Ammonia Impact Assessment – Integrated Pig Farm at Moate, Co Laois

Prepared for:

Tulleka Trading Ltd

December 2023

Final

Prepared by:

Katestone Environmental Pty Ltd
Office 5a, Portlaoise Enterprise Centre, Clonminam Industrial Estate, Portlaoise, Co Laois

www.katestone.global
admin@katestone.global
Ph +353 (87) 365 6879

Document Control

Deliverable #:	DK21007-7
Title:	Ammonia Impact Assessment – Integrated Pig Farm at Moate, Co Laois
Version:	Final
Client:	Tulleka Trading Ltd
Document reference:	DK21007-7 Tulleka - Moate Pig - Ammonia Assessment.docx
Prepared by:	Micheal Fogarty, Paddy McDowell and Natalie Shaw
Reviewed by:	Natalie Shaw and Simon Welchman
Approved by:	 Simon Welchman 08/12/2023

Disclaimer

http://katestone.com.au/disclaimer/

Copyright

Contents

Tables

Figures

Glossary

Term	Definition
g/s	gram per second
kg	kilogram
kg/m³	Kilogram per cubic meter
km	kilometre
km/hr	kilometre per hour
m	metre
m/s	metres per second
m^2	square metres
m^3	cubic metres
m^3/s	cubic metres per second
m³/hr	cubic metres per hour
mg	milligram
Z_0	roughness length
$\mu g/m^3$	micrograms per cubic meter

Abbreviations	Definition
AG4	Air Guidance 4
BAT	Best available techniques
EPA	Environmental Protection Agency
EF	Emission factor
EU	European Union

EXECUTIVE SUMMARY

Tulleka Trading Ltd commissioned Katestone to complete an ammonia impact assessment (AIA) for a pig farm located at Graigue, County Laois (Site). The AIA is required to determine the potential impacts of emissions from a proposed development at the pig farm that will includ4 he:

- A reduction of the stocking density at the site by:
    - Constructing four new pig housing units to increase the total floor space
    - Maintaining pig numbers at current levels
- Construction of a new farrowing house to improve animal welfare
- Alteration of manure storage practices at eleven (11) of the thirteen (13) existing housing units at the site, which will be changed from deep pit storage tanks to shallow pit storage tanks to reduce emissions from the site
- Alteration of ventilation points on some of the pig housing units to reduce the potential impact of emissions exhausted from these sources.

The AIA is required to determine the potential impact of ammonia emissions from the proposed development on ecologically sensitive locations at nearby Natura 2000 sites. The assessment will be submitted as part of planning and licensing applications for the pig farm.

The AIA was conducted in accordance with the stepwise assessment procedure described in EPA's Ammonia and Nitrogen Assessment Guidance (EPA, 2021) for intensive agricultural installation (IAI) and recognised techniques for dispersion modelling specified in EPA's Air Dispersion Modelling Guidance Note (AG4).

The stepwise procedure is designed to evaluate IAIs based on risk of adverse impacts due to ammonia emissions. Low risk projects can be evaluated using simple screening procedures (Step 1, Step 2 or Step 3). If an IAI does not meet the evaluation criteria of Step 1, Step 2 or Step 3, a detailed dispersion modelling assessment as described in Step 4, Step5 or Step 6 may be required and presented to EPA to consider the application.

Once an assessment meets the requirements of the evaluation criteria for any of the steps, the applicant does not need to consider the requirements of subsequent steps and an application can be made for EPA's consideration. If an assessment does not meet the evaluation criteria of a step, the applicant must undertake assessment described in subsequent steps to determine if the application can be presented for EPA's consideration.

For the proposed development, the results of Step 1 of EPA's Ammonia and Nitrogen Assessment Guidance indicates background levels of ammonia and nitrogen deposition exceed the critical level for ammonia or the critical load for nitrogen deposition at some locations on nearby Natura 2000 sites. Accordingly, the applicant was required to skip Step 2 and Step 3 and complete a Step 4 assessment.

The Step 4 assessment indicates the following:

- The results exceed the Step 4 evaluation criteria indicating that a cumulative assessment (Step 5 Assessment) would be required for the following locations:
    - The River Barrow and Nore SAC (Discrete Receptors –1 - 57)
    - The Lisbigney Bog SAC (58 - 65)
- The results of the assessment were below the Step 4 evaluation criteria at all modelled locations on the Nore River SAC (Receptors 35 - 57) indicating that no further assessment would be required on this SAC.

A Step 5 assessment was undertaken in accordance with the requirements of EPA's Ammonia and Nitrogen Assessment Guidance. The results of the Step 5 assessment indicated that the cumulative impact of the pig farm with other IAIs was well below the in-combination evaluation criteria defined in Step 5 at all modelled locations.

Final Report Findings

In summary, the results of the assessment under EPA's Ammonia and Nitrogen Assessment Guidance indicate that the proposed pig farm **complies** with the EPA evaluation criteria at all sensitive locations, namely:

- River Barrow and Nore SAC
- Lisbigney Bog SAC
- The Nore River SPA.

1. INTRODUCTION

Katestone Environmental Pty Ltd (Katestone) was commissioned by Tulleka Trading Limited (Tulleka Trading) to complete an assessment of the impact of ammonia and nitrogen on Natura 2000 sites in the vicinity of a pig farm (Moate Pig Farm) it operates at Moate, Graigue, County Laois (Site).

The AIA is required to determine the impacts of emissions from a proposed development at the pig farm.

As part of the proposed development, Tulleka Trading proposes to:

- Reduce the stocking density of production pigs at the farm by:
    - Constructing four new pig housing units to increase the total floor space
    - Maintaining pig numbers at current levels
- Construct a new farrowing house to improve the welfare of farrowing pigs
- Alter manure storage practices at eleven (11) of the thirteen (13) existing housing units at the site by changing deep pit storage tanks to shallow pit storage tanks to reduce emissions from the site
- Alter ventilation points on some of the pig housing units to reduce the potential impact of emissions exhausted from these sources.

The Moate Pig Farm is operated under an Industrial Emissions License (IEL). EPA issued an Integrated Pollution Prevention and Control (IPPC) licence (Register number P0710-03) for the housing units on 22 December 2011 (EPA, 2011). The IPPC licence was amended to an IEL, which was issued by EPA to Mr. Paul Tully on 18 December 2013 (EPA, 2013). The licence boundary of the Site will have to be adjusted to incorporate the proposed new housing units.

This ammonia and nitrogen impact assessment was undertaken using dispersion modelling techniques. The dispersion modelling has been completed in accordance with the requirements of EPA's Air Dispersion Modelling Guidance Note (AG4). The assessment has also been conducted in accordance with Licence Application guidance issued by EPA titled: Assessment of the impact of ammonia and nitrogen on Natura 2000 sites from intensive agricultural installations (EPA, 2022), which is referred to here as EPA's Ammonia and Nitrogen Assessment Guidance.

2. OVERVIEW OF THE MOATE PIG FARM

The Moate Pig Farm is located approximately 3.0 km northeast of the village of Ballinakill, Co. Laois. It is located in an area of semi-complex terrain close to a number of hills and a river valley.

There are three (3) Natura 2000 sites within 10 km of the Moate Pig Farm. The proposed licence boundary of the Site and its environs are presented in Figure 1. All pig housing units will be located within the proposed licence boundary of the Site.

A Site plan illustrating the layout of the existing housing units and proposed housing units is presented in Figure 1 and Figure 2.

The existing housing units have the following maximum animal holding capacities:

- 650 sows
- 120 maiden gilts
- 4,300 weaners
- 4,800 production pigs (growers and finishers).

As part of the proposed development, emissions from all housing units will be captured and ventilated through elevated chimney stacks. Some of the chimney stacks on current housing units will be increased in height as part of the proposed development. This will significantly reduce the potential impact of emissions in the vicinity of the Site.

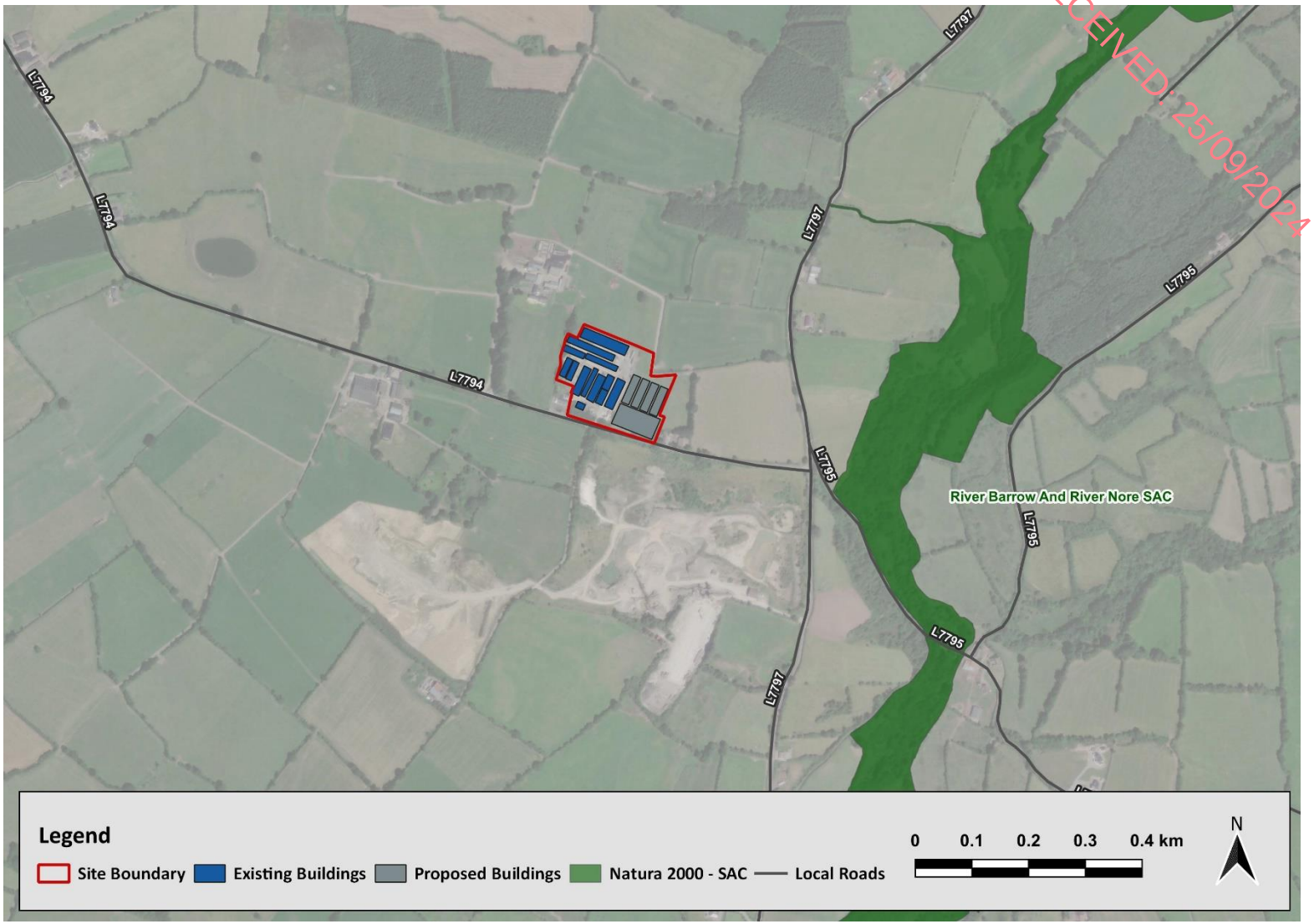

Figure 1 **Moate Pig Farm proposed Site boundary (red line) and the surrounding environment**

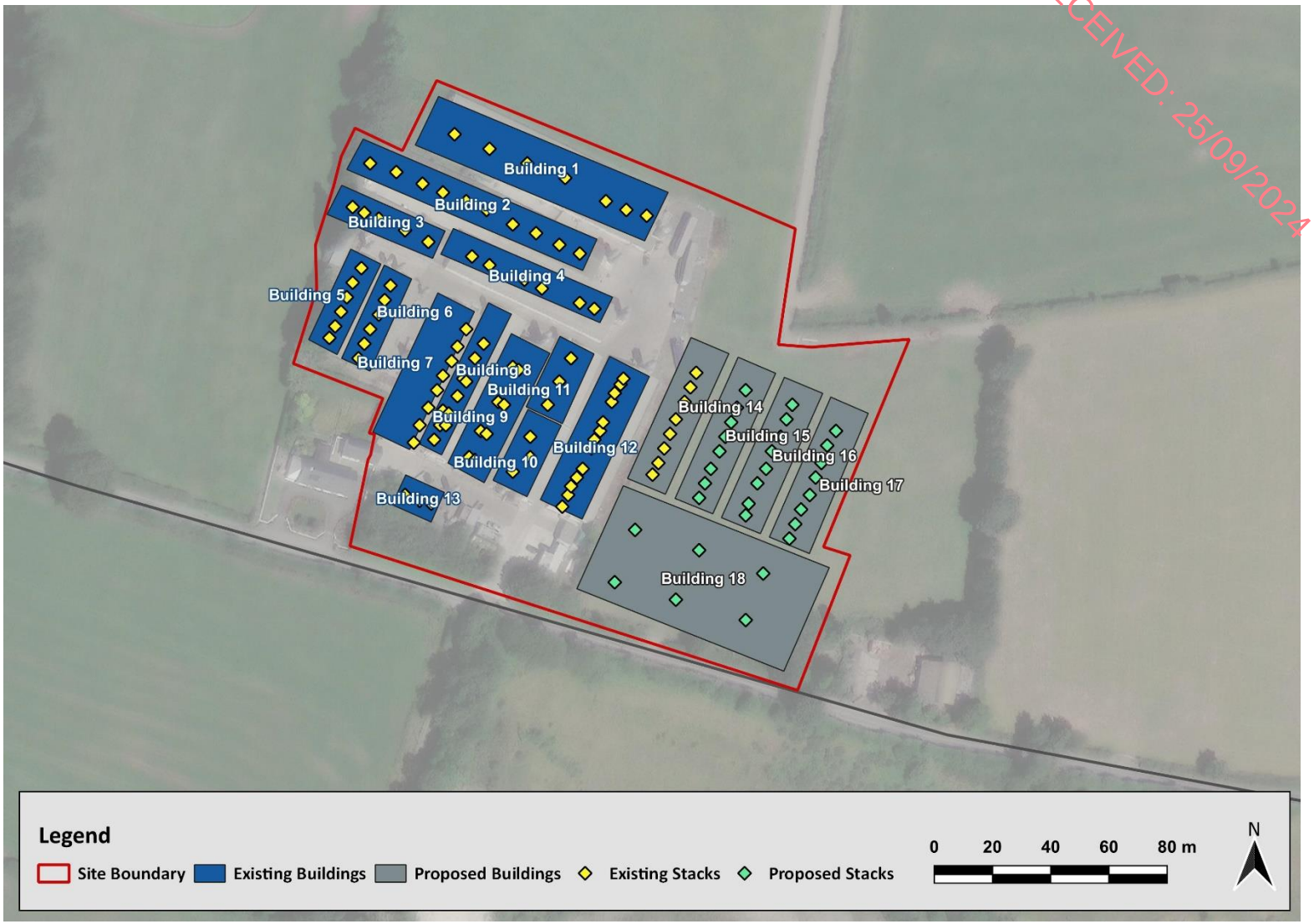

Figure 2 **Moate Pig Farm Site plan – existing and proposed housing units and existing and proposed chimney stacks**

3. REGULATORY FRAMEWORK AND ASSESSMENT CRITERIA

3.1 *Environmental Protection Agency Acts 1992 and 2003*

The *Environmental Protection Agency Act 1992 (EPA Act)* and Part 2 of the *Protection of the Environment Act 2003* are collectively referred to as the *Environmental Protection Agency Acts 1992 and 2003*. These Acts provide for the management of air emissions from activities (meaning any process, development or operation) that are listed in the First Schedule of the Acts.

Section 4 (2) of the *Environmental Protection Agency Acts 1992 and 2003* defines Air Pollution as follows:

> *"…the direct or indirect introduction to an environmental medium, as a result of human activity, of substances, heat or noise which may be harmful to human health or the quality of the environment, result in damage to material property, or impair or interfere with amenities and other legitimate uses of the environment, and includes –*
>
> *(a) 'air pollution' for the purposes of the Air Pollution Act 1987,*
>
> *(b) ……..*
>
> *(c) ……."*

The *Air Pollution Act 1987* (AP Act) provides for the control of air pollution and other matters connected with air pollution. Under the AP Act 'pollutant' means any substance that is specified in the First Schedule or any other substance (including a substance which gives rise to odour) or energy which, when emitted into the atmosphere either by itself or in combination with any other substance, may cause air pollution.

Section 4 of the AP Act defines air pollution as follows:

> *"Air pollution" in this Act means a condition of the atmosphere in which a pollutant is present in such a quantity as to be liable to —*
>
> (1) *be injurious to public health, or*
>
> *(ii) have a deleterious effect on flora or fauna or damage property, or*
>
> *(iii) impair or interfere with amenities or with the environment."*

Section 24 of the AP Act details the obligations of the occupier of a premises in respect to preventing emissions, nuisance and what constitutes defences against prosecution:

> *(1) The occupier of any premises, other than a private dwelling, shall use the best practicable means to limit and, if possible, to prevent an emission from such premises.*
>
> *(2) The occupier of any premises shall not cause or permit an emission from such premises in such a quantity, or in such a manner, as to be a nuisance.*
>
> *(3) In any prosecution for a contravention of this section, it shall be a good defence to establish that—*
>
> *(a) the best practicable means have been used to prevent or limit the emission concerned, or*
>
> *(b) the emission concerned was in accordance with a licence under this Act, or*
>
> *(c) the emission concerned was in accordance with an emission limit value, or*
>
> *(d) the emission concerned was in accordance with a special control area order in operation in relation to the area concerned, or*

I in the case of an emission of smoke, the emission concerned was in accordance with regulations under section 25, or

(f) the emission did not cause air pollution.

Section 75 (1) of the *Environmental Protection Agency Acts 1992 and 2003* requires the EPA to publish reasonable and desirable quality objectives to protect the environment, namely:

"The Agency shall, in relation to any environmental medium and without prejudice to its functions under section 103, specify and publish quality objectives which the Agency considers reasonable and desirable for the purposes of environmental protection."

3.2 Birds Directive and Habitats Directive

Concerned with the decline of wild bird species, EU Member States unanimously adopted the Birds Directive (79/409/EEC) in April 1979 that aims to conserve species of wild birds and the habitats that are crucial for their conservation. The Birds Directive was amended in 2009 (2009/147/EC).

The Habitats Directive (92/43/EEC) aims to promote the maintenance of biodiversity, taking account of economic, social, cultural and regional requirements. It forms the cornerstone of Europe's nature conservation policy with the Birds Directive and establishes the EU wide Natura 2000 ecological network of protected areas.

The Habitats Directive requires EU Member States to take measures to maintain or restore natural habitats and wildlife species at a favourable conservation status. Sites designated under the Birds Directive and the Habitats Directive form the Natura 2000 network. Maintaining or restoring the Natura 2000 network is an obligation that must be considered concurrently with requirements for increased food production and economic growth targets set for agricultural sectors in EU Member States.

The main aim of the Habitats Directive is to contribute towards the conservation of biodiversity by requiring EU Member States to take measures to maintain or restore natural habitats and wild species listed on the Annexes to the Directive at a favourable conservation status. These annexes list habitats (Annex I) and species (Annexes II, IV and V) that are considered threatened in the EU territory. The listed habitats and species represent a considerable proportion of biodiversity in Ireland and the Habitats Directive itself is one of the most important pieces of legislation governing the conservation of biodiversity in Europe.

The protection and conservation duties of EU Member States for Natura 2000 sites are specified in Article 6 of the Habitats Directive and are summarised below:

- Article 6(1): establish necessary conservation measures, management plans and appropriate statutory, administrative or contractual measures which correspond to the ecological requirements of the natural habitats and species present at the sites
- Article 6(2): take appropriate steps to avoid deterioration of Natura 2000 sites
- Article 6(3) and 6(4): assess the impact of new plans and projects and only agree to the plan or project if it will not adversely affect the integrity of the site unless the plan or project is imperative for reasons of overriding public interest.

The European Communities (Birds and Natural Habitats) Regulations 2011 to 2015, as amended (Birds and Natural Habitats Regulations) give effect to the Habitats Directive in Irish law. The regulations require, inter alia, that a public authority carry out screening for Appropriate Assessment of a plan or project for which an application for consent is received, to assess, in view of best scientific knowledge and in view of the conservation objectives of the site, if that plan or project, individually or in combination with other plans or projects is likely to have a significant effect on the European site. Where it is determined that an Appropriate Assessment is required, the Birds and Natural Habitats Regulations require that the assessment carried out by a public authority include a determination

pursuant to Article 6(3) of the Habitats Directive as to whether or not the plan or project would adversely affect the integrity of a European site.

3.3 Ammonia impact assessment – Guidance

In May 2021, due to a high volume of intensive agriculture applications/reviews and licenses, the Environmental Protection Agency (EPA) published EPA's Ammonia and Nitrogen Assessment Guidance. The Guidance was updated in March 2023. It describes how applicants should assess, the impact of air emissions, as part of a licence application for the following activities listed under the First Schedule of the Environmental Protection Agency Acts 1992 as amended:

- Class 6.1 (the rearing of poultry in an installation, where the capacity exceeds 40,000 places)
- Class 6.2 (the rearing of pigs in an installation where the capacity exceeds – (a) 750 places for sows, or. (b) 2,000 places for production pigs).

EPA's Ammonia and Nitrogen Assessment Guidance describes a six-step process for the assessment of emissions of ammonia to the atmosphere from intensive agricultural installations (IAIs). Step 1 needs to be completed for all applications to inform the additional steps that need to be completed.

Compliance with the criteria defined in the subsequent steps means that no further steps need to be undertaken and the compliant results can be presented to EPA for review as part of the approvals process.

EPA's Ammonia and Nitrogen Assessment Guidance provides instructions on the steps needed to determine the information required to allow for an AA Stage 1 screening process and where necessary, a Stage 2 AA assessment for Natura 2000 sites (EPA, 2023). The six (6) steps are described in detail and in graphical summary format in EPA's Ammonia and Nitrogen Assessment Guidance.

The graphical summary format of the step-wise approach is reproduced here in Figure 3. Katestone followed the step-wise approach described in EPA's Ammonia and Nitrogen Assessment Guidance in this assessment. The methodology adopted to complete this assessment is described in Section 6.

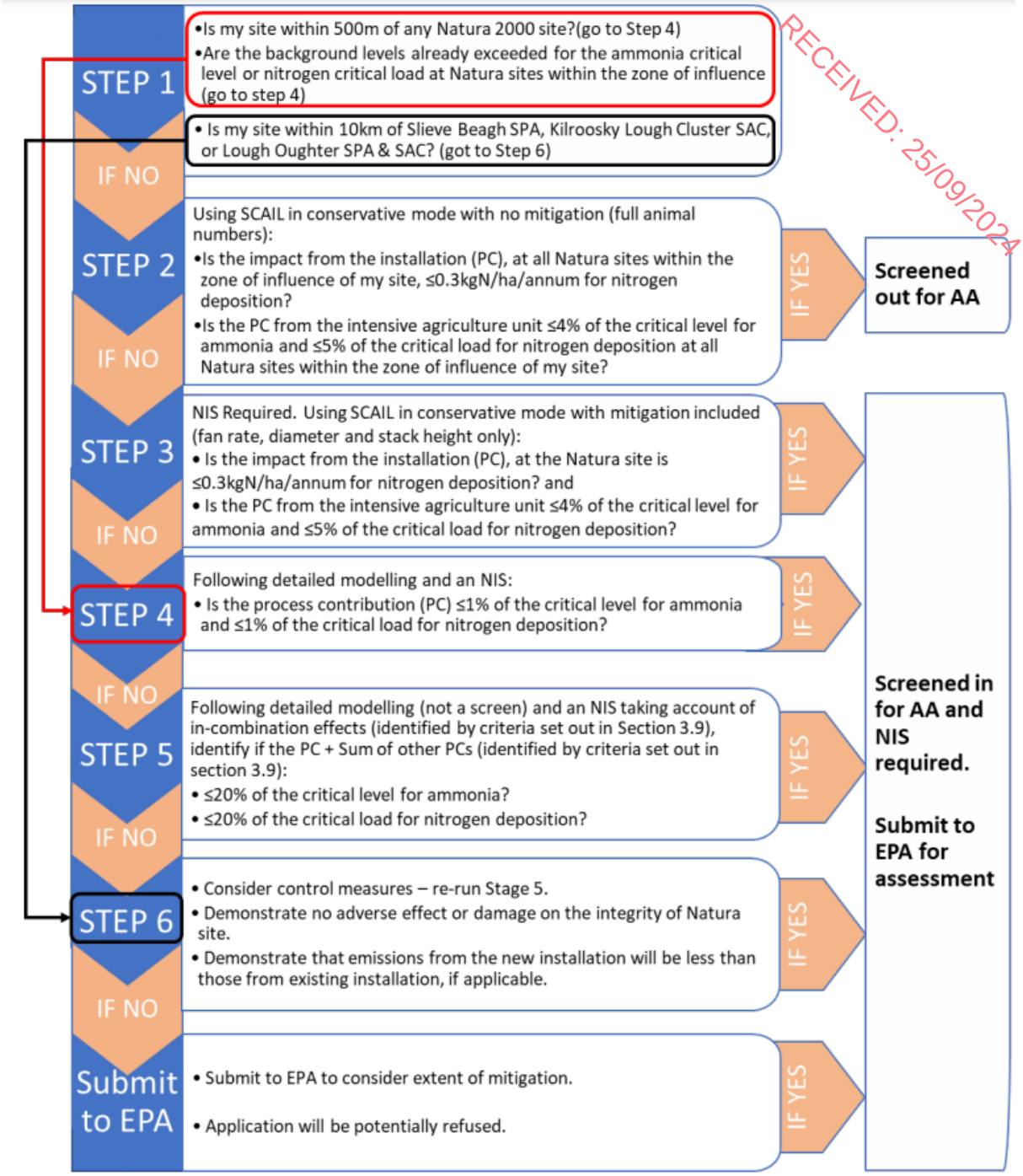

Figure 3 **The steps involved in the assessment process described in EPA's Ammonia and Nitrogen Assessment Guidance (reproduced from EPA, 2023)**

3.4 Assessment Criteria

The compliance criteria adopted in the assessment are based on critical limits. A critical limit, in its simplest form, is a threshold set to indicate when impacts on the terrestrial environment occur from air pollution. These can be used as part of the regulatory process for the assessment of impacts of air quality on terrestrial ecology (Kelleghan *et al.*, 2022). The EPA's Ammonia and Nitrogen Assessment Guidance adopts criteria based on critical limits including:

- Critical levels for ammonia
- Empirical critical loads for nitrogen deposition.

Both critical levels and loads are international guidelines used to protect habitats, primarily across Europe. Critical levels here refer specifically to the threshold for impacts that can occur directly from atmospheric ammonia, allowing for an acute measurement of direct effects. Critical levels are defined as "the concentration in the atmosphere above which direct adverse effects on receptors, such as plants, ecosystems or materials, may occur according to present knowledge" (Posthumus, 1988; Kelleghan *et al.*, 2022).

Empirical critical loads are based on total nitrogen deposition. A critical load is defined as a deposition rate below which, significant harmful effects do not occur "according to present knowledge" (Posthumus, 1988).

The critical level for ammonia and the critical load for nitrogen deposition for each of the species and habitat are presented in Section 4.4 for the modelled discrete receptors.

4. EXISTING ENVIRONMENT

This section presents information on the existing environment in the vicinity of the Site, within the dispersion modelling domain and within the meteorological modelling domain. The meteorological modelling domain has been generated using geophysical data (terrain and land use) and meteorological data.

The extents of the dispersion modelling domain were determined based on the locations of the nearest ecological receptors in all directions from the Site.

4.1 Local terrain and land-use

The Site is in a remote rural location surrounded by pasture. The site is located near the base of a valley that is oriented north to south; however, the valley bends to an east west orientation immediately north of the site. The Owenbeg River follows the valley and flows from north to south at a point 500 m due east of the site.

The Moate Pig Farm is at an elevation of approximately 180 m. The terrain drops to 150 m approximately 500 to east of the site and from this point rises to rises to over 282 m within 2.5 km. This elevated land extends south for about 5 km with further elevated land approximately 5 km due south of the site. The terrain is relatively flat north, west and southeast of the site. There are rolling hills immediately southwest, south and southeast of the site with parts of the terrain both higher and lower than the site.

The complexities of the local terrain and proximity of the Owenbeg River and river valley are likely to have an important effect on dispersion conditions in the vicinity of the proposed farm.

The terrain of the modelling domain is presented as a 2-dimenstional surface plot in in Figure 4.

The hills of the modelling domain will affect synoptic scale wind patterns in the area by:

- Blocking wind coming from certain directions
- Channelling winds along the valleys created by the hills
- Creating very specific local air flows under low windspeed conditions due to katabatic and anabatic air flows created by the slopes of the hills.

The hills to the east of the pig farm result in a north-south oriented valley.

The proximity of the Site to local terrain and the Owenbeg River is likely to have an important effect on dispersion conditions near the Site and across the modelling domain.

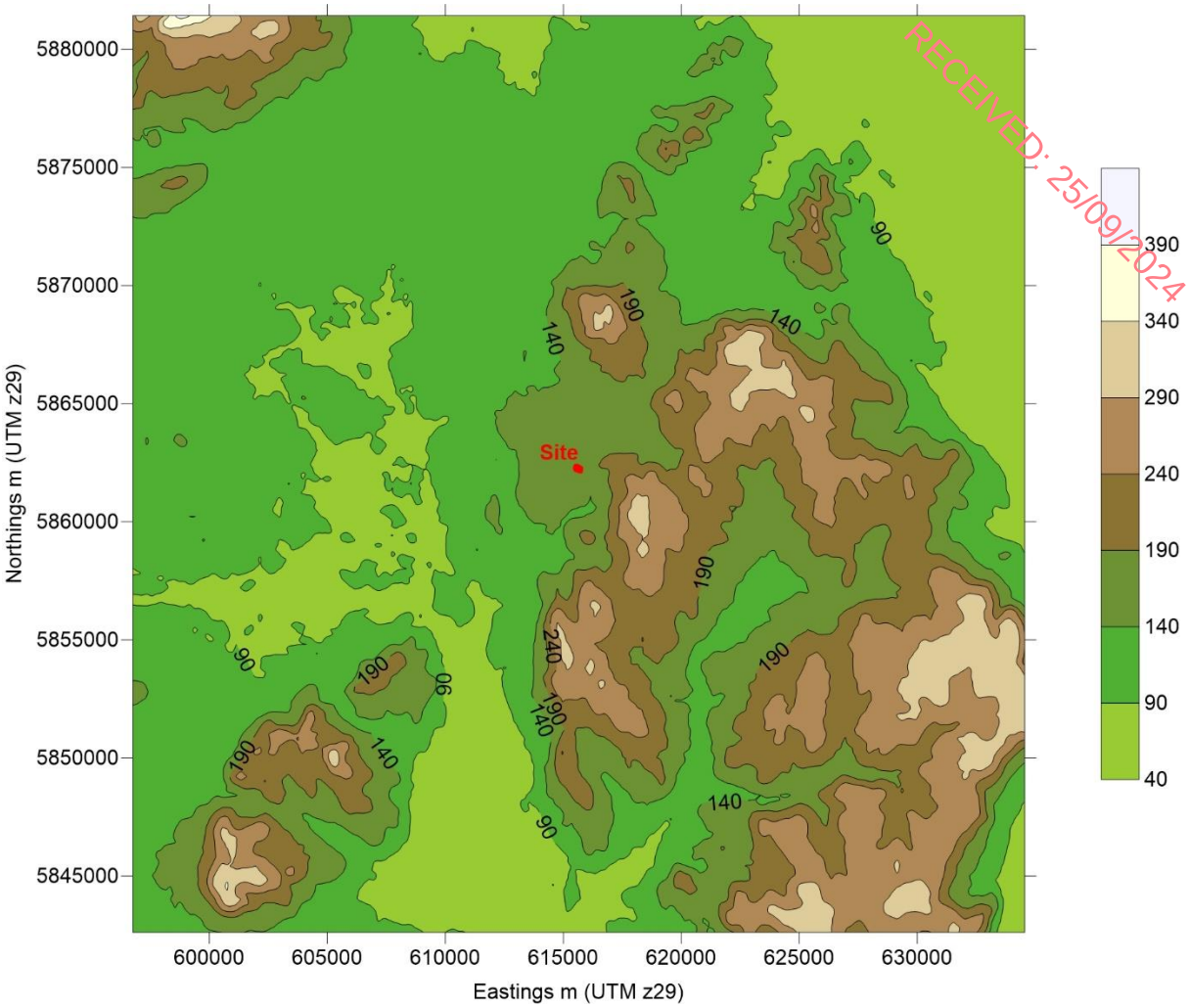

Figure 4 2-dimensional terrain of the modelled domain

4.2 Meteorology

Wind speed and wind direction are important parameters for the transport and dispersion of air pollutants from a source. The winds in the vicinity of the Site have been characterised using a three-dimensional meteorological model called CALMET. The 1-hour average wind speed for the modelling period is 3.99m/s. This compares to a 1-hour average wind speed of 4.3 m/s at Gurteen between 2008 and 2018 (EPA, 2020). A wind rose representing the annual distribution of 1-hour average winds is presented in Figure 5.

The prevailing wind direction in Ireland is between south and west. It is clear from Figure 5 that these winds influence wind patterns at the Site. A significant proportion of wind from the northeast is also prevalent at the site. Daytime winds between 6 am and 6 pm are heavily influenced by the prevailing winds. During late evening and early morning, prevailing winds also dominate; however, there is also a substantial proportion of winds from the northwest as indicated in the diurnal wind roses (Figure 6).

The seasonal distribution of wind speed and wind direction is presented in Figure 7. The strongest winds at the Site occur most frequently from the south during the winter months. The greatest proportion of light winds occur during summer. There is a distinct north-easterly component to the wind rose in all seasons. A significant proportion of light north-easterly winds occur during spring months.

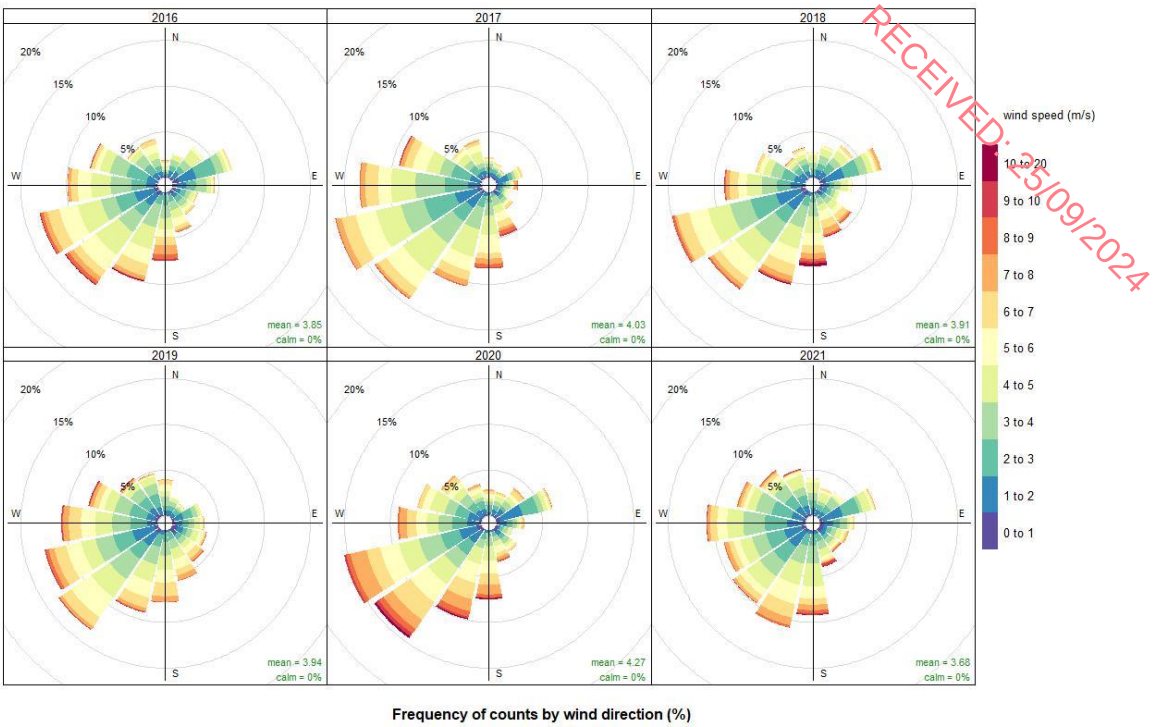

Figure 5 **Annual wind distribution predicted at the Site using CALMET for 2016 to 2021**

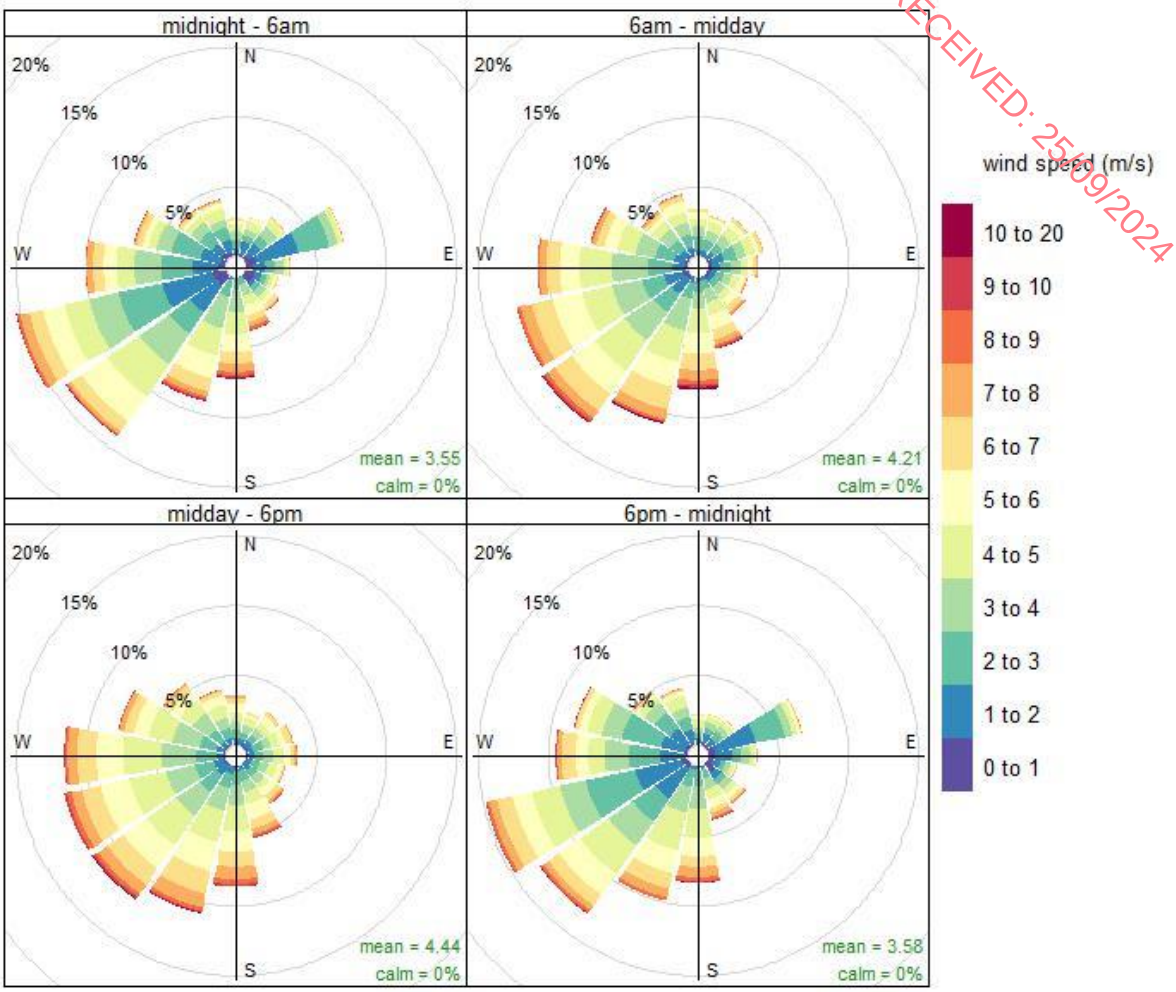

Figure 6 **Diurnal wind distribution predicted at the Site using CALMET**

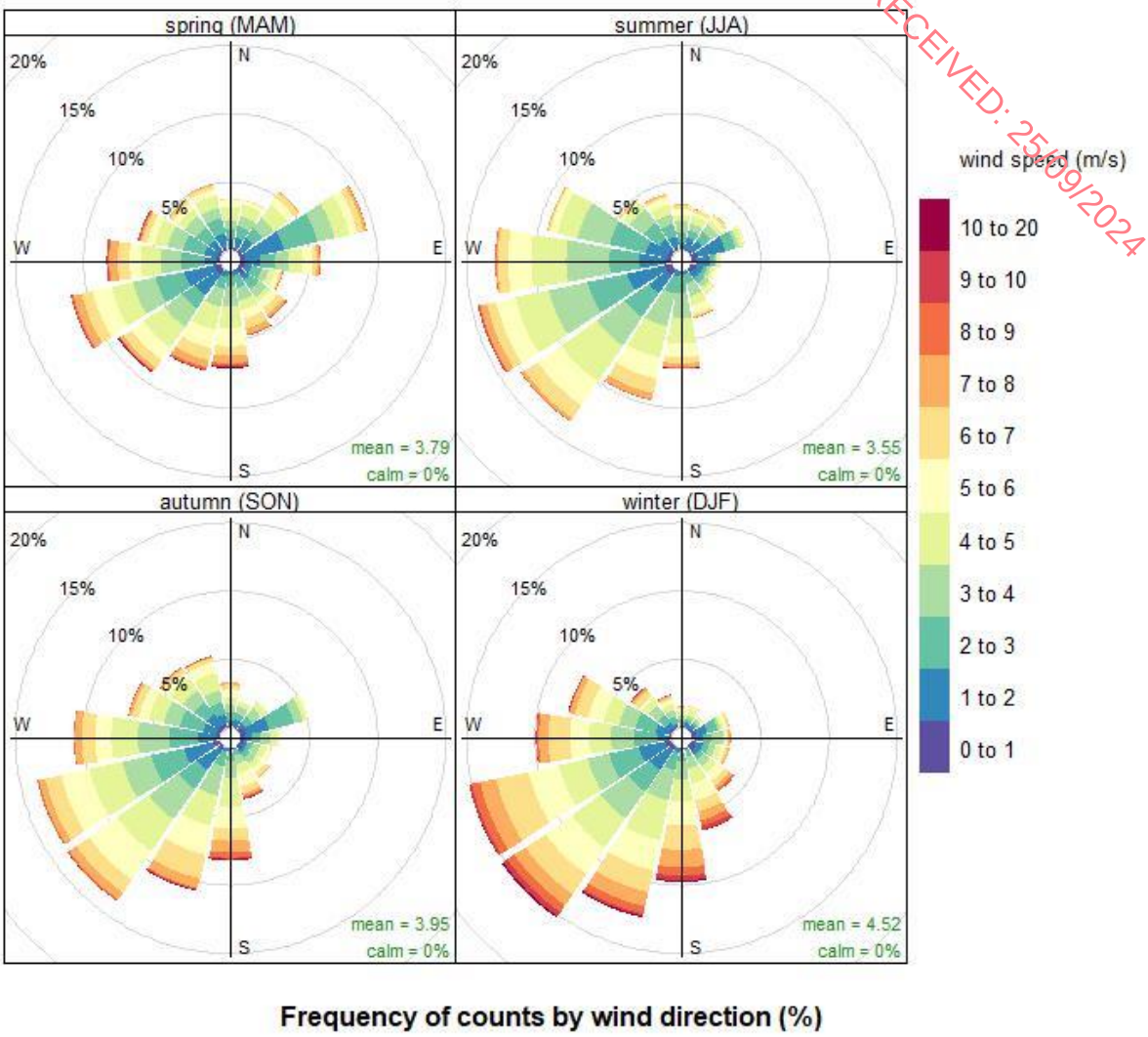

Figure 7 Seasonal wind distribution predicted at the Site using CALMET

4.3 Background concentrations of ammonia and nitrogen deposition

The background ammonia concentration and nitrogen deposition flux rates at each modelled sensitive receptor were obtained from the Simple Calculation of Atmospheric Impacts Limits (SCAIL) online tool as recommended in EPA's Ammonia and Nitrogen Assessment Guidance (EPA, 2023). The background concentrations of ammonia and nitrogen deposition levels adopted in the assessment are presented in Table 1.

Background ammonia concentration and nitrogen deposition flux rates adopted in the assessment were included in the assessment methodology defined in EPA's Ammonia and Nitrogen Assessment Guidance.

Table 1 **The background concentrations of ammonia and nitrogen deposition levels adopted in the assessment (based on SCAIL)**

Receptor	SCAIL Background	
	Concentration of ammonia (µg/m³)	Nitrogen Deposition Flux (kg/ha/yr)
DR1	3.03	18.46
DR2	3.03	19.56
DR3	3.03	20.96
DR4	3.03	21.46
DR5	3.26	31.01
DR6	3.26	26.71
DR7	3.03	23.36
DR8	3.03	23.66
DR9	3.03	24.56
DR10	3.26	26.21
DR11	3.26	29.51
DR12	3.26	31.11
DR13	3.26	33.01
DR14	3.26	34.01
DR15	3.06	33.74
DR16	3.06	28.64
DR17	3.06	24.44
DR18	3.06	21.34
DR19	3.06	20.44
DR20	3.06	20.24
DR21	3.06	18.54
DR22	3.06	16.24
DR23	3.06	15.24
DR24	2.69	12.91
DR25	2.69	11.81
DR26	2.69	10.61
DR27	2.69	11.41
DR28	2.69	10.91
DR29	2.69	10.31
DR30	2.71	9.03
DR31	2.71	8.63
DR32	2.68	8.08
DR33	2.77	7.89
DR34	2.77	7.83
DR35	2.91	7.89
DR36	2.91	7.86
DR37	2.97	7.89

Receptor	SCAIL Background	
	Concentration of ammonia (µg/m³)	Nitrogen Deposition Flux (kg/ha/yr)
DR38	2.97	7.82
DR39	2.98	7.58
DR40	3.08	7.7
DR41	3.1	7.72
DR42	3.1	7.72
DR43	3.01	7.68
DR44	2.93	7.63
DR45	2.89	7.39
DR46	2.84	7.29
DR47	2.84	7.44
DR48	2.88	7.26
DR49	2.88	7.19
DR50	2.81	6.88
DR51	2.78	7.27
DR52	2.72	7.37
DR53	2.76	7.54
DR54	2.76	7.51
DR55	2.85	7.58
DR56	2.86	7.62
DR57	2.88	7.73
DR58	2.9	7.99
DR59	2.92	8.02
DR60	2.92	7.98
DR61	2.92	7.94
DR62	2.96	7.99
DR63	2.96	7.99
DR64	2.96	7.99
DR65	2.91	7.92

4.4 Sensitive receptors

The sensitive receptors that are nearest to the Site are presented in Figure 8. The sensitive receptors included in the dispersion modelling assessment are at locations on Natura 2000 sites in the vicinity of the pig farm. EPA's Ammonia and Nitrogen Assessment Guidance requires Natura 2000 sites within 10 km of an intensive agricultural installation to be included in a screening assessment. The Natura 2000 sites within 10 km of the pig farm that were considered in this assessment include:

- River Barrow and Nore SAC (Site code)
- River Nore SPA (004233)
- Lisbigney Bog SAC (000869).

The Lisbigney Bog SAC and the part of the River Barrow and Nore SAC that are within 10 km of the pig farm contain a range of ammonia and nitrogen sensitive species and habitats that are listed as conservation interests for these sites.

The River Barrow and Nore SAC includes areas of habitats and species with sensitivity to atmospheric nitrogen deposition. However, the only habitat with sensitivity to atmospheric ammonia and nitrogen deposition on the River Barrow and Nore SAC within 10 km of the pig farm is Alluvial Forests with *alnus glutinosa and fraxinus excelsior* (NPWS, 2011).

The closest portion of the River Barrow and Nore SAC within 10 km of the pig farm is a stretch of the Owenabeg River (a tributary of the River Nore). The closest point of the Owenbeg River is 500 m east of the site. This stretch of the Owenabeg River flows through agricultural land. A review of the conservation objectives published by NPWS for this portion of the River Barrow and Nore SAC indicates that there are no ammonia and nitrogen sensitive species or habitats identified along the stretch of the Owenabeg River within 10 km of the pig farm (NPWS, 2011).

The River Nore flows from north to southwest of the site. The closest point of the River Nore is 6.2 km southwest of the site. A review of the conservation objectives published by NPWS for the stretch of the River Nore within 10 km of the site indicates that there is a single area of Alluvial Forests with *alnus glutinosa and fraxinus excelsior* 6.6 km west of the site. There were no other ammonia and nitrogen sensitive species or habitats identified along the stretch of the River Nore within 10 km of the pig farm (NPWS, 2011).

A further tributary of the River Nore, the Erkina River that forms part of the River Barrow and Nore SAC is within 10 km of the Site. A review of the conservation objectives published by NPWS for the stretch of the Erkina River within 10 km of the site indicates that there is a single area of Alluvial Forests with *alnus glutinosa and fraxinus excelsior* 9.9 km southwest of the site (NPWS, 2011).

The Lisbigney Bog SAC includes areas of habitats and species with sensitivity to atmospheric ammonia and nitrogen deposition. The habitat with sensitivity to atmospheric ammonia and nitrogen deposition on the Lisbigney Bog SAC within 10 km of the pig farm is Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*. This species occurs throughout the Lisbigney Bog SAC (NPWS, 2021).

The site-specific conservation objectives aim to define favourable conservation condition for particular habitats or species at that Natura 2000 site.

The habitats and species listed as conservation objectives at the Natura 2000 within 10 km of the pig farm and with sensitivity to atmospheric ammonia and nitrogen deposition include:

- Alluvial Forests with *alnus glutinosa and fraxinus excelsior*
- Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae.*

These habitats are listed as conservation objectives at the Natura 2000 sites as follows:

- The River Barrow and Nore SAC (NPWS, 2011).
    - Alluvial Forests
- The Lisbigney Bog SAC (NPWS, 2021):
    - Calcareous fens.

A critical level for ammonia and the critical load for nitrogen deposition was adopted at each Discrete location included in the modelling assessment. For each location published critical level for ammonia and the critical load for nitrogen deposition for the habitat was adopted based on the type of species identified at the modelled location. If a modelled location did no contain a habitat or species listed as a conservation objective and with sensitivity to atmospheric ammonia and nitrogen deposition, then the critical level for ammonia and the critical load for nitrogen deposition that is relevant for higher species and habitats that are not sensitive to ammonia was adopted as the relevant criteria level at that point.

Table 2 The critical level for ammonia and the critical load for nitrogen deposition for each of the species and habitat within 10 km of the pig farm

Habitat or Species	Critical Level	Critical Load
	µg/m³	kg/ha/year
Alluvial Forests	3.0	15.4
Calcareous fens	3.0	15.0
[1] In the absence of published critical loads the community change point published in the UCD NPWS document was applied (NPWS, 2022)		

The critical level for ammonia and the critical load for nitrogen at each modelled location is presented in Table 2. If no sensitive species or habitat has been identified at a modelled receptor location, the critical level and critical load for higher species that are not sensitive to ammonia or nitrogen deposition was adopted at that location.

The sensitive receptor locations included in the dispersion modelling assessment are presented graphically in a map in Figure 8. The sensitive receptors are presented in tabular format in Table 3, which includes for each location:

- The conservation objectives of the habitats or species identified at that point
- The critical level for ammonia adopted in the modelling assessment
- The critical load for nitrogen deposition adopted in the modelling assessment.

Table 3 **Sensitive receptor locations included in the dispersion modelling assessment, the conservation interest at each location, the critical level for ammonia adopted in the modelling assessment and the critical load for nitrogen deposition at each location.**

Receptor	Species or Habitat				Ammonia Concentration	Nitrogen Deposition
	Alluvial Forests (91E0)	Calcerous Fens (7210)	White-Clawed Crayfish (1092)	Nore Freshwater Pearl Mussel (1990)	µg/m³	kg/ha/yr
DR1					3	30
DR2					3	30
DR3					3	30
DR4					3	30
DR5					3	30
DR6					3	30
DR7					3	30
DR8					3	30
DR9					3	30
DR10					3	30
DR11					3	30
DR12					3	30
DR13					3	30
DR14					3	30
DR15					3	30
DR16					3	30
DR17					3	30
DR18					3	30
DR19					3	30
DR20					3	30
DR21					3	30
DR22					3	30

Receptor	Species or Habitat				Ammonia Concentration	Nitrogen Deposition
	Alluvial Forests (91E0)	Calcerous Fens (7210)	White-Clawed Crayfish (1092)	Nore Freshwater Pearl Mussel (1990)	ug/m³	kg/ha/yr
DR23					3	30
DR24					3	30
DR25					3	30
DR26					3	30
DR27					3	30
DR28					3	30
DR29			✓		3	30
DR30					3	30
DR31			✓		3	30
DR32			✓		3	30
DR33					3	30
DR34					3	30
DR35			✓		3	30
DR36			✓		3	30
DR37			✓		3	30
DR38					3	30
DR39					3	30
DR40					3	30
DR41					3	30
DR42				✓	3	30
DR43			✓	✓	3	30
DR44					3	30
DR45	✓		✓		3	15.4
DR46				✓	3	30
DR47			✓	✓	3	30

Receptor	Species or Habitat				Ammonia Concentration	Nitrogen Deposition
	Alluvial Forests (91E0)	Calcerous Fens (7210)	White-Clawed Crayfish (1092)	Nore Freshwater Pearl Mussel (1990)	ug/m³	kg/ha/yr
DR48				✓	3	30
DR49	✓			✓	3	15.4
DR50	✓			✓	3	15.4
DR51	✓			✓	3	15.4
DR52				✓	3	30
DR53				✓	3	30
DR54				✓	3	30
DR55					3	30
DR56					3	30
DR57					3	30
DR58		✓		✓	3	15
DR59		✓			3	15
DR60		✓			3	15
DR61		✓			3	15
DR62		✓			3	15
DR63		✓			3	15
DR64		✓			3	15
DR65		✓			3	15

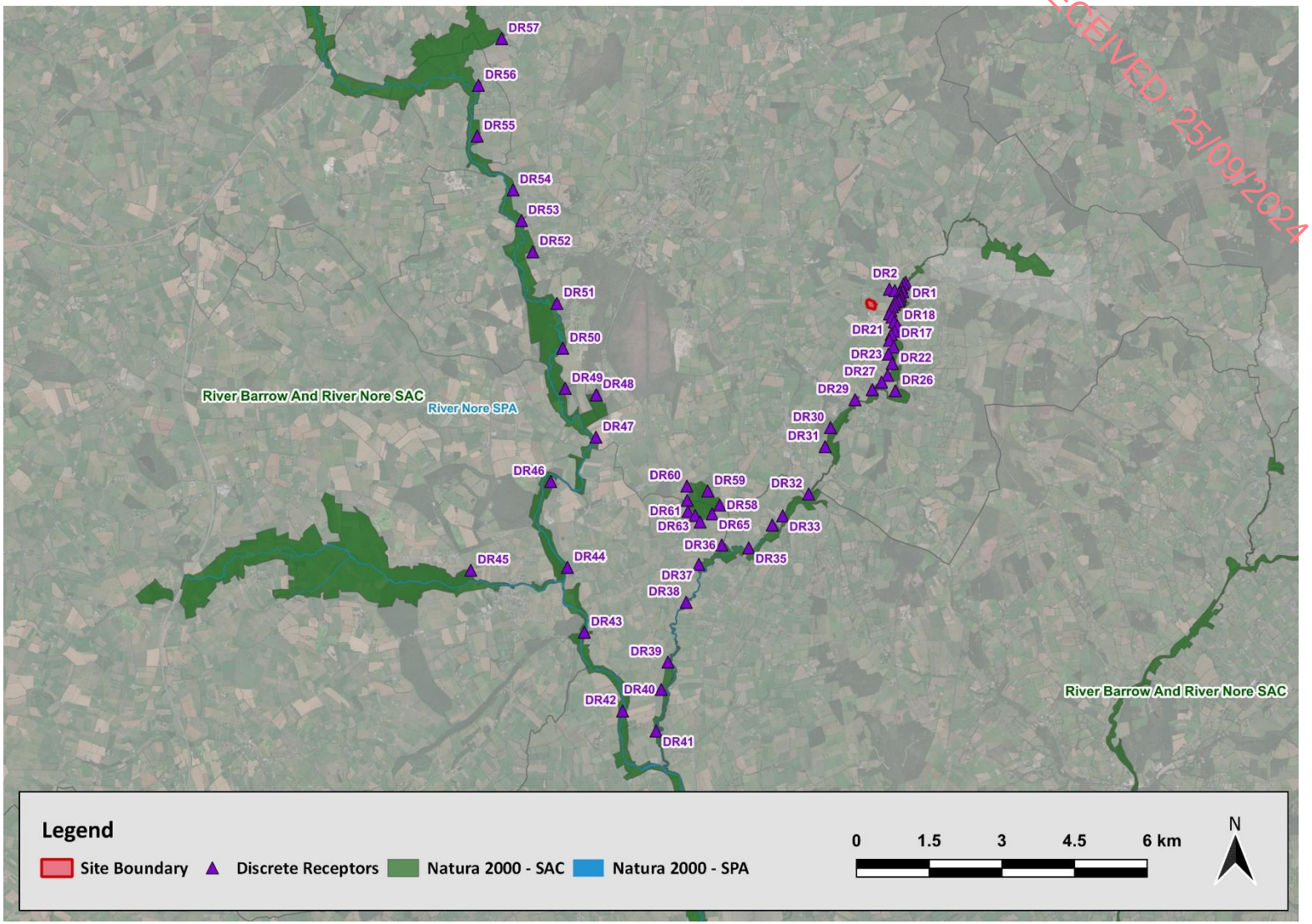

Figure 8 **The sensitive receptors included in the dispersion modelling assessment to represent locations on Natura 2000 sites**

5. ASSESSMENT

5.1 Dispersion modelling methodology

The following sections describe the dispersion modelling methodology that was adopted to determine concentrations of ammonia and deposition rates of nitrogen from the pig farm in combination with background levels at ecologically sensitive locations near the Site. The methodology is based on a dispersion modelling study incorporating source characteristics and operational activity data of the pig farm with meteorological data that is representative of the Site and surrounding region. The dispersion modelling assessment has been prepared in accordance with industry standards, regulatory requirements and best practice approaches.

The assessment methodology has included:

- Determination of the locations and emission characteristics at the pig farm.
- Derivation of an emissions inventory based on its design and data from the literature for the pig farm.
- Generation of a representative meteorological dataset using prognostic meteorological modelling techniques.
- Characterisation of meteorological conditions in the region using prognostic meteorological data.
- Dispersion modelling using the regulatory dispersion model, CALPUFF, to predict ground-level concentrations of ammonia and nitrogen deposition at sensitive receptor locations.

5.2 SCAIL-Agriculture

The baseline levels of ammonia and flux rates of nitrogen deposition at the sensitive ecological receptor locations were determined using SCAIL- Agriculture for Step 1 of EPA's Ammonia and Nitrogen Assessment Guidance.

SCAIL-Agriculture is a tool for assessing impacts of atmospheric nitrogen from agricultural installations in the UK and Ireland. It is a model underpinned by a detailed air dispersion model, AERMOD (Kelleghan *et al.*, 2022).

SCAIL-Agriculture includes estimates of baseline levels of ammonia and flux rates of nitrogen deposition across Ireland. The SCAIL-Agriculture ambient concentration model (1 x 1 km grid) has been updated to include modelled 2018 emissions by the UKCEH on behalf of the EPA. Similarly, the coarser international 2018 European Monitoring and Evaluation Programme (EMEP) national concentration and deposition models for Ireland have been made available through the AmmoniaN2K website (AmmoniaN2K, 2021). Both these models currently rely on the MapEire emissions model, which utilises cattle and sheep distribution from 2010 and locations of pig and poultry farms from 2015 according to the Irish Wildlife Manual 135 (Kelleghan *et al.*, 2022).

5.3 Meteorological modelling

5.3.1 Overview

EPA's Air Dispersion Modelling Guidance Note (AG4) states that the dispersion process is dependent on the underlying meteorological conditions and ensuring that the air dispersion model includes representative meteorological data is critical. In the absence of Site-specific meteorological data, AG4 requires the use of representative data observed at a Met Eireann monitoring location. AG4 states:

> *The USEPA (24) has defined meteorological representativeness as:*

> *"the extent to which a set of {meteorological} measurements taken in a space-time domain reflects the actual conditions in the same or different space-time domain taken on a scale appropriate for a specific application"*

and has expanded on this definition by outlining the factors to consider in the selection of appropriate meteorological data:

- *Proximity of the meteorological station to the modelling domain;*
- *The complexity of the terrain;*
- *The exposure of the meteorological monitoring Site;*
- *The period of time during which data is collected."*

The modelling domain includes areas of semi-complex terrain. The meteorological parameters that affect dispersion are likely to vary spatially and temporally across the modelling domain due to the complexity of the terrain.

The closest Met Eireann monitoring location to the Site is at Oak Park, Co. Carlow, which is 25 km east of the pig farm. This monitoring station is in rural rolling landscape. It sits at a low point in the local terrain and is close to the River Barrow. Meteorological data at Barrow Park is characterised by frequent northerly and southerly winds that occur due to the north-south orientation of the valley in which the monitoring station is located. The meteorological station at Oak Park is not likely to be representative of meteorological conditions at the Site as the terrain at both locations is very different.

A review by Katestone indicates that there are no other meteorological observation stations on the Met Eireann Network that meet the requirements specified in AG4 to be considered representative of the modelling domain.

Where site-specific or representative meteorological data is not available, AG4 provides the following alternatives:

> *Prognostic meteorological data should be considered in locations where there is no comparable representative Met Eireann station particularly in areas of complex terrain or at a land / sea interface.*

and

> *Prognostic meteorological data may be useful in locations where there is no comparable representative Met Eireann station. Locations where prognostic meteorological data may be required include regions of complex terrain and at a land/sea interface in circumstances where the nearest meteorological stations are outside of the modelling domain. As outlined by the USEPA, meteorological data should be spatially representative of the modelling domain and in particular of the pathway from the source to the most impacted receptor.*

Accordingly, prognostic meteorological data was generated for the Site due to the complexity of the terrain. The approach adopted to generate representative site-specific data used a numerical model to generate a 3-dimensional grid of spatially varying meteorological parameters to represent conditions surrounding the Site. The approach is described in Appendix A1.

5.3.2 Meteorology

The prognostic model TAPM (developed in Australia by the Commonwealth Scientific and Industrial Research Organisation [CSIRO], version 4.0.5) and the diagnostic meteorological model CALMET (developed by EarthTec, version 6.5) were used to generate the three-dimensional meteorological dataset for the region.

The CALMET simulation was initialised with the gridded TAPM 3D wind field data from the innermost nest. CALMET treats the prognostic model output as the initial guess field for the CALMET diagnostic model wind fields. The initial

guess field is then adjusted for the kinematic effects of terrain, slope flows, blocking effects and 3D divergence minimisation.

The three-dimensional wind field produced by TAPM/CALMET was then used to create a meteorological file suitable for us with the CALPUFF dispersion model.

Details of the model configuration and evaluation are presented in Appendix A.

The TAPM/CALMET approach has been used in jurisdictions like Australia to generate suitable meteorological data for modelling impacts for over 15 years. It has been adopted in the assessment of a number of proposed projects in Ireland in the last 5 years. There is significant experience using these approaches in jurisdictions such as Australia. Industry specific guidance on modelling odour dispersion from sources such as intensive poultry farms and cattle feedlots recommend the use of TAPM/CALMET to generate representative site-specific data. Research in Europe indicates that meteorological data generated using a numerical model provided a better indication of locations where odour nuisance occurred (Feliubadaló et al, 2008). In that study, locations of likely odour nuisance were determined using the German VDI grid assessment approach. The correlation between observed and modelled odour concentrations was significantly better using the TAPM/CALMET approach compared to traditional steady state gaussian models such as AERMOD.

5.4 Emissions

The derivation of the ammonia emissions inventory adopted for the dispersion modelling assessment is presented in this section. Ammonia emission inventories were derived for the old housing units and the new housing units at the pig farm.

There are no emissions monitoring data available for the pig farm. Ammonia emission rates from the pig housing units at pig farms vary considerably depending on factors such as:

- The ventilation rate which is heavily influenced by:
    - The target temperature of the pigs in the unit which is influenced by:
        - Type of pig (sow, weaner, fattener).
        - The age of the pigs
    - The ambient temperature outside the pig unit.
- The design of the housing system including but not limited to the following:
    - Depth of manure holding pits
    - Frequency on manure removal
    - Ventilation design
    - Surface area of manure exposed beneath the slats.
- The depth of manure in the house, which varies considerably with season.

The ammonia emission inventory derived for the pig farm is based on:

- The design and operation of the old housing units and the new housing units at the pig farm.
- Ammonia emission rates for housing units presented in the latest Best Reference (BREF) document for the intensive rearing of poultry or pigs (IRPP) (EC, 2017).

The existing housing units are operated as traditional deep pit housing units. The pig diets at the existing housing units are formulated with reduced protein content to limit emissions. The pig diets at the existing housing units will continue to be formulated with reduced protein content to limit emissions. As part of the proposed development

only House 1 and House 4 (see Figure 2) will be operated as traditional deep pit housing units. All other existing housing units will be operated as shallow pit housing units.

The pig farm will be operated so that no external slurry storage will be required as part of the proposed development. This will be despite operating some existing and all proposed housing units with shallow tanks as there is sufficient slurry storage capacity in the deep pit storage tanks of House 1 and House 4 and the shallow pit tanks of all other housing units to meet the regulatory requirements for slurry storage at the site.

The ammonia emission rates adopted in the dispersion modelling assessment for the existing housing units operated with shallow tanks and the proposed housing units are based on BAT[1] emission rates contained in the BREF for IRPP. The BREF reports acceptable emission limits (AEL) for various techniques as ranges. The upper limit of the ranges has been adopted for the old housing units for the proposed development as follows:

- 2.7 kg.animal^{-1}.year^{-1} for dry sows
- 2.7 kg.animal^{-1}.year^{-1} for gilts
- 5.6 kg.animal^{-1}.year^{-1} for farrowing sows
- 0.53 kg.animal^{-1}.year^{-1} for weaners
- 2.6 kg.animal^{-1}.year^{-1} for fatteners.

The BREF provides a single BAT-AEL for fattener pigs. Fattener pigs; however, can be classified as growers and finishers with growers defined with a weight range between 30 kg and 60 kg and finishers defined with a weight range between 60 kg and 120 kg. Fatteners are split into finishers and growers in Irish EPA guidance and the SCAIL online tool. The rate of ammonia emissions from the SCAIL online tool for fatteners include:

- 4.14 kg.animal^{-1}.year^{-1} for finishers
- 1.59 kg.animal^{-1}.year^{-1} for growers.

The emission rates of ammonia from growers are, therefore, 38% of the emission rates for finishers.

In a pig production unit if all fatteners are raised to the same production weight, the ratio of fattener pigs will be:

- One third growers
- Two thirds are finishers.

A weighted average emission rate for fatteners (finishers and growers) based on SCAIL ammonia emission rates and the ratio of pigs in each category is 3.29 kg.animal^{-1}.year^{-1}. Considering that the ammonia emissions rate adopted for fatteners in SCAIL is 4.14 kg.animal^{-1}.year^{-1}, the ammonia emission rate for finishers is, on average, 79.4% of the emission rate of fatteners.

The BAT-AEL for fatteners has been adapted for the number of grower and finisher pigs accommodated in existing and new housing units by scaling the BAT-AEL for fatteners by 79.4% to account for the emission rate of growers and finishers as a combined group. The BAT-AEL for fattener pigs of 2.6 kg.animal^{-1}.year^{-1} adopted in the assessment is, therefore, 2.1 kg.animal^{-1}.year^{-1}.

The ammonia emission rates adopted for the housing units operated with deep pits including House 1 (dry sows) and House 4 (fatteners) are based on data presented in the BREF for IRPP including the following based on data from Table 5.4 of the BAT conclusions for *existing plants using a deep pit in combination with nutritional*

[1] Based on data from Table 5.4 of the BAT conclusions, which presents AELs for piggeries that are designed and operated in accordance with BAT.

management techniques. The BAT-AELs for upper range of ammonia emissions for *existing plants using a deep pit in combination with nutritional management techniques* are:

- 4.0 kg.animal^{-1}.year^{-1} for dry sows
- 3.6 kg.animal^{-1}.year^{-1} for fatteners.

The BAT-AEL for fatteners housed with deep pit storage has been adapted for the number of grower and finisher pigs accommodated in housing unit by scaling the BAT-AEL for fatteners by 79.4% to account for the emission rate of growers and finishers as a combined group as described previously in this section. The ammonia emission rates adopted for the this housing unit at the proposed development is, therefore, 2.86 kg.animal^{-1}.year^{-1}.

The assessment was conducted in accordance with recognized techniques for dispersion modelling specified in EPA's Air Dispersion Modelling Guidance Note (AG4). CALPUFF was used to predict ground-level concentrations of ammonia and nitrogen deposition rates across the modelling domain and at sensitive ecological receptor locations on nearby Natura 2000 site due to sources at the pig farm.

The details of source characterization utilized for the pig farm in the modelling assessment are provided in Section 5.8.

5.5 Deposition

Deposition flux rates of nitrogen at sensitive receptors were estimated based on the predicted concentrations of ammonia across the modelled domain and using the following calculation methodology that is described in AG4:

> *The critical loads in ecologically sensitive areas such as SPAs, SACs and NHAs can be determined using the methodology outlined in the UK publication "AQTAG06 – Technical Guidance on Detailed Modelling Approach For An Appropriate Assessment For Emissions To Air" (Environment Agency, 2014)(64) . The approach is based on using the maximum annual average ground level concentration within the ecologically sensitive area and converting this concentration into a deposition flux based on a chemical species specific deposition velocity (m/s) as outlined in Table A3.*

The recommended dry deposition velocities for ammonia in Table A3 of AG4 are:

- 0.02 m/s for grassland
- 0.03 m/s for forest.

Dry deposition flux (µg m^{-2} s^{-1}) is calculated as the product of the ground-level process contribution (µg/m^3) and the deposition velocity (m/s).

The dry deposition velocities adopted in the modelling assessment was assumed to be 0.02 m/s for all modelled sensitive locations as the modelled locations do not contain forestry.

5.6 Building downwash

When modelling emissions from an industrial installation it should be borne in mind that stacks that are relatively short can be subjected to additional turbulence due to the presence of nearby buildings. Buildings are considered nearby if they are within five times the lesser of the building height or maximum projected building width (but not greater than 800m) (EPA, 2020).

A plume of a short stack is likely to be downwashed if its height is less than two and a half times the height of nearby buildings within a distance of 10 x L from each source, where L is the lesser of the height or width of the building. A Building Profile Input Program (BPIP) was used to determine the effects of buildings on the point sources of emissions at the pig farm. The Plume Rise Model Enhancements (PRIME) algorithm is recommended in EPA

Guidance for use with AERMOD. PRIME was used in the dispersion modelling assessment to determine the effect of building induced turbulence on plumes from point sources at the pig farm.

The PRIME algorithm takes into account the position of each stack relative to each relevant building and the projected shape of each building for 36 wind directions (at 10º intervals). The model determines the change in plume centreline location with downwind distance based on the slope of the mean streamlines and coupled to a numerical plume rise model.

Twenty onsite buildings/structures have been included in the BPIP program to represent pig housing units and other onsite buildings. The coordinates used in the configuration of the pig housing units and onsite buildings in the PRIME BPIP model for this assessment are presented in Table 4.

Table 4 Pig housing units included and configuration of the pig housing units in BPIP

Building	Easting	Northing	Height (m)
	UTM (m)	UTM (m)	
B1	615620.3	5862310	5.4
	615541.5	5862343	
	615549.5	5862360	
	615628.3	5862327	
B2	615599	5862300	5.4
	615518	5862335	
	615523.6	5862345	
	615603.9	5862311	
B3	615547.5	5862304	4.6
	615511.2	5862319	
	615516.3	5862329	
	615551.7	5862314	
B4	615604.9	5862282	5.1
	615550.3	5862306	
	615554.6	5862315	
	615609.3	5862291	
B5	615514.7	5862271	3
	615504.9	5862276	
	615519.4	5862308	
	615529.7	5862302	
B6	615526	5862266	3.5
	615516.2	5862270	
	615530.9	5862302	
	615540.2	5862297	
B7	615539.6	5862239	2
	615527	5862245	
	615549.3	5862292	
	615561.8	5862286	
B8	615550.6	5862237	3.1

Building	Easting	Northing	Height (m)
	UTM (m)	UTM (m)	
	615542.8	5862241	
	615566.7	5862289	
	615574.5	5862285	
B9	615565.2	5862227	3.5
	615552.7	5862234	
	615574.5	5862278	
	615587.7	5862272	
B10	615579.9	5862222	5.1
	615568.2	5862228	
	615580.2	5862252	
	615591.6	5862247	
B11	615592	5862248	3.2
	615579.6	5862253	
	615591.2	5862278	
	615602.9	5862271	
B12	615598.8	5862215	4.4
	615584.5	5862221	
	615608.3	5862271	
	615621.9	5862264	
B13	615547	5862214	3.6
	615551.4	5862224	
	615538.2	5862230	
	615533.5	5862220	
B14	615614.8	5862229	4.37
	615635.7	5862275	
	615648.4	5862270	
	615627.6	5862223	
B15	615630.9	5862222	4.37
	615652.1	5862268	
	615664.6	5862263	
	615643.8	5862217	
B16	615646.9	5862215	4.37
	615668.1	5862261	
	615680.5	5862256	
	615659.7	5862210	
B17	615683.6	5862254	4.37
	615695.9	5862249	
	615676.3	5862203	
	615663.5	5862209	

Building	Easting	Northing	Height (m)
	UTM (m)	UTM (m)	
B18	615683.7	5862198	7.1
	615668	5862162	
	615597	5862191	
	615613	5862226	

5.7 Sources of Emissions

The pig housing units included in the dispersion modelling assessment are presented in Table 5, which specifies:

- The housing unit at the pig farm (existing and proposed)
- The type of pigs housed (proposed development as modelled)
- The type of ventilation (proposed development as modelled)
- The number of pigs housed in the building (proposed development as modelled)
- The number of sources used to represent the mechanical ventilation points in the modelling assessment.

All pig housing units at the Site will be mechanically ventilated sheds and were configured as point sources in the modelling assessment.

The sources included in the modelling assessment, the number of pigs per source and the ammonia emission rate per source are presented in Table 5.

Table 5 Pig housing units included in the dispersion modelling assessment

Housing Unit	Type of Pig	Type of Ventilation	Number of Housed Pigs	Number of modelled sources
B1	Dry Sow	Mechanical	607[a]	6
B2	Fattener	Mechanical	723	10
B3	2nd stage weaner	Mechanical	637	5
B4	Fattener	Mechanical	407	6
B5	2nd stage weaner	Mechanical	590	6
B6	2nd stage weaner	Mechanical	563	6
B7	Farrowing	Mechanical	28	8
B8	Farrowing	Mechanical	18	10
B9	1st stage weaner	Mechanical	1720	8
B10	Fattener	Mechanical	303	3
B11	2nd stage weaner	Mechanical	541	3
B12	Fattener	Mechanical	739	13
B13	2nd	Mechanical	249	3
B14	Fattener	Mechanical	657	8
B15	Fattener	Mechanical	657	8
B16	Fattener	Mechanical	657	8
B17	Fattener	Mechanical	657	8
B18	Farrowing	Mechanical	117	6

[a] 487 dry sows plus 120 Maiden Gilts

Table 6 Sources and ammonia emission rate of sources included in the modelling assessment

Housing unit	Source number	Number of pigs per source[1]	Ammonia emission rate (g/s)
B1	B1_DS_1	101	1.28E-02
	B1_DS_2	101	1.28E-02
	B1_DS_3	101	1.28E-02
	B1_DS_4	101	1.28E-02
	B1_DS_5	101	1.28E-02
	B1_DS_6	101	1.28E-02
B2	B2_Ft1_1	72	4.74E-03
	B2_Ft1_2	72	4.74E-03
	B2_Ft1_3	72	4.74E-03
	B2_Ft1_4	72	4.74E-03
	B2_Ft1_5	72	4.74E-03
	B2_Ft1_6	72	4.74E-03
	B2_Ft1_7	72	4.74E-03
	B2_Ft1_8	72	4.74E-03

Housing unit	Source number	Number of pigs per source[1]	Ammonia emission rate (g/s)
	B2_Ft1_9	72	4.74E-03
	B2_Ft1_10	72	4.74E-03
B3	B3_Ft2_1	127	2.14E-03
	B3_Ft2_2	127	2.14E-03
	B3_Ft2_3	127	2.14E-03
	B3_Ft2_4	127	2.14E-03
	B3_Ft2_5	127	2.14E-03
B4	B4_Ft3_1	68	6.15E-03
	B4_Ft3_2	68	6.15E-03
	B4_Ft3_3	68	6.15E-03
	B4_Ft3_4	68	6.15E-03
	B4_Ft3_5	68	6.15E-03
	B4_Ft3_6	68	6.15E-03
B5	B5_2nd_1	98	1.65E-03
	B5_2nd_2	98	1.65E-03
	B5_2nd_3	98	1.65E-03
	B5_2nd_4	98	1.65E-03
	B5_2nd_5	98	1.65E-03
	B5_2nd_6	98	1.65E-03
B6	B6_2nd_1	94	1.58E-03
	B6_2nd_2	94	1.58E-03
	B6_2nd_3	94	1.58E-03
	B6_2nd_4	94	1.58E-03
	B6_2nd_5	94	1.58E-03
	B6_2nd_6	94	1.58E-03
B7	B7_Fr1_1	4	6.22E-04
	B7_Fr1_2	4	6.22E-04
	B7_Fr1_3	4	6.22E-04
	B7_Fr1_4	4	6.22E-04
	B7_Fr1_5	4	6.22E-04
	B7_Fr1_6	4	6.22E-04
	B7_Fr1_7	4	6.22E-04
	B7_Fr1_8	4	6.22E-04
B8	B7_Fr2_1	2	3.16E-04
	B7_Fr2_2	2	3.16E-04
	B7_Fr2_3	2	3.16E-04
	B7_Fr2_4	2	3.16E-04
	B7_Fr2_5	2	3.16E-04
	B7_Fr2_6	2	3.16E-04
	B7_Fr2_7	2	3.16E-04

Housing unit	Source number	Number of pigs per source[1]	Ammonia emission rate (g/s)
	B7_Fr2_8	2	3.16E-04
	B7_Fr2_9	2	3.16E-04
	B7_Fr2_10	2	3.16E-04
B9	B9_Wn_1	215	3.61E-03
	B9_Wn_2	215	3.61E-03
	B9_Wn_3	215	3.61E-03
	B9_Wn_4	215	3.61E-03
	B9_Wn_5	215	3.61E-03
	B9_Wn_6	215	3.61E-03
	B9_Wn_7	215	3.61E-03
	B9_Wn_8	215	3.61E-03
B10	B10_2nd_1	101	6.62E-03
	B10_2nd_2	101	6.62E-03
	B10_2nd_3	101	6.62E-03
B11	B11_2nd_1	180	3.03E-03
	B11_2nd_2	180	3.03E-03
	B11_2nd_3	180	3.03E-03
B12	B12_Ft6_1	57	3.72E-03
	B12_Ft6_2	57	3.72E-03
	B12_Ft6_3	57	3.72E-03
	B12_Ft6_4	57	3.72E-03
	B12_Ft6_5	57	3.72E-03
	B12_Ft6_6	57	3.72E-03
	B12_Ft6_7	57	3.72E-03
	B12_Ft6_8	57	3.72E-03
	B12_Ft6_9	57	3.72E-03
	B12_Ft6_10	57	3.72E-03
	B12_Ft6_11	57	3.72E-03
	B12_Ft6_12	57	3.72E-03
	B12_Ft6_13	57	3.72E-03
B13	B13_2nd_1	83	1.39E-03
	B13_2nd_2	83	1.39E-03
	B13_2nd_3	83	1.39E-03
B14	B14_FT7_1	82	5.38E-03
	B14_FT7_2	82	5.38E-03
	B14_FT7_3	82	5.38E-03
	B14_FT7_4	82	5.38E-03
	B14_FT7_5	82	5.38E-03
	B14_FT7_6	82	5.38E-03
	B14_FT7_7	82	5.38E-03

Housing unit	Source number	Number of pigs per source[1]	Ammonia emission rate (g/s)
	B14_FT7_8	82	5.38E-03
B15	B15_FT7_1	82	5.38E-03
	B15_FT7_2	82	5.38E-03
	B15_FT7_3	82	5.38E-03
	B15_FT7_4	82	5.38E-03
	B15_FT7_5	82	5.38E-03
	B15_FT7_6	82	5.38E-03
	B15_FT7_7	82	5.38E-03
	B15_FT7_8	82	5.38E-03
B16	B16_FT7_1	82	5.38E-03
	B16_FT7_2	82	5.38E-03
	B16_FT7_3	82	5.38E-03
	B16_FT7_4	82	5.38E-03
	B16_FT7_5	82	5.38E-03
	B16_FT7_6	82	5.38E-03
	B16_FT7_7	82	5.38E-03
	B16_FT7_8	82	5.38E-03
B17	B17_FT7_1	82	5.38E-03
	B17_FT7_2	82	5.38E-03
	B17_FT7_3	82	5.38E-03
	B17_FT7_4	82	5.38E-03
	B17_FT7_5	82	5.38E-03
	B17_FT7_6	82	5.38E-03
	B17_FT7_7	82	5.38E-03
	B17_FT7_8	82	5.38E-03
B18	B18_FW9_1	19	3.45E-03
	B18_FW9_2	19	3.45E-03
	B18_FW9_3	19	3.45E-03
	B18_FW9_4	19	3.45E-03
	B18_FW9_5	19	3.45E-03
	B18_FW9_6	19	3.45E-03

[1] Calculated as the total number of pigs in the housing unit divided by the number of sources included in the modelling assessment for that housing unit

5.8 Source configuration

The pig housing units at the pig farm are all mechanically ventilated and were, therefore, modelled as point sources in the modelling assessment. This section describes the configuration of the point sources included in the CALPUFF modelling assessment.

Table 7 lists the point sources included in the modelling assessment and relevant modelling parameters including:

- The source coordinates

- The base elevations
- Stack height
- Stack diameter
- Exhaust temperature
- Exhaust velocity.

The building locations, configuration and heights were determined from Site plans provided by Tulleka Trading correspondence between Katestone and Tulleka Trading and from satellite imagery.

Table 7 Source parameters for the point sources at the pig farm

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Velocity
	km	km	m	m	m	°C	m/s
B1_DS_1	615555	5862347	175.8	10.0	0.55	21	7.60
B1_DS_2	615567	5862342	175.9	10.0	0.55	21	7.60
B1_DS_3	615580	5862337	176.1	10.0	0.55	21	7.60
B1_DS_4	615593	5862332	176.2	10.0	0.55	21	7.60
B1_DS_5	615607	5862324	176.4	10.0	0.55	21	7.60
B1_DS_6	615614	5862321	176.5	10.0	0.55	21	7.60
B2_Ft1_1	615526	5862337	176.3	10.0	0.55	21	7.03
B2_Ft1_2	615535	5862334	176.2	10.0	0.55	21	7.03
B2_Ft1_3	615544	5862330	176.1	10.0	0.55	21	7.03
B2_Ft1_4	615551	5862327	176.0	10.0	0.55	21	7.03
B2_Ft1_5	615559	5862324	176.1	10.0	0.55	21	7.03
B2_Ft1_6	615566	5862321	176.1	10.0	0.55	21	7.03
B2_Ft1_7	615575	5862316	176.3	10.0	0.55	21	7.03
B2_Ft1_8	615583	5862313	176.4	10.0	0.55	21	7.03
B2_Ft1_9	615591	5862309	176.5	10.0	0.55	21	7.03
B2_Ft1_10	615598	5862306	176.5	10.0	0.55	21	7.03
B3_Ft2_1	615520	5862322	176.5	10.0	0.55	25	7.03
B3_Ft2_2	615524	5862320	176.5	10.0	0.55	25	7.03
B3_Ft2_3	615529	5862318	176.4	10.0	0.55	25	7.03
B3_Ft2_4	615538	5862314	176.3	10.0	0.55	25	7.03
B3_Ft2_5	615546	5862310	176.3	10.0	0.55	25	7.03
B4_Ft3_1	615561	5862305	176.3	10.0	0.55	21	7.60
B4_Ft3_2	615567	5862302	176.3	10.0	0.55	21	7.60
B4_Ft3_3	615579	5862297	176.5	10.0	0.55	21	7.60
B4_Ft3_4	615585	5862294	176.6	10.0	0.55	21	7.60
B4_Ft3_5	615598	5862289	176.7	10.0	0.55	21	7.60
B4_Ft3_6	615603	5862287	176.8	10.0	0.55	21	7.60
B5_2nd_1	615512	5862277	177.1	4.0	0.40	25	7.07
B5_2nd_2	615514	5862281	177.0	4.0	0.40	25	7.07
B5_2nd_3	615516	5862286	176.9	4.0	0.40	25	7.07
B5_2nd_4	615518	5862291	176.8	4.0	0.40	25	7.07
B5_2nd_5	615520	5862296	176.8	4.0	0.40	25	7.07
B5_2nd_6	615523	5862301	176.7	4.0	0.40	25	7.07
B6_2nd_1	615522	5862270	177.0	4.0	0.40	25	7.07
B6_2nd_2	615524	5862275	176.9	4.0	0.40	25	7.07
B6_2nd_3	615526	5862280	176.8	4.0	0.40	25	7.07
B6_2nd_4	615529	5862285	176.7	4.0	0.40	25	7.07

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Velocity
	km	km	m	m	m	°C	m/s
B6_2nd_5	615531	5862290	176.7	4.0	0.40	25	7.07
B6_2nd_6	615533	5862295	176.6	4.0	0.40	25	7.07
B7_Fr1_1	615541	5862241	177.0	2.0	0.40	25	5.35
B7_Fr1_2	615543	5862247	176.9	2.0	0.40	25	5.35
B7_Fr1_3	615546	5862253	176.8	2.0	0.40	25	5.35
B7_Fr1_4	615549	5862259	176.7	2.0	0.40	25	5.35
B7_Fr1_5	615551	5862264	176.6	2.0	0.40	25	5.35
B7_Fr1_6	615554	5862269	176.5	2.0	0.40	25	5.35
B7_Fr1_7	615556	5862274	176.5	2.0	0.40	25	5.35
B7_Fr1_8	615559	5862280	176.5	2.0	0.40	25	5.35
B7_Fr2_1	615548	5862242	176.9	3.5	0.45	25	5.59
B7_Fr2_2	615550	5862247	176.8	3.5	0.35	25	5.10
B7_Fr2_3	615552	5862247	176.8	3.5	0.35	25	5.10
B7_Fr2_4	615551	5862252	176.7	3.5	0.35	25	5.10
B7_Fr2_5	615553	5862251	176.7	3.5	0.35	25	5.10
B7_Fr2_6	615556	5862257	176.7	3.5	0.35	25	5.10
B7_Fr2_7	615558	5862263	176.6	3.5	0.35	25	5.10
B7_Fr2_8	615559	5862262	176.7	3.5	0.65	25	3.85
B7_Fr2_9	615562	5862270	176.6	3.5	0.65	25	5.11
B7_Fr2_10	615565	5862275	176.6	3.5	0.65	25	5.11
B9_Wn_1	615560	5862236	176.9	3.9	0.65	25	5.44
B9_Wn_2	615562	5862235	176.9	3.9	0.65	25	5.44
B9_Wn_3	615564	5862245	176.9	3.9	0.65	25	5.44
B9_Wn_4	615566	5862244	176.9	3.9	0.65	25	5.44
B9_Wn_5	615570	5862255	176.8	3.9	0.65	25	5.44
B9_Wn_6	615572	5862254	176.8	3.9	0.65	25	5.44
B9_Wn_7	615575	5862267	176.7	3.9	0.65	25	5.44
B9_Wn_8	615577	5862266	176.8	3.9	0.65	25	5.44
B10_2nd_1	615581	5862243	177.0	5.5	0.65	21	5.44
B10_2nd_2	615575	5862231	177.1	5.5	0.65	21	5.44
B10_2nd_3	615581	5862236	177.1	5.5	0.65	21	5.44
B11_2nd_1	615595	5862270	176.9	3.6	0.65	25	5.44
B11_2nd_2	615591	5862262	176.9	3.6	0.65	25	5.44
B11_2nd_3	615587	5862254	177.0	3.6	0.65	25	5.44
B12_Ft6_1	615592	5862219	177.3	6.0	0.55	21	7.60
B12_Ft6_2	615594	5862223	177.4	6.0	0.55	21	7.60
B12_Ft6_3	615595	5862226	177.3	6.0	0.55	21	7.60
B12_Ft6_4	615597	5862229	177.3	6.0	0.55	21	7.60
B12_Ft6_5	615599	5862232	177.3	6.0	0.55	21	7.60

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Velocity
	km	km	m	m	m	°C	m/s
B12_Ft6_6	615602	5862239	177.3	6.0	0.55	21	7.60
B12_Ft6_7	615603	5862242	177.2	6.0	0.55	21	7.60
B12_Ft6_8	615605	5862245	177.2	6.0	0.55	21	7.60
B12_Ft6_9	615606	5862248	177.2	6.0	0.55	21	7.60
B12_Ft6_10	615609	5862255	177.2	6.0	0.55	21	7.60
B12_Ft6_11	615610	5862258	177.1	6.0	0.55	21	7.60
B12_Ft6_12	615612	5862261	177.1	6.0	0.55	21	7.60
B12_Ft6_13	615613	5862263	177.1	6.0	0.65	21	5.44
B13_2nd_1	615538	5862223	176.8	4.0	0.65	25	5.44
B13_2nd_2	615543	5862221	176.9	4.0	0.65	25	5.44
B13_2nd_3	615547	5862220	176.9	4.0	0.65	25	5.44
B14_FT7_1	615623.2	5862230	177.6	8.5	0.55	21	7.60
B14_FT7_2	615625	5862235	177.5	8.5	0.55	21	7.60
B14_FT7_3	615627.5	5862239	177.5	8.5	0.55	21	7.60
B14_FT7_4	615629.5	5862245	177.5	8.5	0.55	21	7.60
B14_FT7_5	615631.7	5862249	177.4	8.5	0.55	21	7.60
B14_FT7_6	615634	5862255	177.4	8.5	0.55	21	7.60
B14_FT7_7	615636.6	5862260	177.4	8.5	0.55	21	7.60
B14_FT7_8	615639	5862266	177.3	8.5	0.55	21	7.60
B15_FT7_1	615639	5862222	177.8	8.5	0.55	21	7.60
B15_FT7_2	615641	5862227	177.8	8.5	0.55	21	7.60
B15_FT7_3	615643.5	5862232	177.7	8.5	0.55	21	7.60
B15_FT7_4	615646.1	5862239	177.7	8.5	0.55	21	7.60
B15_FT7_5	615648.2	5862243	177.6	8.5	0.55	21	7.60
B15_FT7_6	615650.7	5862249	177.6	8.5	0.55	21	7.60
B15_FT7_7	615652.8	5862254	177.6	8.5	0.55	21	7.60
B15_FT7_8	615655.3	5862259	177.5	8.5	0.55	21	7.60
B16_FT7_1	615655.9	5862217	177.8	8.5	0.55	21	7.60
B16_FT7_2	615656.7	5862221	178.0	8.5	0.55	21	7.60
B16_FT7_3	615659.8	5862227	177.9	8.5	0.55	21	7.60
B16_FT7_4	615662.3	5862233	177.9	8.5	0.55	21	7.60
B16_FT7_5	615664.6	5862238	177.9	8.5	0.55	21	7.60
B16_FT7_6	615667.5	5862244	177.8	8.5	0.55	21	7.60
B16_FT7_7	615669.8	5862249	177.8	8.5	0.55	21	7.60
B16_FT7_8	615671.8	5862254	177.7	8.5	0.55	21	7.60
B17_FT7_1	615670.7	5862209	177.7	8.5	0.55	21	7.60
B17_FT7_2	615672.9	5862214	177.9	8.5	0.55	21	7.60
B17_FT7_3	615674.8	5862218	178.1	8.5	0.55	21	7.60
B17_FT7_4	615677.3	5862224	178.1	8.5	0.55	21	7.60

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Velocity
	km	km	m	m	m	°C	m/s
B17_FT7_5	615679.6	5862229	178.1	8.5	0.55	21	7.60
B17_FT7_6	615681.3	5862234	178.1	8.5	0.55	21	7.60
B17_FT7_7	615683.5	5862240	178.0	8.5	0.55	21	7.60
B17_FT7_8	615686.4	5862246	178.0	8.5	0.55	21	7.60
B18_FW9_1	615617	5862211	177.3	7.7	0.65	25	5.44
B18_FW9_2	615639.2	5862205	177.3	7.7	0.65	25	5.44
B18_FW9_3	615661.5	5862197	177.3	7.7	0.65	25	5.44
B18_FW9_4	615610.3	5862194	176.8	7.7	0.65	25	5.44
B18_FW9_5	615631.9	5862187	176.8	7.7	0.65	25	5.44
B18_FW9_6	615655.6	5862181	176.8	7.7	0.65	25	5.44

5.9 In-combination modelling assessment

An in-combination assessment is a requirement of Step 5 of EPA's Ammonia and Nitrogen Assessment Guidance.

The in-combination modelling assessment needs to include other sources which may act in-combination with the application/review installation. The other sources that need to be included in the in-combination modelling assessment are defined in Section 3.9 of EPA's Ammonia and Nitrogen Assessment Guidance, which is reproduced here:

> *Other sources of nitrogen and ammonia (other PCs) to the Natura 2000 site(s), which could act in combination with emissions from the proposed/expanded installation, to impact the protected habitat, must be accounted for at relevant stages of the appropriate assessment process (screening stage details are set in Section 4 of this document). The in-combination assessment which needs to be conducted, is dependent on the size of the activity and the distance from the Natura site.*
>
> *At the target Natura 2000 site(s) (i.e. that/those identified, as possibly impacted by emissions from the applicant/review installation), all IAIs, which meet the following two criteria and which (with abatement in place), have a PC of ≥4% of the critical level for ammonia and/or ≥5% of the critical load for nitrogen deposition at the relevant Natura site must be included:*
>
> 1) *Developments that have planning permission and/or licences but are not yet (fully) operating; including those both above and below licensing thresholds that may contribute to ammonia and nitrogen emissions; and*
> 2) *Developments that started operating/increased their numbers, after the most recent update of background levels; including those both above and below licensing thresholds, that may contribute to ammonia and nitrogen emissions*
>
> *The criteria to use in order to determine the geographical range of the installations, which meet the above criteria, to include in the in-combination assessment is outlined below. (see Figure 1):*
>
> - *All below threshold installations within 5km of the Natura site*
> - *All licensed installations within 10km of the Natura site*

6. AMMONIA AND NITROGEN ASSESSMENT RESULTS

The results of the assessment are presented in this section. Katestone followed the step-wise approach described in EPA's Ammonia and Nitrogen Assessment Guidance in this assessment. The results of each step considered in the modelling assessment are presented in this section.

In summary, following the step-wise approach described in EPA's Ammonia and Nitrogen Assessment Guidance required the following steps to be completed:

- Step 1
- Step 4
- Step 5.

6.1 Results of Step 1

Question 2 of Step 1 in the EPA's Ammonia and Nitrogen Assessment Guidance asks:

> *Are the background levels already exceeded for the ammonia critical level or nitrogen critical load at Natura sites within the zone of influence of my site (as reported by SCAIL)?*

The background concentrations of ammonia and the background nitrogen deposition flux as determined using the SCAIL screening tool are presented along with the appropriate critical level for ammonia and critical load for nitrogen deposition fluxes in Table 8.

The results show that the background concentrations of ammonia and the background nitrogen deposition flux exceed the relevant critical level for ammonia and critical load for nitrogen deposition fluxes at a number of the modelled discrete receptor locations.

According to Step 1 of EPA's Ammonia and Nitrogen Assessment Guidance:

- The approaches using the SCAIL-Agriculture model described in Step 2 and Step 3 of the EPA's Ammonia and Nitrogen Assessment Guidance are not applicable.
- A detailed assessment completed in accordance with Step 4 of EPA's Ammonia and Nitrogen Assessment Guidance is, therefore, required to be completed. The results of the Step 4 assessment are presented in Section 6.2.

Table 8 Background concentrations of ammonia and the background nitrogen deposition flux as determined using the SCAIL screening tool are presented along with the appropriate critical level for ammonia and critical load for nitrogen deposition fluxes

Receptor	SCAIL background concentration of ammonia	Critical Level	SCAIL background nitrogen deposition flux	Critical Load
	µg/m³		kg/ha/yr	
DR1	3.03	3	18.5	30
DR2	3.03	3	19.6	30
DR3	3.03	3	21.0	30
DR4	3.03	3	21.5	30
DR5	3.26	3	31.0	30
DR6	3.26	3	26.7	30
DR7	3.03	3	23.4	30

Receptor	SCAIL background concentration of ammonia	Critical Level	SCAIL background nitrogen deposition flux	Critical Load
	µg/m³		kg/ha/yr	
DR8	3.03	3	23.7	30
DR9	3.03	3	24.6	30
DR10	3.26	3	26.2	30
DR11	3.26	3	29.5	30
DR12	3.26	3	31.1	30
DR13	3.26	3	33.0	30
DR14	3.26	3	34.0	30
DR15	3.06	3	33.7	30
DR16	3.06	3	28.6	30
DR17	3.06	3	24.4	30
DR18	3.06	3	21.3	30
DR19	3.06	3	20.4	30
DR20	3.06	3	20.2	30
DR21	3.06	3	18.5	30
DR22	3.06	3	16.2	30
DR23	3.06	3	15.2	30
DR24	2.69	3	12.9	30
DR25	2.69	3	11.8	30
DR26	2.69	3	10.6	30
DR27	2.69	3	11.4	30
DR28	2.69	3	10.9	30
DR29	2.69	3	10.3	30
DR30	2.71	3	9.0	30
DR31	2.71	3	8.6	30
DR32	2.68	3	8.1	30
DR33	2.77	3	7.9	30
DR34	2.77	3	7.8	30
DR35	2.91	3	7.9	30
DR36	2.91	3	7.9	30
DR37	2.97	3	7.9	30
DR38	2.97	3	7.8	30
DR39	2.98	3	7.6	30
DR40	3.08	3	7.7	30
DR41	3.1	3	7.7	30
DR42	3.1	3	7.7	30
DR43	3.01	3	7.7	30
DR44	2.93	3	7.6	30
DR45	2.89	3	7.4	15.4

Receptor	SCAIL background concentration of ammonia	Critical Level	SCAIL background nitrogen deposition flux	Critical Load
	µg/m³		kg/ha/yr	
DR46	2.84	3	7.3	30
DR47	2.84	3	7.4	30
DR48	2.88	3	7.3	30
DR49	2.88	3	7.2	15.4
DR50	2.81	3	6.9	15.4
DR51	2.78	3	7.3	15.4
DR52	2.72	3	7.4	30
DR53	2.76	3	7.5	30
DR54	2.76	3	7.5	30
DR55	2.85	3	7.6	30
DR56	2.86	3	7.6	30
DR57	2.88	3	7.7	30
DR58	2.9	3	8.0	15
DR59	2.92	3	8.0	15
DR60	2.92	3	8.0	15
DR61	2.92	3	7.9	15
DR62	2.96	3	8.0	15
DR63	2.96	3	8.0	15
DR64	2.96	3	8.0	15
DR65	2.91	3	7.9	15

6.2 Results of Step 4

Step 4 of EPA's Ammonia and Nitrogen Assessment Guidance requires a licensee/applicant to complete a detailed dispersion modelling assessment.

Dispersion modelling has been conducted for five years of meteorological data. The following sections present the highest concentrations across the five-year modelled period as Required by EPA dispersion modelling guidance.

The predicted ground-level concentrations of ammonia and annual average flux rate of nitrogen deposition at modelled locations on the nearest Natura 2000 sites due to the pig farm are presented in Table 9. Many of the modelled locations included in the modelling assessment are within the boundary of a Natura 2000 site; however, no sensitive ecological species or habitat has been identified as part of NPWS mapping at these locations. The locations in italics in Table 9 indicate locations with no identified sensitive ecological species or habitat. The locations marked in bold are locations at which sensitive ecological species or habitats have been mapped as indicated in Table 3 of Section 4.4.

The results in Table 9 are compared against the Step 4 criteria identified in EPA's Ammonia and Nitrogen Assessment Guidance, which require the process contribution of the pig farm (PC) to be:

- ≤1% of the critical level for ammonia
- ≤1% of the critical load for nitrogen deposition?

The results presented in Table 9 show that, in relation to the 1% threshold identified in Step 4 of EPA's Ammonia and Nitrogen Assessment Guidance, the PC due to the pig farm once the proposed development is completed:

- Exceeds for ammonia and nitrogen deposition at a number of modelled discrete receptor locations on:
    - The River Barrow and Nore SAC (Discrete Receptors –1 - 57)
    - The Lisbigney Bog SAC (58 - 65).
- Does not exceed at any of the modelled discrete receptor locations on the Nore River SPA (Discrete Receptors – 35 - 57).

The results indicate that the maximum potential impact of the proposed development at a location at which sensitive ecological species or habitats have been mapped is 1.8% of the critical level or critical load of the sensitive species or habitat identified at that location.

If the criteria identified in Step 4 of EPA's Ammonia and Nitrogen Assessment Guidance are exceeded, the licensee/applicant is required to undertake the assessment defined in Step 5 of EPA's Ammonia and Nitrogen Assessment Guidance. Step 5 requires detailed modelling that takes account of in-combination effects. Step 5 of EPA's Ammonia and Nitrogen Assessment Guidance is presented in Section 6.3 for the modelled sensitive locations on the River Barrow and Nore SAC and the Lisbigney Bog SAC.

Table 9 The predicted ground-level concentrations of ammonia and annual average flux rate of nitrogen deposition at the nearest ecologically sensitive locations due to the pig farm

Receptor	Concentration of ammonia (µg/m³)		PC as a percentage of Critical Level	Nitrogen Deposition Flux (kg/ha/yr)		PC as a percentage of Critical Load
	Process Contribution (Pig Farm)	Critical Level		Process Contribution (Pig Farm)	Critical Load	
*DR1**	*0.72*	*3*	*24%*	*6.8*	*30.0*	*23%*
*DR2**	*0.79*	*3*	*26%*	*7.4*	*30.0*	*25%*
*DR3**	*0.89*	*3*	*30%*	*8.4*	*30.0*	*28%*
*DR4**	*0.95*	*3*	*32%*	*9.0*	*30.0*	*30%*
*DR5**	*1.71*	*3*	*57%*	*16.2*	*30.0*	*54%*
*DR6**	*1.29*	*3*	*43%*	*12.2*	*30.0*	*41%*
*DR7**	*1.06*	*3*	*35%*	*10.0*	*30.0*	*33%*
*DR8**	*1.07*	*3*	*36%*	*10.1*	*30.0*	*34%*
*DR9**	*1.07*	*3*	*36%*	*10.1*	*30.0*	*34%*
*DR10**	*1.09*	*3*	*36%*	*10.3*	*30.0*	*34%*
*DR11**	*1.39*	*3*	*46%*	*13.2*	*30.0*	*44%*
*DR12**	*1.55*	*3*	*52%*	*14.6*	*30.0*	*49%*
*DR13**	*1.78*	*3*	*59%*	*16.8*	*30.0*	*56%*
*DR14**	*1.71*	*3*	*57%*	*16.2*	*30.0*	*54%*
*DR15**	*1.41*	*3*	*47%*	*13.3*	*30.0*	*44%*
*DR16**	*0.84*	*3*	*28%*	*7.9*	*30.0*	*26%*
*DR17**	*0.56*	*3*	*19%*	*5.3*	*30.0*	*18%*
*DR18**	*0.40*	*3*	*13%*	*3.8*	*30.0*	*13%*
*DR19**	*0.37*	*3*	*12%*	*3.5*	*30.0*	*12%*

Receptor	Concentration of ammonia (µg/m³)		PC as a percentage of Critical Level	Nitrogen Deposition Flux (kg/ha/yr)		PC as a percentage of Critical Load
	Process Contribution (Pig Farm)	Critical Level		Process Contribution (Pig Farm)	Critical Load	
*DR20**	*0.37*	*3*	*12%*	*3.5*	*30.0*	*12%*
*DR21**	*0.33*	*3*	*11%*	*3.2*	*30.0*	*11%*
*DR22**	*0.22*	*3*	*7.2%*	*2.0*	*30.0*	*6.8%*
*DR23**	*0.24*	*3*	*7.9%*	*2.2*	*30.0*	*7.5%*
*DR24**	*0.15*	*3*	*5.1%*	*1.5*	*30.0*	*4.8%*
*DR25**	*0.13*	*3*	*4.3%*	*1.2*	*30.0*	*4.1%*
*DR26**	*0.11*	*3*	*3.6%*	*1.0*	*30.0*	*3.4%*
*DR27**	*0.10*	*3*	*3.3%*	*0.9*	*30.0*	*3.2%*
*DR28**	*0.07*	*3*	*2.3%*	*0.7*	*30.0*	*2.2%*
DR29	**0.05**	**3**	**1.7%**	**0.5**	**30.0**	**1.6%**
DR30	**0.04**	**3**	**1.2%**	**0.3**	**30.0**	**1.2%**
DR31	**0.03**	**3**	**0.9%**	**0.3**	**30.0**	**0.8%**
DR32	**0.02**	**3**	**0.6%**	**0.2**	**30.0**	**0.6%**
DR33	**0.01**	**3**	**0.5%**	**0.1**	**30.0**	**0.5%**
DR34	**0.01**	**3**	**0.5%**	**0.1**	**30.0**	**0.4%**
DR35	**0.01**	**3**	**0.4%**	**0.1**	**30.0**	**0.4%**
DR36	**0.02**	**3**	**0.5%**	**0.1**	**30.0**	**0.5%**
DR37	**0.01**	**3**	**0.5%**	**0.1**	**30.0**	**0.4%**
*DR38**	*0.01*	*3*	*0.5%*	*0.1*	*30.0*	*0.4%*
*DR39**	*0.01*	*3*	*0.4%*	*0.1*	*30.0*	*0.4%*
*DR40**	*0.01*	*3*	*0.4%*	*0.1*	*30.0*	*0.4%*
*DR41**	*0.01*	*3*	*0.3%*	*0.1*	*30.0*	*0.3%*
DR42	**0.02**	**3**	**0.6%**	**0.2**	**30.0**	**0.5%**
DR43	**0.01**	**3**	**0.4%**	**0.1**	**30.0**	**0.4%**
DR44*	***0.01***	***3***	***0.3%***	***0.1***	***30.0***	***0.3%***
DR45	**0.01**	**3**	**0.3%**	**0.1**	**15.4**	**0.6%**
DR46	**0.01**	**3**	**0.3%**	**0.1**	**30.0**	**0.3%**
DR47	**0.01**	**3**	**0.3%**	**0.1**	**30.0**	**0.3%**
DR48	**0.01**	**3**	**0.4%**	**0.1**	**30.0**	**0.3%**
DR49	**0.01**	**3**	**0.4%**	**0.1**	**15.4**	**0.7%**
DR50	**0.01**	**3**	**0.4%**	**0.1**	**15.4**	**0.7%**
DR51	**0.02**	**3**	**0.5%**	**0.1**	**15.4**	**1.0%**
DR52	**0.01**	**3**	**0.3%**	**0.1**	**30.0**	**0.3%**
DR53	**0.01**	**3**	**0.3%**	**0.1**	**30.0**	**0.3%**
DR54	**0.01**	**3**	**0.3%**	**0.1**	**30.0**	**0.3%**
*DR55**	*0.01*	*3*	*0.3%*	*0.1*	*30.0*	*0.3%*
DR56*	0.01	3	0.2%	0.0	30.0	0.2%
*DR57**	*0.01*	*3*	*0.2%*	*0.1*	*30.0*	*0.2%*
DR58	**0.02**	**3**	**0.6%**	**0.2**	**15.0**	**1.2%**

Receptor	Concentration of ammonia (µg/m³)		PC as a percentage of Critical Level	Nitrogen Deposition Flux (kg/ha/yr)		PC as a percentage of Critical Load
	Process Contribution (Pig Farm)	Critical Level		Process Contribution (Pig Farm)	Critical Load	
DR59	0.02	3	0.8%	0.2	15.0	1.6%
DR60	0.02	3	0.8%	0.2	15.0	1.5%
DR61	0.03	3	0.9%	0.2	15.0	1.7%
DR62	0.03	3	0.9%	0.3	15.0	1.8%
DR63	0.03	3	0.9%	0.3	15.0	1.7%
DR64	0.02	3	0.8%	0.2	15.0	1.5%
DR65	0.02	3	0.7%	0.2	15.0	1.3%
* No sensitive ecological species or habitat has been identified as part of NPWS mapping at these locations						

6.3 Results of Step 5

Step 5 of EPA's Ammonia and Nitrogen Assessment Guidance requires detailed modelling to determine the in-combination effects of:

- The pig farm
- Intensive agricultural installations (AIA) built or approved since the most recent update of background levels (determined using SCAIL-Agriculture).

The most recent update to background levels of ammonia and nitrogen deposition was in 2018 with data used based on the locations of pig and poultry farms up to 2015 (Kelleghan *et al.*, 2022).

The results have been assessed against the Step 5 criteria identified in EPA's Ammonia and Nitrogen Assessment Guidance that require the cumulative impact to be less than:

- 20% of the critical level for ammonia
- 20% of the critical load for nitrogen deposition.

Step 4 of EPA's Ammonia and Nitrogen Assessment Guidance indicated that a Step 5 assessment was required for:

- The River Barrow and Nore SAC
- The Lisbigney Bog SAC.

Only discrete receptor locations with mapped sensitive habitat or species were included in the Step 5 assessment.

A review of nearby IAIs (IAI Review) was undertaken to identify all IAI developments that received licence/planning approval to facilitate increased animal numbers since 2015 or IAI developments that were built since 2015 within the following set-back distances identified in Step 5 of EPA's Ammonia and Nitrogen Assessment Guidance for:

- Licensed IAI within 10 km of the closest point to the pig farm of:
    - The River Barrow and Nore SAC
    - The Lisbigney Bog SAC.
- Sub-threshold Licensed IAI within 5 km to the pig farm of:
    - The River Barrow and Nore SAC
    - The Lisbigney Bog SAC.

The IAI Review included detailed searches of satellite imagery, the EPA licence database and the planning systems of:

- Laois County Council
- Kilkenny County Council.

The areas searched were determined using the methodology defined in EPA's Ammonia and Nitrogen Assessment Guidance and are presented in Figure 9.

The IAI Review identified:

- There are a small number of IAI in the area surrounding the Site
- There have been no new EPA licence approvals for IAI within the search areas since most recent update of background levels in 2015

- EPA has not approved any increases in stocking numbers at any EPA licensed IAI within the search areas since most recent update of background levels in 2015
- EPA has not approved any licence applications/amendments/reviews for any EPA licensed IAI within the search areas since most recent update of background levels in 2015
- A single planning approval for an upgrade to a pig housing unit at a sub-threshold IAI within a 5 km setback distance from the River Barrow and Nore SAC since most recent update of background levels in 2015 was granted with approval however the conditional approval did not result in an increase in animal numbers at the site.

The IAI review identified that there are no other sources that may act in-combination with the application/review installation as defined in section 3.9 of EPA's Ammonia and Nitrogen Assessment Guidance. The cumulative assessment as set out in Step 5 of EPA's Ammonia and Nitrogen Assessment Guidance would therefore be based on the impact of the farm alone as determined in Step 4 of EPA's Ammonia and Nitrogen Assessment Guidance as presented in Table 9 of Section 6.2.

The results of the cumulative impact assessment described in this section was determined and presented against the Step 5 criteria at sensitive locations identified for:

- The River Barrow and Nore SAC (Receptors – 29 – 37; 42 – 43; 45 – 54) in Section 6.3.1
- The Lisbigney Bog SAC (Receptors – 58 - 65) in 6.3.2.

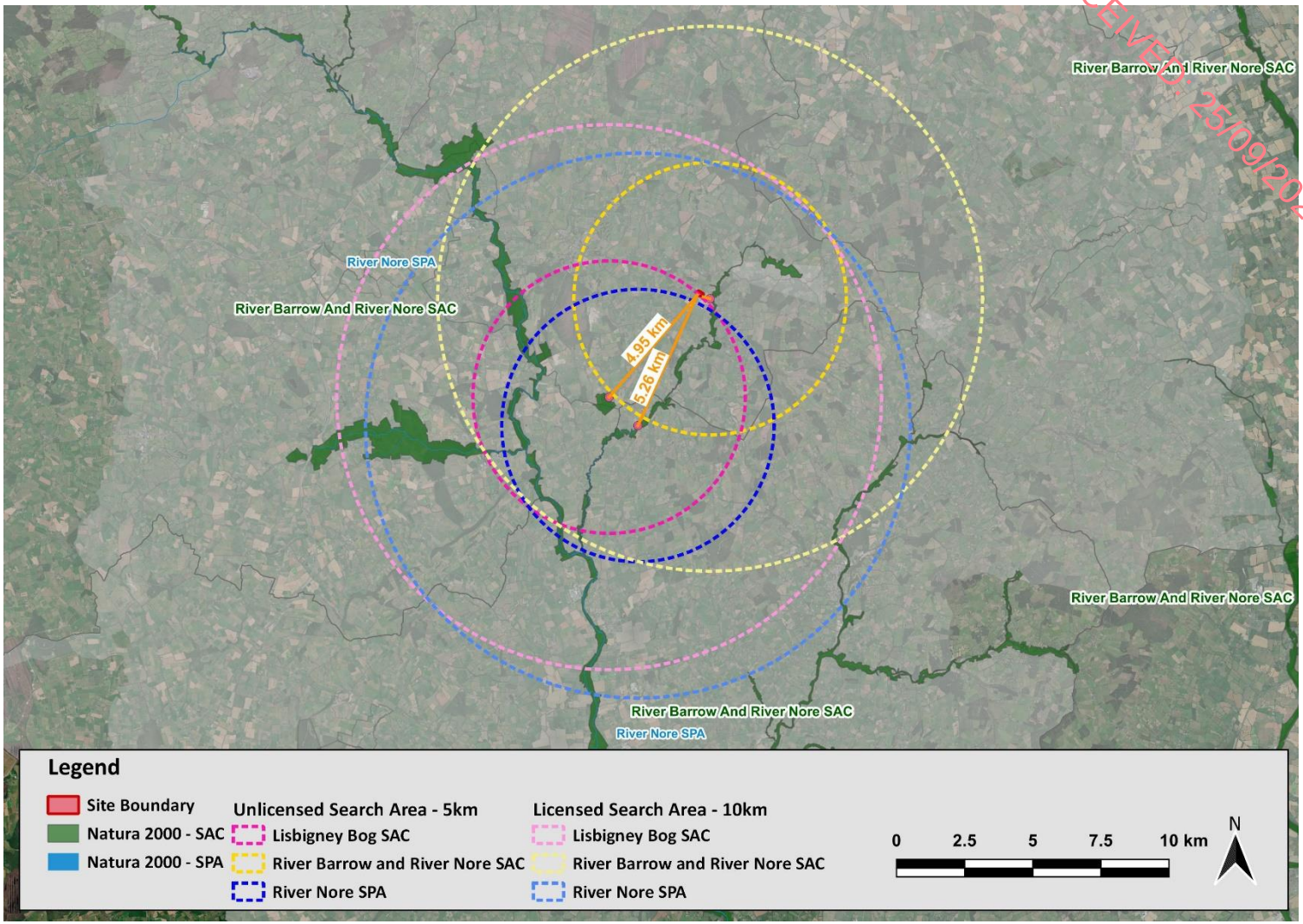

Figure 9 **Areas searched that were included in the cumulative assessment using the methodology defined in EPA's Ammonia and Nitrogen Assessment Guidance**

6.3.1 Step 5 Cumulative Assessment – River Barrow and Nore SAC

The results of the Step 5 cumulative assessment on ecologically sensitive receptors on the River Barrow and Nore SAC are presented in Table 10.

The results show that the worst-case cumulative impact due to the pig farm in combination with other IAIs that meet the requirements of Step 5 are:

- 1.7% of the critical level for ammonia
- 1.6% of the critical load for nitrogen deposition.

The predicted impacts are considerably lower than the 20% threshold level defined in Step 5 EPA's Ammonia and Nitrogen Assessment Guidance at all ecologically sensitive receptor locations modelled on the River Barrow and Nore SAC.

Table 10 **Predicted cumulative ground-level concentrations of ammonia and annual average nitrogen deposition at ecologically sensitive locations on the River Barrow and Nore SAC due to the pig farm in combination with background facilities that meet the requirements of Step 5**

Receptor	Concentration of ammonia (µg/m³)		PC as a percentage of Critical Level	Nitrogen Deposition Flux (kg/ha/yr)		PC as a percentage of Critical Load
	Process Contribution (Pig Farm)	Critical Level		Process Contribution (Pig Farm)	Critical Load	
DR29	0.05	3	**1.7%**	0.5	30.0	**1.6%**
DR30	0.04	3	1.2%	0.3	30.0	1.2%
DR31	0.03	3	0.9%	0.3	30.0	0.8%
DR32	0.02	3	0.6%	0.2	30.0	0.6%
DR33	0.01	3	0.5%	0.1	30.0	0.5%
DR34	0.01	3	0.5%	0.1	30.0	0.4%
DR35	0.01	3	0.4%	0.1	30.0	0.4%
DR36	0.02	3	0.5%	0.1	30.0	0.5%
DR37	0.01	3	0.5%	0.1	30.0	0.4%
DR42	0.02	3	0.6%	0.2	30.0	0.5%
DR43	0.01	3	0.4%	0.1	30.0	0.4%
DR45	0.01	3	0.3%	0.1	15.4	0.6%
DR46	0.01	3	0.3%	0.1	30.0	0.3%
DR47	0.01	3	0.3%	0.1	30.0	0.3%
DR48	0.01	3	0.4%	0.1	30.0	0.3%
DR49	0.01	3	0.4%	0.1	15.4	0.7%
DR50	0.01	3	0.4%	0.1	15.4	0.7%
DR51	0.02	3	0.5%	0.1	15.4	1.0%
DR52	0.01	3	0.3%	0.1	30.0	0.3%
DR53	0.01	3	0.3%	0.1	30.0	0.3%
DR54	0.01	3	0.3%	0.1	30.0	0.3%

6.3.2 Step 5 Cumulative Assessment – Lisbigney Bog SAC

The results of the Step 5 cumulative assessment on ecologically sensitive receptors on the Lisbigney Bog SAC are presented in Table 11.

The results show that the worst-case cumulative impact due to the pig farm in combination with other IAIs that meet the requirements of Step 5 are:

- 0.9% of the critical level for ammonia
- 1.8% of the critical load for nitrogen deposition.

The predicted impacts are considerably lower than the 20% threshold level defined in Step 5 EPA's Ammonia and Nitrogen Assessment Guidance at all ecologically sensitive receptor locations modelled on the Lisbigney Bog SAC.

Table 11 **The predicted cumulative ground-level concentrations of ammonia and annual average flux rate of nitrogen deposition at the ecologically sensitive locations on the Lisbigney Bog SAC due to the pig farm in combination with background facilities that meet the requirements of Step 5**

Receptor	Concentration of ammonia (µg/m³)		PC as a percentage of Critical Level	Nitrogen Deposition Flux (kg/ha/yr)		PC as a percentage of Critical Load
	Process Contribution (Pig Farm)	Critical Level		Process Contribution (Pig Farm)	Critical Load	
DR58	0.02	3	0.6%	0.2	15.0	1.2%
DR59	0.02	3	0.8%	0.2	15.0	1.6%
DR60	0.02	3	0.8%	0.2	15.0	1.5%
DR61	0.03	3	0.9%	0.2	15.0	1.7%
DR62	0.03	3	0.9%	0.3	15.0	1.8%
DR63	0.03	3	0.9%	0.3	15.0	1.7%
DR64	0.02	3	0.8%	0.2	15.0	1.5%
DR65	0.02	3	0.7%	0.2	15.0	1.3%

7. CONCLUSIONS

Tulleka Trading commissioned Katestone to complete an ammonia impact assessment (AIA) for a pig farm located at Moate, Graigue, County Laois.

Tulleka Trading proposes to:

- Reduce the stocking density of production pigs at the site by:
    - Constructing four new pig housing units to increase the total floor space
    - Maintaining pig numbers at current levels
- Construct a new farrowing house to improve the welfare of farrowing pigs
- Alter manure storage practices at eleven (11) of the thirteen (13) existing housing units at the site, which will be changed from deep pit storage tanks to shallow pit storage tanks to reduce emissions from the site
- Alter ventilation points on some of the pig housing units to reduce the potential impact of emissions exhausted from these sources.

The assessment is required to determine the potential impact of ammonia emissions from the proposed development at the pig farm at ecologically sensitive locations on nearby Natura 2000 sites. The assessment will be submitted as part of planning and licensing applications for the pig farm.

The AIA was conducted in accordance with:

- The stepwise procedure described in EPA's Ammonia and Nitrogen Assessment Guidance (EPA, 2023).
- Recognised techniques for dispersion modelling specified in EPA's Air Dispersion Modelling Guidance Note (AG4). The dispersion model, CALPUFF, was used to predict ground-level concentrations of ammonia and nitrogen deposition flux rates across the model domain due to the pig farm.

The results of the AIA are presented here:

- The results of the Step 1 assessment indicated that:
    - The approaches using the SCAIL-Agriculture model described in Step 2 and Step 3 of the EPA's Ammonia and Nitrogen Assessment Guidance are not applicable
    - A detailed assessment completed in accordance with Step 4 of EPA's Ammonia and Nitrogen Assessment Guidance is, therefore, required to be completed.
- The results of the Step 4 assessment show that, in relation to the 1% threshold identified in Step 4 of EPA's Ammonia and Nitrogen Assessment Guidance, the PC due to the proposed development at the pig farm:
    - Exceeds for ammonia and nitrogen deposition at a number of modelled discrete receptor locations on:
        - The River Barrow and Nore SAC (Discrete Receptors –1 - 57)
        - The Lisbigney Bog SAC (58 - 65)
    - Does not exceed at any of the modelled discrete receptor locations on the Nore River SPA (Discrete Receptors – 35 - 57).
- The results of the Step 4 assessment indicate that a Step 5 assessment, involving detailed modelling that takes account of in-combination effects, is required for the modelled sensitive locations on the River Barrow and Nore SAC and the Lisbigney Bog SAC.

- The Step 5 assessment requires a review of background IAIs that needed to be included in the in-combination assessment. This review determined there is no requirement for a cumulative assessment of impacts on the River Barrow and Nore SAC or the Lisbigney Bog SAC as no IAI meets the requirements of Step 5 of EPA's Ammonia and Nitrogen Assessment Guidance to be included. Accordingly, the cumulative impact on the River Barrow and Nore SAC or the Lisbigney Bog SAC of all IAI as defined in Step 5 of EPA's Ammonia and Nitrogen Assessment Guidance is equal to the impact of the pig farm in isolation.
- The Step 5 assessment included an in-combination assessment of the pig farm and IAIs that met the requirement for inclusion in the modelling assessment. The results of the in-combination assessments show that:
    - At modelled locations on the River Barrow and Nore SAC with mapped sensitive habitats or species the worst-case cumulative impact due to the pig farm in combination with other IAIs that meet the requirements of Step 5 was well below in-combination assessment level of 20% with the highest modelled results at any of the modelled sensitive locations being:
        - 1.7% of the critical level for ammonia
        - 1.6% of the critical load for nitrogen deposition.
    - At the modelled locations on the Lisbigney Bog SAC the worst-case cumulative impact due to the pig farm in combination with other IAIs that meet the requirements of Step 5 was well below in-combination assessment level of 20% with the highest modelled results at any of the modelled sensitive locations being:
        - 0.9% of the critical level for ammonia
        - 1.8% of the critical load for nitrogen deposition.

The results of the assessment therefore indicate that:

- The impacts of the proposed pig farm in isolation are under EPA limits and therefore **complies** with the Step 4 evaluation criteria at all modelled locations on the Nore River SPA.
- The cumulative impacts of the proposed pig farm with background IAIs are under EPA limits and therefore **complies** with the Step 5 evaluation criteria at all modelled locations on:
    - The River Barrow and Nore SAC
    - The Lisbigney Bog SAC.

8. REFERENCES

EPA, 2011, Integrated Pollution Prevention and Control Licence. P0710-03. Mr. Paul Tully, Moate Pig Unit, Ballinakill, Portlaoise, Co. Laois. https://epawebapp.epa.ie/licences/lic_eDMS/090151b2804d505b.pdf

EPA, 2013, Section 82A(11) Amendment to Industrial Emissions Licence P0710-03. Mr. Paul Tully, Moate Pig Unit, Ballinakill, Portlaoise, Co. Laois. https://epawebapp.epa.ie/licences/lic_eDMS/090151b2804d2f0c.pdf

EPA (2017) Guidelines on the information to be contained in environmental impact assessment reports Draft, August 2017. Environmental Protection Agency. An Ghníomhaireacht um Chaomhnú Comhshaoil PO Box 3000, Johnstown Castle, Co. Wexford, Ireland. http://www.epa.ie/pubs/advice/ea/EPA%20EIAR%20Guidelines.pdf

EPA (2020) Air Dispersion Modelling from Industrial Installations Guidance Note (AG4). Environmental Protection Agency, Johnstown Castle Estate, Wexford, Ireland. https://www.epa.ie/pubs/advice/air/emissions/AG4%20Guidance%20note%20for%20web.pdf

EPA (2023) Licence Application Instruction Note 1 (IN1) - Assessment of the impact of ammonia and nitrogen on Natura 2000 Sites from intensive agricultural installations. Version 2.0 March 2023. Environmental Protection Agency. An Ghníomhaireacht um Chaomhnú Comhshaoil PO Box 3000, Johnstown Castle, Co. Wexford, Ireland. https://www.epa.ie/publications/licensing--permitting/industrial/ied/Assessment-of-Impact-of--Ammonia-and-Nitrogen-on-Natura-sites-from-Intensive-Agriculture-Installations-2023.pdf

EPA, 2022, Instruction note for the assessment of odour emissions from Intensive Agriculture pig installations. PO Box 3000, Johnstown Castle Estate, County Wexford, Y35 W821, Ireland. 05 August 2022 https://www.epa.ie/publications/licensing--permitting/industrial/ied/EPA-Instruction-note-for-the-assessment-of-odour-emissions-from-Intensive-Agriculture-pig-installations.pdf

Hayes, E.T., Curran, T.P., Dodd, V.A. 2006. Odour and ammonia emissions from intensive pig units in Ireland. Bioresource technology 97 (7), 940-948

Hayes, E.T. (2004). Odour and ammonia emissions from intensive pig and poultry units in Ireland. PhD Thesis. University College Dublin, Belfield, Dublin 4

Kelleghan, D.B., Fogarty, M., Welchman, S., Cummins, T., & Curran, T.P. (2022) Agricultural atmospheric ammonia: identification & assessment of potential impacts. Irish Wildlife Manuals, No. 135. National Parks and Wildlife Service, Department of Housing, Local Government and Heritage, Ireland

NPWS (2011) Conservation Objectives: River Barrow and River Nore SAC 002162. Version 1. National Parks and Wildlife Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs. https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO002162.pdf

NPWS (2021) Conservation Objectives: Lisbigney Bog SAC 000869 Version 1. National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht. https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO000869.pdf

NPWS (2022) Conservation Objectives: River Nore SPA [004233]. National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht. https://www.npws.ie/sites/default/files/protected-sites/conservation_objectives/CO004233.pdf

Teagasc (2018) Pig Farmers' Conference 2018 Conference Proceedings Cavan Crystal Hotel, 23rd October 2018 & Horse & Jockey Hotel, 24th October 2018. https://www.teagasc.ie/media/webSite/publications/2018/Pig-Farmers-Conference-2018.pdf

APPENDIX A MODELLING METHODOLOGY

A1 METEOROLOGICAL MODELLING

A1.1 TAPM

The meteorological model, TAPM (The Air Pollution Model) Version 4.0.5, was developed by the CSIRO and has been validated by the CSIRO, Katestone and others for many locations in Australia, southeast Asia, North America and Ireland. Katestone has used the TAPM model throughout Australia and has performed well for simulating regional winds patterns. Katestone has recently used the TAPM model to generate gridded data over Cork city and Harbour. The data generated correlated well with observed data at Cork Airport. TAPM has proven to be a useful model for simulating meteorology in locations where monitoring data is unavailable.

TAPM requires synoptic meteorological information for the region surrounding the project. This information is generated by a global model similar to the large-scale models used to forecast the weather. The data are supplied on a grid resolution of approximately 75 km, and at elevations of 100 metres to five kilometres above the ground. TAPM uses this synoptic information, along with specific details of the location such as surrounding terrain, land-use, soil moisture content and soil type to simulate the meteorology of a region as well as at a specific location.

TAPM resolves local terrain and land-use features that may influence local meteorology and generates a meteorological dataset that is representative of Site-specific geographic conditions. A year of synoptic data must be selected as input for TAPM. The selection of this year should be such that the year is representative of typical meteorological conditions (and therefore is not necessarily the most recent year of available data) and whether monitoring data is available for the time period to validate the output dataset. In addition, Katestone's experience elsewhere suggests that variability of dispersion meteorological conditions from year to year are unlikely to change the outcome of the air quality assessment.

TAPM was configured as follows:

- 42 x 42 grid point domain with an outer grid resolution of 30 kilometres and nesting grids of 10, 3.0 1.0 and 0.3 kilometres.
- 5 modelled years (1 January 2016 to 31 December 2020)
- Grid centered near the Project Site at latitude 52°53'59.99 and longitude - 7°17'0.02
- US Geological Survey EROS global terrain height database
- TAPM default land use database, modified to be consistent with aerial imagery in the innermost grid
- 25 vertical grid levels
- No data assimilation.

A1.2 CALMET meteorological modelling

CALMET is an advanced non-steady-state diagnostic 3D meteorological model with micro-meteorological modules for overwater and overland boundary layers. The model is the meteorological pre-processor for the CALPUFF modelling system. CALMET is capable of reading hourly meteorological data as data assimilation from multiple Sites within the modelling domain; it can also be initialised with the gridded three-dimensional prognostic output from other meteorological models such as TAPM. This can improve dispersion model output, particularly over complex terrain as the near surface meteorological conditions are calculated for each grid point.

CALMET (version 6.5.0) was used to simulate meteorological conditions in the region. The CALMET simulation was initialised with the gridded TAPM 3D wind field data from the 1 km grid. CALMET treats the prognostic model

output as the initial guess field for the CALMET diagnostic model wind fields. The initial guess field is then adjusted for the kinematic effects of terrain, slope flows, blocking effects and 3D divergence minimisation.

CALMET was configured with twelve vertical levels with heights at 20, 60, 100, 150, 200, 250, 350, 500, 800, 1600, 2600 and 4600 metres at each grid point.

All options and factors were selected in accordance with NSW EPA CALPUFF Guidance released by TRC Environmental in 2011 except where noted below.

Key features of CALMET used to generate the wind fields are as follows:

- Domain area of 190 x 195 grid cells at 200m spacing
- 5 years modelled (1 January 2016 to 31 December 2020)
- Prognostic wind fields input as MM5/3D.dat for “initial guess” field (as generated by TAPM)
- Gridded cloud cover from prognostic relative humidity at all levels
- No extrapolation of surface wind observations to upper layers (not used in no-obs mode)
- Terrain radius of influence set to 7 km
- Maximum search radius of 10 grid cells in averaging process
- Use prognostic relative humidity
- Land use data modified to be consistent with aerial imagery.

All other options set to default.

A2 CALPUFF DISPERSION MODELLING

CALPUFF simulates the dispersion of air pollutants to predict ground-level concentration and deposition rates across a network of receptors spaced at regular intervals, and at identified discrete locations. CALPUFF is a non-steady-state Lagrangian Gaussian puff model containing parameterisations for complex terrain effects, overwater transport, coastal interaction effects, building downwash, wet and dry removal, and simple chemical transformation. CALPUFF employs the 3D meteorological fields generated from the CALMET model by simulating the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal. CALPUFF takes into account the geophysical features of the study area that affects dispersion of pollutants and ground-level concentrations of those pollutants in identified regions of interest. CALPUFF contains algorithms that can resolve near-source effects such as building downwash, transitional plume rise, partial plume penetration, sub-grid scale terrain interactions, as well as the long-range effects of removal, transformation, vertical wind shear, overwater transport and coastal interactions. Emission sources can be characterised as arbitrarily-varying point, area, volume and lines or any combination of those sources within the modelling domain.

Key features of CALPUFF used to simulate dispersion:

- Domain area of 190 x 195 grid cells at 200m spacing
- 5 years modelled (1 January 2015 to 31 December 2019)
- Gridded 3D hourly-varying meteorological conditions generated by CALMET
- Partial plume path adjustment for terrain modelled
- Dispersion coefficients calculated internally from sigma v and sigma w using micrometeorological variables.

All other options set to default.