersion Modelling System (ADMS) ADMS 5 is a new generation Gaussian plume air dispersion model, which means that the atmospheric boundary layer properties are characterised by two parameters; the boundary layer depth and the Monin-Obukhov length rather than in terms of the single parameter Pasquill-Gifford class.

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

ADMS has a number of model options 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].

Prior to April 2019 the GFS was a spectral model, post April 2019 the physics are discrete. The physics/dynamics model has a resolution or had an equivalent resolution of approximately 7 km over the 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 records may be over represented because the instrumentation used may not record wind speed 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 and wind directions are modified during the modelling by the treatment of roughness lengths (see Section 4.7) and because terrain data is included in the modelling. The terrain and roughness length modified wind rose for High Emmotland Farm, is shown in Figure 2b; although there is little modification in this case, elsewhere in the modelling domain the modified wind roses may differ more markedly, reflecting the local flow in that part of the domain. The resolution of FLOWSTAR is 64 by 64 grid points and the effective resolution of the wind field is approximately 340 m. 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 53.948 N, 0.346 W, 2020-2023

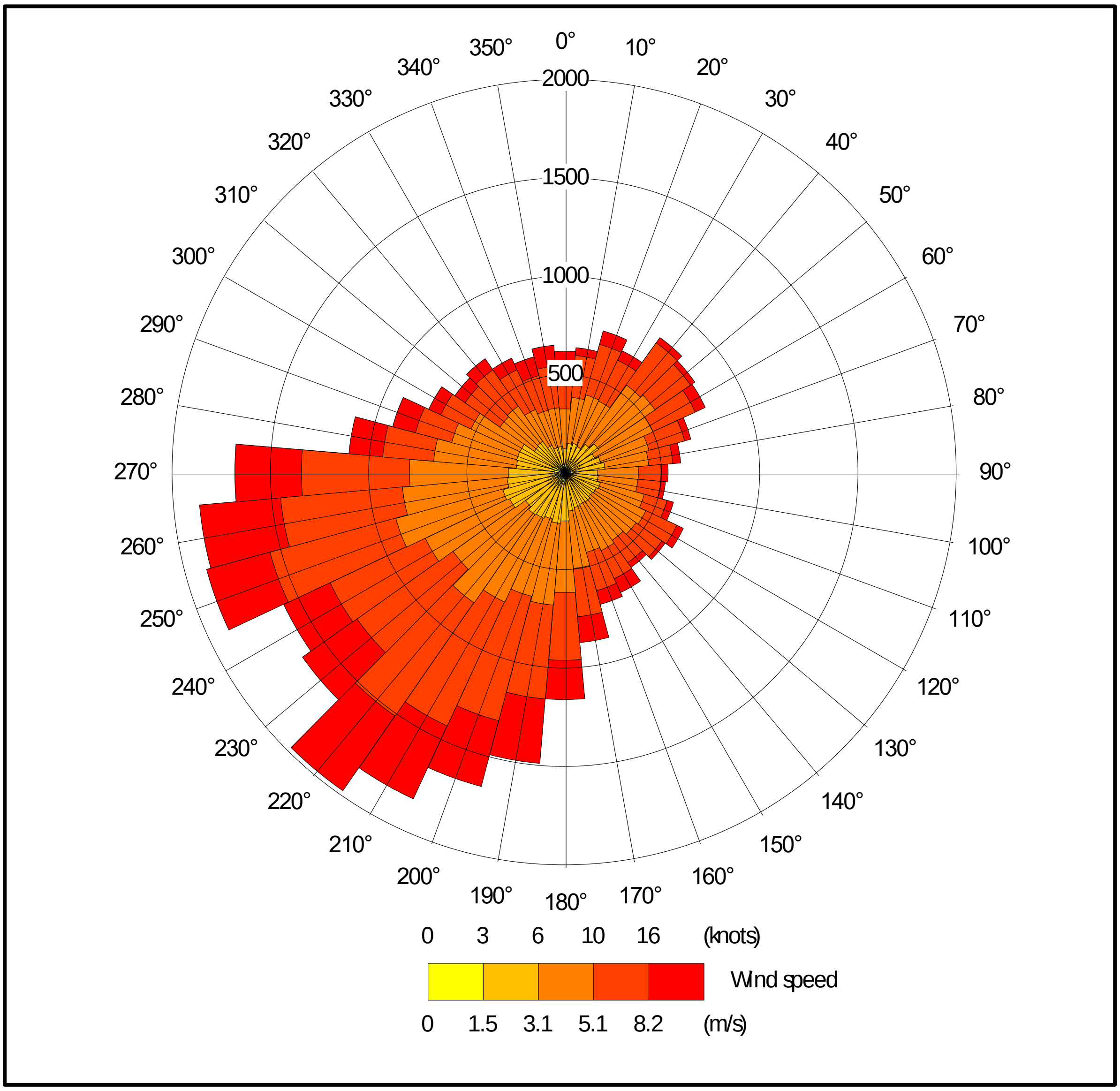
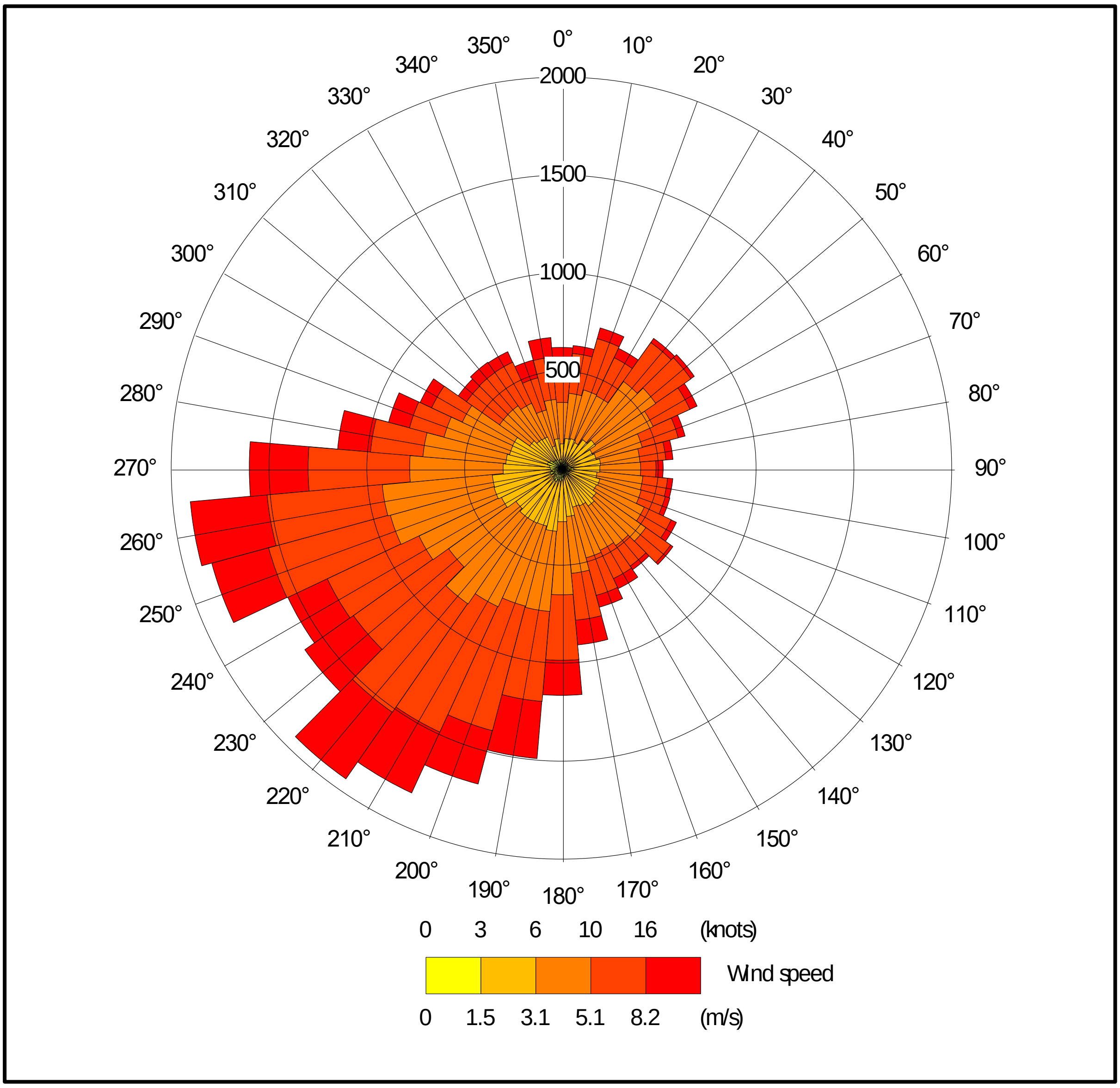


Figure 2b. The wind rose. FLOWSTAR data for NGR 508500, 451700, 2019-2022



4.2 Emission sources

Emissions from the naturally ventilated houses and the gable end fans have been represented by volume sources within ADMS. Details of the volume source parameters are shown in Tables 3a and 3b. The positions of the volume sources are shown in Figure 3 (marked by red shaded rectangles).

The poultry houses have ranging areas, a further source of ammonia. Emissions from the ranging areas are represented by area sources within ADMS. Note, the area sources cover the parts of the ranges that are most likely to be used frequently and not the whole of the ranging areas. Details of the area source parameters are shown in Table 3b. The positions of the area sources are shown in Figure 3 (marked by pale blue shaded polygons).

Table 3a. Volume source parameters

Source ID (actual house number)	Length (m)	Width (m)	Depth (m)	Base height (m)	Emission temperature (°C)	Baseline Emission rate[1] (g-NH_3/s)
H1	40.8	12.9	3.0	0.0	Ambient	0.031688
H2_GAB	10	21.6	3.0	1.0	Ambient	0.031688
H4	26.0	82.3	3.0	0.0	Ambient	0.031688

Table 3c. Area source parameters

Source ID (actual house number)	Area (m^2)	Base height (m)	Emission temperature (°C)	Baseline Emission rate[1] (g-NH_3/s)
H1_RAN	1,770.6	0.0	Ambient	0.007130
H2_RAN	7,806.8	0.0	Ambient	0.007130
H4_RAN	11,983.4	0.0	Ambient	0.007130

1. See Tables 2a, 2b and 2c, Section 3.5.

4.3 Modelled buildings

Not modelled.

4.4 Discrete receptors

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

4.5 Cartesian grid

To produce the contour plots presented in Section 5 of this report and to define the spatially varying deposition velocity field, two regular Cartesian grids have been defined within ADMS. The individual grid receptors are defined at ground level within ADMS. The two regular Cartesian grids are shown 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 22.0 km by 22.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS; therefore, the effective resolution of the wind field is approximately 340 m.

4.7 Surface Roughness Length

In this case, a spatially varying roughness length file has been defined, this is based upon the Defra Living Landscapes land use database. The GFS meteorological data is assumed to have a roughness length of 0.118 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 (central area of the modelling domain).

Figure 3. The positions of modelled sources and buildings

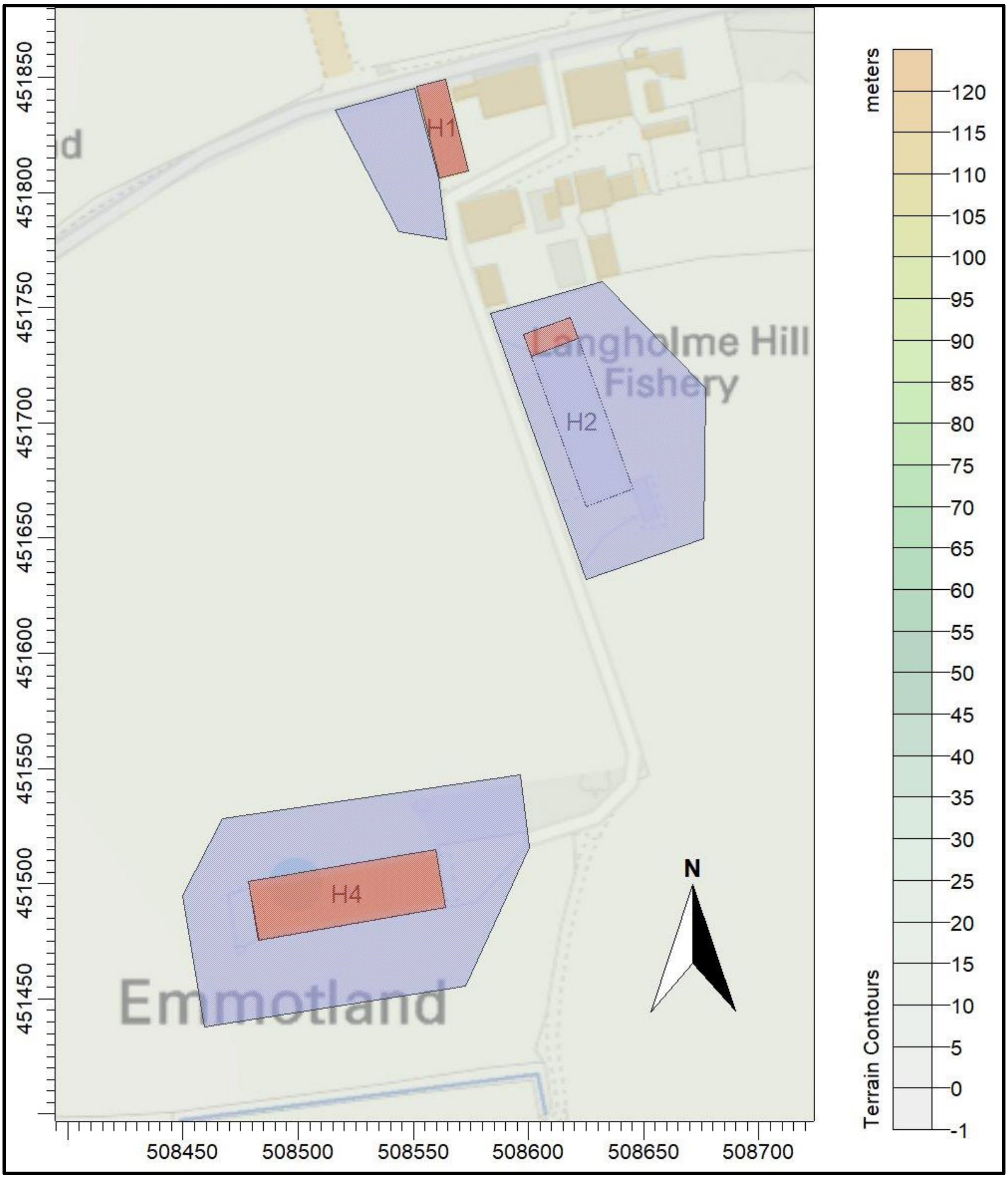


Figure 4a. The discrete receptors and regular Cartesian grids - a broadscale view

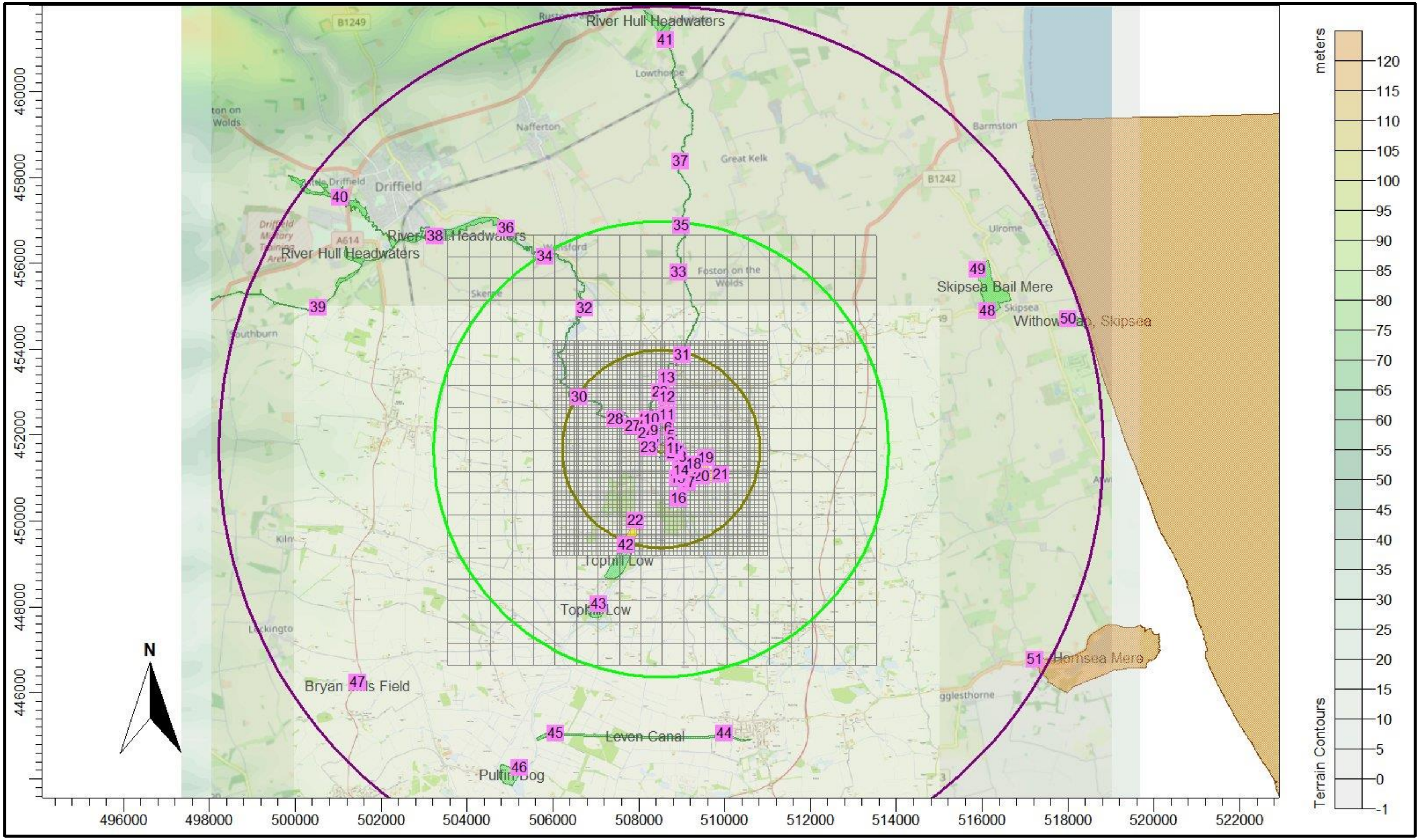


Figure 4b. The discrete receptors and regular Cartesian grids - a closer view

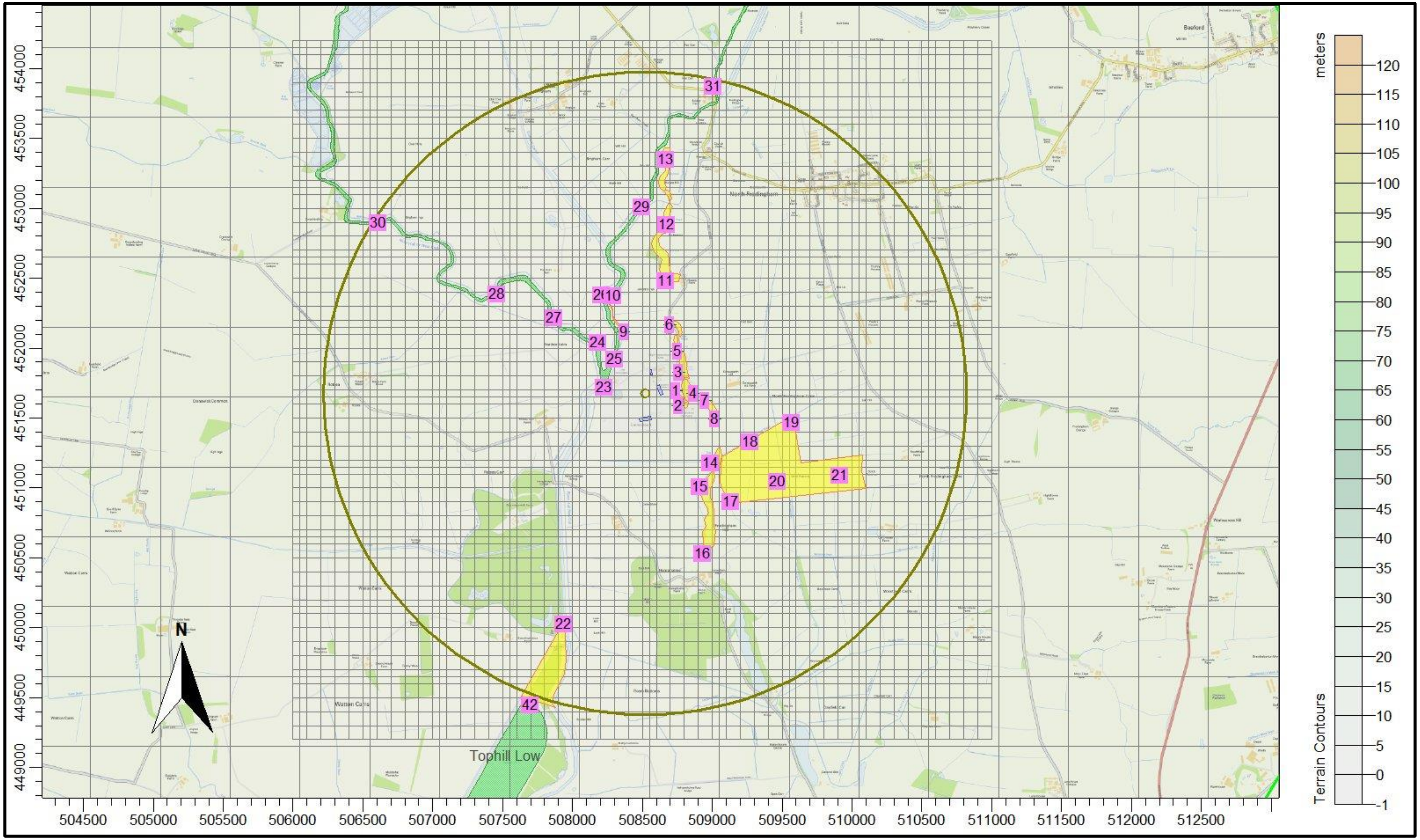
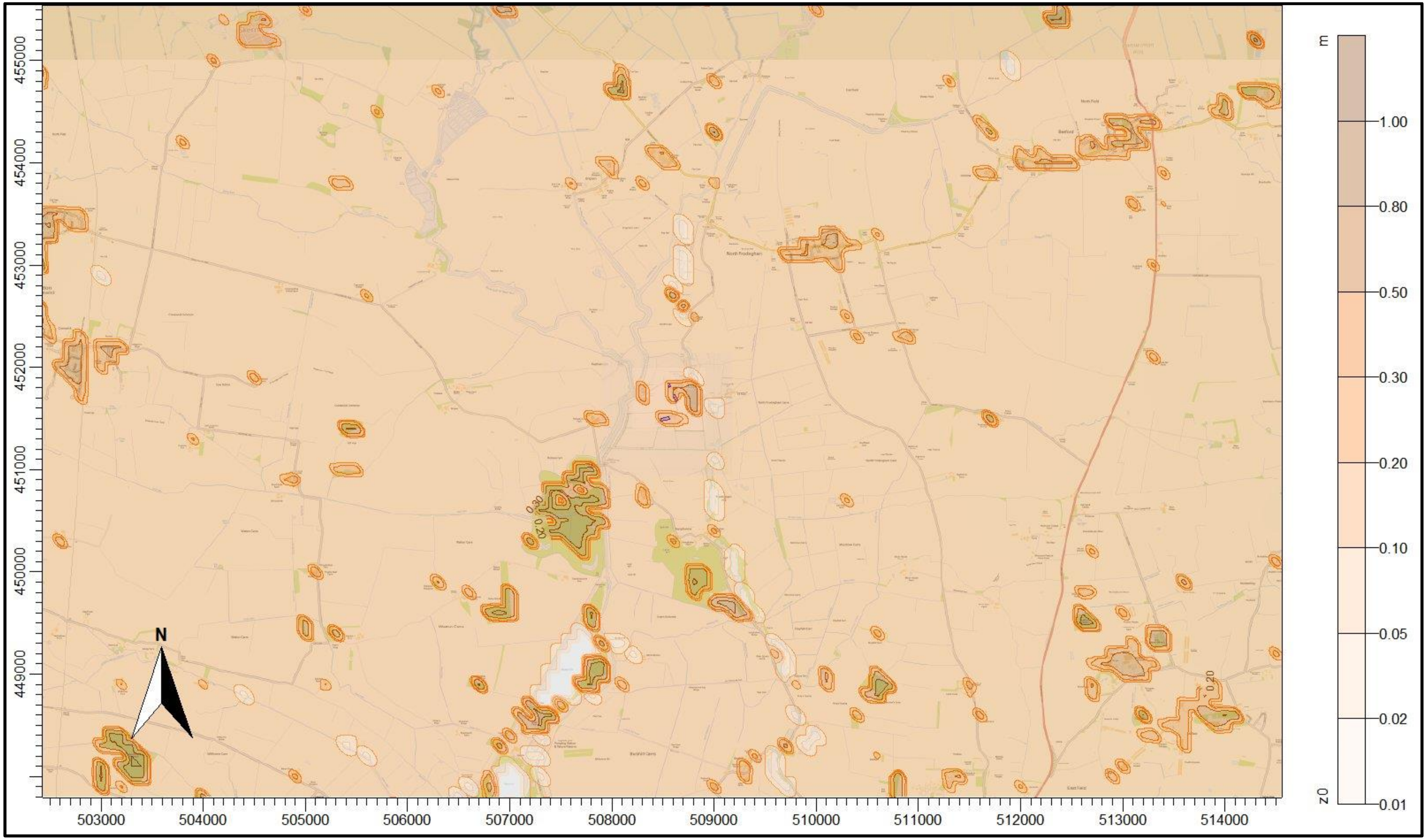


Figure 5. The spatially varying surface roughness field



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 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. Land use data used to derive deposition velocity is based upon the Defra Living Landscapes land use database.

In summary, the method is as follows:

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

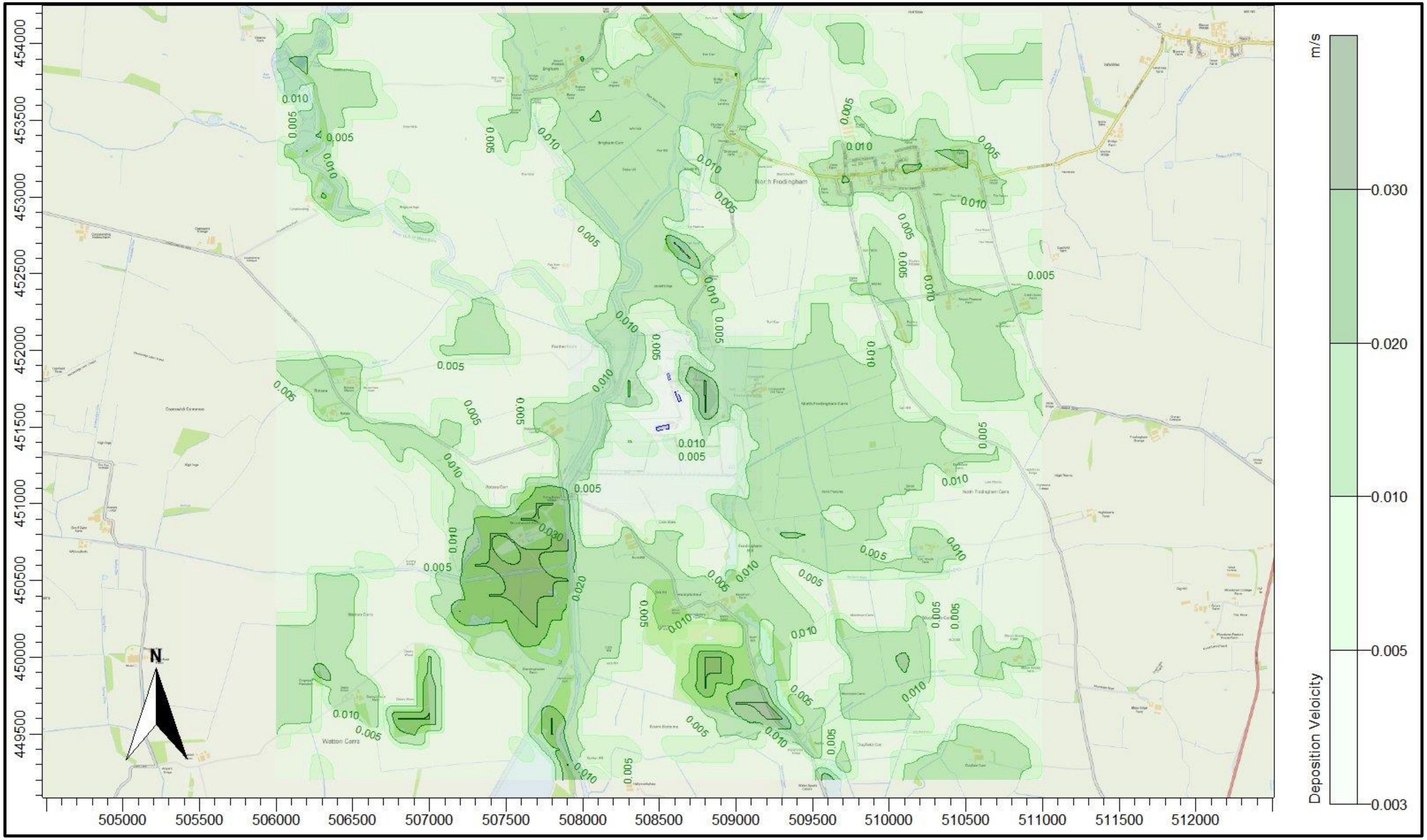
Table 4. Deposition velocities

NH_3 concentration (PC + background) (µg/m^3)	< 10	10 - 20	20 - 30	30 - 80	> 80
Deposition velocity - woodland (m/s)	0.03	0.015	0.01	0.005	0.003
Deposition velocity - short vegetation (m/s)	0.02 (0.010 0.015 over heavily grazed grassland)	0.015	0.01	0.005	0.003
Deposition velocity - arable farmland/rye grass (m/s)	0.005	0.005	0.005	0.005	0.003

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

A contour plot of the spatially varying deposition field is provided in Figure 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 run a total of eight times; once for each year of the meteorological record and in the following two modes:

- In basic mode without calms or terrain – GFS data.
- With calms and without terrain – GFS data.

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

Please note that the only purpose of this preliminary modelling is to test sensitivity to light/calm winds at receptors close to the source. Details of the predicted annual mean ammonia concentrations at each receptor are provided in Table 5.

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

Receptor number	X(m)	Y(m)	Designation	Maximum annual mean ammonia concentration - (µg/m³) Existing		Maximum annual mean ammonia concentration - (µg/m³) Proposed	
				No Calms No Terrain	Calms No Terrain	No Calms No Terrain	Calms No Terrain
1	508739	451692	LWS	3.450	3.691	3.534	3.761
2	508757	451587	LWS	1.377	1.572	1.581	1.772
3	508759	451826	LWS	2.313	2.601	2.243	2.497
4	508862	451677	LWS	1.283	1.395	1.352	1.463
5	508750	451981	LWS	1.201	1.350	1.162	1.290
6	508696	452170	LWS	0.511	0.578	0.516	0.579
7	508946	451628	LWS	0.793	0.858	0.855	0.921
8	509015	451496	LWS	0.406	0.453	0.462	0.511
9	508365	452114	LWS	0.256	0.319	0.272	0.334
10	508289	452375	LWS	0.127	0.157	0.139	0.169
11	508665	452479	LWS	0.182	0.212	0.196	0.226
12	508671	452884	LWS	0.084	0.099	0.093	0.108
13	508665	453348	LWS	0.046	0.054	0.051	0.060
14	508987	451181	LWS	0.189	0.234	0.227	0.272
15	508913	451007	LWS	0.135	0.171	0.162	0.201
16	508928	450531	LWS	0.058	0.074	0.068	0.085
17	509131	450904	LWS	0.094	0.119	0.110	0.135
18	509271	451332	LWS	0.175	0.196	0.206	0.227
19	509563	451469	LWS	0.144	0.157	0.159	0.172
20	509467	451044	LWS	0.082	0.096	0.098	0.112
21	509910	451092	LWS	0.068	0.075	0.078	0.085
22	507938	450025	LWS	0.035	0.042	0.041	0.048
23	508225	451720	LWS	0.429	0.508	0.472	0.551
24	508178	452041	River Hull Headwaters SSSI	0.217	0.279	0.231	0.291
25	508303	451920	River Hull Headwaters SSSI	0.488	0.611	0.478	0.589
26	508206	452381	River Hull Headwaters SSSI	0.107	0.134	0.119	0.146
27	507866	452216	River Hull Headwaters SSSI	0.096	0.123	0.105	0.132
28	507460	452384	River Hull Headwaters SSSI	0.054	0.068	0.059	0.073
29	508499	453009	River Hull Headwaters SSSI	0.057	0.070	0.063	0.077
30	506610	452897	River Hull Headwaters SSSI	0.021	0.026	0.023	0.029
31	509004	453873	River Hull Headwaters SSSI	0.034	0.039	0.038	0.043
32	506731	454954	River Hull Headwaters SSSI	0.008	0.009	0.008	0.010
33	508939	455805	River Hull Headwaters SSSI	0.010	0.012	0.012	0.014
34	505812	456176	River Hull Headwaters SSSI	0.004	0.005	0.005	0.006
35	508988	456894	River Hull Headwaters SSSI	0.007	0.008	0.008	0.009
36	504911	456820	River Hull Headwaters SSSI	0.003	0.004	0.004	0.004
37	508963	458380	River Hull Headwaters SSSI	0.005	0.005	0.005	0.006
38	503265	456635	River Hull Headwaters SSSI	0.002	0.003	0.003	0.003
39	500534	454972	River Hull Headwaters SSSI	0.003	0.004	0.003	0.004
40	501047	457539	River Hull Headwaters SSSI	0.002	0.002	0.002	0.002
41	508624	461214	River Hull Headwaters SSSI	0.002	0.003	0.003	0.003
42	507697	449449	Tophill Low SSSI	0.021	0.025	0.024	0.028
43	507059	448084	Tophill Low SSSI	0.009	0.011	0.010	0.012
44	509996	445058	Leven Canal SSSI	0.003	0.004	0.004	0.005
45	506065	445058	Leven Canal SSSI	0.004	0.004	0.004	0.005
46	505234	444272	Pulfin Bog SSSI	0.003	0.003	0.003	0.004
47	501448	446251	Bryan Mills Field SSSI	0.002	0.002	0.002	0.003
48	516112	454898	Skipsea Bail Mere SSSI	0.004	0.005	0.004	0.005
49	515898	455861	Skipsea Bail Mere SSSI	0.004	0.004	0.004	0.005
50	518006	454716	Withow Gap, Skipsea SSSI	0.003	0.003	0.003	0.004
51	517236	446776	Hornsea Mere SSSI/SPA	0.003	0.003	0.003	0.003

5.2 Detailed deposition modelling

In this case, detailed modelling has been carried out over a high resolution (100 m) domain that extends 5.0 km by 5.0 km around the site. 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. Outside of this 5.0 km by 5.0 km domain, a fixed deposition velocity of 0.005 m/s is assumed (with appropriate deposition velocities applied post-modelling at the discrete receptors).

The predicted process contribution of the existing and proposed poultry houses to maximum annual mean ground level ammonia concentrations and nitrogen deposition rates at the discrete receptors are shown in Tables 6a (Existing Scenario) and 6b (Proposed Scenario). In these Tables, process contributions which are in excess of the Environment Agency's upper threshold percentage of the relevant Critical Level or Critical Load for the site (50% for a SSSI, 20% for a SPA and 100% for a LWS) are coloured red. Process contributions which are in the range between the Environment Agency's upper threshold percentage and lower threshold percentage of the relevant Critical Level or Critical Load for the site (50% and 20% for a SSSI, 20% and 4% for a SPA and 100% and 1090% for a LWS) are coloured blue. In addition, process contributions which exceed 1% of the relevant Critical Level or Critical Load for the SSSIs are highlighted with bold text.

The predicted changes in the process contribution (Proposed Scenario minus Existing Scenario) are shown in Table 7.

Contour plots of the predicted maximum annual mean ammonia concentration and the maximum annual nitrogen deposition rate are shown in Figure 7a and Figure 7b (Existing Scenario) and Figure 8a and Figure 8b (Proposed Scenario).

The predicted process contribution of the existing and proposed poultry houses to maximum annual mean ground level ammonia concentrations and nitrogen deposition rates at the discrete receptors assuming the EA mandated emissions factors and ranging usage figures are shown in Tables 8a (Existing Scenario) and 8b (Proposed Scenario).

Please note that The ADMS calms module cannot be used in conjunction with spatially varying deposition and that calms corrections are not applied; however preliminary modelling does suggest calms may be significant.

Table 6a. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors - Existing Scenario - AS Modelling & Data Ltd. method

Receptor number	X(m)	Y(m)	Designation	Site Parameters			Maximum annual 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	508739	451692	LWS	0.005	3.0	n/a	4.540	**151.32**	5.89	-
2	508757	451587	LWS	0.005	3.0	n/a	3.734	**124.47**	4.85	-
3	508759	451826	LWS	0.030	3.0	10.0	2.900	96.68	22.60	**225.97**
4	508862	451677	LWS	0.005	3.0	n/a	1.657	55.25	2.15	-
5	508750	451981	LWS	0.005	3.0	n/a	1.748	58.25	2.27	-
6	508696	452170	LWS	0.005	3.0	n/a	0.903	30.09	1.17	-
7	508946	451628	LWS	0.005	3.0	n/a	1.133	37.75	1.47	-
8	509015	451496	LWS	0.005	3.0	n/a	0.805	26.83	1.05	-
9	508365	452114	LWS	0.005	3.0	n/a	0.614	20.46	0.80	-
10	508289	452375	LWS	0.005	3.0	n/a	0.262	8.72	0.34	-
11	508665	452479	LWS	0.005	3.0	n/a	0.320	10.68	0.42	-
12	508671	452884	LWS	0.005	3.0	n/a	0.137	4.55	0.18	-
13	508665	453348	LWS	0.005	3.0	n/a	0.068	2.28	0.09	-
14	508987	451181	LWS	0.030	3.0	10.0	0.469	15.64	3.66	36.56
15	508913	451007	LWS	0.030	3.0	10.0	0.321	10.71	2.50	25.04
16	508928	450531	LWS	0.030	3.0	10.0	0.110	3.66	0.85	8.55
17	509131	450904	LWS	0.020	3.0	10.0	0.177	5.88	0.92	9.17
18	509271	451332	LWS	0.030	3.0	10.0	0.308	10.27	2.40	23.99
19	509563	451469	LWS	0.030	3.0	10.0	0.181	6.03	1.41	14.10
20	509467	451044	LWS	0.030	3.0	10.0	0.140	4.67	1.09	10.92
21	509910	451092	LWS	0.030	3.0	10.0	0.081	2.70	0.63	6.30
22	507938	450025	LWS	0.020	3.0	10.0	0.053	1.77	0.28	2.76
23	508225	451720	LWS	0.020	3.0	10.0	0.954	31.79	4.95	49.53
24	508178	452041	River Hull Headwaters SSSI	0.020	3.0	15.0	0.440	**14.66**	2.28	**15.23**
25	508303	451920	River Hull Headwaters SSSI	0.020	3.0	15.0	1.020	**33.99**	5.30	**35.31**
26	508206	452381	River Hull Headwaters SSSI	0.020	3.0	15.0	0.222	**7.40**	1.15	**7.69**
27	507866	452216	River Hull Headwaters SSSI	0.020	3.0	15.0	0.164	**5.47**	0.85	**5.69**
28	507460	452384	River Hull Headwaters SSSI	0.020	3.0	15.0	0.078	**2.59**	0.40	**2.69**
29	508499	453009	River Hull Headwaters SSSI	0.020	3.0	15.0	0.096	**3.19**	0.50	**3.32**
30	506610	452897	River Hull Headwaters SSSI	0.020	3.0	15.0	0.027	0.90	0.14	0.93
31	509004	453873	River Hull Headwaters SSSI	0.020	3.0	15.0	0.045	**1.50**	0.23	**1.56**
32	506731	454954	River Hull Headwaters SSSI	0.020	1.0	10.0	0.011	**1.13**	0.06	0.59
33	508939	455805	River Hull Headwaters SSSI	0.020	1.0	10.0	0.013	**1.34**	0.07	0.70
34	505812	456176	River Hull Headwaters SSSI	0.020	1.0	10.0	0.006	0.57	0.03	0.30
35	508988	456894	River Hull Headwaters SSSI	0.020	1.0	10.0	0.009	0.88	0.05	0.45
36	504911	456820	River Hull Headwaters SSSI	0.020	1.0	10.0	0.004	0.38	0.02	0.20
37	508963	458380	River Hull Headwaters SSSI	0.020	1.0	10.0	0.005	0.55	0.03	0.28
38	503265	456635	River Hull Headwaters SSSI	0.020	1.0	10.0	0.003	0.30	0.02	0.15
39	500534	454972	River Hull Headwaters SSSI	0.020	1.0	10.0	0.003	0.25	0.01	0.13
40	501047	457539	River Hull Headwaters SSSI	0.020	1.0	10.0	0.002	0.19	0.01	0.10
41	508624	461214	River Hull Headwaters SSSI	0.020	1.0	10.0	0.003	0.28	0.01	0.14
42	507697	449449	Tophill Low SSSI	0.005	3.0	n/a	0.027	0.90	0.04	-
43	507059	448084	Tophill Low SSSI	0.005	3.0	n/a	0.010	0.34	0.01	-
44	509996	445058	Leven Canal SSSI	0.020	3.0	n/a	0.003	0.10	0.02	-
45	506065	445058	Leven Canal SSSI	0.020	3.0	n/a	0.003	0.12	0.02	-
46	505234	444272	Pulfin Bog SSSI	0.020	3.0	10.0	0.003	0.08	0.01	0.13
47	501448	446251	Bryan Mills Field SSSI	0.020	3.0	10.0	0.002	0.07	0.01	0.12
48	516112	454898	Skipsea Bail Mere SSSI	0.005	n/a	n/a	0.005	-	0.01	-
49	515898	455861	Skipsea Bail Mere SSSI	0.005	n/a	n/a	0.005	-	0.01	-
50	518006	454716	Withow Gap, Skipsea SSSI	0.020	n/a	n/a	0.004	-	0.02	-
51	517236	446776	Hornsea Mere SSSI/SPA	0.020	1.0	10.0	0.002	0.21	0.01	0.11

Table 6b. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors - Proposed Scenario - AS Modelling & Data Ltd. method

Receptor number	X(m)	Y(m)	Designation	Site Parameters			Maximum annual 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	508739	451692	LWS	0.005	3.0	n/a	3.309	**110.29**	4.30	-
2	508757	451587	LWS	0.005	3.0	n/a	2.421	80.69	3.14	-
3	508759	451826	LWS	0.030	3.0	10.0	1.761	58.70	13.72	**137.19**
4	508862	451677	LWS	0.005	3.0	n/a	1.106	36.88	1.44	-
5	508750	451981	LWS	0.005	3.0	n/a	0.897	29.89	1.16	-
6	508696	452170	LWS	0.005	3.0	n/a	0.442	14.74	0.57	-
7	508946	451628	LWS	0.005	3.0	n/a	0.733	24.42	0.95	-
8	509015	451496	LWS	0.005	3.0	n/a	0.506	16.86	0.66	-
9	508365	452114	LWS	0.005	3.0	n/a	0.307	10.24	0.40	-
10	508289	452375	LWS	0.005	3.0	n/a	0.141	4.70	0.18	-
11	508665	452479	LWS	0.005	3.0	n/a	0.170	5.66	0.22	-
12	508671	452884	LWS	0.005	3.0	n/a	0.076	2.53	0.10	-
13	508665	453348	LWS	0.005	3.0	n/a	0.039	1.30	0.05	-
14	508987	451181	LWS	0.030	3.0	10.0	0.287	9.58	2.24	22.39
15	508913	451007	LWS	0.030	3.0	10.0	0.196	6.52	1.52	15.24
16	508928	450531	LWS	0.030	3.0	10.0	0.066	2.20	0.51	5.14
17	509131	450904	LWS	0.020	3.0	10.0	0.107	3.58	0.56	5.57
18	509271	451332	LWS	0.030	3.0	10.0	0.189	6.31	1.47	14.75
19	509563	451469	LWS	0.030	3.0	10.0	0.112	3.75	0.88	8.76
20	509467	451044	LWS	0.030	3.0	10.0	0.086	2.85	0.67	6.67
21	509910	451092	LWS	0.030	3.0	10.0	0.050	1.65	0.39	3.86
22	507938	450025	LWS	0.020	3.0	10.0	0.032	1.06	0.16	1.65
23	508225	451720	LWS	0.020	3.0	10.0	0.554	18.45	2.88	28.76
24	508178	452041	River Hull Headwaters SSSI	0.020	3.0	15.0	0.233	**7.76**	1.21	**8.06**
25	508303	451920	River Hull Headwaters SSSI	0.020	3.0	15.0	0.497	**16.57**	2.58	**17.21**
26	508206	452381	River Hull Headwaters SSSI	0.020	3.0	15.0	0.122	**4.07**	0.63	**4.23**
27	507866	452216	River Hull Headwaters SSSI	0.020	3.0	15.0	0.093	**3.09**	0.48	**3.21**
28	507460	452384	River Hull Headwaters SSSI	0.020	3.0	15.0	0.045	**1.49**	0.23	**1.55**
29	508499	453009	River Hull Headwaters SSSI	0.020	3.0	15.0	0.054	**1.80**	0.28	**1.87**
30	506610	452897	River Hull Headwaters SSSI	0.020	3.0	15.0	0.016	0.52	0.08	0.55
31	509004	453873	River Hull Headwaters SSSI	0.020	3.0	15.0	0.026	0.86	0.13	0.89
32	506731	454954	River Hull Headwaters SSSI	0.020	1.0	10.0	0.007	0.67	0.03	0.35
33	508939	455805	River Hull Headwaters SSSI	0.020	1.0	10.0	0.008	0.79	0.04	0.41
34	505812	456176	River Hull Headwaters SSSI	0.020	1.0	10.0	0.003	0.34	0.02	0.18
35	508988	456894	River Hull Headwaters SSSI	0.020	1.0	10.0	0.005	0.51	0.03	0.27
36	504911	456820	River Hull Headwaters SSSI	0.020	1.0	10.0	0.002	0.23	0.01	0.12
37	508963	458380	River Hull Headwaters SSSI	0.020	1.0	10.0	0.003	0.32	0.02	0.17
38	503265	456635	River Hull Headwaters SSSI	0.020	1.0	10.0	0.002	0.17	0.01	0.09
39	500534	454972	River Hull Headwaters SSSI	0.020	1.0	10.0	0.001	0.15	0.01	0.08
40	501047	457539	River Hull Headwaters SSSI	0.020	1.0	10.0	0.001	0.11	0.01	0.06
41	508624	461214	River Hull Headwaters SSSI	0.020	1.0	10.0	0.002	0.16	0.01	0.09
42	507697	449449	Tophill Low SSSI	0.005	3.0	n/a	0.016	0.54	0.02	-
43	507059	448084	Tophill Low SSSI	0.005	3.0	n/a	0.006	0.20	0.01	-
44	509996	445058	Leven Canal SSSI	0.020	3.0	n/a	0.002	0.06	0.01	-
45	506065	445058	Leven Canal SSSI	0.020	3.0	n/a	0.002	0.07	0.01	-
46	505234	444272	Pulfin Bog SSSI	0.020	3.0	10.0	0.002	0.05	0.01	0.08
47	501448	446251	Bryan Mills Field SSSI	0.020	3.0	10.0	0.001	0.04	0.01	0.07
48	516112	454898	Skipsea Bail Mere SSSI	0.005	n/a	n/a	0.003	-	0.00	-
49	515898	455861	Skipsea Bail Mere SSSI	0.005	n/a	n/a	0.003	-	0.00	-
50	518006	454716	Withow Gap, Skipsea SSSI	0.020	n/a	n/a	0.002	-	0.01	-
51	517236	446776	Hornsea Mere SSSI/SPA	0.020	1.0	10.0	0.001	0.12	0.01	0.06

Table 7. Changes in predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors - AS Modelling & Data Ltd. method

Receptor number	X(m)	Y(m)	Designation	Site Parameters			Maximum annual 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	508739	451692	LWS	0.005	3.0	n/a	-1.231	-41.03	-1.60	-
2	508757	451587	LWS	0.005	3.0	n/a	-1.313	-43.78	-1.71	-
3	508759	451826	LWS	0.030	3.0	10.0	-1.139	-37.98	-8.88	-88.78
4	508862	451677	LWS	0.005	3.0	n/a	-0.551	-18.37	-0.72	-
5	508750	451981	LWS	0.005	3.0	n/a	-0.851	-28.36	-1.10	-
6	508696	452170	LWS	0.005	3.0	n/a	-0.461	-15.35	-0.60	-
7	508946	451628	LWS	0.005	3.0	n/a	-0.400	-13.33	-0.52	-
8	509015	451496	LWS	0.005	3.0	n/a	-0.299	-9.97	-0.39	-
9	508365	452114	LWS	0.005	3.0	n/a	-0.307	-10.23	-0.40	-
10	508289	452375	LWS	0.005	3.0	n/a	-0.121	-4.02	-0.16	-
11	508665	452479	LWS	0.005	3.0	n/a	-0.151	-5.02	-0.20	-
12	508671	452884	LWS	0.005	3.0	n/a	-0.061	-2.02	-0.08	-
13	508665	453348	LWS	0.005	3.0	n/a	-0.030	-0.99	-0.04	-
14	508987	451181	LWS	0.030	3.0	10.0	-0.182	-6.06	-1.42	-14.17
15	508913	451007	LWS	0.030	3.0	10.0	-0.126	-4.19	-0.98	-9.80
16	508928	450531	LWS	0.030	3.0	10.0	-0.044	-1.46	-0.34	-3.41
17	509131	450904	LWS	0.020	3.0	10.0	-0.069	-2.31	-0.36	-3.60
18	509271	451332	LWS	0.030	3.0	10.0	-0.119	-3.96	-0.92	-9.25
19	509563	451469	LWS	0.030	3.0	10.0	-0.068	-2.28	-0.53	-5.34
20	509467	451044	LWS	0.030	3.0	10.0	-0.055	-1.82	-0.43	-4.26
21	509910	451092	LWS	0.030	3.0	10.0	-0.031	-1.05	-0.24	-2.45
22	507938	450025	LWS	0.020	3.0	10.0	-0.021	-0.71	-0.11	-1.11
23	508225	451720	LWS	0.020	3.0	10.0	-0.400	-13.33	-2.08	-20.77
24	508178	452041	River Hull Headwaters SSSI	0.020	3.0	15.0	-0.207	-6.90	-1.08	-7.17
25	508303	451920	River Hull Headwaters SSSI	0.020	3.0	15.0	-0.522	-17.42	-2.71	-18.09
26	508206	452381	River Hull Headwaters SSSI	0.020	3.0	15.0	-0.100	-3.33	-0.52	-3.46
27	507866	452216	River Hull Headwaters SSSI	0.020	3.0	15.0	-0.072	-2.38	-0.37	-2.48
28	507460	452384	River Hull Headwaters SSSI	0.020	3.0	15.0	-0.033	-1.09	-0.17	-1.14
29	508499	453009	River Hull Headwaters SSSI	0.020	3.0	15.0	-0.042	-1.39	-0.22	-1.44
30	506610	452897	River Hull Headwaters SSSI	0.020	3.0	15.0	-0.011	-0.37	-0.06	-0.39
31	509004	453873	River Hull Headwaters SSSI	0.020	3.0	15.0	-0.019	-0.64	-0.10	-0.66
32	506731	454954	River Hull Headwaters SSSI	0.020	1.0	10.0	-0.005	-0.47	-0.02	-0.24
33	508939	455805	River Hull Headwaters SSSI	0.020	1.0	10.0	-0.006	-0.56	-0.03	-0.29
34	505812	456176	River Hull Headwaters SSSI	0.020	1.0	10.0	-0.002	-0.23	-0.01	-0.12
35	508988	456894	River Hull Headwaters SSSI	0.020	1.0	10.0	-0.004	-0.36	-0.02	-0.19
36	504911	456820	River Hull Headwaters SSSI	0.020	1.0	10.0	-0.002	-0.15	-0.01	-0.08
37	508963	458380	River Hull Headwaters SSSI	0.020	1.0	10.0	-0.002	-0.22	-0.01	-0.12
38	503265	456635	River Hull Headwaters SSSI	0.020	1.0	10.0	-0.001	-0.12	-0.01	-0.06
39	500534	454972	River Hull Headwaters SSSI	0.020	1.0	10.0	-0.001	-0.10	-0.01	-0.05
40	501047	457539	River Hull Headwaters SSSI	0.020	1.0	10.0	-0.001	-0.08	0.00	-0.04
41	508624	461214	River Hull Headwaters SSSI	0.020	1.0	10.0	-0.001	-0.11	-0.01	-0.06
42	507697	449449	Tophill Low SSSI	0.005	3.0	n/a	-0.011	-0.36	-0.01	-
43	507059	448084	Tophill Low SSSI	0.005	3.0	n/a	-0.004	-0.14	-0.01	-
44	509996	445058	Leven Canal SSSI	0.020	3.0	n/a	-0.001	-0.04	-0.01	-
45	506065	445058	Leven Canal SSSI	0.020	3.0	n/a	-0.001	-0.05	-0.01	-
46	505234	444272	Pulfin Bog SSSI	0.020	3.0	10.0	-0.001	-0.03	-0.01	-0.05
47	501448	446251	Bryan Mills Field SSSI	0.020	3.0	10.0	-0.001	-0.03	0.00	-0.05
48	516112	454898	Skipsea Bail Mere SSSI	0.005	n/a	n/a	-0.002	-	0.00	-
49	515898	455861	Skipsea Bail Mere SSSI	0.005	n/a	n/a	-0.002	-	0.00	-
50	518006	454716	Withow Gap, Skipsea SSSI	0.020	n/a	n/a	-0.002	-	-0.01	-
51	517236	446776	Hornsea Mere SSSI/SPA	0.020	1.0	10.0	-0.001	-0.08	0.00	-0.04

Table 8a. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors - Existing Scenario – EA mandated method

Receptor number	X(m)	Y(m)	Designation	Site Parameters			Maximum annual 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	508739	451692	LWS	0.005	3.0	n/a	3.580	**119.33**	4.65	-
2	508757	451587	LWS	0.005	3.0	n/a	2.656	88.54	3.45	-
3	508759	451826	LWS	0.030	3.0	10.0	1.631	54.37	12.71	**127.07**
4	508862	451677	LWS	0.005	3.0	n/a	1.015	33.83	1.32	-
5	508750	451981	LWS	0.005	3.0	n/a	0.991	33.03	1.29	-
6	508696	452170	LWS	0.005	3.0	n/a	0.513	17.09	0.67	-
7	508946	451628	LWS	0.005	3.0	n/a	0.693	23.09	0.90	-
8	509015	451496	LWS	0.005	3.0	n/a	0.506	16.86	0.66	-
9	508365	452114	LWS	0.005	3.0	n/a	0.362	12.06	0.47	-
10	508289	452375	LWS	0.005	3.0	n/a	0.153	5.11	0.20	-
11	508665	452479	LWS	0.005	3.0	n/a	0.186	6.19	0.24	-
12	508671	452884	LWS	0.005	3.0	n/a	0.081	2.70	0.11	-
13	508665	453348	LWS	0.005	3.0	n/a	0.041	1.37	0.05	-
14	508987	451181	LWS	0.030	3.0	10.0	0.293	9.77	2.28	22.83
15	508913	451007	LWS	0.030	3.0	10.0	0.199	6.64	1.55	15.52
16	508928	450531	LWS	0.030	3.0	10.0	0.066	2.22	0.52	5.18
17	509131	450904	LWS	0.020	3.0	10.0	0.108	3.60	0.56	5.61
18	509271	451332	LWS	0.030	3.0	10.0	0.190	6.33	1.48	14.79
19	509563	451469	LWS	0.030	3.0	10.0	0.112	3.73	0.87	8.71
20	509467	451044	LWS	0.030	3.0	10.0	0.087	2.89	0.68	6.76
21	509910	451092	LWS	0.030	3.0	10.0	0.050	1.66	0.39	3.88
22	507938	450025	LWS	0.020	3.0	10.0	0.033	1.09	0.17	1.70
23	508225	451720	LWS	0.020	3.0	10.0	0.582	19.39	3.02	30.22
24	508178	452041	River Hull Headwaters SSSI	0.020	3.0	15.0	0.258	**8.60**	1.34	**8.94**
25	508303	451920	River Hull Headwaters SSSI	0.020	3.0	15.0	0.596	**19.88**	3.10	**20.65**
26	508206	452381	River Hull Headwaters SSSI	0.020	3.0	15.0	0.132	**4.41**	0.69	**4.58**
27	507866	452216	River Hull Headwaters SSSI	0.020	3.0	15.0	0.096	**3.20**	0.50	**3.32**
28	507460	452384	River Hull Headwaters SSSI	0.020	3.0	15.0	0.045	**1.50**	0.23	**1.56**
29	508499	453009	River Hull Headwaters SSSI	0.020	3.0	15.0	0.057	**1.90**	0.30	**1.97**
30	506610	452897	River Hull Headwaters SSSI	0.020	3.0	15.0	0.016	0.53	0.08	0.55
31	509004	453873	River Hull Headwaters SSSI	0.020	3.0	15.0	0.027	0.91	0.14	0.95
32	506731	454954	River Hull Headwaters SSSI	0.020	1.0	10.0	0.007	0.70	0.04	0.36
33	508939	455805	River Hull Headwaters SSSI	0.020	1.0	10.0	0.008	0.84	0.04	0.44
34	505812	456176	River Hull Headwaters SSSI	0.020	1.0	10.0	0.004	0.36	0.02	0.18
35	508988	456894	River Hull Headwaters SSSI	0.020	1.0	10.0	0.006	0.55	0.03	0.29
36	504911	456820	River Hull Headwaters SSSI	0.020	1.0	10.0	0.002	0.24	0.01	0.12
37	508963	458380	River Hull Headwaters SSSI	0.020	1.0	10.0	0.003	0.34	0.02	0.18
38	503265	456635	River Hull Headwaters SSSI	0.020	1.0	10.0	0.002	0.18	0.01	0.10
39	500534	454972	River Hull Headwaters SSSI	0.020	1.0	10.0	0.002	0.15	0.01	0.08
40	501047	457539	River Hull Headwaters SSSI	0.020	1.0	10.0	0.001	0.12	0.01	0.06
41	508624	461214	River Hull Headwaters SSSI	0.020	1.0	10.0	0.002	0.17	0.01	0.09
42	507697	449449	Tophill Low SSSI	0.005	3.0	n/a	0.017	0.56	0.02	-
43	507059	448084	Tophill Low SSSI	0.005	3.0	n/a	0.006	0.21	0.01	-
44	509996	445058	Leven Canal SSSI	0.020	3.0	n/a	0.002	0.06	0.01	-
45	506065	445058	Leven Canal SSSI	0.020	3.0	n/a	0.002	0.07	0.01	-
46	505234	444272	Pulfin Bog SSSI	0.020	3.0	10.0	0.002	0.05	0.01	0.08
47	501448	446251	Bryan Mills Field SSSI	0.020	3.0	10.0	0.001	0.05	0.01	0.07
48	516112	454898	Skipsea Bail Mere SSSI	0.005	n/a	n/a	0.003	-	0.00	-
49	515898	455861	Skipsea Bail Mere SSSI	0.005	n/a	n/a	0.003	-	0.00	-
50	518006	454716	Withow Gap, Skipsea SSSI	0.020	n/a	n/a	0.002	-	0.01	-
51	517236	446776	Hornsea Mere SSSI/SPA	0.020	1.0	10.0	0.001	0.13	0.01	0.07

Table 8b. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors - Proposed Scenario - EA mandated method

Receptor number	X(m)	Y(m)	Designation	Site Parameters			Maximum annual ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level (µg/m³)	Critical Load (kg/ha)	Process Contribution (µg/m³)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	508739	451692	LWS	0.005	3.0	n/a	4.449	**148.29**	5.78	-
2	508757	451587	LWS	0.005	3.0	n/a	2.918	97.27	3.79	-
3	508759	451826	LWS	0.030	3.0	10.0	1.947	64.90	15.17	**151.70**
4	508862	451677	LWS	0.005	3.0	n/a	1.249	41.62	1.62	-
5	508750	451981	LWS	0.005	3.0	n/a	0.964	32.12	1.25	-
6	508696	452170	LWS	0.005	3.0	n/a	0.466	15.52	0.60	-
7	508946	451628	LWS	0.005	3.0	n/a	0.806	26.85	1.05	-
8	509015	451496	LWS	0.005	3.0	n/a	0.552	18.41	0.72	-
9	508365	452114	LWS	0.005	3.0	n/a	0.328	10.94	0.43	-
10	508289	452375	LWS	0.005	3.0	n/a	0.151	5.03	0.20	-
11	508665	452479	LWS	0.005	3.0	n/a	0.180	5.99	0.23	-
12	508671	452884	LWS	0.005	3.0	n/a	0.081	2.71	0.11	-
13	508665	453348	LWS	0.005	3.0	n/a	0.042	1.40	0.05	-
14	508987	451181	LWS	0.030	3.0	10.0	0.307	10.24	2.39	23.93
15	508913	451007	LWS	0.030	3.0	10.0	0.208	6.94	1.62	16.23
16	508928	450531	LWS	0.030	3.0	10.0	0.069	2.31	0.54	5.41
17	509131	450904	LWS	0.020	3.0	10.0	0.114	3.79	0.59	5.90
18	509271	451332	LWS	0.030	3.0	10.0	0.200	6.67	1.56	15.60
19	509563	451469	LWS	0.030	3.0	10.0	0.122	4.08	0.95	9.53
20	509467	451044	LWS	0.030	3.0	10.0	0.091	3.04	0.71	7.10
21	509910	451092	LWS	0.030	3.0	10.0	0.053	1.77	0.41	4.14
22	507938	450025	LWS	0.020	3.0	10.0	0.034	1.14	0.18	1.78
23	508225	451720	LWS	0.020	3.0	10.0	0.588	19.59	3.05	30.52
24	508178	452041	River Hull Headwaters SSSI	0.020	3.0	15.0	0.249	**8.31**	1.29	**8.63**
25	508303	451920	River Hull Headwaters SSSI	0.020	3.0	15.0	0.528	**17.60**	2.74	**18.28**
26	508206	452381	River Hull Headwaters SSSI	0.020	3.0	15.0	0.132	**4.38**	0.68	**4.55**
27	507866	452216	River Hull Headwaters SSSI	0.020	3.0	15.0	0.099	**3.30**	0.51	**3.43**
28	507460	452384	River Hull Headwaters SSSI	0.020	3.0	15.0	0.047	**1.58**	0.25	**1.64**
29	508499	453009	River Hull Headwaters SSSI	0.020	3.0	15.0	0.058	**1.93**	0.30	**2.01**
30	506610	452897	River Hull Headwaters SSSI	0.020	3.0	15.0	0.017	0.55	0.09	0.58
31	509004	453873	River Hull Headwaters SSSI	0.020	3.0	15.0	0.028	0.94	0.15	0.97
32	506731	454954	River Hull Headwaters SSSI	0.020	1.0	10.0	0.007	0.74	0.04	0.38
33	508939	455805	River Hull Headwaters SSSI	0.020	1.0	10.0	0.009	0.88	0.05	0.46
34	505812	456176	River Hull Headwaters SSSI	0.020	1.0	10.0	0.004	0.37	0.02	0.19
35	508988	456894	River Hull Headwaters SSSI	0.020	1.0	10.0	0.006	0.58	0.03	0.30
36	504911	456820	River Hull Headwaters SSSI	0.020	1.0	10.0	0.003	0.25	0.01	0.13
37	508963	458380	River Hull Headwaters SSSI	0.020	1.0	10.0	0.004	0.36	0.02	0.19
38	503265	456635	River Hull Headwaters SSSI	0.020	1.0	10.0	0.002	0.19	0.01	0.10
39	500534	454972	River Hull Headwaters SSSI	0.020	1.0	10.0	0.002	0.16	0.01	0.08
40	501047	457539	River Hull Headwaters SSSI	0.020	1.0	10.0	0.001	0.13	0.01	0.07
41	508624	461214	River Hull Headwaters SSSI	0.020	1.0	10.0	0.002	0.18	0.01	0.10
42	507697	449449	Tophill Low SSSI	0.005	3.0	n/a	0.018	0.59	0.02	-
43	507059	448084	Tophill Low SSSI	0.005	3.0	n/a	0.007	0.22	0.01	-
44	509996	445058	Leven Canal SSSI	0.020	3.0	n/a	0.002	0.07	0.01	-
45	506065	445058	Leven Canal SSSI	0.020	3.0	n/a	0.002	0.08	0.01	-
46	505234	444272	Pulfin Bog SSSI	0.020	3.0	10.0	0.002	0.06	0.01	0.09
47	501448	446251	Bryan Mills Field SSSI	0.020	3.0	10.0	0.001	0.05	0.01	0.08
48	516112	454898	Skipsea Bail Mere SSSI	0.005	n/a	n/a	0.003	-	0.00	-
49	515898	455861	Skipsea Bail Mere SSSI	0.005	n/a	n/a	0.003	-	0.00	-
50	518006	454716	Withow Gap, Skipsea SSSI	0.020	n/a	n/a	0.002	-	0.01	-
51	517236	446776	Hornsea Mere SSSI/SPA	0.020	1.0	10.0	0.001	0.14	0.01	0.07

Figure 7a. Maximum annual ammonia concentration - Existing Scenario

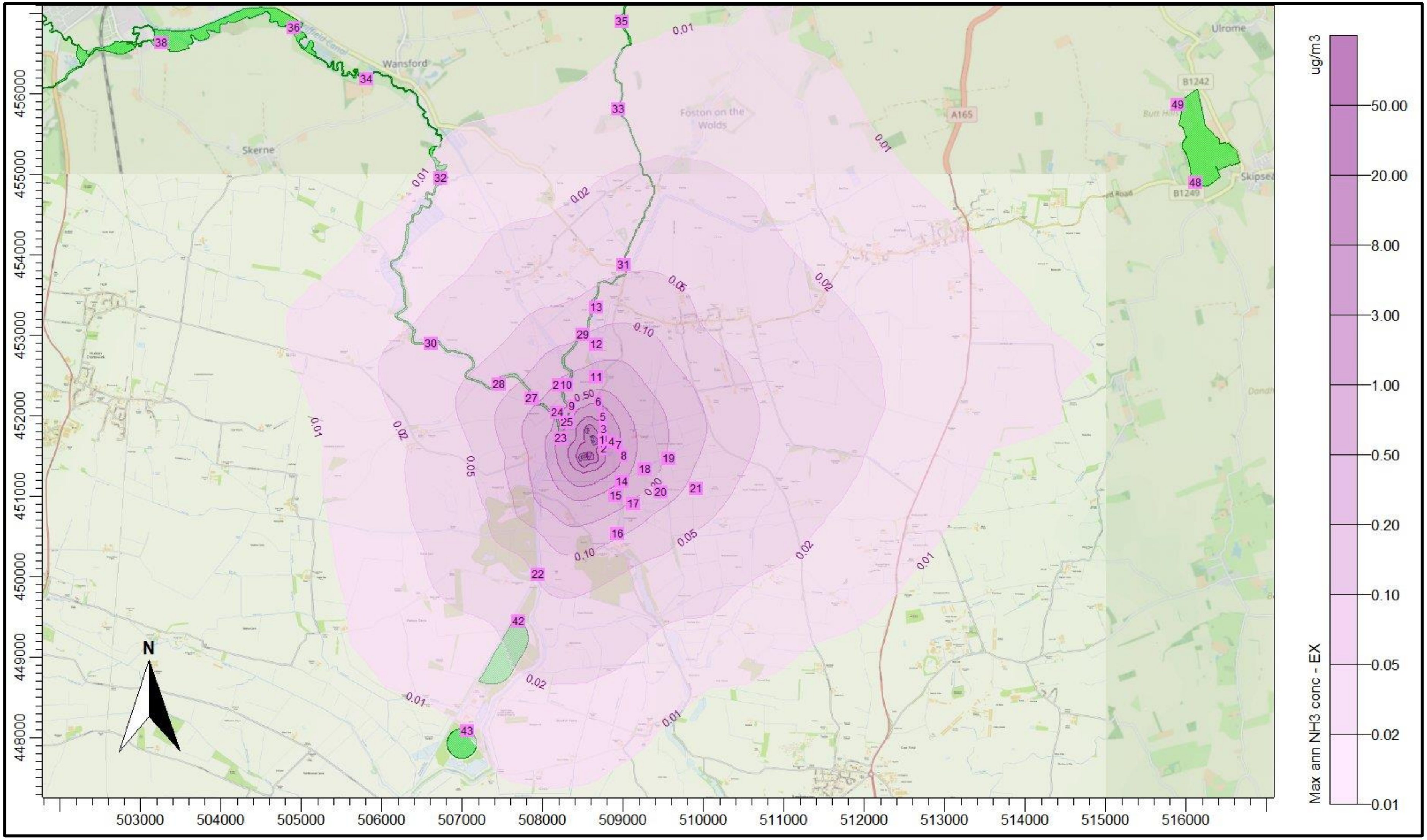


Figure 7b. Maximum annual nitrogen deposition rate - Existing Scenario

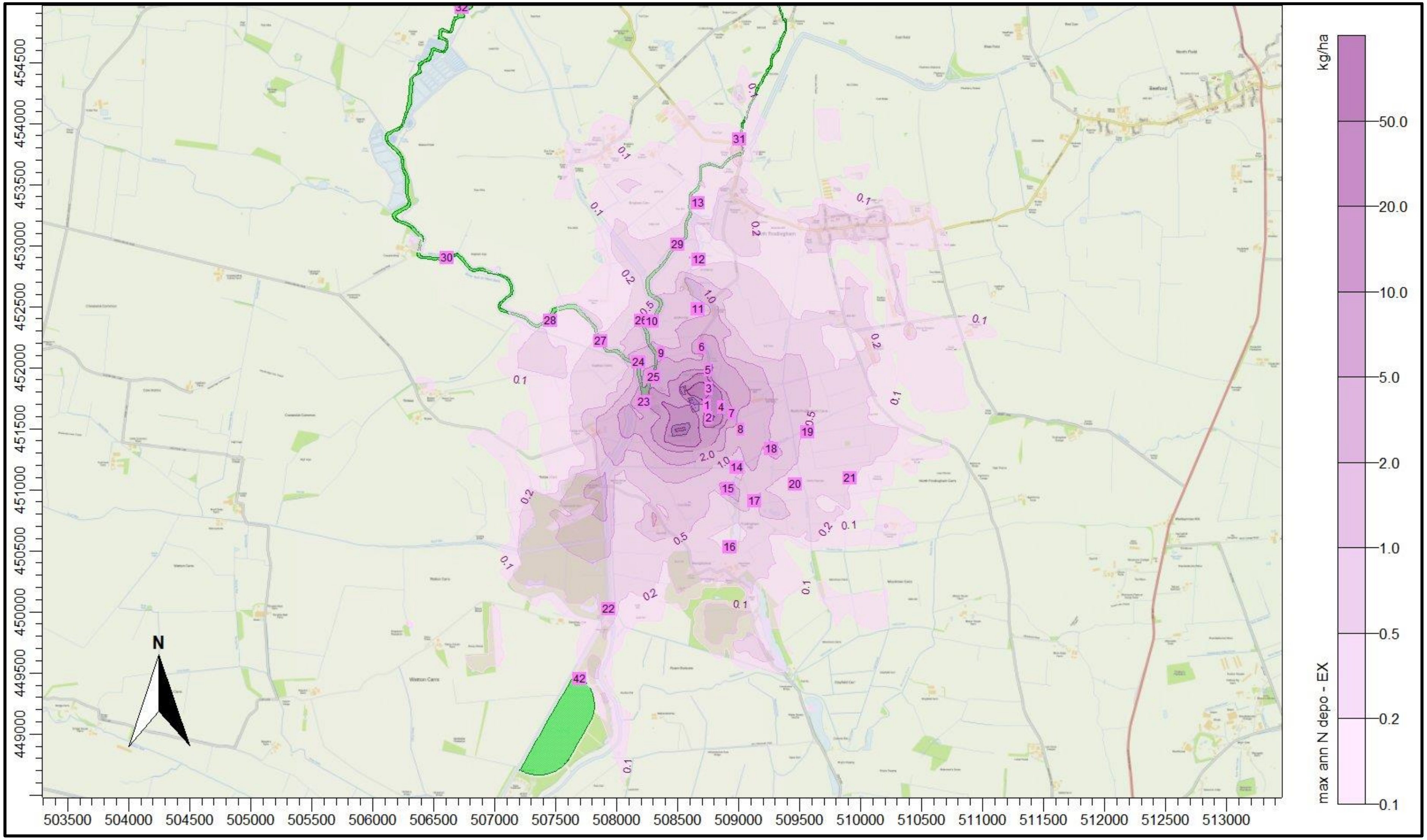


Figure 8a. Maximum annual ammonia concentration - Proposed Scenario

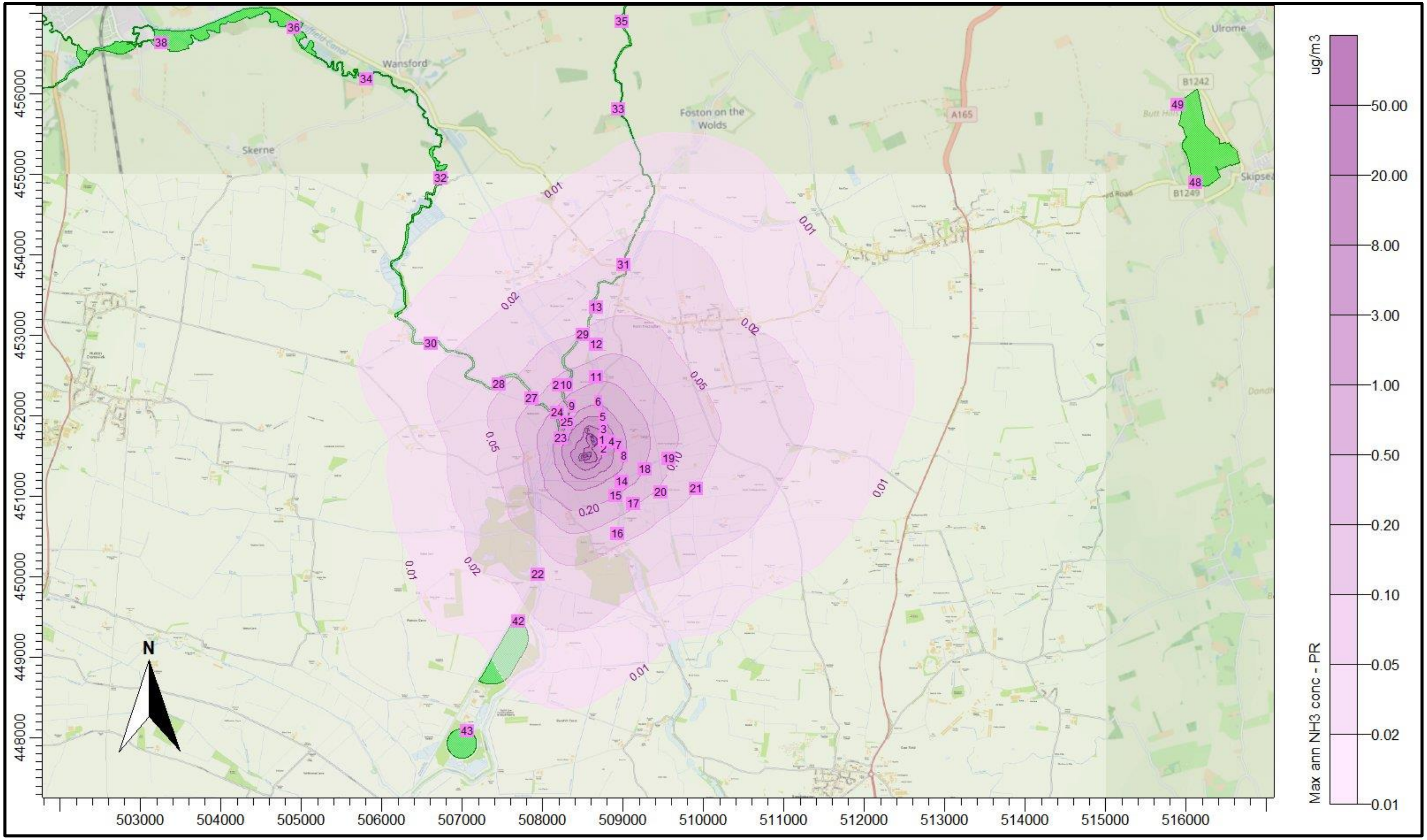
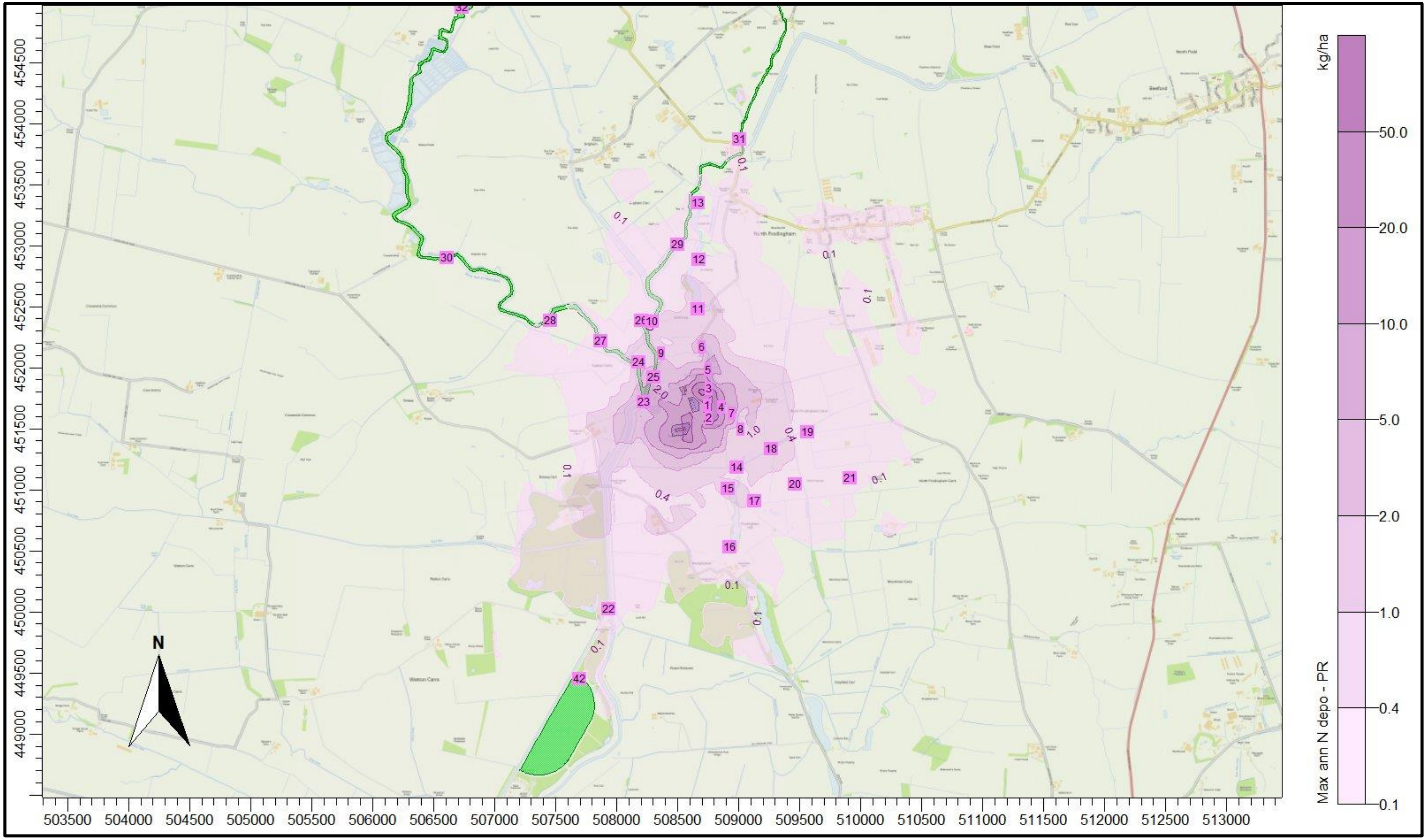


Figure 8b. Maximum annual nitrogen deposition rate - Proposed Scenario



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Mr. Steve Raasch, on behalf of Mr. Tim Warkup, to use computer modelling to assess the impact of ammonia emissions from the existing and proposed free range egg laying chicken houses at High Emmotland Farm, Howes Lane, Emmotland, Driffield, East Riding of Yorkshire. YO25 8JS.

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

Existing Scenario

The modelling predicts that:

Process contributions to ammonia concentration and nitrogen deposition exceed the Environment Agency's upper threshold percentage of Critical Level and Critical Load at some of the closer parts of the LWSs.

Process contributions to ammonia concentration and nitrogen deposition exceed the Environment Agency's lower percentage of Critical Level and Critical Load at closer parts of The River Hull Headwaters SSSI.

Process contributions to ammonia concentration and nitrogen deposition exceed 1% of Critical Level and/or Critical Load along approximately 6 km of The River Hull Headwaters SSSI.

Proposed Scenario

The modelling predicts that:

Process contributions to ammonia concentration and nitrogen deposition would continue to exceed the Environment Agency's upper threshold percentage of Critical Level and Critical Load at some of the closer LWSs; however, the extent and magnitude of the exceedances would be significantly reduced.

Process contributions to ammonia concentration and nitrogen deposition would fall to be below the Environment Agency's lower percentage of Critical Level and Critical Load at closer parts of The River Hull Headwaters SSSI.

Process contributions to ammonia concentration and nitrogen deposition would exceed 1% of Critical Level and/or Critical Load along approximately 4 km of The River Hull Headwaters SSSI.

7. References

Cambridge Environmental Research Consultants (CERC) (website).

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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).