A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Existing and Proposed Broiler Chicken Rearing Houses at Morton Ley Farm, near Osbaston in Oswestry

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Rosina Bloor of Roger Parry & Partners LLP., on behalf of Morton Growers Ltd., to use computer modelling to assess the impact of ammonia emissions from the existing and proposed broiler chicken rearing houses at Morton Ley Farm, near Osbaston, Oswestry. SY10 8BG.

Ammonia emission rates from the poultry houses have been assessed and quantified based upon the Environment Agency's standard ammonia emission factors and also upon an emissions model that estimates emissions from the Pollo Compact Air Scrubber ammonia scrubbing equipment that would be fitted to the existing and proposed poultry houses. 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 broiler rearing houses at Morton Ley Farm is in a rural area, approximately 750 m to the west-north-west of the village of Osbaston in Shropshire. The surrounding land is used largely for a mixture of arable and livestock farming, but there are also some isolated wooded areas. The site is at an altitude of around 70 m and is surrounded by relatively flat land.

There are currently four broiler chicken rearing houses at Moreton Ley Farm. The existing houses are currently ventilated by roof fans and gable ends fans with dust baffles.

Under the proposal, two new poultry houses would be constructed to the south-west of the existing buildings. The four existing and two proposed poultry houses would provide accommodation for up to 350,000 broiler chickens in total. The existing and proposed poultry houses would be ventilated by air scrubber units, which would provide the majority of the ventilation, for the majority of the time. Backup ventilation in case of scrubber failure and for supplementary ventilation which would be required at the end of crops in warm weather, would be provided by high speed ridge or roof fans, each with a short chimney. The chickens would be reared from day old chicks up to 38 days old and there would be approximately 7.5 flocks per annum.

Five scenarios have been modelled:

Scenario 1 - The four existing poultry houses with current ventilation system. (The Existing Scenario).
Scenario 2 - The two proposed poultry houses with standard ventilation.
Scenario 3 - The four existing houses, fitted with the Pollo air scrubber units.
Scenario 4 - The two proposed poultry houses, fitted with the Pollo air scrubber units.
Scenario 5 - The existing and proposed poultry houses, all fitted with the Pollo air scrubber units. (The Proposed Scenario).

There are several sites designated as Local Wildlife Sites (LWSs) and Priority Habitats (PHs) within 2 km of the existing and proposed poultry houses. There are also thirteen Sites of Special Scientific Interest (SSSIs) within 10 km, one of which is also designated as a Ramsar Site and one is also designated as a Special Area of Conservation (SAC). Some further details of SSSIs, Ramsar site and SAC are provided below:

- Morton Pool and Pasture SSSI/Ramsar site - Approximately 1.1 km to the west-north-west - The chief interest of Morton Pool is the fen and carr vegetation around it. The damp peaty pasture west of Morton Pool is exceptionally rich in flowering plants and is one of the best examples of damp grassland in Shropshire.
- Crofts Mill Pasture SSSI - Approximately 1.3 km to the north-north-west - A particularly rich example of damp peaty pasture.
- Llanymynech and Llynclys Hills SSSI - Approximately 3.3 km to the west - Extensive grassland, scrub and woodland communities and also natural rock faces, screes, a series of abandoned quarries and areas affected by past lead and copper mining. This site is particularly important for its limestone plants. The screes and shaded rocks at the base of the cliff are especially valuable for mosses and liverworts.
- Sweeney Fen SSSI Sweeney Fen - Approximately 3.9 km to the west-north-west - A small area of base-rich marsh and fen which has developed adjacent to a limestone stream. A thin deposit of peat has accumulated.

- Blodwel Marsh SSSI - Approximately 4.5 km to the west - A small but exceptionally rich area of fen pasture on base-rich peat, in a low-lying area west of the limestone outcrop of Llynclys Hill. This is one of a range of small, peaty grasslands in north-west Shropshire.
- Montgomery Canal, Aston Locks - Keeper's Bridge SSSI - Approximately 2.8 km to the north-north-east - A disused length of canal which is among the best localities for aquatic plants in Shropshire.
- Trefonen Marshes SSSI - Approximately 6.8 km to the west-north-west - A series of base-rich marshes and areas of dry Carboniferous limestone grassland in the valley of a tributary of the River Morda. Some of the damp areas beside the stream have developed into alder woodland.
- Craig Sychtyn SSSI - Approximately 7.9 km to the west-north-west - A west-facing Carboniferous limestone crag with woodland, scrub, grassland and rock face communities.
- Ty-Brith Meadows SSSI - Approximately 8.3 km to the south-west - An extensive example of unimproved lowland mesotrophic grassland managed as traditional hay meadow.
- Breidden Hill SSSI - Approximately 8.2 km to the south - Of outstanding importance for its uncommon plants. The presence of intruded igneous rocks, particularly dolerite, in this geologically complex site has led to a remarkable mixture of both lime-loving and acid-loving plants. Low outcrops and screes of igneous rocks support a notable and characteristic lower plant flora, with many species of mosses and lichens.
- Lin Can Moss SSSI - Approximately 6.4 km to the east-south-east - A small quaking bog which is believed to have developed in recent years. The surface is dominated by *Sphagnum recurvum*. The uncommon slender sedge *Carex lasiocarpa* has been found and other characteristic plants include sundew *Drosera rotundifolia*.
- Fernhill Pastures SSSI - Approximately 9.5 km to the north - A series of traditionally managed fen-meadows situated on gently sloping ground alongside the River Perry in north west Shropshire.
- Montgomery Canal SSSI/SAC - Approximately 4.9 km to the south-west - Of special interest because it supports aquatic, emergent and marginal plant communities of exceptional richness, including a large population of the internationally rare and threatened floating water plantain *Luronium natans* and a several other rare and scarce water plants. An important aquatic invertebrate assemblage is also present.

Maps of the surrounding area showing the positions of the existing and proposed poultry houses and the nearby wildlife sites are provided in Figures 1a and 1b. In the figures, the LWSs are shaded in yellow, the SSSIs are shaded in green, the SAC is shaded in purple and the Ramsar site is shaded in blue, the site of the existing poultry houses is outlined in red and the site of the proposed poultry houses is outlined in blue.

Figure 1a. The area surrounding Morton Ley Farm, with circles radii at 2km (olive), 5 km (green) and 10 km (purple)

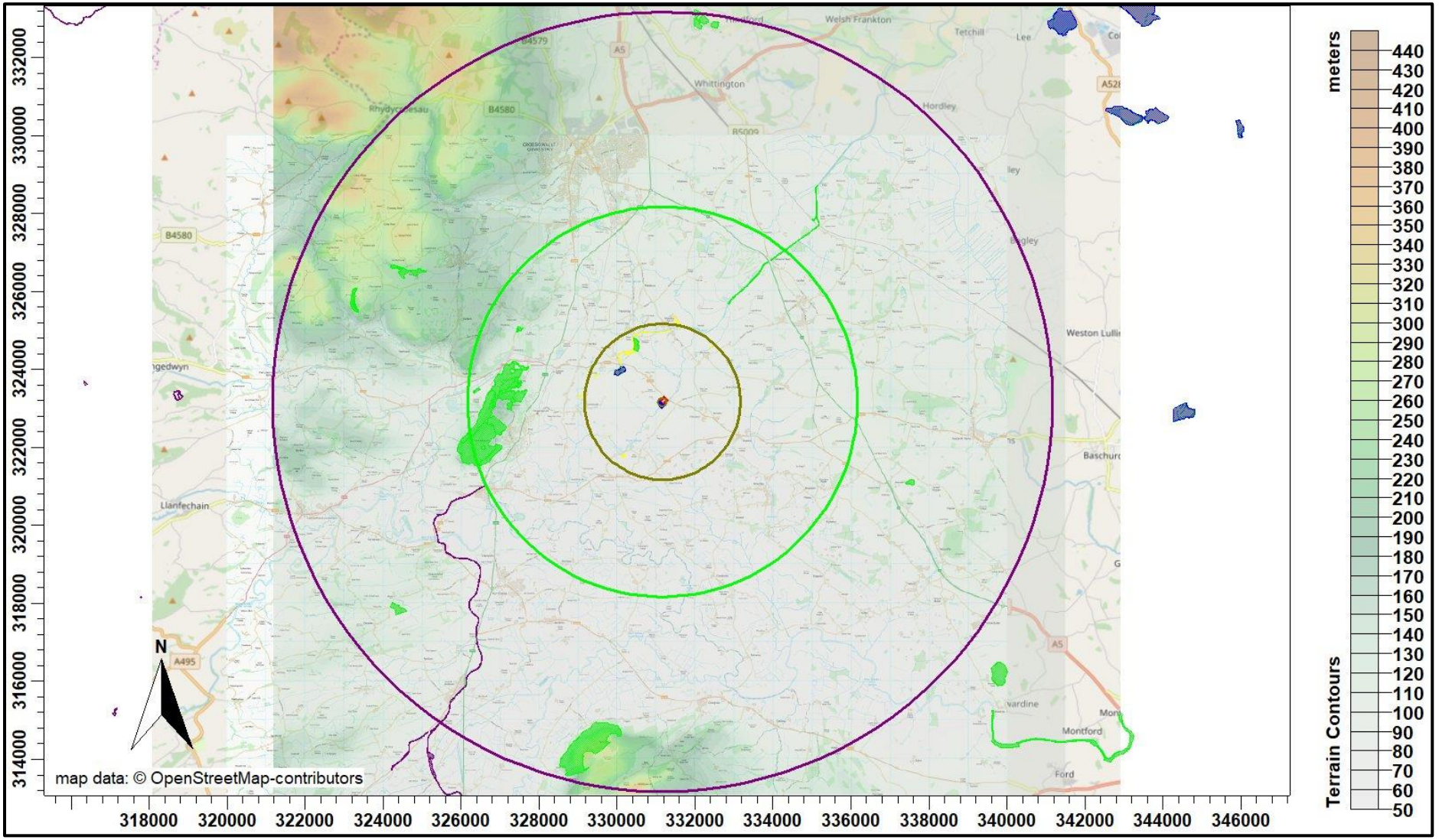
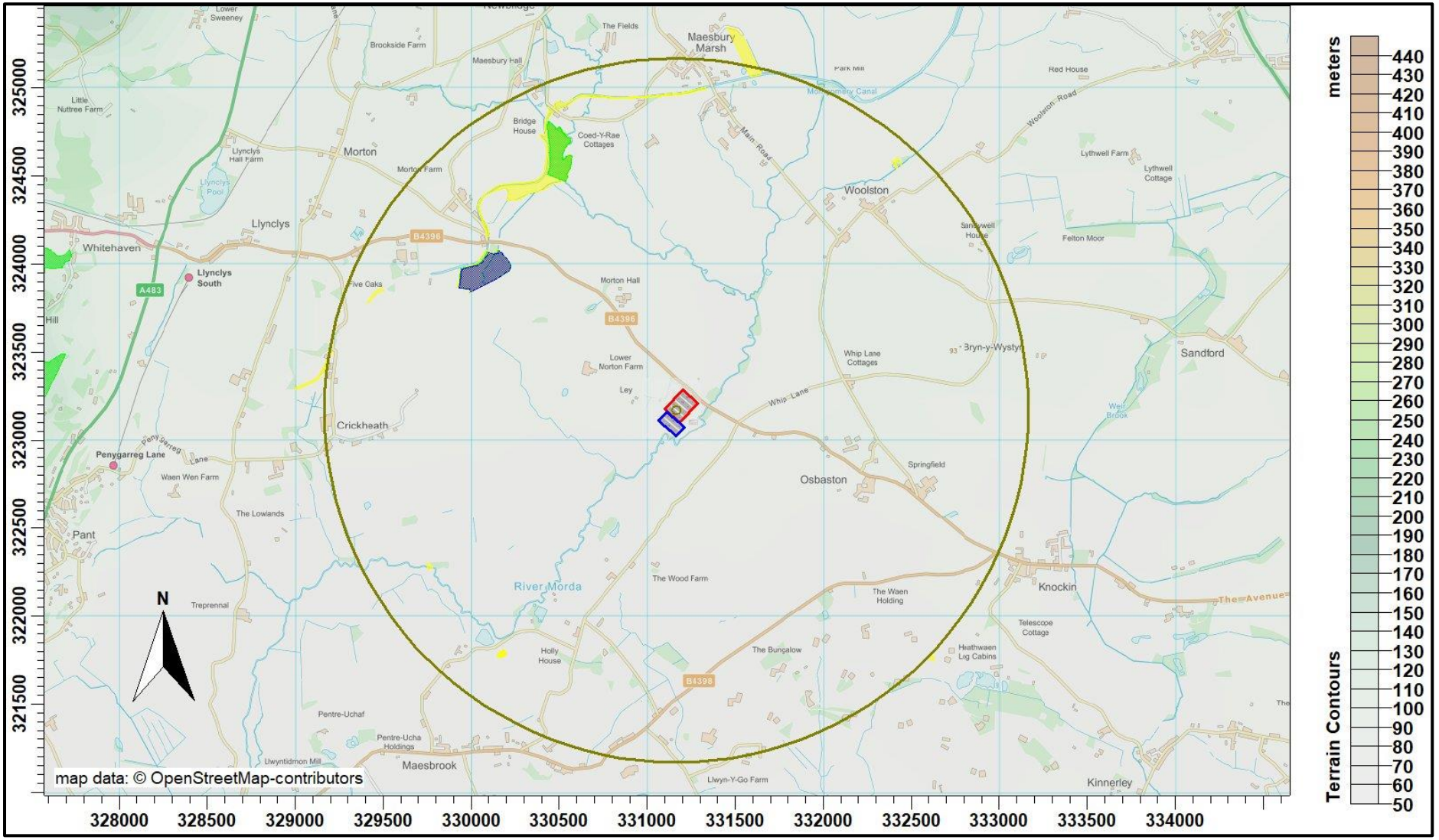


Figure 1b. The area surrounding Morton Ley Farm - a closer view



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 background ammonia concentration (annual mean) in the area around the site of the poultry unit and the wildlife sites is 2.85 $\mu g\text{-}NH_3/m^3$. The background nitrogen deposition rate to woodland is 35.98 kg-N/ha/y and to short vegetation is 20.72 kg-N/ha/y. The background acid deposition rate to woodland is 2.63 keq/ha/y and to short vegetation is 1.52 keq/ha/y. The source of these background figures is the Air Pollution Information System (APIS, January 2022).

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. N.B. Where the Critical Level of 1.0 µg-NH_3/m^3 is assumed, it is usually unnecessary to consider the Critical Load as the Critical Level provides the stricter test. However, it may be necessary to consider nitrogen deposition should a Critical Load of 5.0 kg-N/ha/y be appropriate. Normally, the Critical Load for nitrogen deposition provides a stricter test than does 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)
Non-statutory Sites	1.0 [1]	-	-
Crofts Mill Pasture SSSI, Fernhill Pastures SSSI and Blodwel Marsh SSSI	3.0 [2]	15.0 [3]	-
Llanymynech and Llynclys Hills SSSI and Craig Sychtyn SSSI	1.0 [1 & 2]	15.0 [3]	-
Sweeney Fen SSSI, Trefonen Marshes SSSI	1.0 [1 & 2]	10.0 [3]	-
Lin Can Moss SSSI & Breidden Hill SSSI	1.0 [1 & 2]	5.0 [3]	-
Morton Pool and Pasture Ramsar Site and Ty Brith Meadows SSSI	3.0 [2]	10.0 [3]	-
Montgomery Canal SAC and Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	3.0 [2]	n/a [4]	n/a [4]

1. A precautionary figure used where no details of the ecology of the site are available, or the citation for the site contains reference to sensitive lichens and/or bryophytes.
2. Based upon the citation for the site and information listed on APIS.
3. The lower bound of the range of Critical Loads for the site/species, obtained from APIS.
4. No information on Critical Level/Load given.

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% 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. This advice is based primarily upon the Habitats Directive, EIA Directive and the Countryside and Rights of Way Act. Additionally, this advice is primarily for combustion processes.

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.

3.4.3 Shropshire Council Guidance

In April 2018, Shropshire Council published Interim Guidance Note GN2 (Version 1, April 2018), "Assessing the impact of ammonia and nitrogen on designated sites and Natural Assets from new and expanding livestock units (LSUs)".

AS Modelling & Data Ltd. are currently assessing this guidance; however, in summary, it appears that the following criteria are applicable:

If the sum of the Process Contribution from the application site and other nearby livestock units is less than 1% of the relevant Critical Level or Critical Load (at a wildlife site) then:

- The application can be determined providing avoidance and mitigation measures can be conditioned. It should be noted that it is extremely unlikely that this condition could ever be achieved.

- If the Process Contribution from the application site and other nearby livestock units is greater than 1% of the relevant Critical Level or Critical Load (at a wildlife site) then:

- If the modelled Process Contribution, including BAT (Best Available Techniques) or other avoidance/mitigation measures leads to either; no additional nitrogen deposition or a reduction in background nitrogen deposition (it is assumed this also means no increase in ammonia concentration, or a reduction in concentration), then the application can be determined providing avoidance and mitigation measures can be conditioned. Furthermore, the guidance states that a) new sites would have to be nitrogen neutral (please note that, without some form of nitrogen offset elsewhere, this is not possible) and

b) extensions to existing sites would need to add no extra nitrogen deposition or, ideally, achieve a reduction in the nitrogen background level, by use of Best Available Techniques (BAT) or other mitigation measures.

- If the modelled Process Contribution, including BAT, or other avoidance/mitigation measures is not neutral or do not lead to a reduction in nitrogen deposition (it is assumed this also means ammonia concentration), then if the Predicted Environmental Concentration (sum of process contribution and background levels/loads) leads to an exceedance of the relevant Critical Level or Load at a receptor, then, assessments will be made on a case by case basis.

- In the case of nationally, or internationally designated wildlife sites: If the Predicted Environmental Concentration can be reduced to avoid the exceedance, or it can be demonstrated that there would be no adverse effect on an international site, or no damage to the scientific interest of a national site: then the application can be potentially approved with conditioned control measures; otherwise, the application will be potentially refused when all avenues to reduce the contributions are exhausted and it cannot be shown that damage to the sensitive receptors will not occur.

- In the case of a locally designated site: if control measures are available that can reduce the Predicted Environmental Concentration to avoid exceedance of the ammonia Critical Level or nitrogen Critical Load or it can be demonstrated that there would be no adverse effects then: the application can be potentially approved with conditioned control measures; otherwise, a balanced planning decision will be taken based on the information provided, other material considerations and planning policy.

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 - 00.08%, 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.

AS Modelling & Data Ltd. would note that the DMTs for medium and high development density areas are more than 5 and 10 times lower than the current 1% of Environmental Assessment Level (EAL) that is normally considered negligible when assessing air quality, respectively, and that it is unlikely that any development: agricultural or otherwise; small or large; with or without mitigation, would fall below the DMTs in these areas.

3.5 Quantification of ammonia emissions

3.5.1 Regulatory modelling

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 Environment Agency provides an Intensive farming guidance note which lists standard ammonia emission factors for a variety of livestock, including broiler chickens. The emission factor for broiler chickens is 0.034 kg-NH_3/bird place/y; this figure is used to calculate regulatory baseline/unabated emissions.

3.5.2 Modelling of air scrubber emissions

The ventilation rates used in the calculations are based on industry practices and standard bird growth factors. Minimum ventilation rates are as those of an operational poultry house and maximum ventilation rates are based on Defra guidelines. Target internal temperature is 33 Celsius at the beginning of the crop and is decreased to 22 Celsius by day 34 of the crop. If the external temperature is 7 Celsius, or more, lower than the target temperature, minimum ventilation only is assumed for the calculation. Above this, ventilation rates are increased in proportion to the difference between ambient temperature and target internal temperature. A maximum transitional ventilation rate (35% of the maximum possible ventilation rate) is reached when the ambient temperature is equal to the target temperature. A high ventilation rate (70% maximum possible ventilation rate) is reached when the temperature is 4 degrees above target and if external temperature is above 33 Celsius the maximum ventilation rate is assumed.

Based upon these principles, an ammonia emission rate for each hour of the period modelled is calculated by multiplying the outlet concentration by the ventilation rate.

For the calculation of the emission rates from the air scrubber, the outlet ammonia concentration is assumed to be a constant 2 ppm (1,408.8 µg/m^3). This figure is based upon the guaranteed maximum outlet concentration from the manufacturers of the ammonia scrubbing equipment. It should be noted that, typically, an agricultural wet chemical scrubber can achieve 1 to 1.5 ppm outlet ammonia concentration, therefore the 2 ppm assumed is precautionary. The capacities of the air scrubbers would be 100,000 m^3/h (27.778 m^3/s), if the modelled ventilation rate exceeds the scrubber capacity, additional ventilation would be provided by the ridge mounted fans.

The concentration for unabated bypass emissions that occur when the modelled ventilation rate exceeds the scrubber is based upon long term, high temporal resolution monitoring of broiler rearing houses elsewhere and is dependent upon the crop stage. The internal ammonia concentrations assumed are then set so as to give approximately the same overall emission factor as the regulatory standard emission factor. Similarly, to the scrubber emissions, an emission rate from the bypass

ventilation system is calculated by multiplying the (unabated) internal concentration by the bypass ventilation rate.

Since emissions are variable, to avoid some of the uncertainty introduced because of timing of higher emission rates, wind directions and atmospheric stability and provide robust statistics, three sets of calculations were performed; the first with the first day of the meteorological record coinciding with day 1 of the crop cycle, the second coinciding with day 16 of the crop and the third coinciding with day 32 of the crop.

The annual emission rates are variable, as they depend on ambient temperature and for example how often bypass ventilation is used. However, the average emission rate of all three crop cycles over the four year meteorological record is equivalent to an emission factor of 0.009476 kg-NH_3/bird place/y, which is approximately 27.9% of the standard emission factor of 0.034 kg-NH_3/bird place/y i.e. assuming an outlet concentration of 2 ppm, the use of scrubbers would reduce housing emissions by approximately 72.1% from regulatory emission figures.

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].

The GFS is a spectral model: the physics/dynamics model has an equivalent resolution of approximately 9 km (latterly 6 km) over the UK. Terrain is understood to be resolved at a resolution of approximately 2 km, with sub-9/6 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 over represented, this is because the instrumentation used may not record wind speeds below approximately 0.5 m/s and start up wind speeds may be greater than 1.0 m/s. In NWP data, the wind speed is continuous down to 0.0 m/s, allowing the calms module of ADMS to function correctly.

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

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

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 location at the poultry unit is shown in Figure 2b. The resolution of the wind field in terrain runs is approximately 340 m. Please also 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 52.801 N, 3.021 W, 2018 - 2021

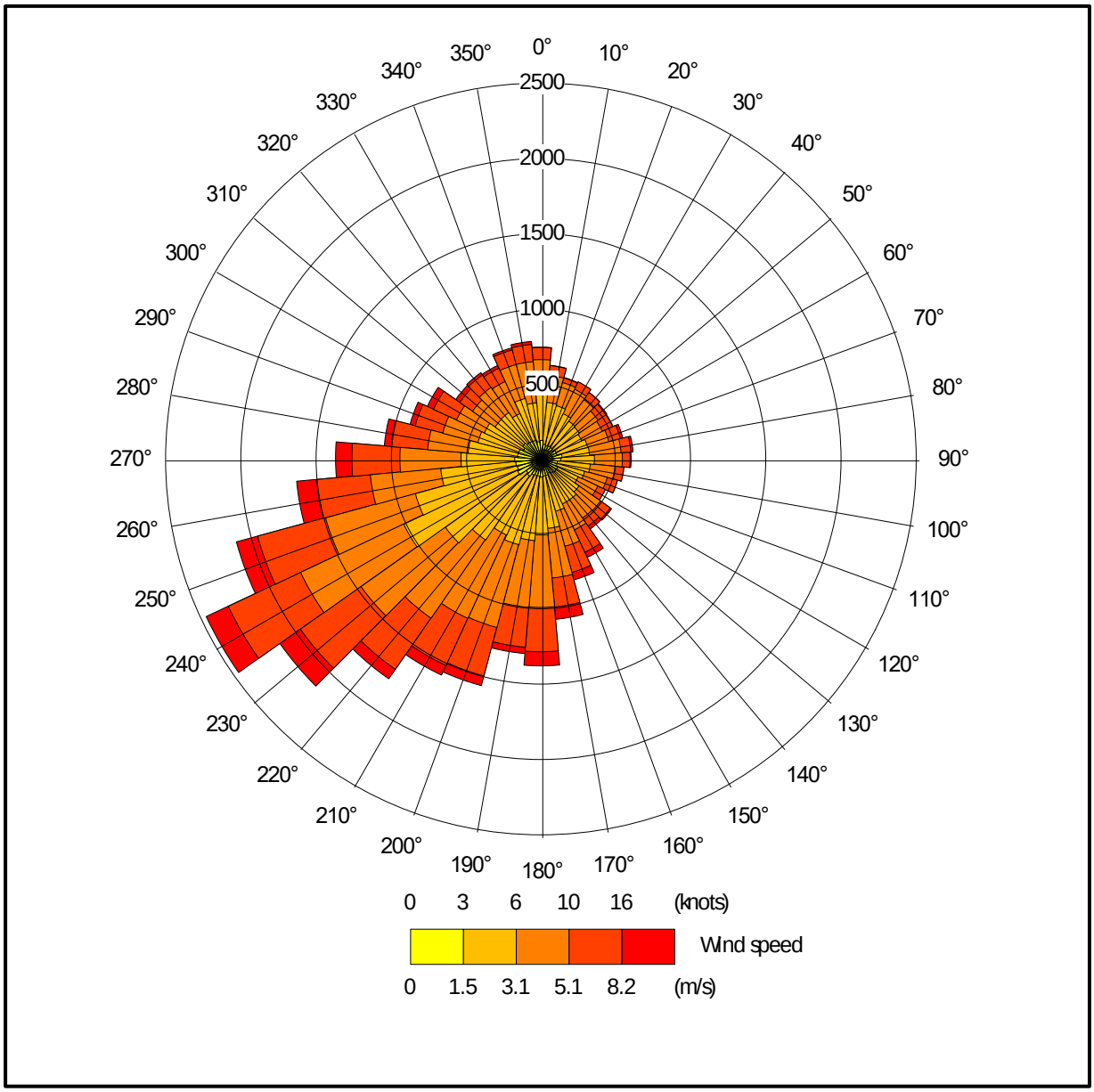
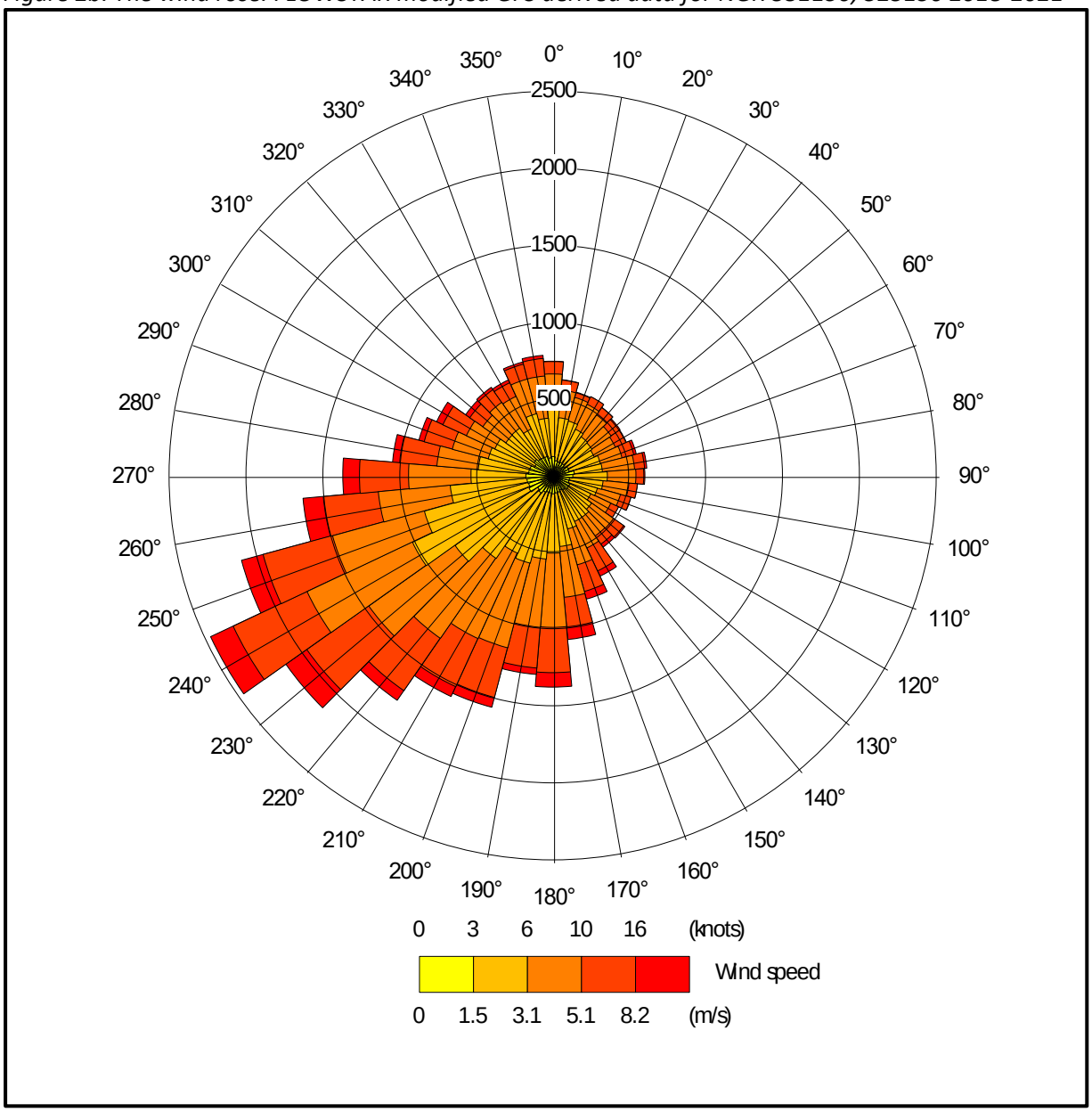


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 331150, 323150 2018-2021



4.2 Emission sources

Emissions from the high speed ridge fans in the existing/unabated scenarios are represented by three point sources per house within ADMS (EX1_NOR to EX4_NOR 1, 2 & 3 and PR5_NOR to PR6_NOR 1, 2 & 3). The existing houses also currently have gable end fans with dust baffles for use in hot weather, these are represented by a single volume source in ADMS (EX_GAB).

Emissions from the air scrubbers and the high speed ridge/roof fans that would be used as bypass/backup ventilation in the proposed scenario are represented by a single point source per house within ADMS (EX1_BYP 1, 2 & 3 to EX4_BYP 1, 2 & 3, PR5_BYP to PR6_BYP 1, 2 & 3, EX1_SCR 1, 2 & 3 to EX4_SCR 1, 2 & 3 and PR5_SCR to PR6_SCR 1, 2 & 3).

Details of the point source and volume source parameters are shown in Tables 2a and 2b. The positions of the sources may be seen in Figure 3.

Table 2a. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (˚C)	Emission rate per source (g-NH_3/s)
EX1_NOR to EX4_NOR 1, 2 & 3	6.0	0.8	11.0	Variable [1]	0.019959 [2]
PR5_NOR 1, 2 & 3 and PR6_NOR 1, 2 & 3	6.0	0.8	11.0	Variable [1]	0.022929
EX1 BYP to EX4_BYP 1, 2 & 3	6.0	0.8	11.0	Variable [1]	Variable [1]
EX1_SCR to EX4_SCR 1, 2 & 3	6.0	0.8	11.0	Variable [1]	Variable [1]
PR5_BYP 1, 2 & 3 and PR6_BYP 1, 2 & 3	6.0	0.8	11.0	Variable [1]	Variable [1]
PR5_SCR 1, 2 & 3 and PR6_SCR 1, 2 & 3	6.0	0.8	11.0	Variable [1]	Variable [1]

Table 2b. Volume source parameters

Source ID (Scenario)	Length Y (m)	Width X (m)	Depth (m)	Base height (m)	Emission temperature (°C)	Emission rate (g-NH_3/s)
EX_GAB	5.0	62.5	3.0	0.0	Ambient	0.119757 [3]

1. Dependent on ambient temperature.
2. Reduced by 50% when the ambient temperature equals or exceeds 21 Celsius.
3. 50% of the total emission emitted only when the ambient temperature equals or exceeds 21 Celsius

4.3 Modelled buildings

The structure of the existing and proposed poultry houses may affect the plumes from the point sources. Therefore, the buildings are modelled within ADMS. The positions of the modelled buildings may be seen in Figure 3, where they are marked by grey rectangles.

4.4 Discrete receptors

Thirty-nine discrete receptors have been defined: ten at the LWSs and PHs (1 to 10), twenty-one at the SSSIs (11 to 23 and 32 to 39), six at Montgomery Canal SSSI/SAC (24 to 29) and two at Morton Pool and Pasture SSSI/Ramsar site (30 to 31). These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figures 4a and 4b, where they are marked by enumerated pink rectangles.

4.5 Cartesian grid

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

4.6 Terrain data

Terrain has been considered in the modelling. The terrain data are based upon the Ordnance Survey 50 m Digital Elevation Model. A 22.0 km x 22.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS. N.B. The resolution of FLOWSTAR is 64 x 64 grid points; therefore, the effective resolution of the wind field is approximately 340 m.

4.7 Roughness Length

A fixed surface roughness length of 0.25 m has been applied over the entire modelling domain. As a precautionary measure, the GFS meteorological data is assumed to have a roughness length of 0.225 m. The effect of the difference in roughness length is precautionary as it increases the frequency of low wind speeds and stability and therefore increases predicted ground level concentrations.

Figure 3. The positions of the modelled buildings and sources

Figure 4a. The discrete receptors and regular Cartesian grids - with circles radii at 2 km (olive), 5 km (green) and 10 km (purple)

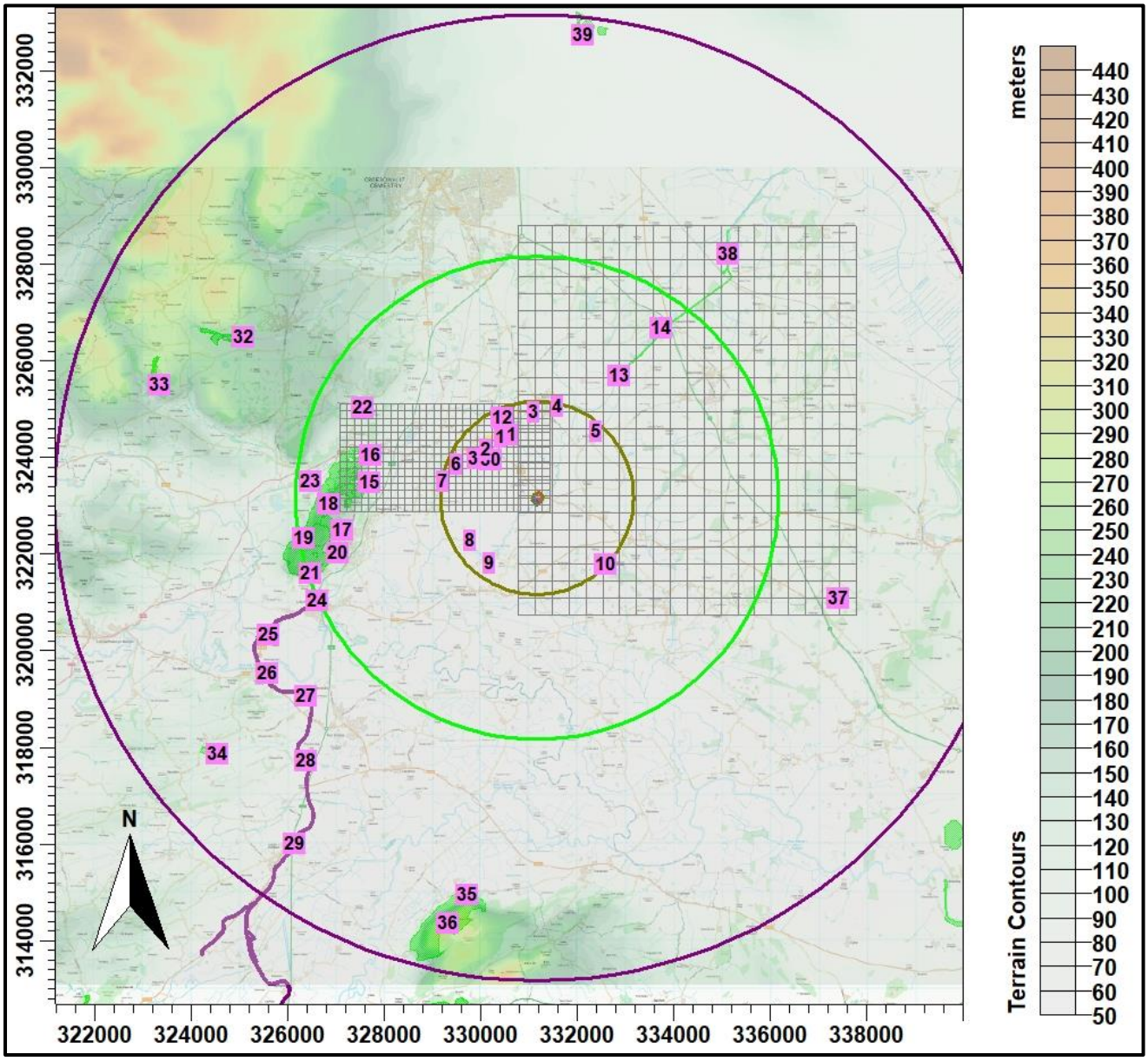
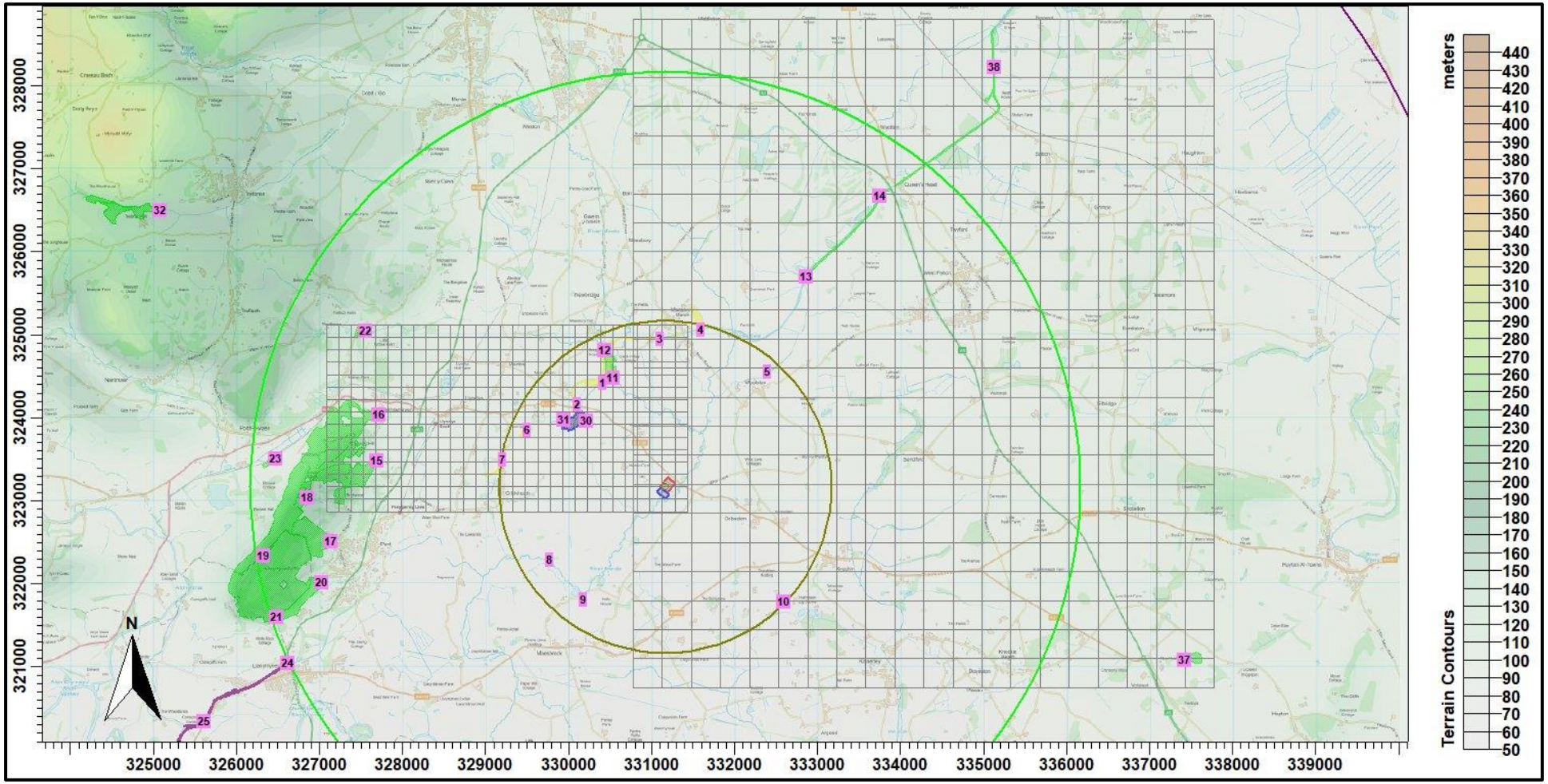


Figure 4b. The discrete receptors and regular Cartesian grids - a closer view



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 0.015 m/s to 0.010 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 3.

Table 3. Deposition velocities

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

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

Contour plots of the spatially varying deposition fields to the east and west of the poultry unit are provided in Figures 5a and 5b.

In this case, as part of the preliminary modelling, the model has also been run with a fixed deposition at 0.003 m/s and similarly to not modelling deposition at all, the predicted ammonia concentrations (and nitrogen and acid deposition rates) are always higher than if deposition were modelled explicitly, particularly where there is some distance between the source and a receptor.

Figure 5a. The spatially varying deposition field - east

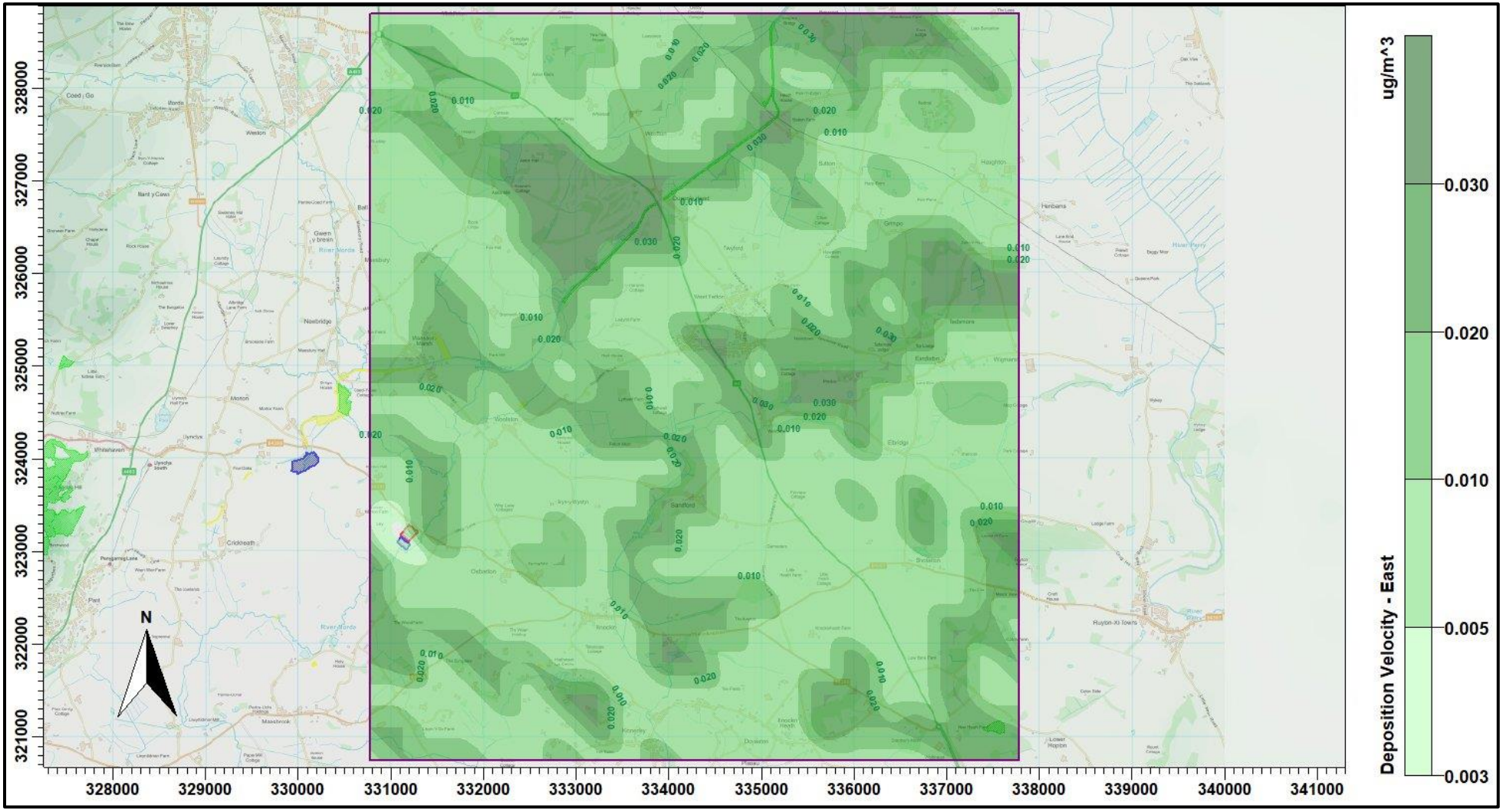
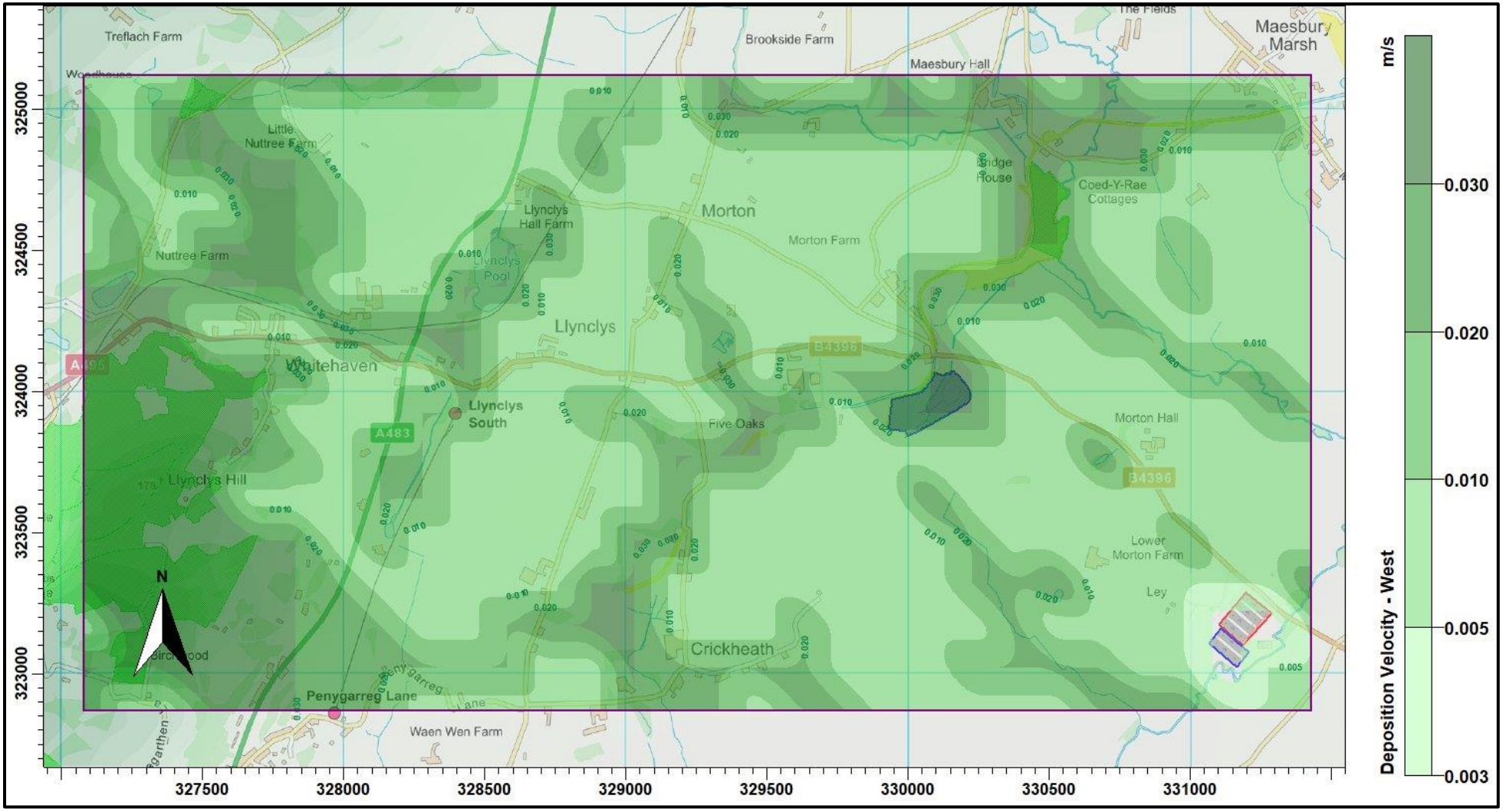


Figure 5b. The spatially varying deposition field - west



5. Details of the Model Runs and Results

Five scenarios have been modelled:

Scenario 1 - The four existing poultry houses with current ventilation system. (The Existing Scenario).

Scenario 2 - The two proposed poultry houses with standard ventilation (ridge fans only).

Scenario 3 - The four existing houses, fitted with the Pollo air scrubber units.

Scenario 4 - The two proposed poultry houses, fitted with the Pollo air scrubber units.

Scenario 5 - The existing and proposed poultry houses, all fitted with the Pollo air scrubber units. (The Proposed Scenario).

5.1 Preliminary modelling

Not conducted. Model sensitivities have been well tested during previous modelling.

5.2 Detailed deposition modelling

The detailed modelling focused over restricted domains covering the poultry unit at Morton Ley Farm and several nearby wildlife sites where the predicted process contributions to ammonia concentrations and nitrogen deposition rates are expected to exceed 1% of the relevant Critical Level and Critical Load for the site.

The predicted maximum annual mean ground level ammonia concentrations and nitrogen deposition rates at the discrete receptors are shown in Tables 4a to 4e (Scenarios 1, 2, 3, 4 and 5). In these tables, predicted ammonia concentrations or nitrogen deposition rates that are in excess of 1% of Critical Level/Load are highlighted with bold text.

The changes in predicted maximum annual mean ground level ammonia concentrations and nitrogen deposition rates at the discrete receptors (Scenario 5 minus Scenario 1) are shown in Table 5.

Contour plots of the predicted ground level maximum annual mean ammonia concentration and the maximum annual nitrogen deposition rate for the Existing Scenario (Scenario 1) and the Proposed Scenario (Scenario 5) are shown in Figures 6a and 6b and Figures 7a and 7b. Please note that contour plots for other scenarios can be provided upon request.

Table 4a. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors - Scenario 1

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	330412	324423	Shropshire Union Canal Field LWS	0.02	1.0	10.0	0.039	**3.87**	0.20	**2.01**
2	330104	324155	Montgomery Canal at Maesbury Marsh LWS	0.02	1.0	10.0	0.036	**3.56**	0.18	**1.85**
3	331104	324950	Montgomery Canal at Maesbury Marsh LWS	0.02	1.0	10.0	0.038	**3.83**	0.20	**1.99**
4	331588	325060	Purple moor-grass & rush pastures PH	0.02	1.0	10.0	0.037	**3.69**	0.19	**1.92**
5	332398	324550	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.068	**6.82**	0.35	**3.54**
6	329499	323850	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.019	**1.88**	0.10	0.97
7	329204	323497	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.015	**1.49**	0.08	0.77
8	329767	322292	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.022	**2.17**	0.11	**1.13**
9	330183	321803	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.026	**2.61**	0.14	**1.36**
10	332593	321777	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.016	**1.55**	0.08	0.81
11	330534	324478	Crofts Mill Pasture SSSI	0.02	3.0	15.0	0.039	**1.29**	0.20	**1.34**
12	330439	324811	Crofts Mill Pasture SSSI	0.02	3.0	15.0	0.028	0.94	0.15	0.97
13	332862	325694	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	0.028	0.92	0.14	-
14	333748	326674	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	0.016	0.52	0.08	-
15	327687	323481	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.006	0.57	0.04	0.30
16	327714	324037	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.007	0.69	0.05	0.36
17	327139	322505	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.004	0.41	0.03	0.21
18	326856	323043	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.004	0.36	0.03	0.19
19	326327	322331	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.003	0.30	0.02	0.15
20	327030	322012	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.004	0.41	0.03	0.22
21	326482	321602	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.003	0.33	0.03	0.17
22	327559	325041	Sweeney Fen SSSI	0.02	1.0	10.0	0.006	0.59	0.03	0.31
23	326466	323500	Blodwel Marsh SSSI	0.02	3.0	15.0	0.004	0.12	0.02	0.13
24	326620	321040	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.004	0.13	0.03	-
25	325607	320338	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.003	0.09	0.02	-
26	325580	319526	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.003	0.09	0.02	-
27	326383	319070	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.004	0.12	0.03	-
28	326372	317709	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.003	0.11	0.03	-
29	326133	315999	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.002	0.08	0.02	-
30	330214	323962	Morton Pool and Pasture SSSI/Ramsar site	0.02	3.0	10.0	0.042	**1.39**	0.22	**2.17**
31	329944	323971	Morton Pool and Pasture SSSI/Ramsar site	0.02	3.0	10.0	0.028	0.93	0.14	**1.45**
32	325072	326494	Trefonen Marshes SSSI	0.02	1.0	10.0	0.002	0.21	0.01	0.11
33	323349	325499	Craig Sychtyn SSSI	0.03	1.0	15.0	0.001	0.15	0.01	0.08
34	324540	317848	Ty-Brith Meadows SSSI	0.02	3.0	10.0	0.002	0.06	0.01	0.10
35	329711	314933	Breidden Hill SSSI	0.03	1.0	5.0	0.003	0.26	0.02	0.41
36	329318	314344	Breidden Hill SSSI	0.03	1.0	5.0	0.001	0.14	0.01	0.22
37	337415	321076	Lin Can Moss SSSI	0.03	1.0	5.0	0.004	0.41	0.03	0.64
38	335126	328219	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	0.009	0.31	0.05	-
39	332121	332760	Fernhill Pastures SSSI	0.02	3.0	15.0	0.005	0.15	0.02	0.16

Table 4b. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors - Scenario 2

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	330412	324423	Shropshire Union Canal Field LWS	0.02	1.0	10.0	0.020	**2.04**	0.11	**1.06**
2	330104	324155	Montgomery Canal at Maesbury Marsh LWS	0.02	1.0	10.0	0.022	**2.20**	0.11	**1.14**
3	331104	324950	Montgomery Canal at Maesbury Marsh LWS	0.02	1.0	10.0	0.021	**2.07**	0.11	**1.07**
4	331588	325060	Purple moor-grass & rush pastures PH	0.02	1.0	10.0	0.020	**2.01**	0.10	**1.04**
5	332398	324550	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.036	**3.57**	0.19	**1.85**
6	329499	323850	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.011	**1.10**	0.06	0.57
7	329204	323497	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.009	0.90	0.05	0.47
8	329767	322292	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.013	**1.27**	0.07	0.66
9	330183	321803	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.016	**1.62**	0.08	0.84
10	332593	321777	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.010	0.96	0.05	0.50
11	330534	324478	Crofts Mill Pasture SSSI	0.02	3.0	15.0	0.021	0.70	0.11	0.73
12	330439	324811	Crofts Mill Pasture SSSI	0.02	3.0	15.0	0.016	0.52	0.08	0.54
13	332862	325694	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	0.015	0.51	0.08	-
14	333748	326674	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	0.009	0.29	0.05	-
15	327687	323481	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.003	0.34	0.03	0.18
16	327714	324037	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.004	0.40	0.03	0.21
17	327139	322505	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.002	0.22	0.02	0.12
18	326856	323043	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.002	0.21	0.02	0.11
19	326327	322331	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.002	0.16	0.01	0.08
20	327030	322012	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.002	0.22	0.02	0.12
21	326482	321602	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.002	0.19	0.01	0.10
22	327559	325041	Sweeney Fen SSSI	0.02	1.0	10.0	0.003	0.35	0.02	0.18
23	326466	323500	Blodwel Marsh SSSI	0.02	3.0	15.0	0.002	0.07	0.01	0.07
24	326620	321040	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.002	0.08	0.02	-
25	325607	320338	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.002	0.05	0.01	-
26	325580	319526	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.002	0.05	0.01	-
27	326383	319070	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.002	0.07	0.02	-
28	326372	317709	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.002	0.06	0.01	-
29	326133	315999	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.001	0.05	0.01	-
30	330214	323962	Morton Pool and Pasture SSSI/Ramsar site	0.02	3.0	10.0	0.027	0.89	0.14	**1.39**
31	329944	323971	Morton Pool and Pasture SSSI/Ramsar site	0.02	3.0	10.0	0.018	0.59	0.09	0.92
32	325072	326494	Trefonen Marshes SSSI	0.02	1.0	10.0	0.001	0.12	0.01	0.06
33	323349	325499	Craig Sychtyn SSSI	0.03	1.0	15.0	0.001	0.08	0.01	0.04
34	324540	317848	Ty-Brith Meadows SSSI	0.02	3.0	10.0	0.001	0.04	0.01	0.06
35	329711	314933	Breidden Hill SSSI	0.03	1.0	5.0	0.001	0.15	0.01	0.23
36	329318	314344	Breidden Hill SSSI	0.03	1.0	5.0	0.001	0.08	0.01	0.13
37	337415	321076	Lin Can Moss SSSI	0.03	1.0	5.0	0.003	0.25	0.02	0.39
38	335126	328219	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	0.005	0.17	0.03	-
39	332121	332760	Fernhill Pastures SSSI	0.02	3.0	15.0	0.003	0.09	0.01	0.09

Table 4c. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors - Scenario 3

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	330412	324423	Shropshire Union Canal Field LWS	0.02	1.0	10.0	0.012	**1.24**	0.06	0.64
2	330104	324155	Montgomery Canal at Maesbury Marsh LWS	0.02	1.0	10.0	0.010	**1.03**	0.05	0.53
3	331104	324950	Montgomery Canal at Maesbury Marsh LWS	0.02	1.0	10.0	0.013	**1.25**	0.07	0.65
4	331588	325060	Purple moor-grass & rush pastures PH	0.02	1.0	10.0	0.010	**1.03**	0.05	0.53
5	332398	324550	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.018	**1.79**	0.09	0.93
6	329499	323850	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.005	0.53	0.03	0.27
7	329204	323497	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.005	0.49	0.03	0.25
8	329767	322292	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.007	0.68	0.04	0.35
9	330183	321803	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.008	0.81	0.04	0.42
10	332593	321777	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.004	0.40	0.02	0.21
11	330534	324478	Crofts Mill Pasture SSSI	0.02	3.0	15.0	0.012	0.39	0.06	0.41
12	330439	324811	Crofts Mill Pasture SSSI	0.02	3.0	15.0	0.008	0.28	0.04	0.29
13	332862	325694	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	0.008	0.27	0.04	-
14	333748	326674	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	0.004	0.15	0.02	-
15	327687	323481	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.002	0.19	0.02	0.10
16	327714	324037	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.002	0.20	0.02	0.10
17	327139	322505	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.001	0.15	0.01	0.08
18	326856	323043	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.001	0.13	0.01	0.07
19	326327	322331	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.001	0.10	0.01	0.05
20	327030	322012	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.001	0.15	0.01	0.08
21	326482	321602	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.001	0.12	0.01	0.06
22	327559	325041	Sweeney Fen SSSI	0.02	1.0	10.0	0.002	0.17	0.01	0.09
23	326466	323500	Blodwel Marsh SSSI	0.02	3.0	15.0	0.001	0.04	0.01	0.04
24	326620	321040	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.001	0.04	0.01	-
25	325607	320338	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.001	0.03	0.01	-
26	325580	319526	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.001	0.03	0.01	-
27	326383	319070	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.001	0.03	0.01	-
28	326372	317709	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.001	0.03	0.01	-
29	326133	315999	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.001	0.02	0.01	-
30	330214	323962	Morton Pool and Pasture SSSI/Ramsar site	0.02	3.0	10.0	0.012	0.39	0.06	0.61
31	329944	323971	Morton Pool and Pasture SSSI/Ramsar site	0.02	3.0	10.0	0.008	0.25	0.04	0.39
32	325072	326494	Trefonen Marshes SSSI	0.02	1.0	10.0	0.001	0.06	0.00	0.03
33	323349	325499	Craig Sychtyn SSSI	0.03	1.0	15.0	0.000	0.04	0.00	0.02
34	324540	317848	Ty-Brith Meadows SSSI	0.02	3.0	10.0	0.000	0.02	0.00	0.03
35	329711	314933	Breidden Hill SSSI	0.03	1.0	5.0	0.001	0.08	0.01	0.12
36	329318	314344	Breidden Hill SSSI	0.03	1.0	5.0	0.000	0.04	0.00	0.07
37	337415	321076	Lin Can Moss SSSI	0.03	1.0	5.0	0.001	0.12	0.01	0.18
38	335126	328219	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	0.002	0.08	0.01	-
39	332121	332760	Fernhill Pastures SSSI	0.02	3.0	15.0	0.001	0.04	0.01	0.04

Table 4d. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors - Scenario 4

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	330412	324423	Shropshire Union Canal Field LWS	0.02	1.0	10.0	0.007	0.66	0.03	0.34
2	330104	324155	Montgomery Canal at Maesbury Marsh LWS	0.02	1.0	10.0	0.007	0.70	0.04	0.36
3	331104	324950	Montgomery Canal at Maesbury Marsh LWS	0.02	1.0	10.0	0.007	0.69	0.04	0.36
4	331588	325060	Purple moor-grass & rush pastures PH	0.02	1.0	10.0	0.006	0.57	0.03	0.29
5	332398	324550	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.010	0.99	0.05	0.52
6	329499	323850	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.003	0.29	0.02	0.15
7	329204	323497	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.003	0.30	0.02	0.16
8	329767	322292	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.004	0.44	0.02	0.23
9	330183	321803	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.005	0.53	0.03	0.28
10	332593	321777	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.003	0.27	0.01	0.14
11	330534	324478	Crofts Mill Pasture SSSI	0.02	3.0	15.0	0.007	0.23	0.04	0.24
12	330439	324811	Crofts Mill Pasture SSSI	0.02	3.0	15.0	0.005	0.17	0.03	0.17
13	332862	325694	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	0.005	0.15	0.02	-
14	333748	326674	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	0.003	0.09	0.01	-
15	327687	323481	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.001	0.12	0.01	0.06
16	327714	324037	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.001	0.12	0.01	0.06
17	327139	322505	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.001	0.09	0.01	0.04
18	326856	323043	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.001	0.08	0.01	0.04
19	326327	322331	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.001	0.06	0.00	0.03
20	327030	322012	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.001	0.08	0.01	0.04
21	326482	321602	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.001	0.07	0.01	0.04
22	327559	325041	Sweeney Fen SSSI	0.02	1.0	10.0	0.001	0.10	0.01	0.05
23	326466	323500	Blodwel Marsh SSSI	0.02	3.0	15.0	0.001	0.02	0.00	0.03
24	326620	321040	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.001	0.02	0.01	-
25	325607	320338	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.001	0.02	0.00	-
26	325580	319526	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.000	0.02	0.00	-
27	326383	319070	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.001	0.02	0.00	-
28	326372	317709	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.001	0.02	0.00	-
29	326133	315999	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.000	0.01	0.00	-
30	330214	323962	Morton Pool and Pasture SSSI/Ramsar site	0.02	3.0	10.0	0.008	0.27	0.04	0.43
31	329944	323971	Morton Pool and Pasture SSSI/Ramsar site	0.02	3.0	10.0	0.005	0.17	0.03	0.26
32	325072	326494	Trefonen Marshes SSSI	0.02	1.0	10.0	0.000	0.03	0.00	0.02
33	323349	325499	Craig Sychtyn SSSI	0.03	1.0	15.0	0.000	0.02	0.00	0.01
34	324540	317848	Ty-Brith Meadows SSSI	0.02	3.0	10.0	0.000	0.01	0.00	0.02
35	329711	314933	Breidden Hill SSSI	0.03	1.0	5.0	0.000	0.05	0.00	0.07
36	329318	314344	Breidden Hill SSSI	0.03	1.0	5.0	0.000	0.03	0.00	0.04
37	337415	321076	Lin Can Moss SSSI	0.03	1.0	5.0	0.001	0.07	0.01	0.11
38	335126	328219	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	0.001	0.05	0.01	-
39	332121	332760	Fernhill Pastures SSSI	0.02	3.0	15.0	0.001	0.02	0.00	0.02

Table 4c. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors - Scenario 5

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	330412	324423	Shropshire Union Canal Field LWS	0.02	1.0	10.0	0.019	**1.90**	0.10	0.99
2	330104	324155	Montgomery Canal at Maesbury Marsh LWS	0.02	1.0	10.0	0.017	**1.72**	0.09	0.89
3	331104	324950	Montgomery Canal at Maesbury Marsh LWS	0.02	1.0	10.0	0.019	**1.94**	0.10	**1.01**
4	331588	325060	Purple moor-grass & rush pastures PH	0.02	1.0	10.0	0.016	**1.59**	0.08	0.83
5	332398	324550	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.028	**2.78**	0.14	**1.44**
6	329499	323850	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.008	0.82	0.04	0.43
7	329204	323497	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.008	0.79	0.04	0.41
8	329767	322292	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.011	**1.12**	0.06	0.58
9	330183	321803	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.013	**1.34**	0.07	0.70
10	332593	321777	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	0.007	0.67	0.03	0.35
11	330534	324478	Crofts Mill Pasture SSSI	0.02	3.0	15.0	0.018	0.62	0.10	0.64
12	330439	324811	Crofts Mill Pasture SSSI	0.02	3.0	15.0	0.013	0.45	0.07	0.47
13	332862	325694	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	0.013	0.42	0.07	-
14	333748	326674	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	0.007	0.23	0.04	-
15	327687	323481	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.003	0.31	0.02	0.16
16	327714	324037	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.003	0.31	0.02	0.16
17	327139	322505	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.002	0.23	0.02	0.12
18	326856	323043	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.002	0.20	0.02	0.11
19	326327	322331	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.002	0.17	0.01	0.09
20	327030	322012	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.002	0.23	0.02	0.12
21	326482	321602	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	0.002	0.19	0.01	0.10
22	327559	325041	Sweeney Fen SSSI	0.02	1.0	10.0	0.003	0.27	0.01	0.14
23	326466	323500	Blodwel Marsh SSSI	0.02	3.0	15.0	0.002	0.07	0.01	0.07
24	326620	321040	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.002	0.07	0.02	-
25	325607	320338	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.001	0.05	0.01	-
26	325580	319526	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.001	0.04	0.01	-
27	326383	319070	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.002	0.05	0.01	-
28	326372	317709	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.001	0.05	0.01	-
29	326133	315999	Montgomery Canal SSSI/SAC	0.03	3.0	-	0.001	0.04	0.01	-
30	330214	323962	Morton Pool and Pasture SSSI/Ramsar site	0.02	3.0	10.0	0.020	0.66	0.10	**1.03**
31	329944	323971	Morton Pool and Pasture SSSI/Ramsar site	0.02	3.0	10.0	0.013	0.42	0.07	0.65
32	325072	326494	Trefonen Marshes SSSI	0.02	1.0	10.0	0.001	0.09	0.00	0.05
33	323349	325499	Craig Sychtyn SSSI	0.03	1.0	15.0	0.001	0.06	0.00	0.03
34	324540	317848	Ty-Brith Meadows SSSI	0.02	3.0	10.0	0.001	0.03	0.00	0.04
35	329711	314933	Breidden Hill SSSI	0.03	1.0	5.0	0.001	0.12	0.01	0.19
36	329318	314344	Breidden Hill SSSI	0.03	1.0	5.0	0.001	0.07	0.01	0.11
37	337415	321076	Lin Can Moss SSSI	0.03	1.0	5.0	0.002	0.19	0.01	0.29
38	335126	328219	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	0.004	0.13	0.02	-
39	332121	332760	Fernhill Pastures SSSI	0.02	3.0	15.0	0.002	0.06	0.01	0.06

Table 5. Changes in Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors - (Scenario 5 - Scenario 1)

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	330412	324423	Shropshire Union Canal Field LWS	0.02	1.0	10.0	-0.020	-1.97	-0.10	-1.02
2	330104	324155	Montgomery Canal at Maesbury Marsh LWS	0.02	1.0	10.0	-0.018	-1.84	-0.10	-0.95
3	331104	324950	Montgomery Canal at Maesbury Marsh LWS	0.02	1.0	10.0	-0.019	-1.89	-0.10	-0.98
4	331588	325060	Purple moor-grass & rush pastures PH	0.02	1.0	10.0	-0.021	-2.10	-0.11	-1.09
5	332398	324550	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	-0.040	-4.04	-0.21	-2.10
6	329499	323850	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	-0.011	-1.06	-0.05	-0.55
7	329204	323497	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	-0.007	-0.70	-0.04	-0.36
8	329767	322292	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	-0.011	-1.05	-0.05	-0.55
9	330183	321803	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	-0.013	-1.27	-0.07	-0.66
10	332593	321777	Lowland fens/Upland fens, flushes & swamps PH	0.02	1.0	10.0	-0.009	-0.88	-0.05	-0.46
11	330534	324478	Crofts Mill Pasture SSSI	0.02	3.0	15.0	-0.020	-0.67	-0.10	-0.70
12	330439	324811	Crofts Mill Pasture SSSI	0.02	3.0	15.0	-0.015	-0.49	-0.08	-0.51
13	332862	325694	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	-0.015	-0.50	-0.08	-
14	333748	326674	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	-0.009	-0.29	-0.05	-
15	327687	323481	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	-0.003	-0.26	-0.02	-0.14
16	327714	324037	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	-0.004	-0.38	-0.03	-0.20
17	327139	322505	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	-0.002	-0.17	-0.01	-0.09
18	326856	323043	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	-0.002	-0.16	-0.01	-0.08
19	326327	322331	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	-0.001	-0.13	-0.01	-0.07
20	327030	322012	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	-0.002	-0.18	-0.01	-0.10
21	326482	321602	Llanymynech and Llynclys Hills SSSI	0.03	1.0	15.0	-0.001	-0.15	-0.01	-0.08
22	327559	325041	Sweeney Fen SSSI	0.02	1.0	10.0	-0.003	-0.32	-0.02	-0.17
23	326466	323500	Blodwel Marsh SSSI	0.02	3.0	15.0	-0.002	-0.06	-0.01	-0.06
24	326620	321040	Montgomery Canal SSSI/SAC	0.03	3.0	-	-0.002	-0.07	-0.02	-
25	325607	320338	Montgomery Canal SSSI/SAC	0.03	3.0	-	-0.001	-0.05	-0.01	-
26	325580	319526	Montgomery Canal SSSI/SAC	0.03	3.0	-	-0.001	-0.05	-0.01	-
27	326383	319070	Montgomery Canal SSSI/SAC	0.03	3.0	-	-0.002	-0.07	-0.02	-
28	326372	317709	Montgomery Canal SSSI/SAC	0.03	3.0	-	-0.002	-0.06	-0.01	-
29	326133	315999	Montgomery Canal SSSI/SAC	0.03	3.0	-	-0.001	-0.04	-0.01	-
30	330214	323962	Morton Pool and Pasture SSSI/Ramsar site	0.02	3.0	10.0	-0.022	-0.73	-0.11	-1.13
31	329944	323971	Morton Pool and Pasture SSSI/Ramsar site	0.02	3.0	10.0	-0.015	-0.51	-0.08	-0.80
32	325072	326494	Trefonen Marshes SSSI	0.02	1.0	10.0	-0.001	-0.12	-0.01	-0.06
33	323349	325499	Craig Sychtyn SSSI	0.03	1.0	15.0	-0.001	-0.09	-0.01	-0.05
34	324540	317848	Ty-Brith Meadows SSSI	0.02	3.0	10.0	-0.001	-0.04	-0.01	-0.06
35	329711	314933	Breidden Hill SSSI	0.03	1.0	5.0	-0.001	-0.14	-0.01	-0.22
36	329318	314344	Breidden Hill SSSI	0.03	1.0	5.0	-0.001	-0.07	-0.01	-0.11
37	337415	321076	Lin Can Moss SSSI	0.03	1.0	5.0	-0.002	-0.23	-0.02	-0.35
38	335126	328219	Montgomery Canal, Aston Locks - Keeper's Bridge SSSI	0.02	3.0	-	-0.005	-0.18	-0.03	-
39	332121	332760	Fernhill Pastures SSSI	0.02	3.0	15.0	-0.003	-0.09	-0.01	-0.09

Figure 6a. Maximum annual ammonia concentration - Scenario 1 (Existing Scenario)

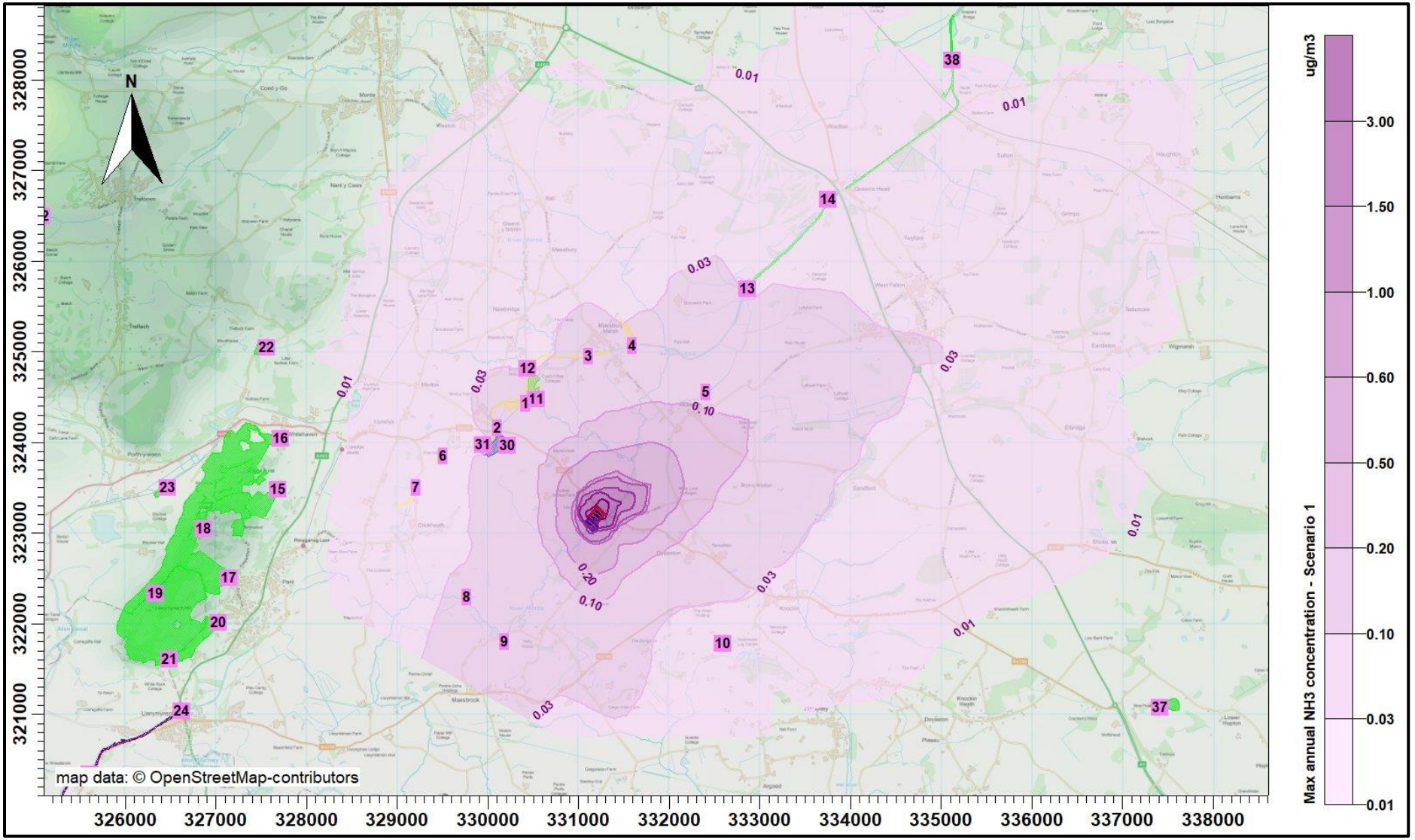


Figure 6b. Maximum annual nitrogen deposition rates - Scenario 1 (Existing Scenario)

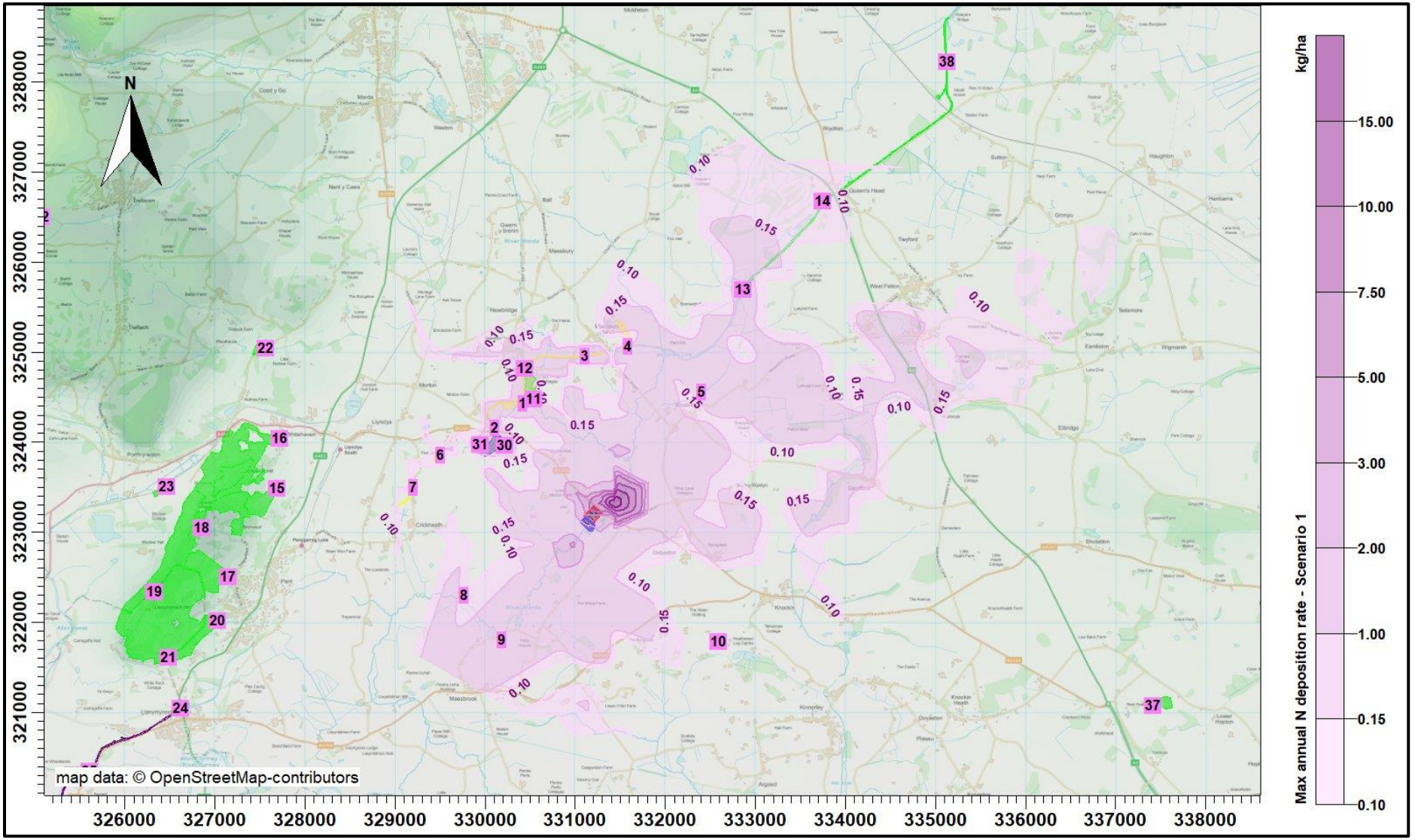


Figure 7a. Maximum annual ammonia concentration - Scenario 5 (Proposed Scenario)

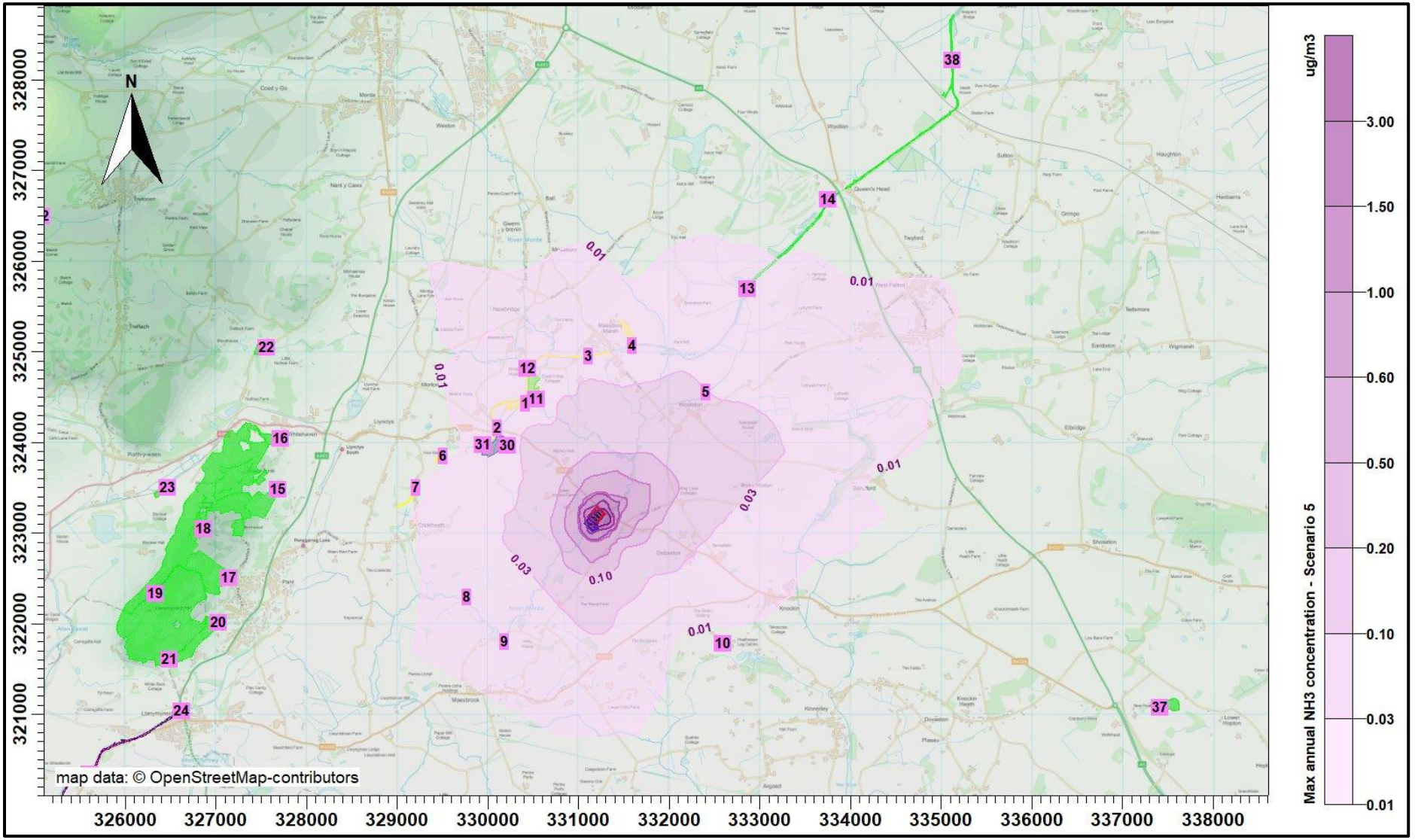
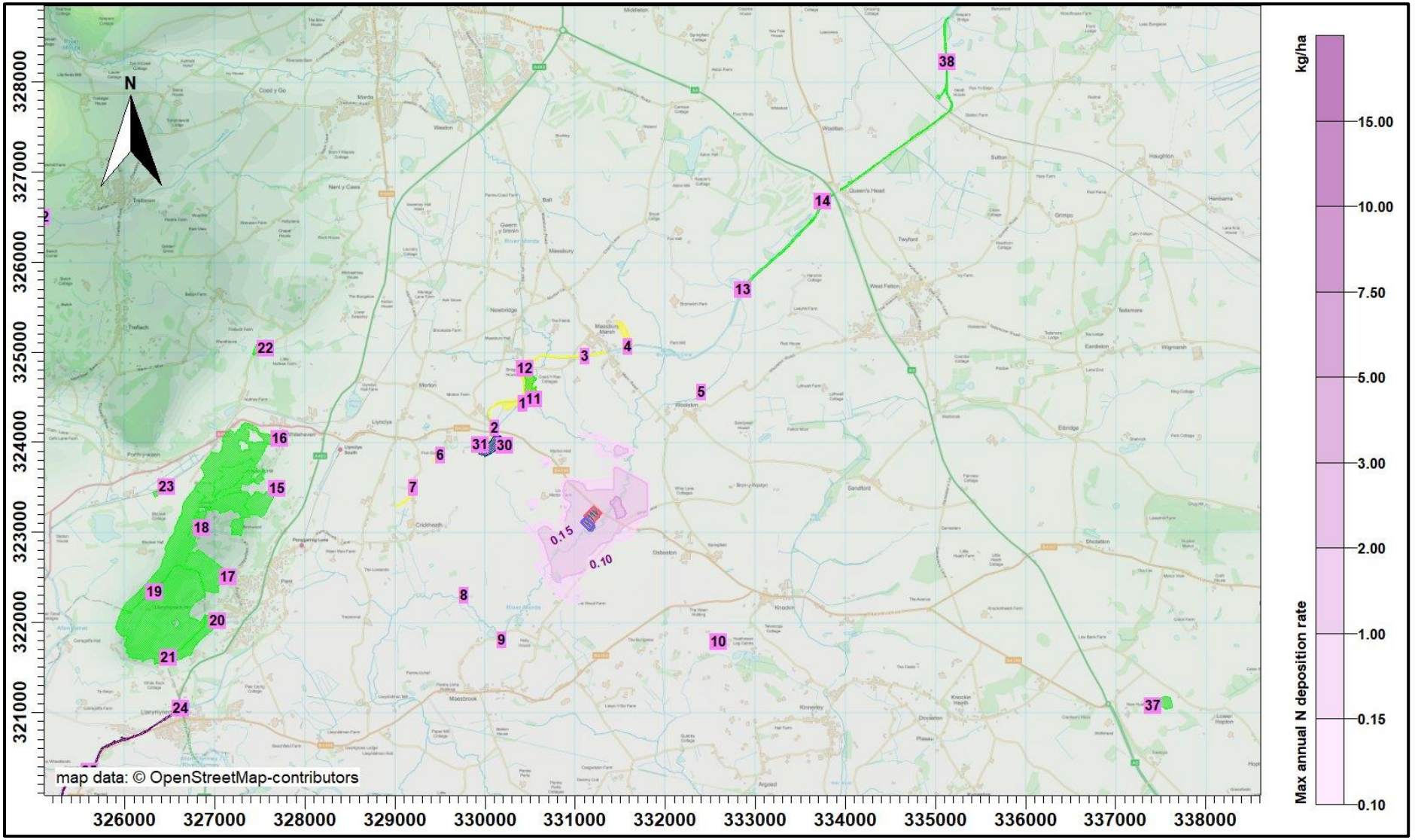


Figure 7b. Maximum annual nitrogen deposition rates - Scenario 5 (Proposed Scenario)



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Rosina Bloor of Roger Parry & Partners LLP., on behalf of Morton Growers Ltd., to use computer modelling to assess the impact of ammonia emissions from the existing and proposed broiler chicken rearing houses at Morton Ley Farm, near Osbaston, Oswestry. SY10 8BG.

Ammonia emission rates from the poultry houses have been assessed and quantified based upon the Environment Agency's standard ammonia emission factors and also upon an emissions model that estimates emissions from the Pollo Compact Air Scrubber ammonia scrubbing equipment that would be fitted to the existing and proposed poultry houses. The ammonia emission rates have then been used as inputs to an atmospheric dispersion and deposition model which calculates ammonia exposure levels and nitrogen and acid deposition rates in the surrounding area.

The detailed modelling of emissions from the scrubbers in the Proposed Scenario (Scenario 5), assuming the scrubber is 100% operational, predicts that:

- At all statutory wildlife sites, the process contribution to annual mean ammonia concentrations and nitrogen deposition rates would be below 1% of the relevant Critical Level/Load for the site, with the exception of a small area of Morton Pool and Pasture SSSI/Ramsar Site, where concentrations would be below 1% of the Critical Level of 3.0 µg-$NH_3/m^3/y$ but deposition rates would exceed 1% by a small margin of the Critical Load of 10.0 kg-N/ha/y; however, this is reduced from the existing scenario.

- Several nearby non-statutory sites would continue to exceed 1% of the precautionary Critical Level of 1.0 $NH_3/m^3/y$ by a small margin; however, in all cases the exceedances are reduced from the existing scenario.

- At all wildlife sites considered, the process contribution to annual mean ammonia concentrations and nitrogen deposition rates would be reduced from the existing scenario.

- The predicted changes in ammonia concentration and nitrogen deposition rate at all wildlife sites are negative. That is, changes are neutral or better and also below the JNCC *de minimus* thresholds.

7. References

Cambridge Environmental Research Consultants (CERC) (website).

Chapman, C. and Kite, B. JNCC Report No. 696. Guidance on Decision-making Thresholds for Air Pollution.

Environment Agency H1 Risk Assessment (website).

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