A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Proposed Piggery at Land East of Weeton North Lane, near Weeton in the East Riding of Yorkshire

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Lizzie Jennings, of Yorkshire Framers Livestock Marketing Ltd., on behalf of Cattle Holderness Ltd., to use computer modelling to assess the impact of ammonia emissions from the proposed piggery at Land East of Weeton North Lane, near Weeton in the East Riding of Yorkshire. HU12 0TA (closest).

Ammonia emission rates from the proposed piggery have been assessed and quantified based upon the Environment Agency's standard ammonia emission factors and the Best Available Techniques (BAT) Reference Document for the Intensive Rearing of Poultry or Pigs. 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

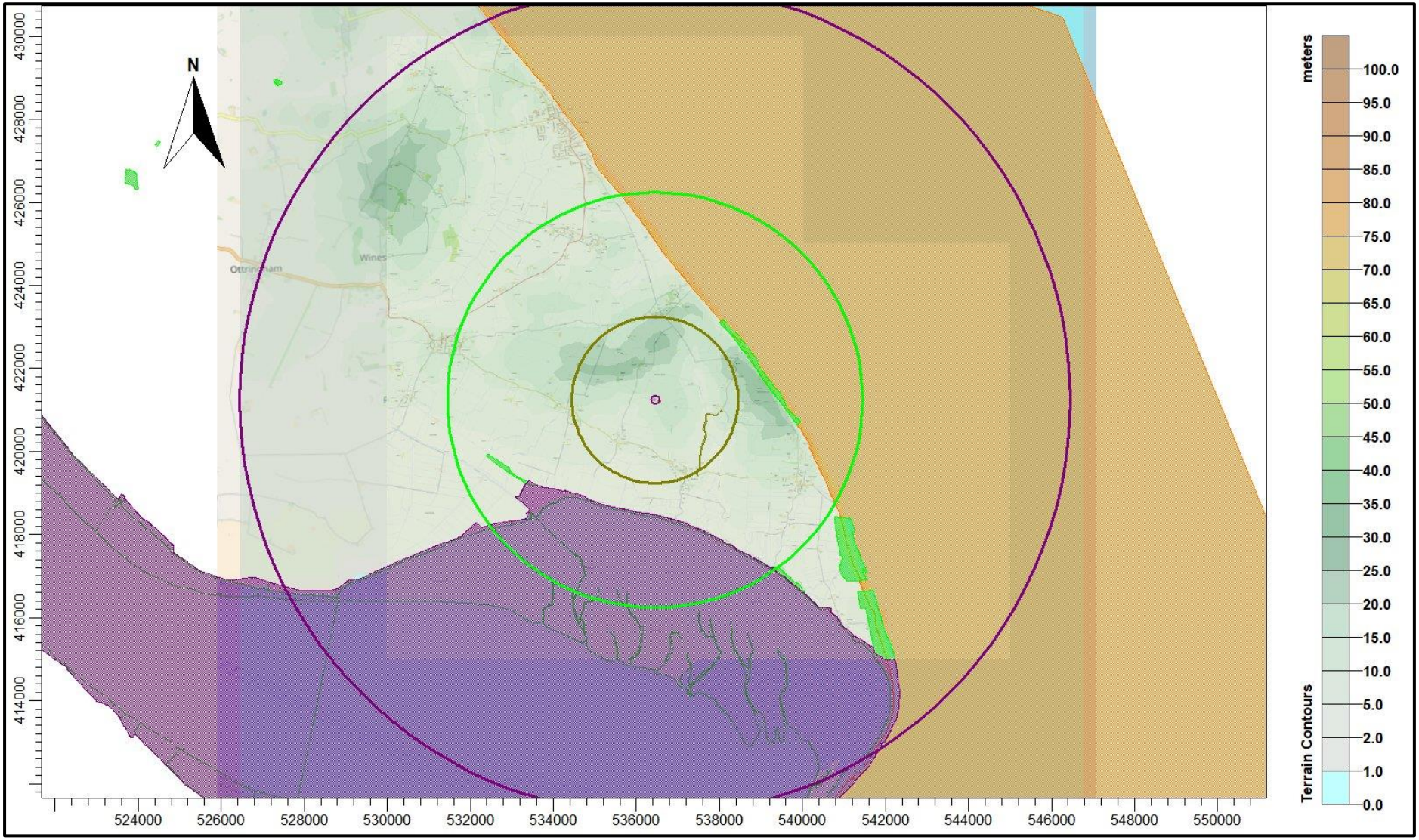
The site of the proposed piggery at Land East of Weeton North Lane, Weeton, is in a rural area approximately 1.1 km to the north-north-east of the village of Weeton in the East Riding of Yorkshire. The surrounding land is used extensively for arable farming. The site of the piggery is at an altitude of around 17 m; the surrounding land falls gently towards The Humber Estuary to the south and rises towards higher ground to the north.

It is proposed that two new pig rearing houses be constructed at Land East of Weeton North Lane, Weeton. This pig houses would provide accommodation for up to 4,000 pigs which would be reared from a weight of 30 kg to a finishing weight of around 110 kg. The pig houses would have fully slatted floors with a vacuum system for frequent slurry removal which would then stored in an enclosed slurry bag located to the east of the housing. The new houses would be ventilated by uncapped high speed ridge or roof fans, each with a short chimney.

There is one Local Wildlife Site (LWS), a roadside verge to the south-east of the site. There are two Sites of Special Scientific Interest (SSSIs) within 5 km of the site of the proposed piggery; Dimlington Cliffs SSSI to the east-north-east and The Humber Estuary SSSI to the south, parts of which are also designated as a Special Area of Conservation (SAC), Special Protection Area (SPA) or a Ramsar site. Parts of the greater Wash SPA are also within 10 km.

A map of the surrounding area showing the positions of the proposed piggery, the LWS, the SSSIs, the SAC, the SPA and the Ramsar site is provided in Figure 1. In this figure, the LWS is shaded olive, the SSSIs are shaded in green, the SPA is shaded in orange, the Ramsar site is shaded in blue, the SAC is shaded in purple and the site of the piggery is outlined in blue.

Figure 1. The area surrounding the proposed piggery – concentric circles radii 2 km (olive), 5 km (green) and 10 km (purple)



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

3.1 Ammonia concentration and nitrogen and acid deposition

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

3.2 Background ammonia levels and nitrogen and acid deposition

The background ammonia concentration (annual mean) in the area around the site is 1.47 µg-NH_3/m^3. The background nitrogen deposition rate to woodland is 26.74 kg-N/ha/y and to short vegetation is 15.96 kg-N/ha/y. The background acid deposition rate to woodland is 1.57 keq/ha/y and to short vegetation is 0.98 keq/ha/y. The source of these background figures is the Air Pollution Information System (APIS, November 2020).

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 µg-NH_3/m^3 as an annual mean. 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 µg-NH_3/m^3 as an annual mean.

Critical Loads for nutrient nitrogen are set under the Convention on Long-Range Transboundary Air Pollution. They are based on empirical evidence, mainly observations from experiments and gradient studies. Critical Loads are given as ranges (e.g. 10-20 kg-N/ha/y); these ranges reflect variation in ecosystem response across Europe.

The Critical Levels and Critical Loads at the wildlife sites assumed in this study are provided in Table 1. Note, the citation for Dimlington Cliff SSSI indicates that the reason for the designation is exclusively due to the geology of this site; therefore, it has not been considered further. 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)
Roadside Verge LWS	1.0 [1]	10.0	-
Humber Estuary SPA/Ramsar (The Lagoons SSSI)	3.0 [2]	8.0 [3]	-
Humber Estuary SAC/SPA/Ramsar/SSSI	3.0 [2]	8.0 [4]	-
Humber Estuary SAC/SPA/Ramsar/SSSI	3.0 [2]	20.0 [4]	-
Greater Wash SPA	n/a [5]	n/a [5]	n/a [5]

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 SSSI and APIS, which does not contain reference to, or does not indicate the presence of, sensitive lichens and/or bryophytes at this site.
3. The lower bound of the range of Critical Loads for habitats present at the site obtained from the APIS website (June 2019).
4. The Critical Loads for habitats present at Humber Estuary SSSI listed at the APIS website range from 5.0 kg-N/ha/y to 20.0 kg-N/ha/y. The habitats within 10 km of the proposed pig houses at Weeton include lowland fen, marsh and swamp, littoral sediment, pioneer, low-mid, mid and upper saltmarshes, for which a Critical Load of 20.0 kg-N/ha/y has been assumed and supralittoral sediment, for which a Critical Load of 8.0 kg/ha/y has been assumed.
5. There are no Critical Levels or Load for any habitat present at the Greater Wash SPA.

3.4 Guidance on the significance of ammonia emissions

3.4.1 Environment Agency Criteria

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

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

If the predicted process contributions to Critical Level or Critical Load are in the range between the lower and upper thresholds; 4% to 20% for SACs, SPAs and Ramsar sites; 20% to 50% for SSSIs and 100% to 100% for other non-statutory wildlife sites, whether or not the impact is deemed acceptable is at the discretion of the Environment Agency. In making their decision, the Environment Agency will

consider whether other farming installations might act in-combination with the farm and the sensitivities of the wildlife sites. In the case of LWSs and AWs, the Environment Agency do not usually consider other farms that may act in-combination and therefore a PC of up to 100% of Critical Level or Critical Load is usually deemed acceptable for permitting purposes and therefore the upper and lower thresholds are the same (100%).

3.4.2 Natural England advisory criterion

Natural England are a statutory consultee at planning and usually advise that, if predicted process contributions exceed 1% 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.

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.

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.

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.

New pig housing must comply with Best Available Techniques Assessment Emission Limits (BAT AEL), which for finisher pigs, with a weight greater than 30 kg, housed on a slatted floor with a vacuum system for the frequent removal of manure, is 2.6 kg-NH_3/place/y. This emission factor has been used to calculate emissions from the proposed pig housing.

For the slurry, which, under the proposals, would be stored in a bag to the east of the proposed houses, the Environment Agency provides an Intensive Farming Guidance note which lists standard ammonia emission factors for a variety of livestock, including manure storage. Slurry bags are usually expected to reduce emission, compared to open slurry storage, by more than 90% Therefore an emission factor of 0.14 kg-NH_3/m² is assumed; this is 10% of the standard emission factor for open slurry storage with no covering.

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

Table 2. Details of pig numbers, emission factors and ammonia emission rates for the proposed piggery

Source	Weight	No. Pigs	Housing	Emission Factor (kg-NH_3/place/y)	Emission Rate (g-NH_3/s)
Proposed pig housing	30 – 100 kg	4,000	Fully slatted floor with a vacuum system	2.6	0.329556
Source	Area (m²)		Emission factor (kg-NH_3/m²)		Emission rate (g-NH_3/s)
Proposed slurry store	2,340		0.14		0.010381

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).

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). 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). The use of NWP data has advantages over traditional meteorological records because:

- Calm periods in traditional records may be over represented, this is because the instrumentation used may not record wind speed below approximately 0.5 m/s and start up wind speeds may be greater than 1.0 m/s. In NWP data, the wind speed is continuous down to 0.0 m/s, allowing the calms module of ADMS to function correctly.

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

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

A wind rose showing the distribution of wind speeds and directions in the GFS derived data is shown in Figure 2a. Wind speeds 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 the area around the proposed pig houses at the site is shown in Figure 2b. Note that, elsewhere in the modelling domain, modified wind roses may differ more or less markedly. The resolution of the wind field in terrain runs is approximately 300 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 in the modelling runs that include terrain.

Figure 2a. The wind rose. GFS derived data for 53.669 N, 0.067 E, 2016 - 2019

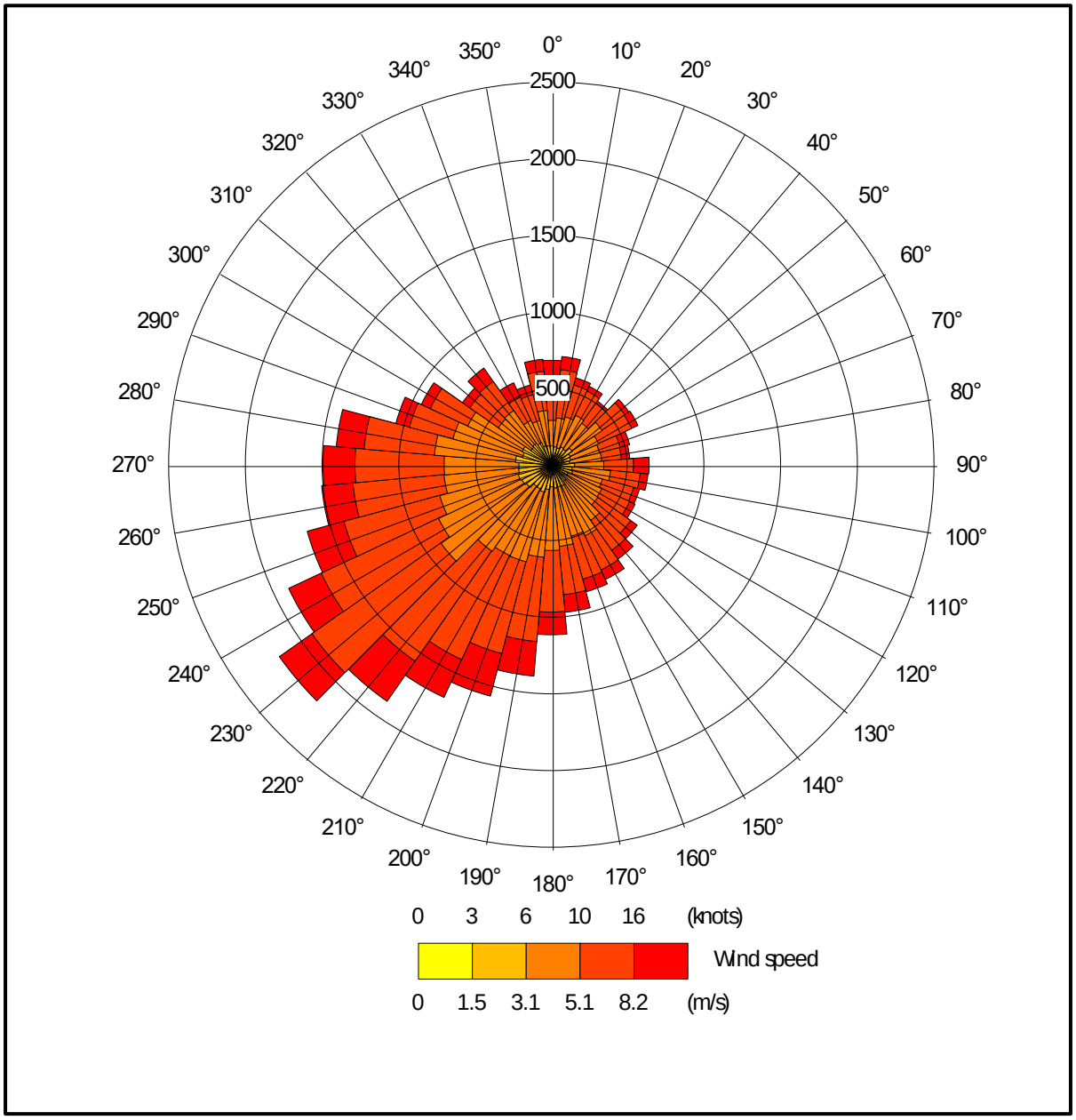
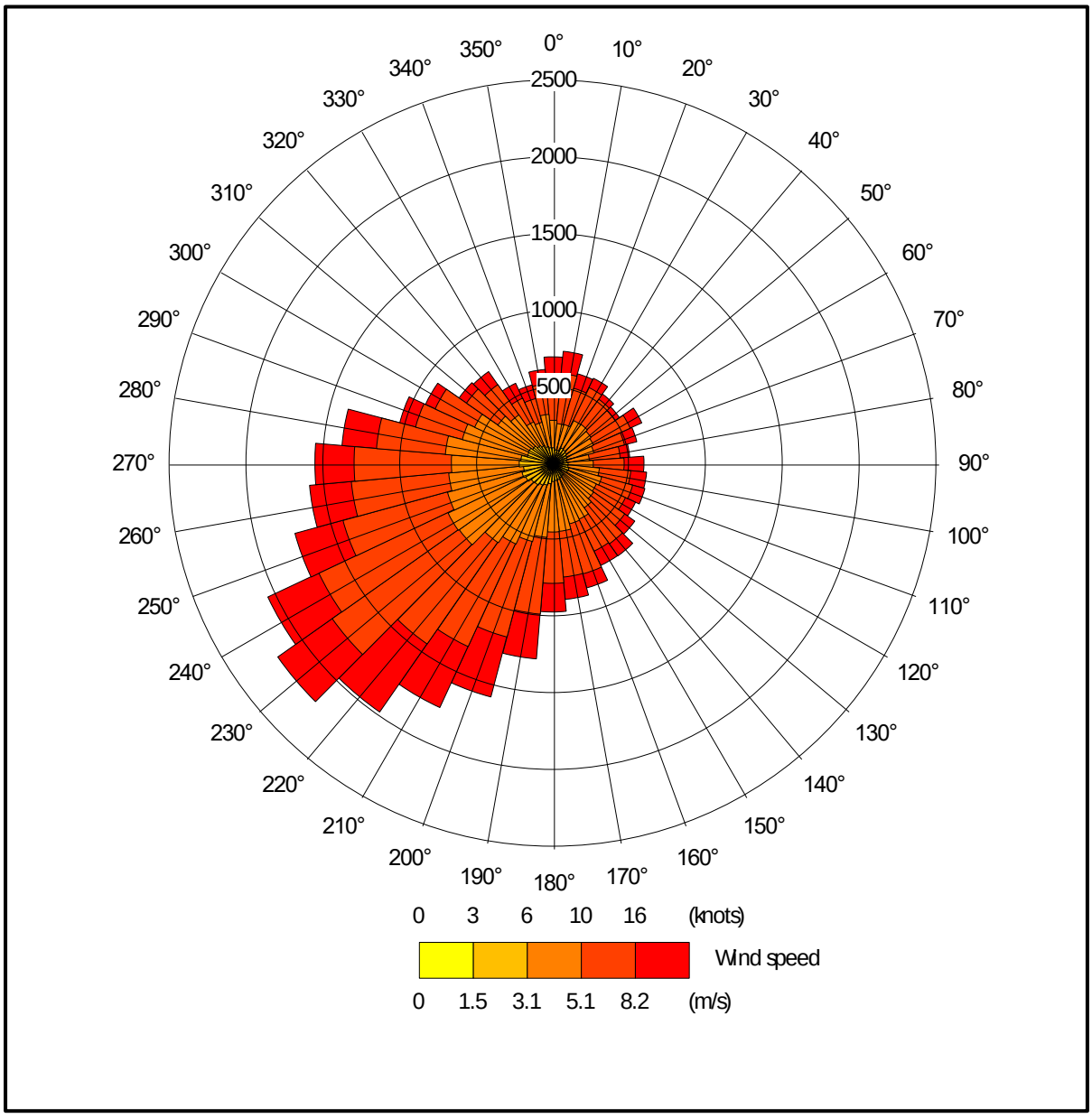


Figure 2b. The wind rose for the site of the proposed piggery, NGR 536625, 421185, derived from FLOWSTAR output



4.2 Emission sources

Emissions from the chimneys of the uncapped high speed ridge or roof fans that would be used to ventilate the proposed pig houses are represented by six point sources within ADMS (PR1 and PR2; 1, 2 & 3). Details of the point source parameters are shown in Table 3a. The positions of the point sources may be seen in Figure 3, where they are indicated by red star symbols.

Table 3a. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (°C)	Emission rate per source (g-NH_3/s)
PR1 to PR2 1, 2 & 3	6.0	0.8	11.0	21.0	0.054926

Emissions from the slurry bag are represented by a volume source within ADMS (SBv). Details of the volume source parameters are shown in Table 3b. The position of the volume source may be seen in Figure 3, where it is indicated by a red rectangle.

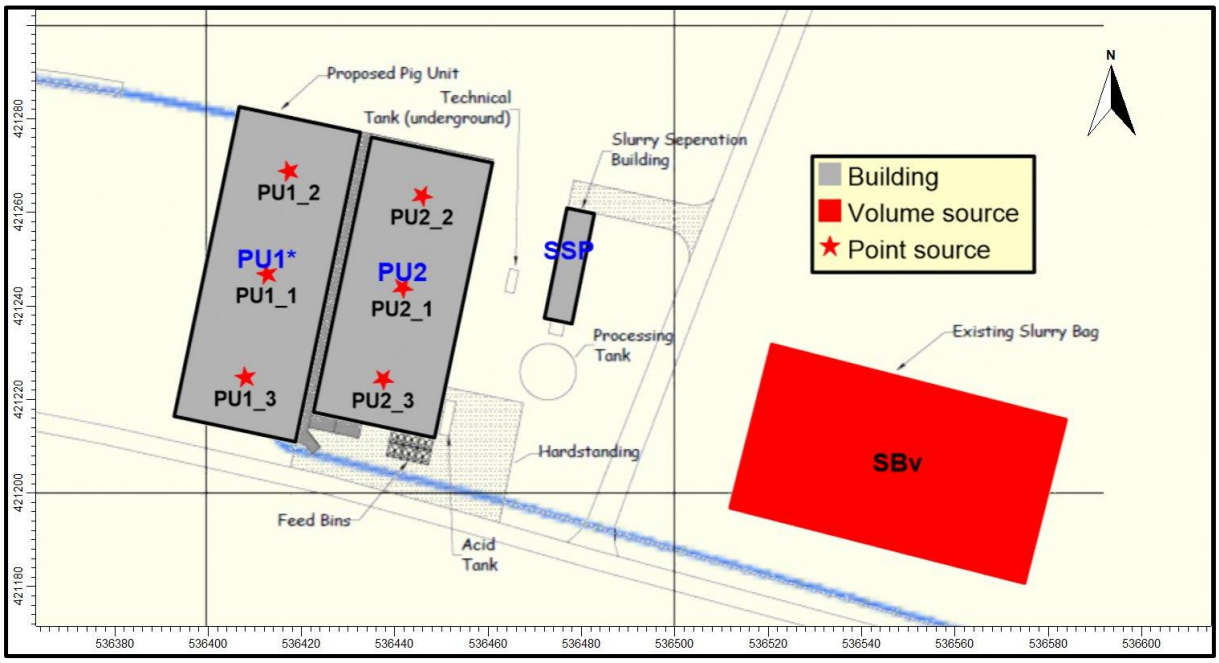
Table 3b. Volume source parameters

Source ID	Length Y (m)	Width X (m)	Depth (m)	Base height (m)	Emission temperature (°C)	Emission rate per source (g-NH_3/s)
SBv	36.0	65.0	1.0	0.0	Ambient	0.010381

4.3 Modelled buildings

The structure of the proposed pig houses and the proposed slurry separation building 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.

Figure 3. The positions of the modelled buildings and sources



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4.4 Discrete receptors

Thirty-two discrete receptors have been defined: five at the LWS (1 to 5); five at the SSSI (6 to 10); fourteen at the SAC/SPA/Ramsar (11 to 24) and eight at the Greater Wash SPA (25 to 32). 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 plot presented in Section 5 of this report 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.

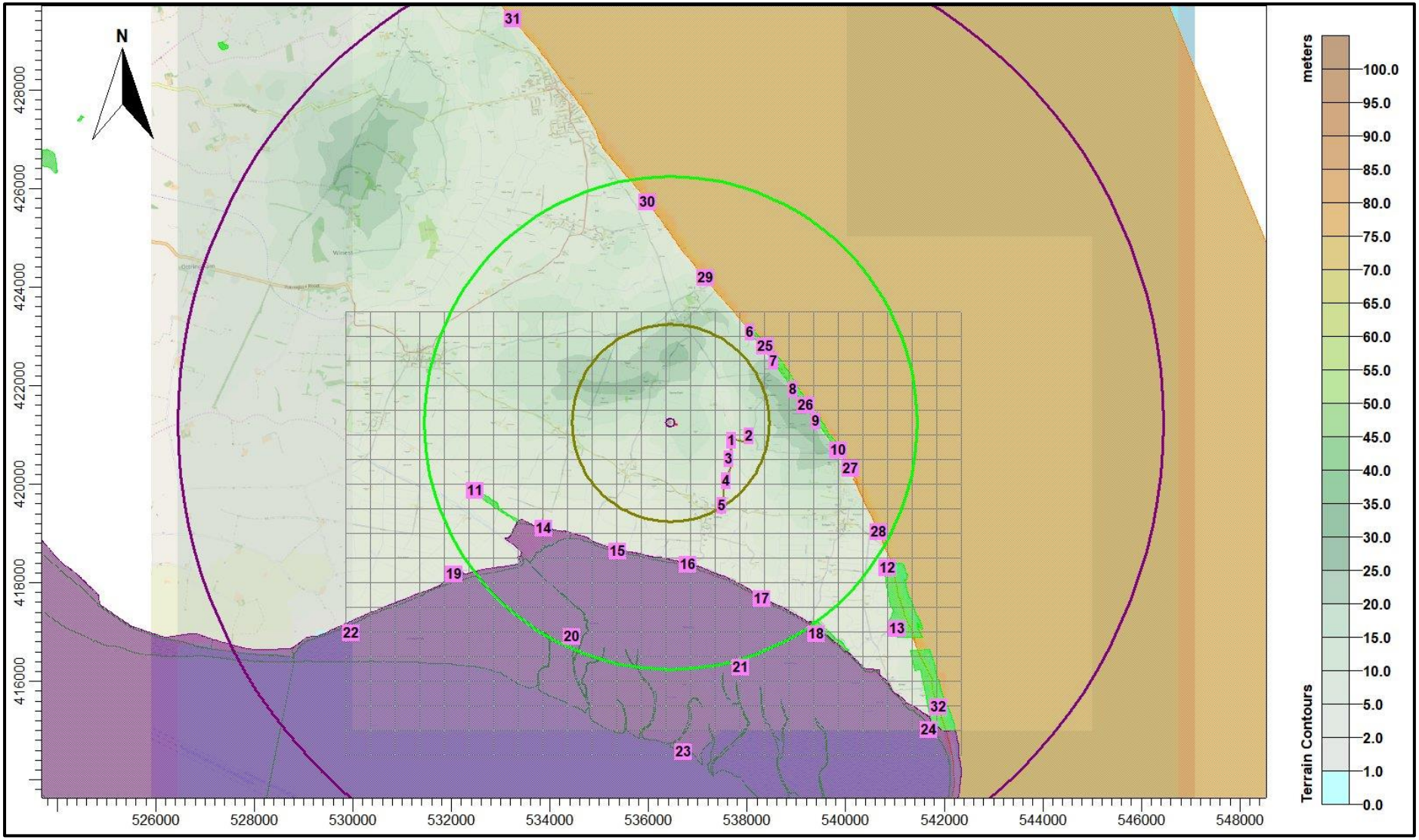
4.6 Terrain data

Terrain has been considered in the modelling. The terrain data are based upon the Ordnance Survey 50 m Digital Elevation Model. A 20.0 km by 20.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS. 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

The site of the proposed pig houses is close to the coast; therefore, a spatially varying surface roughness field has been created. In this field, areas over land are given a roughness length of 0.15 m and areas over the sea are given a roughness length of 0.02 m. The GFS meteorological data is assumed to have a roughness length of 0.15 m. The effect of the difference in roughness over areas of sea is to increase wind speeds and reduce the frequency of low wind speeds, whereas over land, wind speeds will not be altered.

Figure 4. The discrete receptors and Cartesian grid



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4.8 Deposition

The method used to model deposition of ammonia and consequent plume depletion is based on a document titled "Guidance on modelling the concentration and deposition of ammonia emitted from intensive farming" from the Environment Agency's Air Quality Modelling and Assessment Unit, 22 November 2010. In this case, it proves unnecessary to model deposition of ammonia explicitly and where deposition figures are quoted, these are obtained by multiplying the predicted ammonia concentration by an appropriate deposition velocity and a factor of 259.7 to convert units. Please note that, because deposition of ammonia and the consequent plume depletion are not accounted for, this is a precautionary approach. Therefore, 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. In this case, 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 as Environment Agency guidance, particularly where there is some distance between the source and a receptor.

5. Details of the Model Runs and Results

5.1 Preliminary modelling

ADMS was run a total of sixteen times, once for each year of the meteorological record and in the following four modes:

- In basic mode without calms and without 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 4a. In the Table, predicted ammonia concentrations (or concentrations equivalent to deposition rates) that are in excess of the Environment Agency's upper threshold percentage (100% of Critical Level or Load for a non-statutory site, 50% for a SSSI and 20% for an internationally designated site) are coloured red. Concentrations (or concentrations equivalent to deposition rates) in the range between the Environment Agency's lower and upper threshold percentages (100% and 100% for a non-statutory site, 20% and 50% for a SSSI and 4% and 20% for an internationally designated site) are coloured blue. Additionally, predicted ammonia concentrations (or ammonia concentrations equivalent to nitrogen deposition rates[2]) that exceed 1% of the Critical Level or Load at a statutory site are highlighted with bold text. For convenience, cells referring to a LWS are shaded olive, cells referring to a SSSI are shaded green, cells referring to a SPA/Ramsar are shaded orange and cells referring to a SAC/SPA/Ramsar are shaded lilac.

The process contributions expressed as a percentage of the Critical level, a nitrogen deposition rate and the Critical Load are provided in Tables 4b, 4c and 4d, respectively.

A contour plot of the predicted ground level maximum annual mean ammonia concentrations around the site of the proposed pig houses and the discrete receptors, from the preliminary modelling, is shown in Figure 5.

Table 4a. Predicted maximum annual mean ammonia concentration at the discrete receptors

Receptor number	X(m)	Y(m)	Designation	Maximum annual mean ammonia concentration - (µg/m³)			
				GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS No Calms Terrain Fixed depo 0.003 m/s
1	537676	420880	Roadside Verge LWS	0.156	0.157	0.152	0.130
2	538031	420964	Roadside Verge LWS	0.126	0.126	0.120	0.102
3	537631	420506	Roadside Verge LWS	0.100	0.101	0.097	0.082
4	537566	420064	Roadside Verge LWS	0.067	0.069	0.062	0.047
5	537493	419568	Roadside Verge LWS	0.050	0.052	0.047	0.031
6	538047	423085	Dimlington Cliff SSSI	0.064	0.064	0.068	0.057
7	538546	422481	Dimlington Cliff SSSI	0.073	0.073	0.074	0.060
8	538926	421924	Dimlington Cliff SSSI	0.060	0.061	0.059	0.047
9	539399	421281	Dimlington Cliff SSSI	0.051	0.052	0.049	0.039
10	539845	420690	Dimlington Cliff SSSI	0.042	0.042	0.038	0.029
11	532482	419860	Humber Estuary SPA/Ramsar/SSSI	0.014	0.015	0.014	0.009
12	540851	418299	Humber Estuary SPA/Ramsar/The Lagoons SSSI	**0.016**	**0.016**	0.014	0.009
13	541050	417070	Humber Estuary SPA/Ramsar/The Lagoons SSSI	0.011	0.012	0.010	0.006
14	533877	419096	Humber Estuary SAC/SPA/Ramsar/SSSI	0.023	0.024	0.024	0.016
15	535371	418631	Humber Estuary SAC/SPA/Ramsar/SSSI	0.026	0.027	0.026	0.018
16	536800	418365	Humber Estuary SAC/SPA/Ramsar/SSSI	0.027	0.027	0.026	0.018
17	538294	417668	Humber Estuary SAC/SPA/Ramsar/SSSI	0.022	0.022	0.020	0.011
18	539396	416950	Humber Estuary SAC/SPA/Ramsar	0.016	0.016	0.014	0.008
19	532050	418166	Humber Estuary SAC/SPA/Ramsar	0.013	0.013	0.013	0.008
20	534442	416904	Humber Estuary SAC/SPA/Ramsar/SSSI	0.014	0.015	0.014	0.009
21	537862	416273	Humber Estuary SAC/SPA/Ramsar	0.016	0.017	0.015	0.008
22	529966	416978	Humber Estuary SAC/SPA/Ramsar	0.008	0.008	0.008	0.004
23	536717	414564	Humber Estuary SAC/SPA/Ramsar	0.009	0.010	0.009	0.005
24	541681	415006	Humber Estuary SAC/SPA/Ramsar	0.009	0.009	0.008	0.004
25	538364	422785	Greater Wash SPA	0.068	0.068	0.071	0.060
26	539184	421599	Greater Wash SPA	0.053	0.053	0.051	0.041
27	540093	420315	Greater Wash SPA	0.034	0.034	0.031	0.022
28	540669	419035	Greater Wash SPA	0.021	0.021	0.019	0.012
29	537156	424178	Greater Wash SPA	0.040	0.040	0.043	0.031
30	535985	425720	Greater Wash SPA	0.019	0.019	0.020	0.014
31	533241	429422	Greater Wash SPA	0.006	0.006	0.006	0.004
32	541879	415481	Greater Wash SPA	0.009	0.009	0.008	0.004

Table 4b. Predicted maximum annual mean ammonia concentration at the discrete receptors expressed as a percentage of the Critical Level

Receptor number	X(m)	Y(m)	Designation	Critical Level (µg/m³)	Maximum annual mean ammonia concentration - Expressed as %age of Critical level.			
					GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS No Calms Terrain Fixed depo 0.003 m/s
1	537676	420880	Roadside Verge LWS	1.0	15.6	15.7	15.2	13.0
2	538031	420964	Roadside Verge LWS	1.0	12.6	12.6	12.0	10.2
3	537631	420506	Roadside Verge LWS	1.0	10.0	10.1	9.7	8.2
4	537566	420064	Roadside Verge LWS	1.0	6.7	6.9	6.2	4.7
5	537493	419568	Roadside Verge LWS	1.0	5.0	5.2	4.7	3.1
6	538047	423085	Dimlington Cliff SSSI	n/a	n/a	n/a	n/a	n/a
7	538546	422481	Dimlington Cliff SSSI	n/a	n/a	n/a	n/a	n/a
8	538926	421924	Dimlington Cliff SSSI	n/a	n/a	n/a	n/a	n/a
9	539399	421281	Dimlington Cliff SSSI	n/a	n/a	n/a	n/a	n/a
10	539845	420690	Dimlington Cliff SSSI	n/a	n/a	n/a	n/a	n/a
11	532482	419860	Humber Estuary SPA/Ramsar/SSSI	3.0	0.5	0.5	0.5	0.3
12	540851	418299	Humber Estuary SPA/Ramsar/The Lagoons SSSI	3.0	0.5	0.5	0.5	0.3
13	541050	417070	Humber Estuary SPA/Ramsar/The Lagoons SSSI	3.0	0.4	0.4	0.3	0.2
14	533877	419096	Humber Estuary SAC/SPA/Ramsar/SSSI	3.0	0.8	0.8	0.8	0.5
15	535371	418631	Humber Estuary SAC/SPA/Ramsar/SSSI	3.0	0.9	0.9	0.9	0.6
16	536800	418365	Humber Estuary SAC/SPA/Ramsar/SSSI	3.0	0.9	0.9	0.9	0.6
17	538294	417668	Humber Estuary SAC/SPA/Ramsar/SSSI	3.0	0.7	0.7	0.7	0.4
18	539396	416950	Humber Estuary SAC/SPA/Ramsar	3.0	0.5	0.5	0.5	0.3
19	532050	418166	Humber Estuary SAC/SPA/Ramsar	3.0	0.4	0.4	0.4	0.3
20	534442	416904	Humber Estuary SAC/SPA/Ramsar/SSSI	3.0	0.5	0.5	0.5	0.3
21	537862	416273	Humber Estuary SAC/SPA/Ramsar	3.0	0.5	0.6	0.5	0.3
22	529966	416978	Humber Estuary SAC/SPA/Ramsar	3.0	0.3	0.3	0.3	0.1
23	536717	414564	Humber Estuary SAC/SPA/Ramsar	3.0	0.3	0.3	0.3	0.2
24	541681	415006	Humber Estuary SAC/SPA/Ramsar	3.0	0.3	0.3	0.3	0.1
25	538364	422785	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a
26	539184	421599	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a
27	540093	420315	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a
28	540669	419035	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a
29	537156	424178	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a
30	535985	425720	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a
31	533241	429422	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a
32	541879	415481	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a

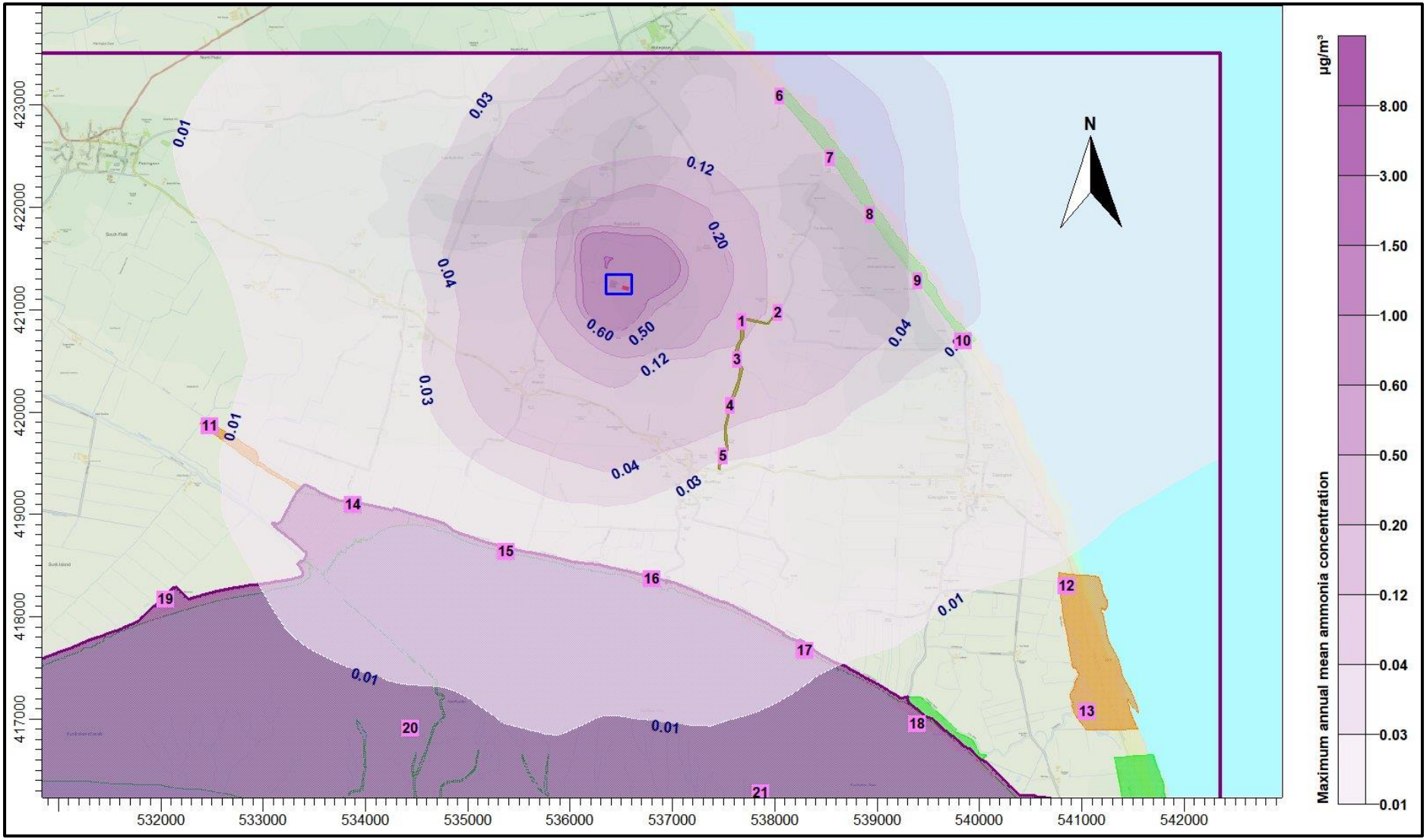
Table 4c. Predicted maximum annual nitrogen deposition rate at the discrete receptors

Receptor number	X(m)	Y(m)	Designation	Critocal Load kg/ha/y	Deposition Velocity	Maximum annual mean ammonia concentration expressed as nitrogen deposition rate - (kg/ha)			
						GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS No Calms Terrain Fixed depo 0.003 m/s
1	537676	420880	Roadside Verge LWS	10.0	0.03	1.21	1.22	1.18	1.02
2	538031	420964	Roadside Verge LWS	10.0	0.03	0.98	0.98	0.94	0.80
3	537631	420506	Roadside Verge LWS	10.0	0.03	0.78	0.78	0.75	0.64
4	537566	420064	Roadside Verge LWS	10.0	0.03	0.53	0.54	0.48	0.37
5	537493	419568	Roadside Verge LWS	10.0	0.03	0.39	0.40	0.36	0.24
6	538047	423085	Dimlington Cliff SSSI	n/a	0.02	0.33	0.33	0.36	0.29
7	538546	422481	Dimlington Cliff SSSI	n/a	0.02	0.38	0.38	0.38	0.31
8	538926	421924	Dimlington Cliff SSSI	n/a	0.02	0.31	0.32	0.31	0.24
9	539399	421281	Dimlington Cliff SSSI	n/a	0.02	0.27	0.27	0.25	0.20
10	539845	420690	Dimlington Cliff SSSI	n/a	0.02	0.22	0.22	0.20	0.15
11	532482	419860	Humber Estuary SPA/Ramsar/SSSI	8.0	0.02	0.07	0.08	0.07	0.05
12	540851	418299	Humber Estuary SPA/Ramsar/The Lagoons SSSI	8.0	0.02	0.08	0.08	0.07	0.05
13	541050	417070	Humber Estuary SPA/Ramsar/The Lagoons SSSI	8.0	0.02	0.06	0.06	0.05	0.03
14	533877	419096	Humber Estuary SAC/SPA/Ramsar/SSSI	20.0	0.02	0.12	0.12	0.12	0.08
15	535371	418631	Humber Estuary SAC/SPA/Ramsar/SSSI	20.0	0.02	0.14	0.14	0.13	0.10
16	536800	418365	Humber Estuary SAC/SPA/Ramsar/SSSI	20.0	0.02	0.14	0.14	0.14	0.09
17	538294	417668	Humber Estuary SAC/SPA/Ramsar/SSSI	20.0	0.02	0.11	0.12	0.10	0.06
18	539396	416950	Humber Estuary SAC/SPA/Ramsar	20.0	0.02	0.08	0.08	0.07	0.04
19	532050	418166	Humber Estuary SAC/SPA/Ramsar	20.0	0.02	0.07	0.07	0.07	0.04
20	534442	416904	Humber Estuary SAC/SPA/Ramsar/SSSI	20.0	0.02	0.07	0.08	0.07	0.04
21	537862	416273	Humber Estuary SAC/SPA/Ramsar	20.0	0.02	0.09	0.09	0.08	0.04
22	529966	416978	Humber Estuary SAC/SPA/Ramsar	20.0	0.02	0.04	0.04	0.04	0.02
23	536717	414564	Humber Estuary SAC/SPA/Ramsar	20.0	0.02	0.05	0.05	0.05	0.03
24	541681	415006	Humber Estuary SAC/SPA/Ramsar	8.0	0.02	0.05	0.05	0.04	0.02
25	538364	422785	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a	n/a
26	539184	421599	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a	n/a
27	540093	420315	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a	n/a
28	540669	419035	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a	n/a
29	537156	424178	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a	n/a
30	535985	425720	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a	n/a
31	533241	429422	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a	n/a
32	541879	415481	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a	n/a

Table 4d. Predicted maximum annual mean ammonia concentration at the discrete receptors expressed as a percentage of the Critical Load

Receptor number	X(m)	Y(m)	Designation	Critocal Load kg/ha/y	Deposition Velocity	Maximum annual mean ammonia concentration - expressed as %age of Critical Load			
						GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS No Calms Terrain Fixed depo 0.003 m/s
1	537676	420880	Roadside Verge LWS	10.0	0.03	12.1	12.2	11.8	10.2
2	538031	420964	Roadside Verge LWS	10.0	0.03	9.8	9.8	9.4	8.0
3	537631	420506	Roadside Verge LWS	10.0	0.03	7.8	7.8	7.5	6.4
4	537566	420064	Roadside Verge LWS	10.0	0.03	5.3	5.4	4.8	3.7
5	537493	419568	Roadside Verge LWS	10.0	0.03	3.9	4.0	3.6	2.4
6	538047	423085	Dimlington Cliff SSSI	n/a	0.02	n/a	n/a	n/a	n/a
7	538546	422481	Dimlington Cliff SSSI	n/a	0.02	n/a	n/a	n/a	n/a
8	538926	421924	Dimlington Cliff SSSI	n/a	0.02	n/a	n/a	n/a	n/a
9	539399	421281	Dimlington Cliff SSSI	n/a	0.02	n/a	n/a	n/a	n/a
10	539845	420690	Dimlington Cliff SSSI	n/a	0.02	n/a	n/a	n/a	n/a
11	532482	419860	Humber Estuary SPA/Ramsar/SSSI	8.0	0.02	0.9	1.0	0.9	0.6
12	540851	418299	Humber Estuary SPA/Ramsar/The Lagoons SSSI	8.0	0.02	1.0	1.0	0.9	0.6
13	541050	417070	Humber Estuary SPA/Ramsar/The Lagoons SSSI	8.0	0.02	0.7	0.8	0.7	0.4
14	533877	419096	Humber Estuary SAC/SPA/Ramsar/SSSI	20.0	0.02	0.6	0.6	0.6	0.4
15	535371	418631	Humber Estuary SAC/SPA/Ramsar/SSSI	20.0	0.02	0.7	0.7	0.7	0.5
16	536800	418365	Humber Estuary SAC/SPA/Ramsar/SSSI	20.0	0.02	0.7	0.7	0.7	0.5
17	538294	417668	Humber Estuary SAC/SPA/Ramsar/SSSI	20.0	0.02	0.6	0.6	0.5	0.3
18	539396	416950	Humber Estuary SAC/SPA/Ramsar	20.0	0.02	0.4	0.4	0.4	0.2
19	532050	418166	Humber Estuary SAC/SPA/Ramsar	20.0	0.02	0.3	0.3	0.3	0.2
20	534442	416904	Humber Estuary SAC/SPA/Ramsar/SSSI	20.0	0.02	0.4	0.4	0.4	0.2
21	537862	416273	Humber Estuary SAC/SPA/Ramsar	20.0	0.02	0.4	0.4	0.4	0.2
22	529966	416978	Humber Estuary SAC/SPA/Ramsar	20.0	0.02	0.2	0.2	0.2	0.1
23	536717	414564	Humber Estuary SAC/SPA/Ramsar	20.0	0.02	0.2	0.2	0.2	0.1
24	541681	415006	Humber Estuary SAC/SPA/Ramsar	8.0	0.02	0.6	0.6	0.5	0.3
25	538364	422785	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a	n/a
26	539184	421599	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a	n/a
27	540093	420315	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a	n/a
28	540669	419035	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a	n/a
29	537156	424178	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a	n/a
30	535985	425720	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a	n/a
31	533241	429422	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a	n/a
32	541879	415481	Greater Wash SPA	n/a	n/a	n/a	n/a	n/a	n/a

Figure 5. Maximum annual mean ammonia concentration – preliminary modelling, fixed deposition velocity run



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6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Lizzie Jennings, of Yorkshire Framers Livestock Marketing Ltd., on behalf of Cattle Holderness Ltd., to use computer modelling to assess the impact of ammonia emissions from the proposed piggery at Land East of Weeton North Lane, near Weeton in the East Riding of Yorkshire. HU12 0TA (closest).

Ammonia emission rates from the proposed piggery have been assessed and quantified based upon the Environment Agency's standard ammonia emission factors and the Best Available Techniques (BAT) Reference Document for the Intensive Rearing of Poultry or Pigs. 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 modelling predicts that the process contribution of the proposed piggery at Land East of Weeton North Lane to annual mean ammonia concentrations and nitrogen deposition rates would be below the Environment Agency's lower threshold percentage of the relevant Critical Level or Critical Load at all the wildlife sites considered and also 1% of the Critical level and critical load at the SSSIs and the SAC/SPA/Ramsar sites.

7. References

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