A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Existing and Proposed Pig Rearing Houses at New House Farm, Chester Road, near Chetwynd in Telford and Wrekin

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Mr. Ian Pick of Ian Pick Associates Ltd., on behalf of M. E. Furniss and Sons, to use computer modelling to assess the impact of ammonia emissions from the existing and proposed pig rearing houses at New House Farm, Chester Road, Chetwynd, Newport. TF10 8BN.

Ammonia emission rates from the existing and proposed pig rearing buildings have been assessed and quantified based upon figures obtained from the Inventory of Ammonia Emissions from UK Agriculture (Misselbrook & Gilhespy) and from the Environment Agency's standard emission factors and BAT/AEL emission factors. The ammonia emission rates have then been used as inputs to an atmospheric dispersion and deposition model which calculates ammonia exposure levels and nitrogen and acid deposition rates in the surrounding area.

This report is arranged in the following manner:

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

2. Background Details

The piggery at New House Farm is in a rural area approximately 650 m to the west of the village of Chetwynd in Telford and Wrekin. The surrounding land is predominantly used for arable farming, but there are some improved grasslands and wooded areas. The site is set in a gently rolling landscape at an elevation of around 74 m.

The existing piggeries at New House Farm provide accommodation for up to 5,550 pigs, of which 450 are breeding sows (and their piglets) and 5,100 are weaner, grower and finisher pigs. The pigs are housed in a variety of buildings which are ventilated either naturally, or using side mounted fans and have solid floors with straw bedding, or slatted floors. Manure from the straw based houses is stored in two middens and slurry from the slatted floor houses is stored in a circular storage tank.

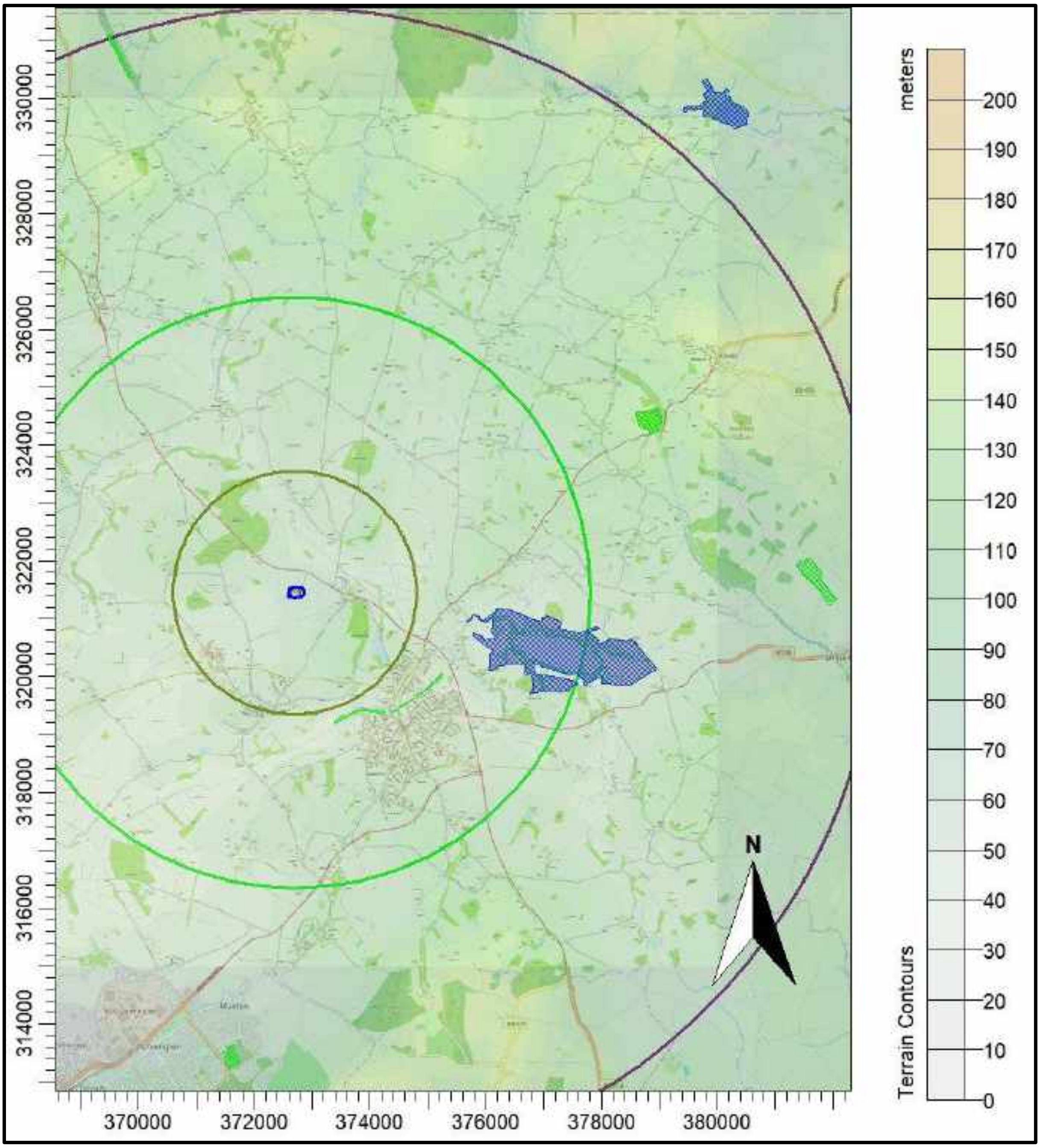
It is proposed that the existing piggeries are entirely decommissioned and several of the existing buildings demolished to make way for three new state of the art pig rearing houses. The three new pig houses would provide accommodation for up to 6,000 finisher pigs which would be reared from a weight of around 40 kg to a weight of around 110 kg. The pigs would be housed on a fully slatted floor system, with slurry temporarily stored beneath the houses, prior to vacuum transfer to the slurry storage tank. The houses would be ventilated by uncapped high speed ridge mounted fans, each with a short chimney.

There are no Ancient Woodland (AW) nor any Local Wildlife Site (LWS), within 2 km of New House Farm. There are six Sites of Special Scientific Interest (SSSIs) within 10 km; one of which is also designated as a Ramsar site. Some further details of the SSSIs/Ramsar site are provided below:

- Aqualate mere SSSI/Ramsar - Approximately 2.9 km to the east-south-east - The mere and its surrounds form a complex of open water, fen, grassland and woodland unrivalled in Staffordshire for the variety of natural features of special scientific interest.
- Newport Canal SSSI - Approximately 2.2 km to the south-east - A length of about 2 km of disused canal which is one of the best localities for aquatic plants in Shropshire. There is a range of submerged and broad-leaved plant communities, a continuous narrow fringe of marginal swamp and, in some places, more extensive areas of fen.
- Loynton Moss SSSI - Approximately 6.4 km to the north-east - A largely wooded basin mire on the site of a former mere occupying a glacial kettle hole. There is a range of successional woodland and scrub communities and mixed tall fen on nutrient-rich peat, a situation unique in Staffordshire.
- Doley Common SSSI - Approximately 8.4 km to the east - A low-lying, agriculturally-unimproved pasture in the flood plain of the Doley Brook. The major interest is a nationally rare and threatened acidic marshy grassland community, which is extremely scarce in Staffordshire.
- Muxton Marsh SSSI - Approximately 7.8 km to the south - Part of a complex of habitats which have developed in an area left semi-derelict by past coal-mining. Impeded drainage caused by spoil dumping has contributed to the formation of wetland habitats here. Reclamation of derelict sites has greatly reduced the area of semi-natural vegetation in this part of Shropshire and this site is the best remaining example of unimproved grassland, fen and carr. The site also includes an area of woodland.
- Tyrley Canal Cutting SSSI - Approximately 9.2 km to the north-north-west - Designated for geological features.

A map of the surrounding area showing the positions of the piggeries at New House Farm and the SSSIs/Ramsar site is provided in Figure 1. In the figure, the SSSIs are shaded in green the SSSI/Ramsar site is shaded in blue and New House Farm is outlined in blue.

Figure 1. The area surrounding New House Farm - concentric circles radii 2 km (olive), 5 km (green) and 10 km (purple)



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 New House Farm and the wildlife sites is 4.19 $\mu g\text{-}NH_3/m^3$. The background nitrogen deposition rate to woodland is 51.52 kg-N/ha/y and to short vegetation is 29.12 kg-N/ha/y. The background acid deposition rate to woodland is 3.71 keq/ha/y and to short vegetation is 2.10 keq/ha/y. The source of these background figures is the Air Pollution Information System (APIS, April 2021).

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 and for sites where there are sensitive lichens and bryophytes present, or 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 µg-NH_3/m^3 is assumed, it is usually unnecessary to consider the Critical Load as the Critical Level provides the stricter test. Normally, the Critical Load for nitrogen deposition provides a stricter test than the Critical Load for acid deposition.

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

Site	Critical Level (µg-NH_3/m^3)	Critical Load Nitrogen Deposition (kg-N/ha/y)	Critical Load Acid Deposition (keq/ha/y)
Aqualate Mere SSSI/Ramsar and Loynton Moss SSSI	1.0 [1 & 3]	10.0 [2]	-
Newport Canal SSSI	3.0 [3]	n/a	n/a
Ducan's Marsh, Claxton SSSI/SAC	1.0 [1 & 3]	15.0 [2]	-
Doley Common SSSI	3.0 [3]	15.0 [2]	-
Muxton Marsh SSSI	3.0 [3]	20.0 [2]	-
Tyrley Canal Cutting SSSI	n/a [4]	n/a [4]	n/a [4]

1. Used as a precautionary figure where details of the site ecology are unavailable, or where sensitive lichens and bryophytes are present.
2. The lower bound of the range of Critical Load (APIS March 2021).
3. Based upon the citation for the site and information from APIS (March 2021).
4. Site designated for geological features.

3.4 Guidance on the significance of ammonia emissions

3.4.1 Environment Agency Criteria

The Environment Agency web-page titled “Intensive farming risk assessment for your environmental permit”, contains a set of criteria, with thresholds defined by percentages of the Critical Level or Critical Load, for: internationally designated wildlife sites (Special Protection Areas (SPAs), Special Areas of Conservation (SACs) and Ramsar sites; Sites of Special Scientific Interest (SSSIs) and other non-statutory wildlife sites. The lower and upper thresholds are: 4% and 20% for SACs, SPAs and Ramsar sites; 20% and 50% for SSSIs and 100% and 100% for non-statutory wildlife sites.

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

If the predicted process contributions to Critical Level or Critical Load are in the range between the lower and upper thresholds; 4% to 20% for SACs, SPAs and Ramsar sites; 20% to 50% for SSSIs and 100% to 100% for other non-statutory wildlife sites, whether or not the impact is deemed acceptable is at the discretion of the Environment Agency. In making their decision, the Environment Agency will consider whether other farming installations might act in-combination with the farm and the sensitivities of the wildlife sites. In the case of LWSs and AWs, the Environment Agency do not usually consider other farms that may act in-combination and therefore a PC of up to 100% of Critical Level or Critical Load is usually deemed acceptable for permitting purposes and therefore the upper and lower thresholds are the same (100%).

3.4.2 Natural England advisory 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.

Note that a process contribution of 1% of Critical Level or Critical Load would normally be considered insignificant. A process contribution that is above 1% of Critical Level or Critical Load should be regarded as potentially significant; however, 1% of Critical Level or Critical Load should not be used as a threshold above which damage is implied.

Recent advice from Natural England[2] states that "At the screening assessment stage for agricultural proposals acting alone the threshold is 4% for both SSSI and N2K sites" and "At the detailed assessment stage where there is an in-combination assessment, the threshold for agricultural proposals is 20% for N2K sites and 50% for SSSIs".

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.
2. Hack, Richard M. "NE guideline screening thresholds for air pollution". Message to Nicola Stone, cc Ian Pick. 2nd October 2020. E-mail.

3.5 Quantification of ammonia emissions

Ammonia emission rates from piggeries 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 ammonia emission factors used for the existing weaner/grower/finisher pigs have been assessed and quantified based upon the figure of 63 g-N/lu/d [1] for grower/finisher pigs on straw obtained the Inventory of Ammonia Emissions from UK Agriculture (Misselbrook & Gilhespy) and industry standard pig growth rates. It should be noted that the Inventory of Ammonia Emissions from UK Agriculture figure for weaner pigs is considerably lower (28 g-N/lu/d); therefore, the ammonia emission factors calculated are probably slightly precautionary in this respect.

Emission rates for the existing sow pigs, the proposed finisher pigs and the manure and slurry storage are based upon the Environment Agency's standard emission factors and BAT/AEL emission factors

1. One Livestock-unit (lu) is 500 kg.

Details of the pig numbers and types and emission factors and calculated ammonia emission rates are provided in Table 2.

Table 2. Details of pig numbers and ammonia emission rates

Source	Pigs	Weight/Type	Ventilation	Flooring	Emission factor (kg-NH_3/pig-place/y)	Emission factor Source	Emission Rate (g-NH_3/s)
EX1	1,890	45-105	Natural	Slatted	5.01	UKAEI	0.300051
EX2	1,240	7-20	Side Fans	Slatted	0.78	UKAEI	0.030649
EX3	1,600	20-45	Side Fans	Solid Floor	2.31	UKAEI	0.117119
EX4	330	Sows	Natural	Straw	5.2	EA/BAT/AEL	0.054377
EX5	39	Sows	Natural	Slatted	4.0	EA/BAT/AEL	0.004943
EX6&7	58	Sows	Natural	Slatted	4.0	EA/BAT/AEL	0.007352
EX8	23	Sows	Natural	Slatted	4.0	EA/BAT/AEL	0.002915
EX9	190	45-105	Natural	Straw	4.42	UKAEI	0.026612
EX10	180	45-105	Natural	Straw	4.42	UKAEI	0.025211
EX11	0	Mill					0.000000
PR1	2,000	40-110	Ridge Fans	Slatted	2.6	EA/BAT/AEL	0.164778
PR2	2,000	40-110	Ridge Fans	Slatted	2.6	EA/BAT/AEL	0.164778
PR3	2,000	40-110	Ridge Fans	Slatted	2.6	EA/BAT/AEL	0.164778
	Area	Tonnes			Emission factor (kg-NH_3/t or m^2/y)		Emission Rate (g-NH_3/s)
MAN1		500			1.49	EA	0.023608
MAN2		100			1.49	EA	0.004722
TANK1	380.1				1.4	EA	0.016864

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 including: 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).

The GFS is a spectral model: the physics/dynamics model has an equivalent resolution of approximately 13 km (latterly 9 km); terrain is understood to be resolved at a resolution of approximately 2 km (with sub-13 km terrain effects parameterised) and data are archived at a resolution of 0.25 degrees. 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 [1]). The use of NWP data has advantages over traditional observational 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, wind speeds and directions will be modified. The terrain and roughness length modified wind rose for New House Farm is shown in Figure 2b. Note that elsewhere in the modelling domain the modified wind roses may differ more markedly and that the resolution of the wind field in terrain runs is approximately 340 m. Please also note that FLOWSTAR 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[2].

1. Note that FLOWSAR 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).

2. 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 point sources emissions, may cause over prediction of ground level concentrations in stable weather conditions and light winds (Steven R. Hanna & Biswanath Chowdhury, 2013). 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. GFS derived data for 52.790 N, 2.405 W, 2017 - 2020

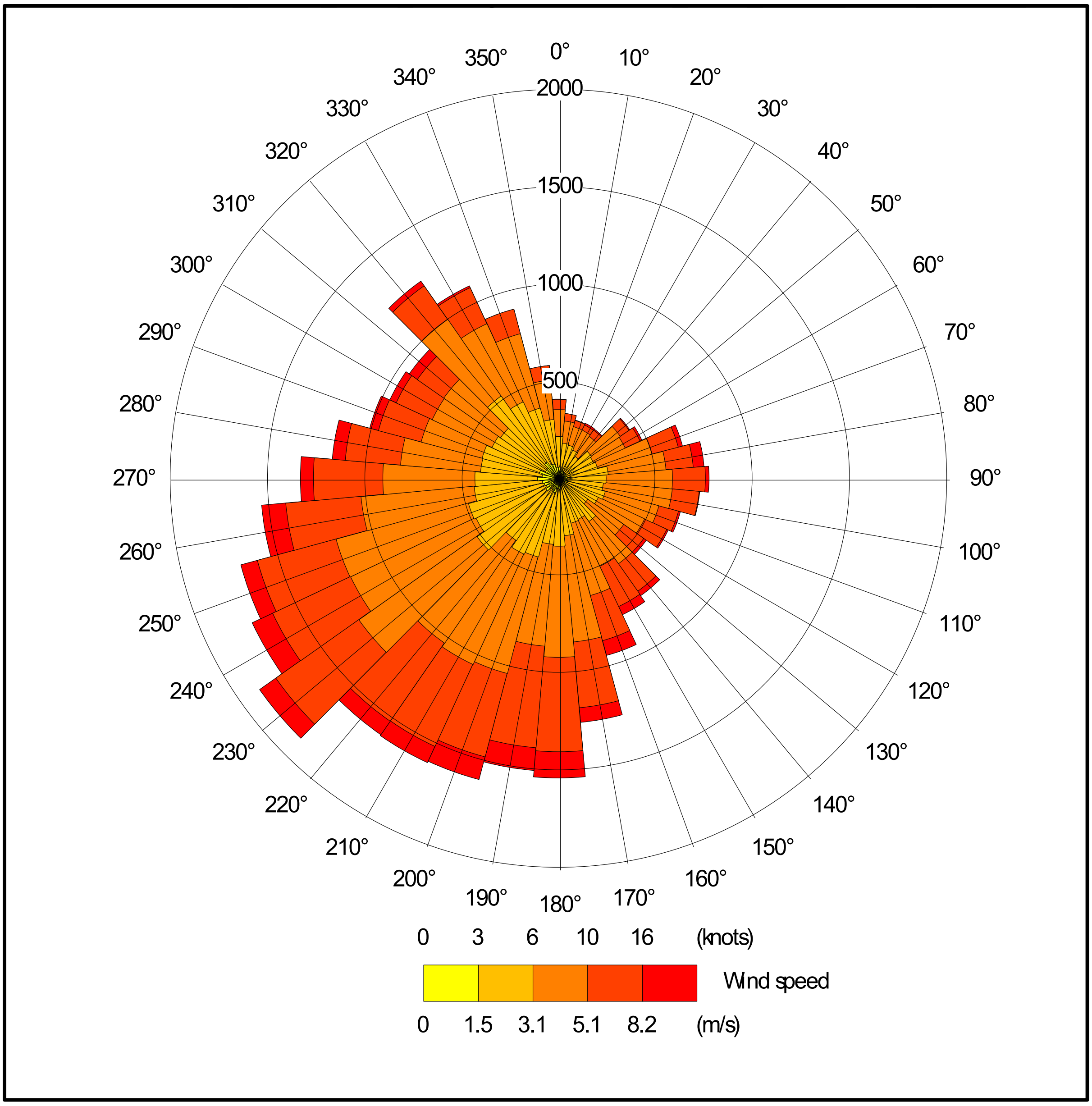
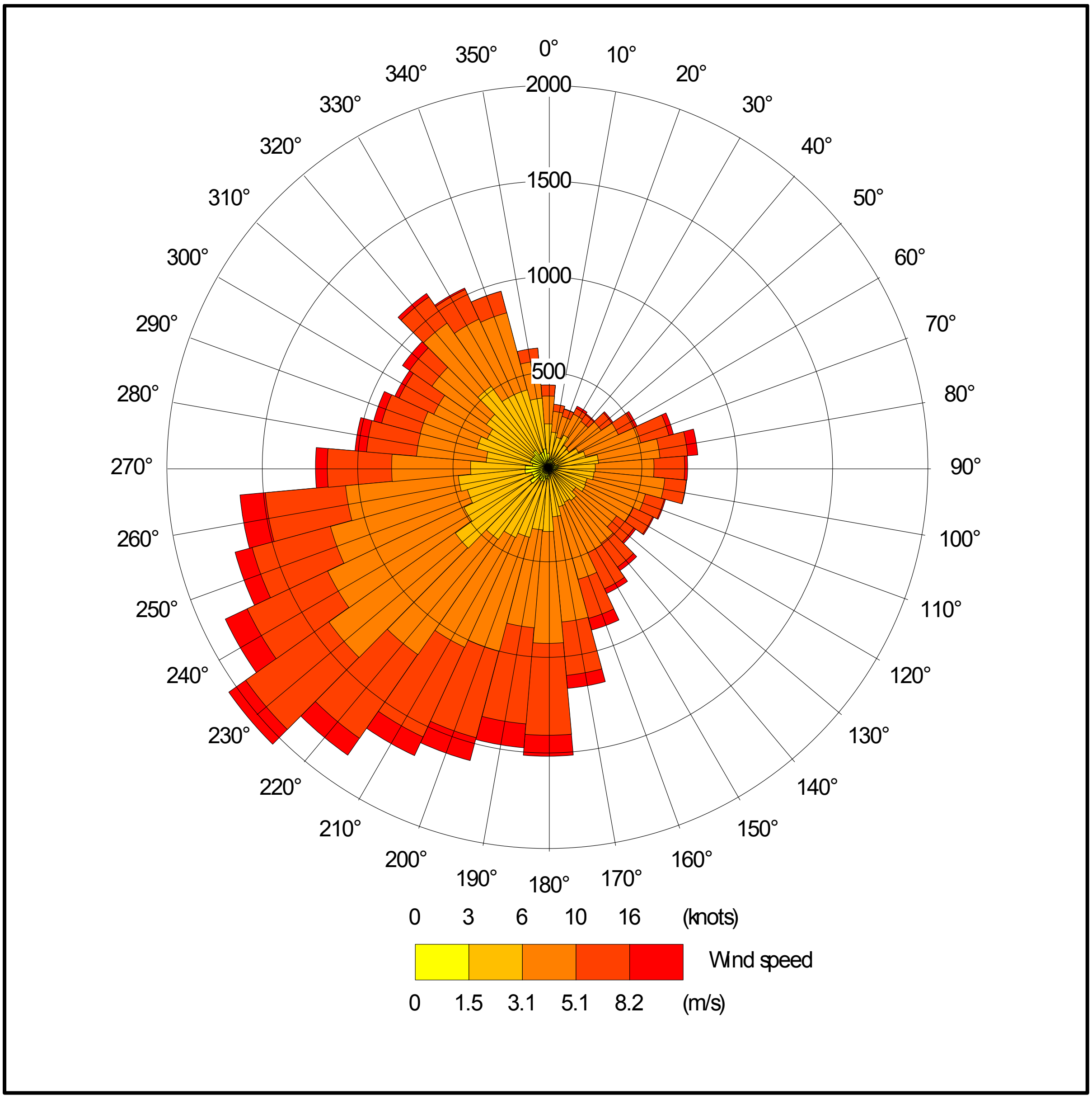


Figure 2b. The wind rose for New House Farm NGR 372700, 321450, derived from FLOWSTAR output



4.2 Emission sources

Emissions from the existing pig housing, manure storage areas and the slurry storage tank, are represented by volume sources within ADMS (EX1, EX2, EX3, EX4, EX5, EX6&7, EX8, EX9, EX10, EX11 and MAN1, MAN2 and TANK1).

Emissions from the chimneys of the uncapped high speed fans that would be used for the ventilation of the proposed pig houses are represented by three point sources per house within ADMS (PR1 1, 2 & 3, PR2 1, 2 & 3 and PR3 1, 2 & 3).

Details of the volume and point source parameters are shown in Tables 2a and 2b. The positions of the volume sources (red shaded rectangles) and point sources (green circles) used may be seen in Figures 3a and 3b.

Table 2a. Volume source parameters

Source ID (Scenario)	Length (m)	Width (m)	Depth (m)	Base height (m)	Emission temperature (°C)	Emission rate ($g\text{-}NH_3/s$)
EX1 (Existing)	31.3	96.0	3.0	1.0	Ambient	0.300051
EX2 (Existing)	31.3	6.7	3.0	1.0	Ambient	0.030649
EX3 (Existing)	45.6	23.1	3.0	1.0	Ambient	0.117119
EX4 (Existing)	50.3	41.3	3.0	1.0	Ambient	0.054377
EX5 (Existing)	17.1	20.2	3.0	1.0	Ambient	0.004943
EX6&7 (Existing)	32.8	34.1	3.0	1.0	Ambient	0.007352
EX8 (Existing)	11.8	31.1	3.0	1.0	Ambient	0.002915
EX9 (Existing)	17.7	35.9	3.0	1.0	Ambient	0.026612
EX10 (Existing)	11.7	31.3	3.0	1.0	Ambient	0.025211
EX11 (Existing)	11.9	31.6	3.0	1.0	Ambient	0.000000
MAN1 (Existing)	10.0	50.0	3.0	0.0	Ambient	0.023608
MAN2 (Existing)	10.7	11.4	3.0	0.0	Ambient	0.004722
TANK1 (Existing & Proposed)	22.0	22.0	2.0	4.0	Ambient	0.016864

Table 2b. Point source parameters

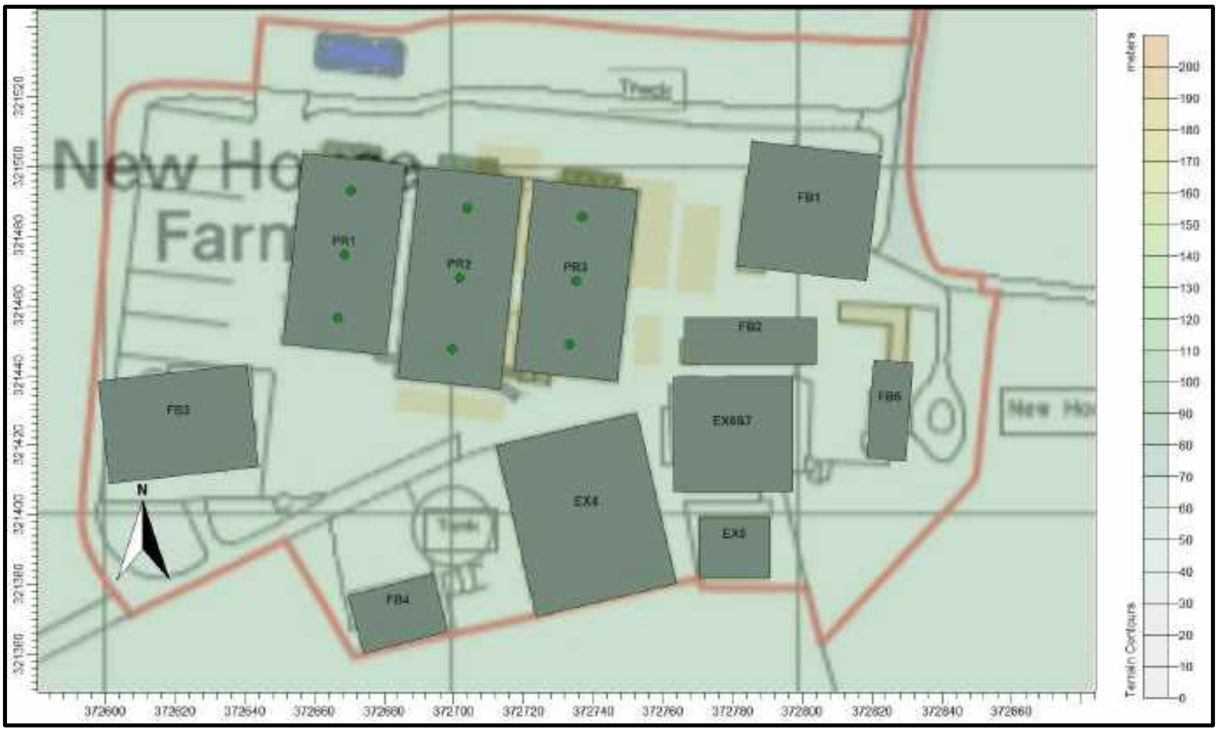
Source ID (Scenario)	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (˚C)	Emission rate per source ($g\text{-}NH_3/s$)
PR1 1, 2 & 3 (Proposed)	9.0	0.8	11.0	21.0	0.054926
PR2 1, 2 & 3 (Proposed)	9.0	0.8	11.0	21.0	0.054926
PR3 1, 2 & 3 (Proposed)	9.0	0.8	11.0	21.0	0.054926

4.3 Modelled buildings

The structure of the proposed pig houses and other nearby buildings may affect the odour plumes from the point sources therefore, the buildings are modelled within ADMS. The positions of the modelled buildings (grey rectangles) may be seen in Figure 3b.

Figure 3a. The positions of the modelled volume sources

Figure 3b. The positions of the modelled buildings and point sources



4.4 Discrete receptors

Forty-four discrete receptors have been defined at the AWs, the LWS and the SSSI/SACs/SPA/Ramsar sites. These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figure 4, 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 field, a regular Cartesian grid has been defined within ADMS. The individual grid receptors are defined at ground level within ADMS. The position of the Cartesian grid may be seen in Figure 4, where it is marked by grey lines.

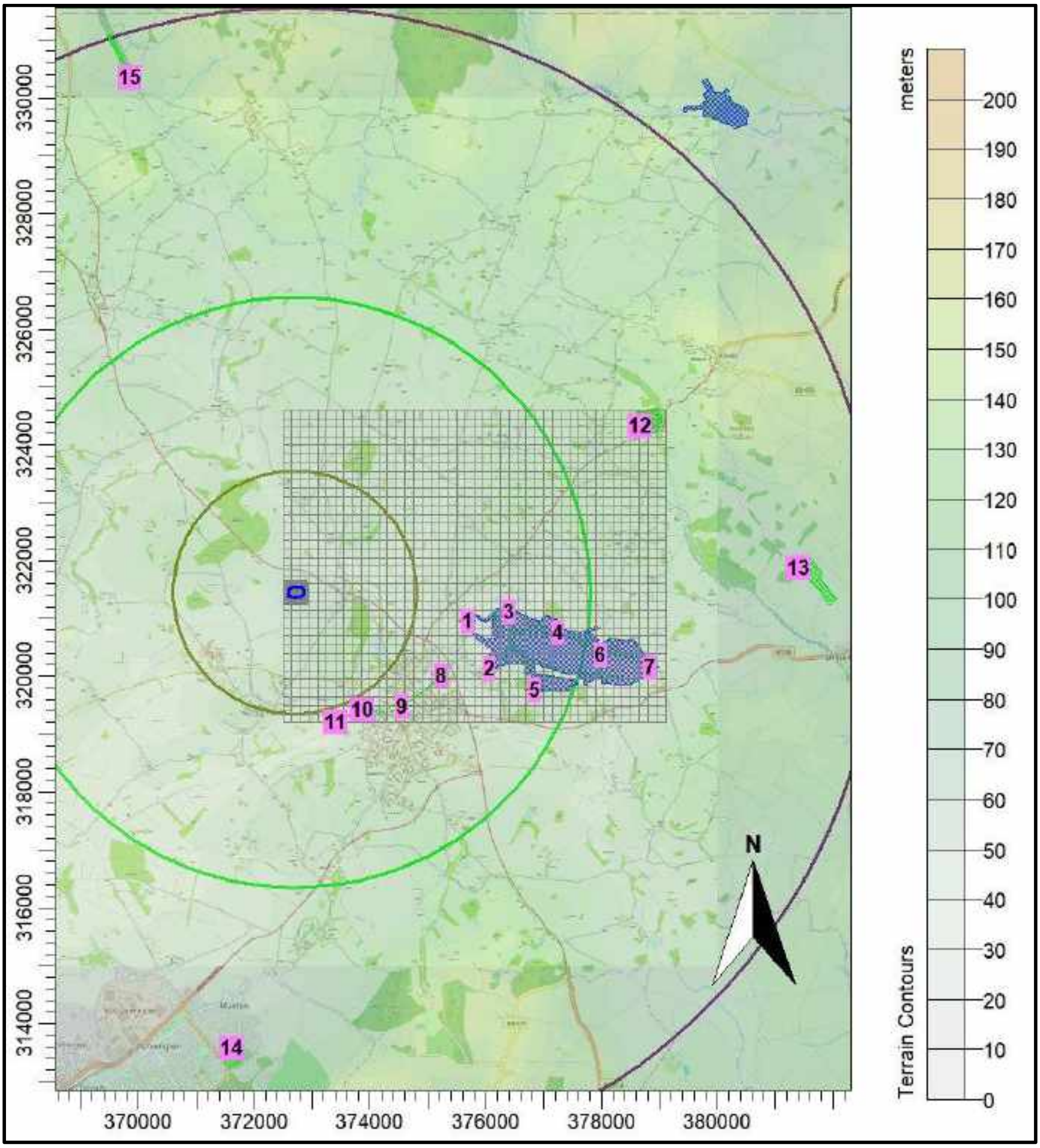
4.6 Terrain data

Terrain has been considered in the modelling. The terrain data are based upon the Ordnance Survey 50 m Digital Elevation Model. A 20 km x 20 km domain has been resampled at 200 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 for the terrain runs is approximately 300 m.

4.7 Roughness Length

A fixed surface roughness length of 0.225 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 0.20 m. The effect of the difference in roughness length is precautionary as it increases the frequency of low wind speeds and the stability and therefore increases predicted ground level concentrations.

Figure 4. The discrete receptors and regular Cartesian grid



4.8 Deposition

The method used to model deposition of ammonia and consequent plume depletion is based primarily upon Frederik Schrader and Christian Brümmer. Land Use Specific Ammonia Deposition Velocities: a Review of Recent Studies (2004–2013). AS Modelling & Data Ltd. has restricted deposition over arable farmland and heavily grazed and fertilised pasture; this is to compensate for possible saturation effects due to fertilizer application and to allow for periods when fields are clear of crops (Sutton), the deposition is also restricted over areas with little or no vegetation and the deposition velocity is set to 0.002 m/s where grid points are over the poultry housing and 0.010 m/s to 0.015 m/s over heavily grazed grassland. Where deposition over water surfaces is calculated, a deposition velocity of 0.005 m/s is used. In summary the method is as follows:

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

Table 4. Deposition velocities

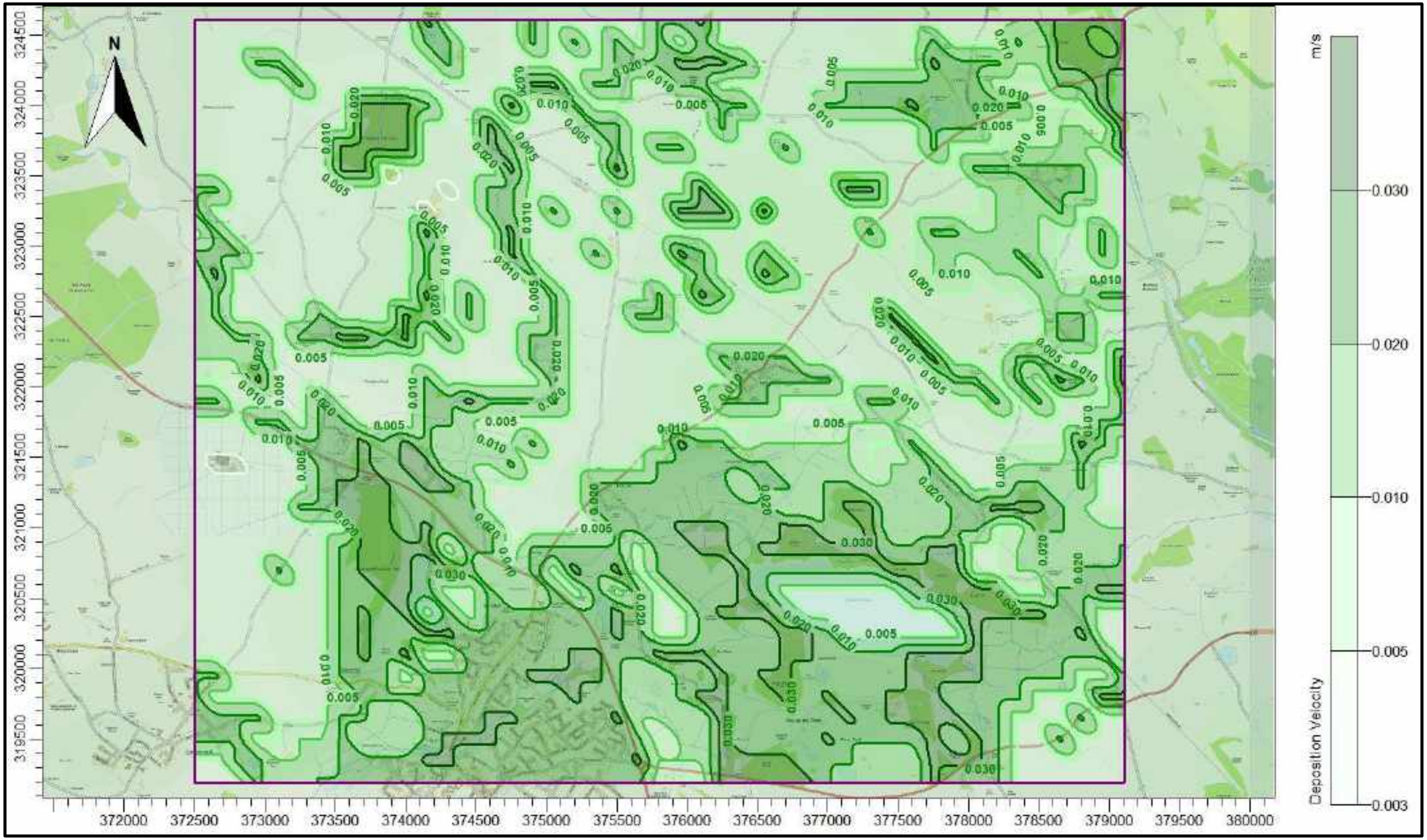
NH_3 concentration (PC + background) ($\mu g/m^3$)	< 10	10 - 20	20 - 30	30 – 80	> 80
Deposition velocity – woodland (m/s)	0.03	0.015	0.01	0.005	0.003
Deposition velocity – short vegetation (m/s)	0.02 (0.010 to 0.015 over heavily grazed grassland)	0.015	0.01	0.005	0.003
Deposition velocity – arable farmland/rye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

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

A contour plot of the spatially varying deposition field is provided in Figure 5.

Please note that, 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 5. 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 sixteen times, once for each year in the meteorological record, in the following four modes:

- In basic mode without calms, or terrain – GFS data.
- With calms and without terrain – GFS data.
- Without calms and with terrain – GFS data.
- Without calms, with terrain and fixed deposition at 0.003 m/s – GFS data.

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

Details of the predicted annual mean ammonia concentrations at each receptor are provided in Table 5. In the Table, predicted ammonia concentrations (or concentrations equivalent to deposition rates) that are in excess of the Environment Agency's upper threshold (20% of Critical Level/Load for a Ramsar Site and 50% of Critical Level/Load for a) are coloured red. Concentrations in the range between the Environment Agency's lower and upper thresholds (4% and 20% for a Ramsar Site and 20% and 50% for a SSSI) are coloured blue. Additionally, concentrations (or concentrations equivalent to deposition rates) that are in excess of 1% of the Critical Level and/or Critical Load at a statutory wildlife site are highlighted with bold text.

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

Receptor number	X(m)	Y(m)	Designation	Maximum annual mean ammonia concentration - (µg/m³)				Maximum annual mean ammonia concentration - (µg/m³)			
				Existing				Proposed			
				GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS Calms Correction Terrain Fixed depo. 0.003 m/s	GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS No Calms Terrain Fixed depo. 0.003 m/s
1	375688	320969	Aqualate Mere SSSI/Ramsar	**0.255**	**0.274**	**0.260**	**0.135**	**0.081**	**0.081**	**0.078**	**0.055**
2	376062	320142	Aqualate Mere SSSI/Ramsar	**0.190**	**0.205**	**0.200**	**0.098**	**0.063**	**0.063**	**0.063**	**0.041**
3	376401	321117	Aqualate Mere SSSI/Ramsar	**0.179**	**0.192**	**0.181**	**0.093**	**0.064**	**0.063**	**0.061**	**0.042**
4	377253	320768	Aqualate Mere SSSI/Ramsar	**0.127**	**0.136**	**0.135**	**0.066**	**0.048**	**0.048**	**0.047**	**0.031**
5	376849	319768	Aqualate Mere SSSI/Ramsar	**0.132**	**0.143**	**0.140**	**0.066**	**0.048**	**0.048**	**0.047**	**0.030**
6	377972	320374	Aqualate Mere SSSI/Ramsar	**0.099**	**0.106**	**0.108**	**0.050**	**0.039**	**0.039**	**0.038**	**0.024**
7	378838	320162	Aqualate Mere SSSI/Ramsar	**0.077**	**0.083**	**0.087**	**0.039**	**0.033**	**0.033**	**0.032**	**0.019**
8	375223	320019	Newport Canal SSSI	**0.261**	**0.292**	**0.264**	**0.128**	**0.076**	**0.076**	**0.075**	**0.052**
9	374554	319493	Newport Canal SSSI	**0.315**	**0.345**	**0.318**	**0.148**	**0.079**	**0.079**	**0.080**	**0.056**
10	373869	319444	Newport Canal SSSI	**0.379**	**0.421**	**0.387**	**0.206**	**0.107**	**0.106**	**0.113**	**0.077**
11	373411	319220	Newport Canal SSSI	**0.341**	**0.372**	**0.381**	**0.198**	**0.090**	**0.090**	**0.101**	**0.067**
12	378665	324343	Loynton Moss SSSI	**0.064**	**0.071**	**0.062**	**0.032**	**0.033**	**0.033**	**0.033**	**0.020**
13	381401	321891	Doley Common SSSI	**0.043**	**0.047**	**0.043**	0.020	0.021	0.021	0.021	0.012
14	371609	313589	Muxton Marsh SSSI	0.028	**0.034**	0.030	0.011	0.012	0.012	0.011	0.006
15	369859	330368	Tyrley Canal Cutting SSSI	0.021	0.026	0.018	0.009	0.011	0.011	0.009	0.006

5.2 Detailed deposition modelling

The detailed deposition modelling was carried out over a domain covering the site of the existing and proposed pig buildings, Aqualate Mere SSSI/Ramsar, Newport Canal SSSI and Loynton Moss SSSI, where the preliminary modelling indicated that annual mean ammonia concentrations, or concentrations equivalent to nitrogen deposition rates would potentially exceed 1% of the relevant Critical Level and/or Critical Load.

The preliminary modelling suggests that the effect of calms might be significant in the existing scenario. Spatially varying deposition and terrain cannot be modelled in conjunction with the calms module of ADMS. Therefore, the deposition runs were made without calms and with terrain and a correction for calms which is based upon the results of the preliminary modelling was applied to the results for the existing scenario. The model was run four times, once for each year of the meteorological record.

The results of the detailed deposition modelling are shown in Tables 6a (Existing Scenario) and 6b (Proposed Scenario). In the Tables, predicted ammonia concentrations and nitrogen deposition rates that are in excess of the Environment Agency's upper threshold (20% of Critical Level for a Ramsar Site and 50% of Critical Level for a SSSI) are coloured red. Concentrations and deposition rates that are in the range between the Environment Agency's lower and upper thresholds (4% and 20% for a Ramsar Site and 20% and 50% for a SSSI) are coloured blue. Additionally, concentrations (or concentrations equivalent to deposition rates) that are in excess of 1% of the Critical Level and/or Critical Load at a statutory wildlife site are highlighted with bold text.

Contour plots of the predicted maximum annual ammonia concentration and the maximum annual predicted nitrogen deposition rate are shown in Figures 6a and 6b (Existing Scenario) and Figures 7a and 7b (Proposed Scenario).

Table 6a. Annual ammonia concentration and nitrogen deposition rate at the discrete receptors - detailed deposition modelling - Existing Scenario

Receptor number	X(m)	Y(m)	Name	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	375688	320969	Aqualate Mere SSSI/Ramsar	0.03	1.0	10.0	0.068	**6.8**	0.53	**5.3**
2	376062	320142	Aqualate Mere SSSI/Ramsar	0.03	1.0	10.0	0.043	**4.3**	0.34	**3.4**
3	376401	321117	Aqualate Mere SSSI/Ramsar	0.03	1.0	10.0	0.045	**4.5**	0.35	**3.5**
4	377253	320768	Aqualate Mere SSSI/Ramsar	0.03	1.0	10.0	0.030	**3.0**	0.24	**2.4**
5	376849	319768	Aqualate Mere SSSI/Ramsar	0.03	1.0	10.0	0.027	**2.7**	0.21	**2.1**
6	377972	320374	Aqualate Mere SSSI/Ramsar	0.03	1.0	10.0	0.022	**2.2**	0.17	**1.7**
7	378838	320162	Aqualate Mere SSSI/Ramsar	0.03	1.0	10.0	0.017	**1.7**	0.14	**1.4**
8	375223	320019	Newport Canal SSSI	0.03	3.0	n/a	0.060	**2.0**	0.47	-
9	374554	319493	Newport Canal SSSI	0.03	3.0	n/a	0.073	**2.4**	0.57	-
10	373869	319444	Newport Canal SSSI	0.03	3.0	n/a	0.130	**4.3**	1.01	-
11	373411	319220	Newport Canal SSSI	0.03	3.0	n/a	0.133	**4.4**	1.04	-
12	378665	324343	Loynton Moss SSSI	0.03	1.0	10.0	0.019	**1.9**	0.15	**1.5**
13	381401	321891	Doley Common SSSI	0.03	3.0	15.0	0.010	0.3	0.08	0.5
14	371609	313589	Muxton Marsh SSSI	0.03	3.0	20.0	0.007	0.2	0.06	0.3
15	369859	330368	Tyrley Canal Cutting SSSI	0.03	n/a	n/a	0.007	-	0.05	-

Table 6b. Annual ammonia concentration and nitrogen deposition rate at the discrete receptors - detailed deposition modelling - Proposed Scenario

Receptor number	X(m)	Y(m)	Name	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	375688	320969	Aqualate Mere SSSI/Ramsar	0.03	1.0	10.0	0.0402	**4.02**	0.31	**3.1**
2	376062	320142	Aqualate Mere SSSI/Ramsar	0.03	1.0	10.0	0.028	**2.8**	0.22	**2.2**
3	376401	321117	Aqualate Mere SSSI/Ramsar	0.03	1.0	10.0	0.030	**3.0**	0.23	**2.3**
4	377253	320768	Aqualate Mere SSSI/Ramsar	0.03	1.0	10.0	0.021	**2.1**	0.16	**1.6**
5	376849	319768	Aqualate Mere SSSI/Ramsar	0.03	1.0	10.0	0.020	**2.0**	0.15	**1.5**
6	377972	320374	Aqualate Mere SSSI/Ramsar	0.03	1.0	10.0	0.016	**1.6**	0.12	**1.2**
7	378838	320162	Aqualate Mere SSSI/Ramsar	0.03	1.0	10.0	0.012	**1.2**	0.10	1.0
8	375223	320019	Newport Canal SSSI	0.03	3.0	n/a	0.036	**1.2**	0.28	-
9	374554	319493	Newport Canal SSSI	0.03	3.0	n/a	0.039	**1.3**	0.31	-
10	373869	319444	Newport Canal SSSI	0.03	3.0	n/a	0.062	**2.1**	0.48	-
11	373411	319220	Newport Canal SSSI	0.03	3.0	n/a	0.050	**1.7**	0.39	-
12	378665	324343	Loynton Moss SSSI	0.03	1.0	10.0	0.013	**1.3**	0.11	**1.1**
13	381401	321891	Doley Common SSSI	0.03	3.0	15.0	0.008	0.3	0.06	0.4
14	371609	313589	Muxton Marsh SSSI	0.03	3.0	20.0	0.005	0.2	0.04	0.2
15	369859	330368	Tyrley Canal Cutting SSSI	0.03	n/a	n/a	0.005	-	0.04	-

Figure 6a. Maximum annual mean ammonia concentration - Existing Scenario

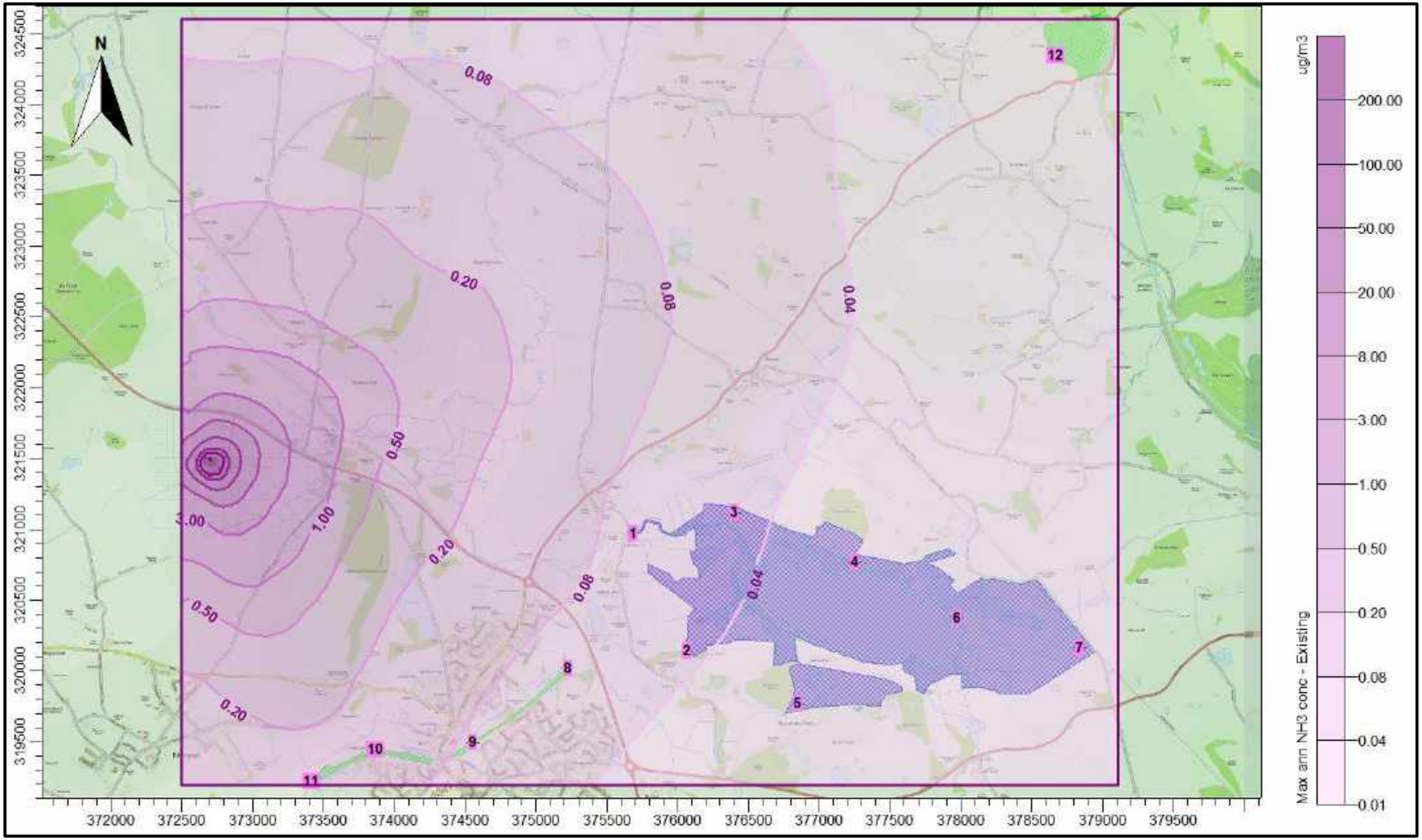


Figure 6b. Maximum annual nitrogen deposition rate - Existing Scenario

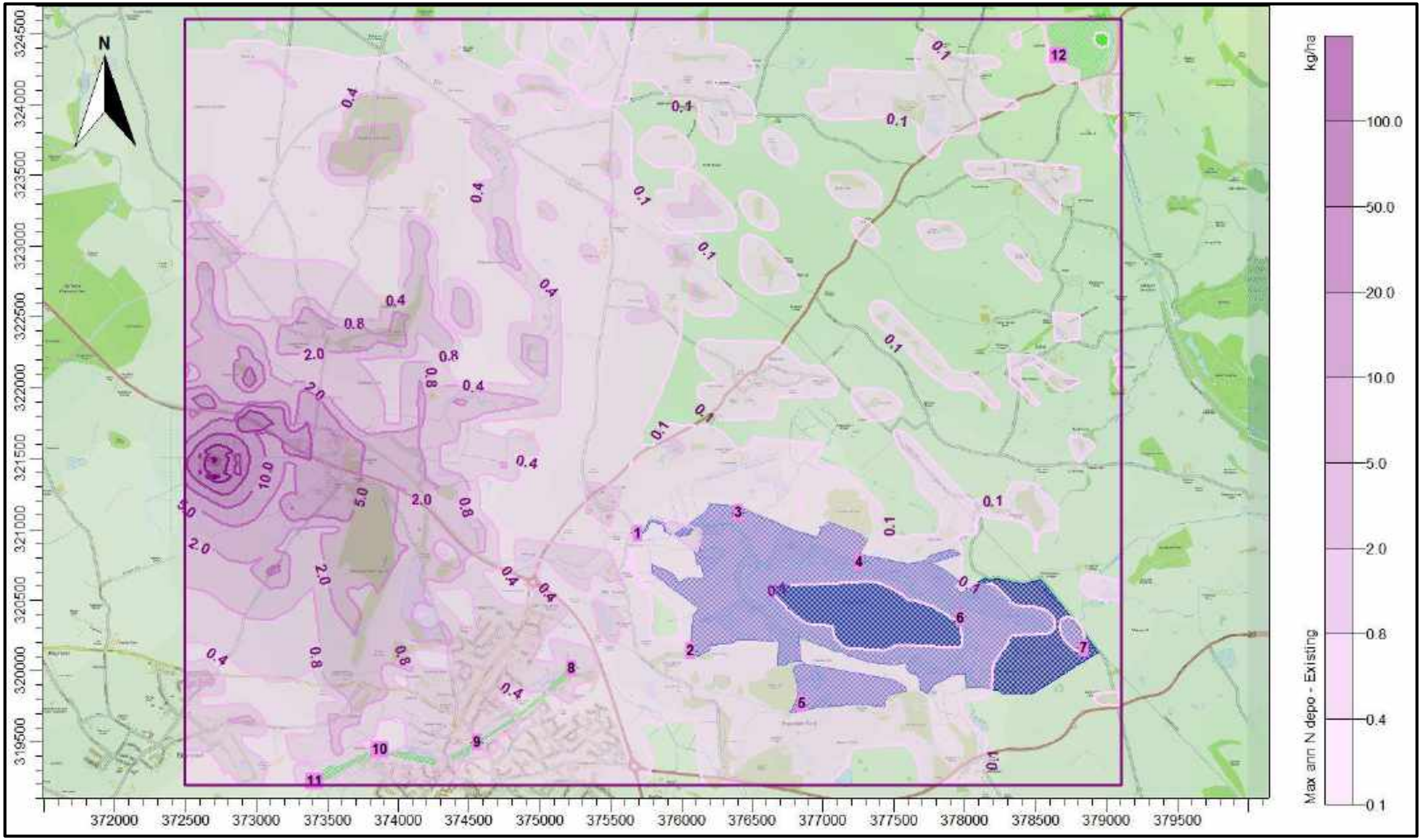


Figure 7a. Maximum annual mean ammonia concentration - Proposed Scenario

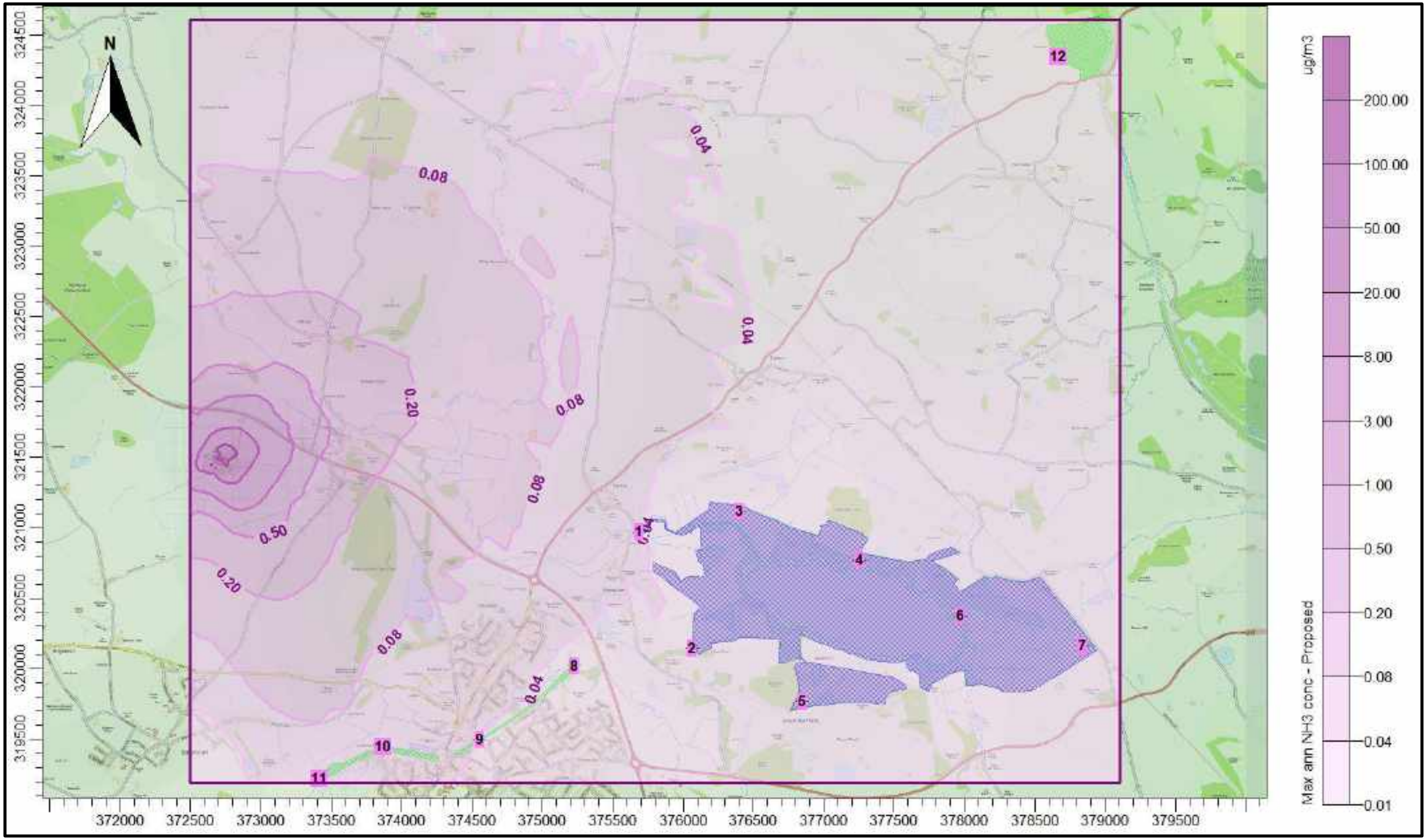
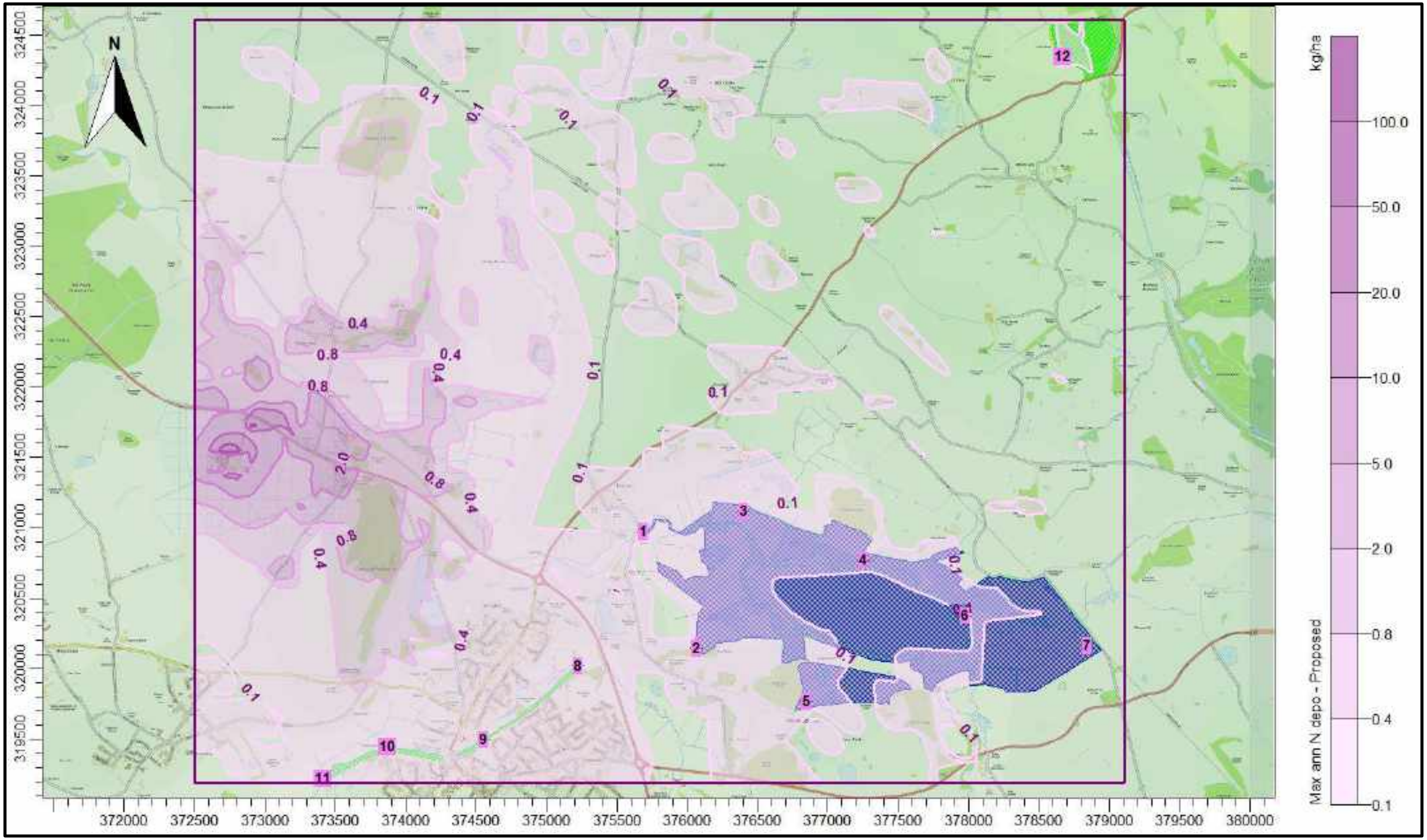


Figure 7b. Maximum annual nitrogen deposition rate - Proposed Scenario



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Mr. Ian Pick of Ian Pick Associates Ltd., on behalf of M. E. Furniss and Sons, to use computer modelling to assess the impact of ammonia emissions from the existing and proposed pig rearing houses at New House Farm, Chester Road, Chetwynd, Newport. TF10 8BN.

Ammonia emission rates from the existing and proposed pig rearing buildings have been assessed and quantified based upon figures obtained the Inventory of Ammonia Emissions from UK Agriculture (Misselbrook & Gilhespy) and from the Environment Agency's standard emission factors and BAT/AEL emission factors. The ammonia emission rates have then been used as inputs to an atmospheric dispersion and deposition model which calculates ammonia exposure levels and nitrogen and acid deposition rates in the surrounding area.

Existing Scenario

The modelling predicts that:

- The process contribution to ammonia concentrations and nitrogen deposition rates over western parts of Aqualate Mere SSSI/Ramsar site are currently in excess of the Environment Agency's lower threshold percentage (4% for internationally designated sites) of the Critical Level and the Critical Load for the site.
- The process contribution to ammonia concentrations and nitrogen deposition rates over eastern parts of Aqualate Mere SSSI/Ramsar site at all other SSSIs is below the Environment Agency's lower threshold percentage (4% for internationally designated sites and 20% for SSSIs) of the relevant Critical Level and the Critical Load for the site.
- There are currently exceedances of 1% of the Critical Level and/or the Critical Load over Aqualate Mere SSSI/Ramsar site, Newport Canal SSSI and Loynton Moss SSSI.

Proposed Scenario

The modelling predicts that:

- The process contribution to ammonia concentrations and nitrogen deposition rates over westernmost parts of Aqualate Mere SSSI/Ramsar site would be slightly in excess of the Environment Agency's lower threshold percentage (4% for internationally designated sites) of the Critical Level and the Critical Load for the site.
- The process contribution to ammonia concentrations and nitrogen deposition rates over most of Aqualate Mere SSSI/Ramsar site at all other SSSIs would below the Environment Agency's lower threshold percentage (4% for internationally designated sites and 20% for SSSIs) of the relevant Critical Level and the Critical Load for the site.
- There would be exceedances of 1% of the Critical Level and/or the Critical Load over Aqualate Mere SSSI/Ramsar site, Newport Canal SSSI and Loynton Moss SSSI.

7. References

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