Ammonia Assessment – Carhue Piggeries Farm, Timoleague, Co. Cork

Prepared for:

Carhue Piggeries Limited

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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

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Prepared by:	Micheal Fogarty, Daniel Gallagher, Paddy McDowell and Natalie Shaw
Reviewed by:	Natalie Shaw and Simon Welchman
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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
m^3/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
UK	United Kingdom
USEPA	United States Environmental Protection Agency

1. INTRODUCTION

Katestone Environmental Pty Ltd (Katestone) was commissioned by Carhue Piggeries Limited (Carhue Piggeries) to complete an ammonia assessment of a pig farm located at Colligboy, Timoleague, Co. Cork (site).

The pig farm includes two sets of housing units including:

- A set of housing units located in the southern area of the site that was initially constructed in the 1990s (old housing units)
- A set of housing units located in the northern area of the site that has been under construction since 2019 (new housing units).

EPA issued an Integrated Pollution Prevention and Control (IPPC) licence (Register number P0621-01) for the old housing units in 2003. In 2013, the licence was amended to an Industrial Emissions Licence (IEL) (Register number P0621-02). Carhue Piggeries anticipates that the new housing units will be incorporated into the IEL, based on a licence review application. This ammonia assessment will form part of the licence review application, being submitted as a supporting document.

This ammonia assessment was undertaken using dispersion modelling techniques. The purpose of the ammonia assessment is to determine concentrations of ammonia and the flux rate of nitrogen deposition at ecologically sensitive locations due to emissions from the pig farm in isolation and in combination with other sources of ammonia (in-combination assessment).

The dispersion modelling has been completed in accordance with the requirements of EPA's Air Dispersion Modelling Guidance Note (AG4). The assessment of ammonia and associated nitrogen deposition has been assessed in accordance with EPA ammonia guidance that was issued in 2021 (EPA, 2021)

The results of the ammonia assessment will be interpreted by Carhue Piggeries' consultant ecologist, Carl Dixon of Dixon Brosnan Environmental Consultants, who has been engaged by Carhue Piggeries to undertake a Natura Impact Statement (NIS) of the pig farm. EPA will consider the NIS when it completes the Appropriate Assessment of the pig farm.

2. OVERVIEW OF THE PIG FARM

The pig farm is located approximately 1.2 km northwest of the village of Timoleague, Co. Cork. It is located at an elevated position that overlooks the agricultural lands of south Co. Cork. The south coast of Cork is approximately 6.5 km south of the site. There are number of rural residences in the vicinity of the site. The boundary of the site and its environs are presented in Figure 1. All pig housing units will be located within the boundary of the site.

A site plan illustrating the layout of the old housing units is presented in Figure 2. A site plan illustrating the layout of the new housing units is presented in Figure 3.

The animal numbers housed in the old housing units as part of the proposed development, are as follows:

- 600 dry sows
- 200 suckling sows
- 135 maiden gilts.
- 6 boars
- 3,090 weaners pigs
- 4,145 fattening pigs

The new housing units will have the following maximum animal holding capacity:

- 670 dry sows
- 280 suckling sows
- 160 maiden gilts.
- 10 boars
- 3,910 weaners pigs
- 4,850 fattening pigs.

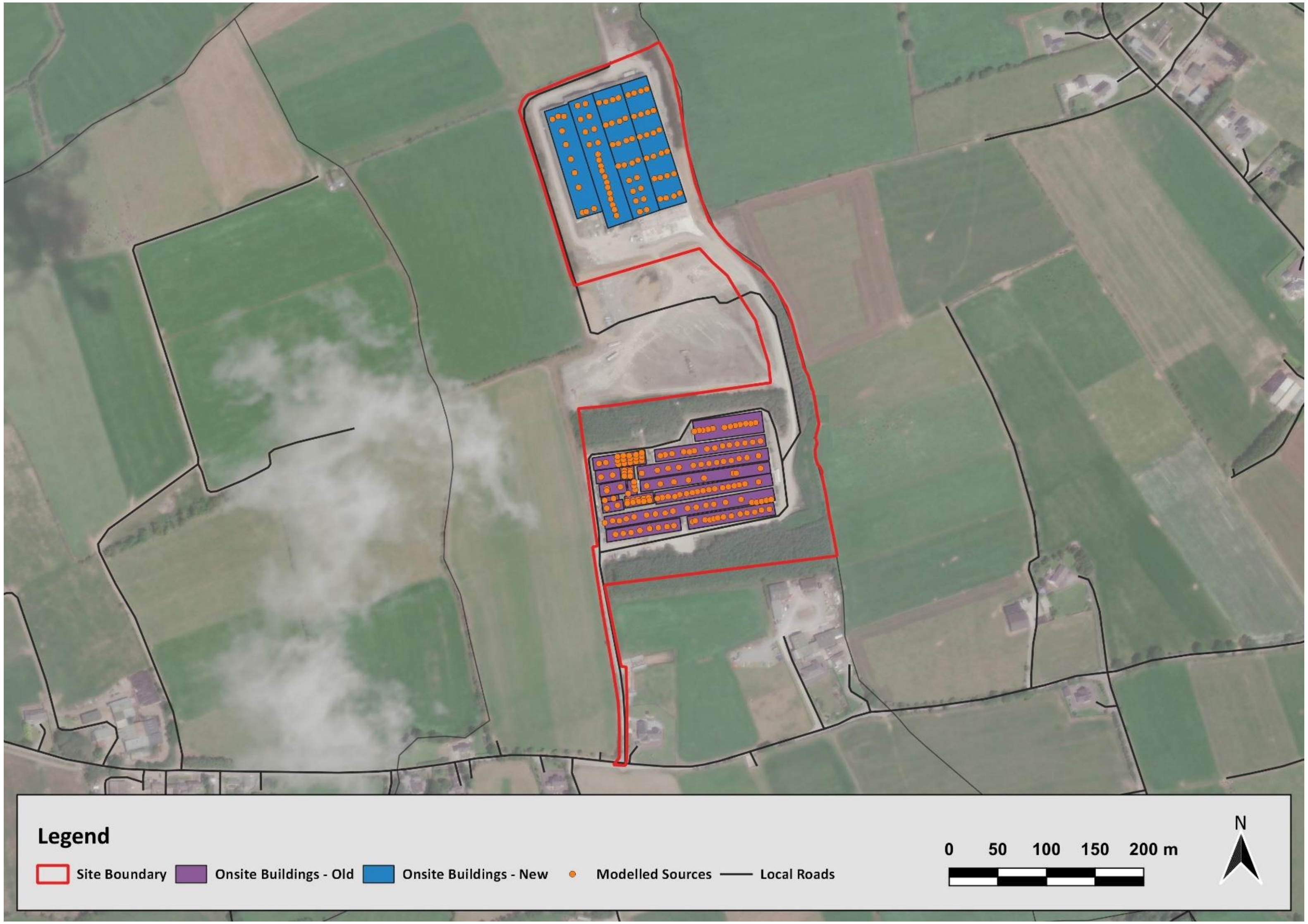

Figure 1 **Carhue pig farm site boundary (red line) and the surrounding environment**

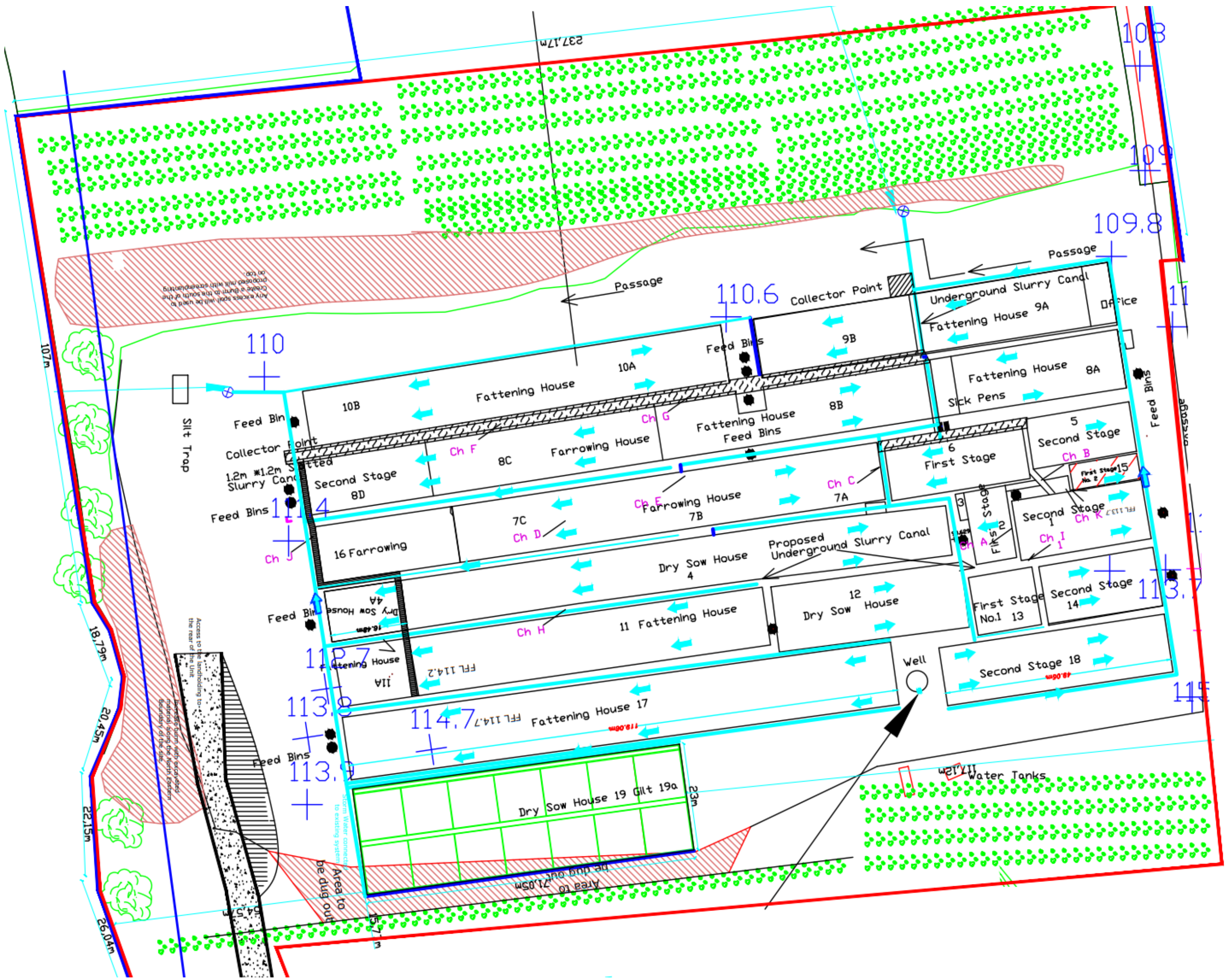

Figure 2 Carhue pig farm site plan – Old housing units

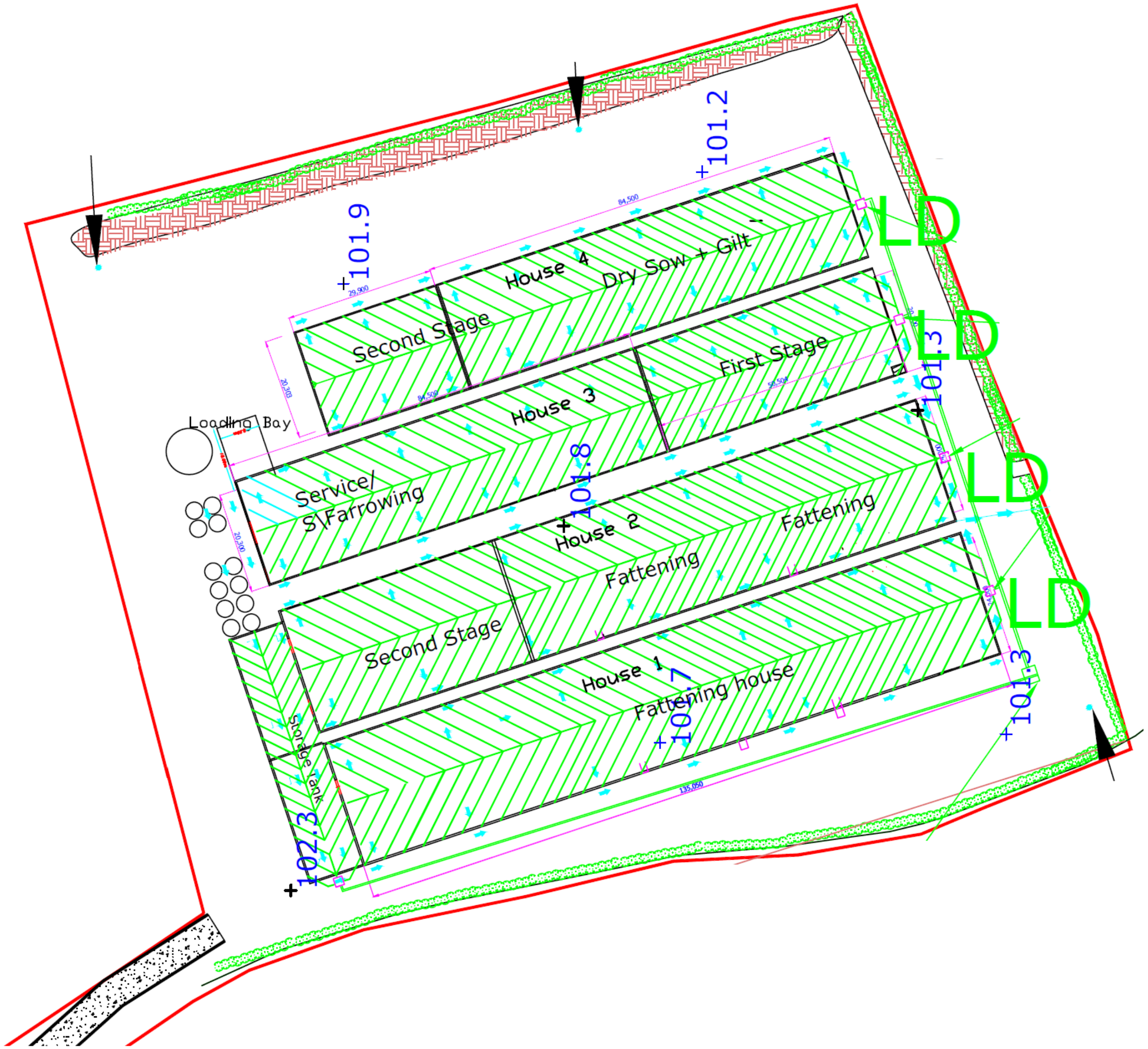

Figure 3 **Carhue pig farm site plan – New housing units**

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 —*
>
> *(i) 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

(e) 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, European 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 Member States.

The main aim of the Habitats Directive is to contribute towards the conservation of biodiversity by requiring 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 guidance, referred to here as the EPA 2021 Ammonia Guidance, on how applicants should assess, the predicted 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).

The EPA 2021 Ammonia 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, 2021).

4. EXISTING ENVIRONMENT

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

The extents of the dispersion modelling domain were determined based on the Identification of ecologically sensitive locations within 10 km of the site (core assessment area).

4.1 Local terrain and land-use

The site is in a remote rural location surrounded by pasture. The old housing units are on the south facing slope of an area of elevated terrain. The new housing units are at the top of this area of elevated terrain. The terrain falls north of the new housing units, the north facing slope forming the southern wall of a valley that contains the Argideen River at its lowest point. The Argideen River runs west to east approximately 1.5 km north of the new housing units. It bends to the south approximately 1.8 km northeast of the site boundary, flowing south for approximately 2 km before bending east and entering the Courtmacsharry Estuary approximately 1.7 km southeast of the site.

The terrain of the region that has been included in the dispersion modelling domain is presented in Figure 4.

The Site is in an area that is likely to have complex meteorological conditions. At its closest point, it is 6.5 km from the coastline. The site is 2 km west of the Courtmacsherry Estuary, which runs from west to east into the Celtic Sea. There are valleys both north and south of the Site with water ways that ultimately enter the Courtmacsherry Estuary including:

- The Spittal Stream that runs from southwest to northeast approximately 2 km south of the Site.
- The River Arigideen that runs from west to east approximately 1.5 km north of the Site before meandering southwards approximately 2 km northeast of the Site.

The Site is in an elevated position compared to the surrounding terrain. The site elevation is approximately 135 m. Only land to the west is higher than the Site, gradually rising to approximately 144 m, 700 m west of the site. The terrain elevation falls to:

- 23 m within 1.3 km of the Site to the north
- 2 m within 2 km of the Site to the east
- 30 m within 1.3 km of the Site to the south.

The terrain and land use of the site are relatively complex due to its location near a ridge, in close proximity to a river valley, mountains and the sea. The complexities of the site in terms of local terrain and proximity to multiple water bodies are likely to have an important effect on dispersion conditions near the site and across the modelling domain.

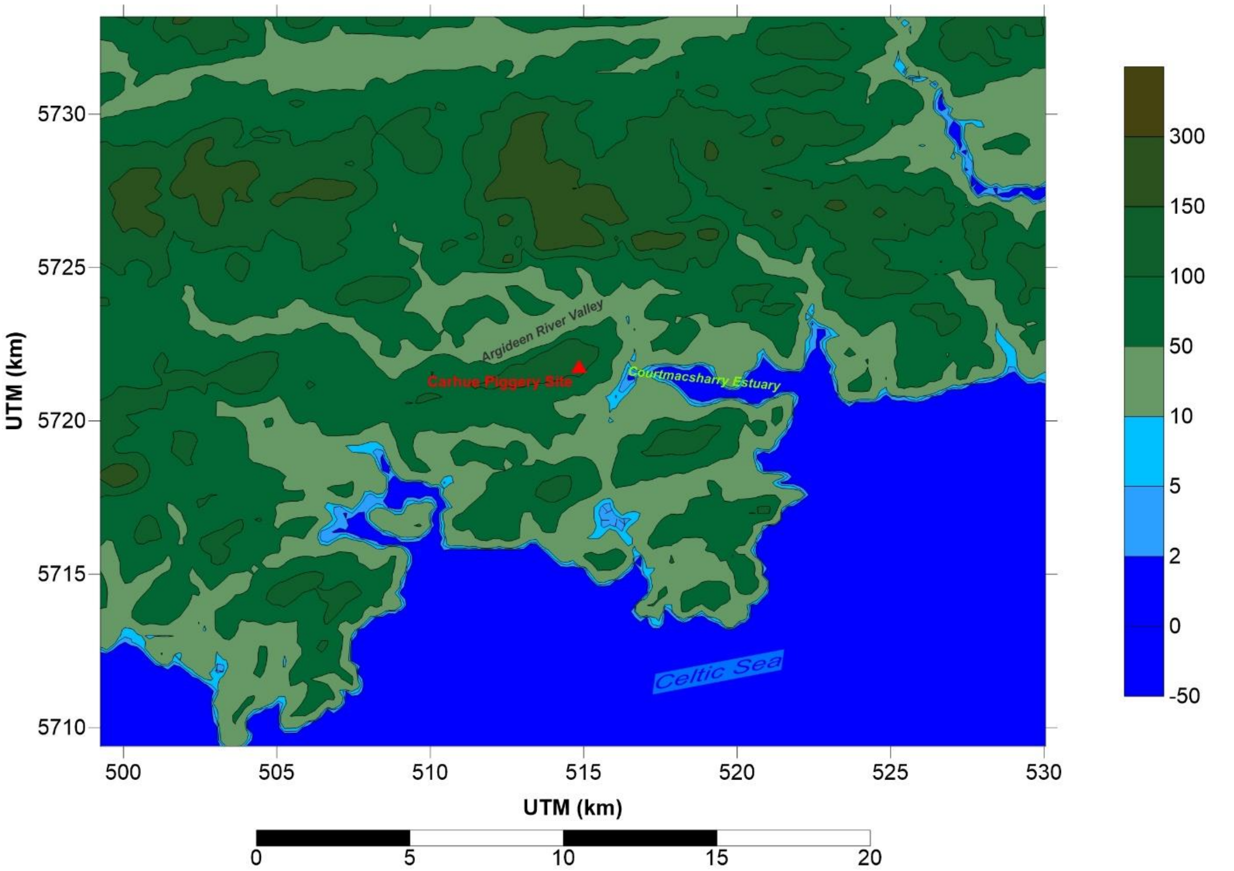

Figure 4 Terrain of the modelled domain

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 4.4 m/s. This compares to a 1-hour average wind speed of 4.8 m/s at Cork Airport in 2014. 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 have a strong influence on wind patterns 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 west and west-southwest during the winter months. The greatest proportion of light winds occur during summer and autumn. There is a distinct north-westerly component to the wind rose in summer. A significant proportion of light northerly winds occur during autumn.

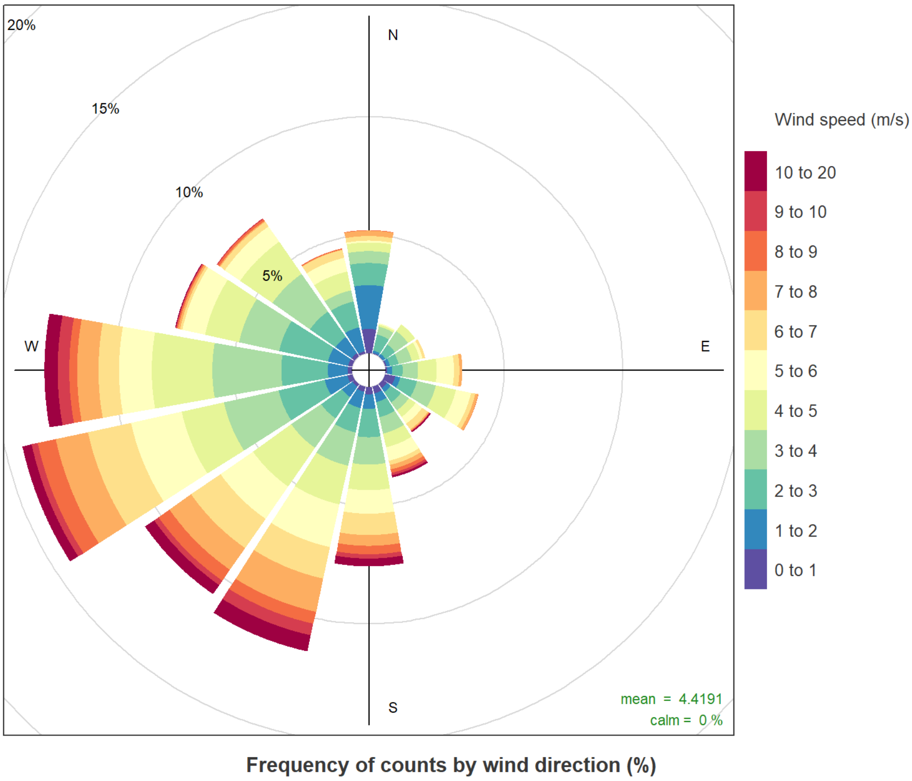

Figure 5 Annual wind distribution predicted at the site using CALMET

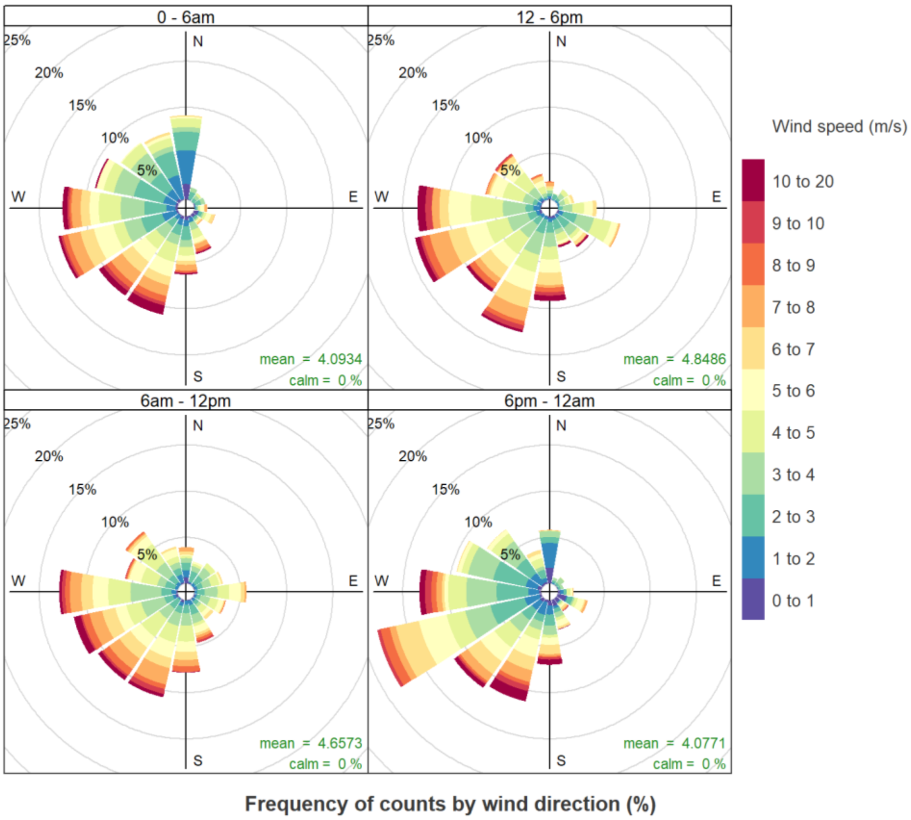

Figure 6 Diurnal wind distribution predicted at the site using CALMET

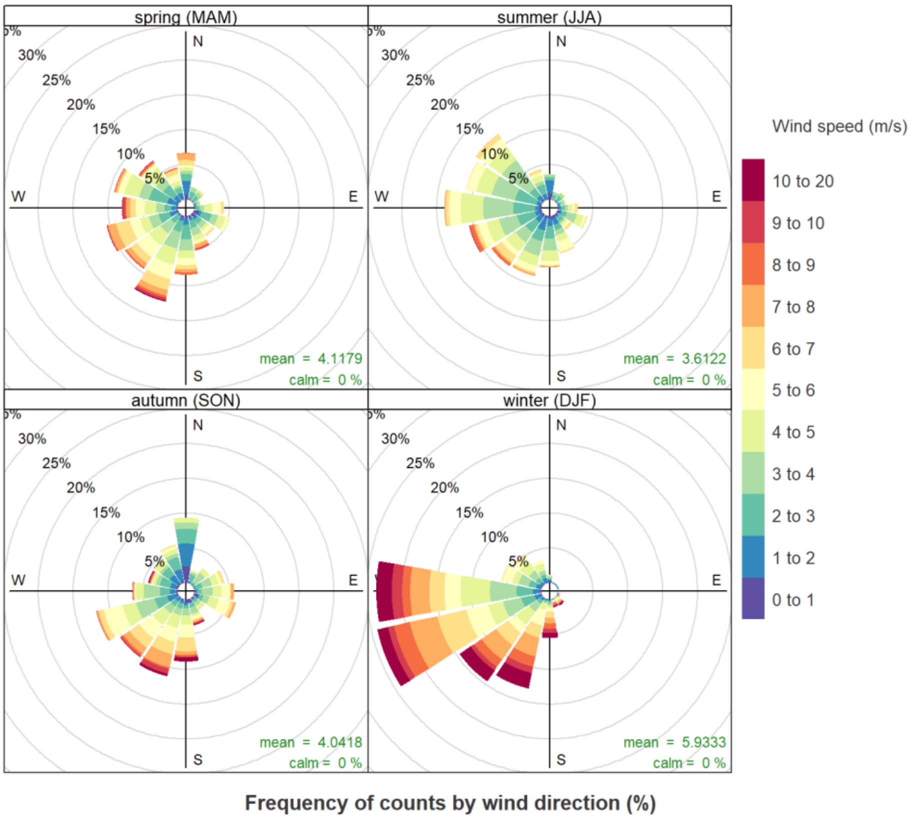

Figure 7 Seasonal wind distribution predicted at the site using CALMET

4.3 Background concentrations of ammonia and nitrogen deposition

The background ammonia concentration and nitrogen deposition levels 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, 2021). The background concentrations of ammonia and nitrogen deposition levels adopted in the assessment are presented in Table 1.

The dispersion modelling assessment has considered the potential impact of the proposed development in isolation and in combination with representative background concentrations of ammonia and rates of nitrogen deposition.

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	2.78	7.98
DR2	2.80	7.98
DR3	2.80	7.98
DR4	2.74	7.75
DR5	2.73	7.75
DR6	2.70	7.62
DR7	2.71	7.62

Receptor	SCAIL Background	
	Concentration of ammonia (µg/m³)	Nitrogen Deposition Flux (kg/ha/yr)
DR8	2.71	7.62
DR9	2.71	7.62
DR10	2.71	7.62
DR11	2.71	7.62
DR12	2.70	7.62
DR13	2.71	7.62
DR14	2.70	7.62
DR15	2.70	7.62
DR16	2.70	7.62
DR17	2.69	7.62
DR18	2.69	7.62
DR19	2.64	7.42
DR20	2.64	7.42
DR21	2.63	7.42
DR22	2.63	7.42
DR23	2.63	7.42
DR24	2.62	7.42
DR25	2.62	7.42
DR26	3.09	8.53
DR27	2.62	7.42
DR28	3.09	8.53
DR29	3.09	8.53
DR30	2.88	7.82
DR31	2.45	7.10
DR32	2.30	6.74
DR33	2.30	6.74
DR34	2.13	6.43
DR35	2.13	6.43
DR36	2.13	6.43
DR37	2.13	6.43
DR38	2.09	6.43
DR39	2.09	6.43
DR40	2.09	6.43
DR41	2.09	6.43
DR42	2.09	6.43
DR43	2.09	6.43
DR44	2.09	6.43
DR45	2.09	6.43
DR46	2.09	6.43

Receptor	SCAIL Background	
	Concentration of ammonia (µg/m³)	Nitrogen Deposition Flux (kg/ha/yr)
DR47	2.09	6.43
DR48	2.10	6.43
DR49	2.10	6.43
DR50	2.10	6.43
DR51	2.09	6.43
DR52	1.80	5.91
DR53	1.80	5.91
DR54	1.80	5.91
DR55	1.80	5.91
DR56	2.14	6.42
DR57	2.05	6.06
DR58	2.15	6.43
DR59	2.09	6.21
DR60	2.01	6.55
DR61	2.01	6.55
DR62	1.96	5.85
DR63	2.05	6.09
DR64	1.90	5.72
DR65	1.90	5.72
DR66	2.04	6.05
DR67	1.90	5.71
DR68	1.90	5.71
DR69	1.90	5.71

4.4 Sensitive receptors

The sensitive receptors included in the dispersion modelling assessment are at ecologically sensitive locations on Natura 2000 sites. The locations were determined in conjunction with the project ecologist. The sensitive receptor locations included in the dispersion modelling assessment are at points on Natura 2000 sites and at woodlands including:

- Courtmacsherry Estuary SAC (DR1 TO DR 52)
- Courtmacsherry Bay SPA (DR1 TO DR 52)
- Seven Heads SPA (52 TO 57)
- Clonakilty Bay SAC (58 TO 69)
- Clonakilty Bay SPA (58 TO 69).

The 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 are presented in Table 2. The sensitive receptor locations included in the dispersion modelling assessment are presented in a map in Figure 8.

Table 2 **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**

Source Number	Conservation Interest Identified	Ammonia - Critical Level (μg/m³)	Nitrogen Deposition - Critical Load
DR1	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR2	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR3	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR4	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR5	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR6	Salt Marsh Habitats	3.0	20.0
DR7	No Conservation Objective identified	3.0	30.0
DR8	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR9	Salt Marsh Habitats	3.0	20.0
DR10	Salt Marsh Habitats	3.0	20.0
DR11	Salt Marsh Habitats	3.0	20.0
DR12	Salt Marsh Habitats	3.0	20.0
DR13	Salt Marsh Habitats	3.0	20.0
DR14	Salt Marsh Habitats	3.0	20.0
DR15	Salt Marsh Habitats	3.0	20.0
DR16	Salt Marsh Habitats	3.0	20.0
DR17	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR18	Salt Marsh Habitats	3.0	20.0
DR19	Salt Marsh Habitats	3.0	20.0
DR20	Salt Marsh Habitats	3.0	20.0
DR21	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR22	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR23	Salt Marsh Habitats	3.0	20.0
DR24	Salt Marsh Habitats	3.0	20.0
DR25	Salt Marsh Habitats	3.0	20.0
DR26	Salt Marsh Habitats	3.0	20.0
DR27	Salt Marsh Habitats	3.0	20.0
DR28	Salt Marsh Habitats	3.0	20.0
DR29	Salt Marsh Habitats	3.0	20.0
DR30	Salt Marsh Habitats	3.0	20.0
DR31	Salt Marsh Habitats	3.0	20.0
DR32	Salt Marsh Habitats	3.0	20.0
DR33	Salt Marsh Habitats	3.0	20.0
DR34	Salt Marsh Habitats	3.0	20.0
DR35	Salt Marsh Habitats	3.0	20.0
DR36	Salt Marsh Habitats	3.0	20.0
DR37	Salt Marsh Habitats	3.0	20.0

Source Number	Conservation Interest Identified	Ammonia - Critical Level (µg/m³)	Nitrogen Deposition - Critical Load
DR38	Salt Marsh Habitats	3.0	20.0
DR39	Salt Marsh Habitats	3.0	20.0
DR40	Sand Dunes	3.0	8.0
DR41	Salt Marsh Habitats	3.0	20.0
DR42	Sand Dunes	3.0	8.0
DR43	Sand Dunes	3.0	8.0
DR44	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR45	Salt Marsh Habitats	3.0	20.0
DR46	Sand Dunes	3.0	8.0
DR47	Sand Dunes	3.0	8.0
DR48	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR49	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR50	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR51	Perrenial Vegetation of Stony Banks	3.0	8.0
DR52	Perrenial Vegetation of Stony Banks	3.0	8.0
DR53	Seven Heads SPA	3.0	30.0
DR54	Seven Heads SPA	3.0	30.0
DR55	Seven Heads SPA	3.0	30.0
DR56	Seven Heads SPA	3.0	30.0
DR57	Seven Heads SPA	3.0	30.0
DR58	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR59	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR60	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR61	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR62	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR63	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR64	Sand Dunes	3.0	8.0
DR65	Sand Dunes	3.0	8.0
DR66	Sand Dunes	3.0	8.0
DR67	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR68	Within SAC boundary - No Conservation Interest Identified	3.0	30.0
DR69	Within SAC boundary - No Conservation Interest Identified	3.0	30.0

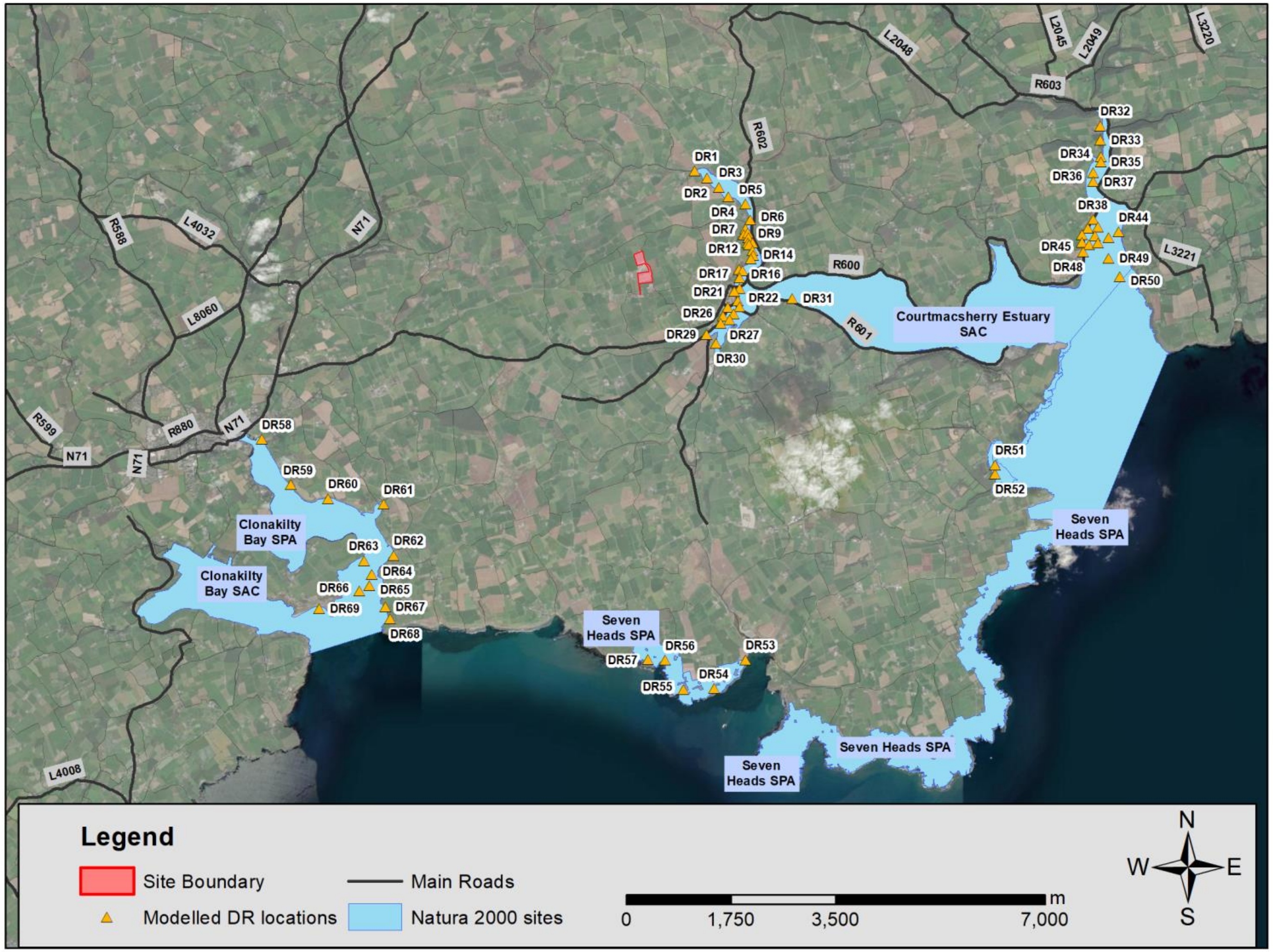

Figure 8 **The sensitive receptors included in the dispersion modelling assessment to represent locations on Natura 2000 sites**

5. AMMONIA ASSESSMENT

5.1 Methodology

The following section describes the 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 and other intensive pig and poultry developments 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 of intensive pig and poultry farms within the dispersion model domain.
- Derivation of an emissions inventory based on its design and data from the literature for:
    - The pig farm
    - Other intensive pig and poultry sources of ammonia emissions within 20 km of 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
    - Across a cartesian grid that covers the modelling domain.

5.2 Meteorological modelling

5.2.1 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 complex terrain and coastal areas. The meteorological parameters that affect dispersion are likely to vary spatially and temporally across the modelling domain due to these factors.

The closest Met Eireann monitoring location to the Site is at Cork Airport, which is 30 km northeast. This monitoring station is in rural rolling landscape. It sits at a high point in the local terrain. There are a number of small river tributaries in the vicinity of Cork Airport that are aligned from north to south. Because of its elevation, exposed location and distance from the coast, the meteorological data collected at Cork Airport is not likely to be representative of meteorological conditions at the Site.

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 and the proximity to the sea. The approach adopted to generate representative site-specific data utilised 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.

5.2.2 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 odour and air contaminant impacts for over 10 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.

5.3 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 old housing units are currently operated as traditional deep pit housing units. The pig diets at the old housing units are formulated with optimised protein content, to limit emissions. The proposed development includes a commitment that the old housing units will be operated as a shallow pit housing system (manure levels maintained below 600 mm), with frequent slurry removal. The pig diets at the old housing units will continue to be formulated with optimised protein content to limit emissions. As part of the proposed development, the old housing units will be operated in accordance with the requirements of BAT 30 in the BREF for IRPP.

The first two ammonia emission controls ensure that the new housing units will operate in accordance with the requirements of BAT 30 in the BREF for IRPP. The use of slurry cooling at the new housing units will significantly reduce emissions of ammonia, as identified in the BREF for IRPP.

The ammonia emission rates adopted in the dispersion modelling assessment are based on the emission rates of BAT compliant pig farms presented in the BREF for IRPP including the following based on data from Table 5.4 of the BAT conclusions, which presents the Bat Acceptable Emission limits (AELs) for piggeries that are designed and operated in accordance with BAT. The BAT-AELs for various BAT techniques are presented in the BAT conclusions 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.

A single BAT-AEL is presented for fattener pigs in the BAT conclusions. Fattener pigs; however, can be classified as growers and finishers with growers defined as pigs in the weight range between 30 kg and 60 kg and finishers defined as pigs in the weight range between 60 kg and 120 kg. Fatteners are split into finishers and growers in Irish EPA guidance and modelling tools for the assessment of emissions from pig housing units including:

- The SCAIL online tool
- A draft EPA odour guidance document issued by EPA (EPA, 2022).

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.

SCAIL therefore indicates that emission rates of ammonia from growers are 38% of the emission rates of ammonia for finishers. In a pig production unit, one third of the fattener pigs are growers and two thirds are finishers. A weighted average emission rate for fatteners (finishers and growers) based on SCAIL ammonia emission rates and the proportion of pigs in each category is 3.29 $kg.animal^{-1}.year^{-1}$ for growers. This indicates that the ammonia emission rate for finishers is, on average, 79.4% of the ammonia emission rate of fatteners. The BAT-AEL for fatteners has been adapted for the number of grower and finisher pigs accommodated in the old housing units and the 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 adopted in the assessment is therefore 2.1 $kg.animal^{-1}.year^{-1}$.

Ammonia emissions from the new housing units will be lower than the upper limit of the BAT-AEL range as the design and operation of the new housing units include multiple BAT technologies. The new housing units will be operated with the following ammonia emission controls:

- Shallow pit (manure levels maintained below 600 mm) housing units, with frequent slurry removal.
- Diets formulated with optimised protein content, to limit emissions
- A slurry cooling system.

The BREF document for the intensive rearing of poultry or pigs references a number of studies that quantified ammonia reduction efficiencies due to slurry cooling. The studies referenced are described in a report described as "a preparatory work for the use by the Technology Committee set up under the Danish Forest and Nature Agency in September 2007 in connection with discussions on the future requirements for documentation of environmental technology for agriculture." (Agrotech 2007)

The Danish and Dutch studies have shown that cooling is an effective method of reducing ammonia evaporation from manure channels and floors. As a starting point, it can be assumed that evaporation is reduced by 5 - 10 percent for each degree the temperature is lowered (Pedersen, 1997). In finisher barns with partially slatted floors and scrapers in the manure channels, the maximum reduction is estimated to be 40% measured in relation to a reference barn with full slatted floor and 30% in relation to a barn with partially slatted floor (Pedersen, 2003). In gestation barns with loose housing and partially slatted floor, the maximum reduction is 30% compared to a similar barn without cooling.

Based on the information presented in the BREF document, this assessment has conservatively assumed that emissions of ammonia from the new housing units will be 20% less than the upper limit of the BAT-AEL range. This is considered conservative as there are multiple BAT compliant technologies in use including:

- The tanks are shallow and the slurry will remain relatively fresh as the age of the slurry in the tanks will be limited due to frequent removal

- The slurry will be kept cool using the cooling system below the slats.

The ammonia emission rates adopted for the new housing units for the proposed development as follows:

- 2.2 $kg.animal^{-1}.year^{-1}$ for dry sows
- 2.2 $kg.animal^{-1}.year^{-1}$ for gilts
- 4.5 $kg.animal^{-1}.year^{-1}$ for farrowing sows
- 0.4 $kg.animal^{-1}.year^{-1}$ for weaners
- 1.7 $kg.animal^{-1}.year^{-1}$ for fatteners.

5.4 Dispersion modelling

The dispersion modelling assessment was conducted in accordance with recognised techniques for dispersion modelling specified in AG4. CALPUFF was used to predict ground-level concentrations of ammonia across the modelling domain and at sensitive receptor locations due to sources at the pig farm in isolation. An in-combination assessment was completed using baseline concentrations of ammonia extracted from SCAIL that represent local intensive pig and poultry sources and non-intensive sources of ammonia emissions.

Point sources of emissions may be subject to building downwash depending on configuration and proximity to buildings as described in Section 5.6.

The pig housing units included in the dispersion modelling assessment are presented in Table 3 and Table 4, which specify:

- The housing unit at the pig farm
- The type of pigs housed
- The type of ventilation
- The number of pigs housed in the building
- The number of sources used to represent the mechanical ventilation points in the modelling assessment
- The modelled emission rate per modelled source.

The existing pig housing units have a capacity to hold 820 dry and farrowing sows. This number was included in the dispersion modelling assessment. However, the maximum number of dry and farrowing sows that will be kept in the existing pig housing units will be 800 as part of the proposed development comprising 600 dry sows and 200 farrowing sows. The dispersion modelling assessment, therefore, provides a conservative indication of the potential impact of emissions from the proposed development.

The pig housing units at the Site are mechanically ventilated and were configured as point sources in the modelling assessment.

To represent the existing pig housing units in the dispersion modelling assessment point sources included in the modelling assessment, the number of pigs per source and the ammonia emission rate per source included in the modeling assessment are presented in Table 3.

To represent the new pig housing units in the dispersion modelling assessment point sources included in the modelling assessment, the number of pigs per source and the ammonia emission rate per source included in the modeling assessment are presented in Table 4.

Table 3 **Old pig housing units included in the dispersion modelling assessment, number of pigs housed, modelled sources per housing unit and ammonia emission rate per modelled source.**

Housing Unit	Type of Pig	Type of Ventilation	Number of Housed Pigs	Number of Modelled Sources	Ammonia Emission Rate per Source (ou/s)
Housing Unit 1	Second stage	Mechanical	450	3	0.0025
Housing Unit 2	First Stage	Mechanical	200	4	0.0008
Housing Unit 4	Dry Sow House	Mechanical	250	7	0.0031
Housing Unit 4a	Dry Sow House	Mechanical	40	1	0.0034
Housing Unit 5	Second stage	Mechanical	300	2	0.0025
Housing Unit 6	First Stage	Mechanical	400	10	0.0007
Housing Unit 7a	Farrowing	Mechanical	40	5	0.0014
Housing Unit 7b	Farrowing	Mechanical	40	6	0.0012
Housing Unit 7c	Farrowing	Mechanical	40	4	0.0018
Housing Unit 8a	Fattening	Mechanical	300	5	0.0039
Housing Unit 8b	Fattening	Mechanical	315	8	0.0026
Housing Unit 8c	Farrowing	Mechanical	40	2	0.0013
Housing Unit 8d	Second stage	Mechanical	240	5	0.0008
Housing Unit 9a	Fattening	Mechanical	300	4	0.0049
Housing Unit 9b	Fattening	Mechanical	300	4	0.0049
Housing Unit 10a	Fattening	Mechanical	520	6	0.0057
Housing Unit 10b	Fattening	Mechanical	320	7	0.0030
Housing Unit 11	Fattening	Mechanical	770	7	0.0072
Housing Unit 11a	Fattening	Mechanical	100	1	0.0066
Housing Unit 12	Dry Sow House	Mechanical	75	5	0.0013
Housing Unit 13	First Stage	Mechanical	250	6	0.0007
Housing Unit 14	Second stage	Mechanical	400	2	0.0034
Housing Unit 15	First Stage	Mechanical	100	2	0.0008
Housing Unit 16	Farrowing	Mechanical	40	2	0.0036
Housing Unit 17	Fattening	Mechanical	1220	14	0.0057
Housing Unit 18	Second stage	Mechanical	750	17	0.0007
Housing Unit 19	Dry Sow House	Mechanical	255	8	0.0027
Housing Unit 19a	Gilt	Mechanical	135	4	0.0029

Table 4 New pig housing units included in the dispersion modelling assessment, number of pigs housed, modelled sources per housing unit and ammonia emission rate per modelled source.

Housing Unit	Type of Pig	Type of Ventilation	Number of Housed Pigs	Number of modelled sources	Ammonia Emission Rate (g/s)
New Housing Unit 1	Fattening	Mechanical	2950	24	0.006443
New Housing Unit 2	Fattening	Mechanical	1900	16	0.006224
	Second stage	Mechanical	1700	8	0.002857
New Housing Unit 3	Farrowing	Mechanical	280	12	0.003315
	First stage	Mechanical	1700	8	0.002857
New Housing Unit 4	Dry Sow House	Mechanical	830[1]	6	0.009178
	Second stage	Mechanical	510	5	0.001371
[1] The 830 pigs comprise of 670 dry sows and 160 gilts will be housed in this section of New Housing Unit 4					

The details of source characterisation utilised for the pig farm in the dispersion modelling assessment are provided in Appendix B1 as follows:

- Table B.1 for sources at the old housing units
- Table B.2 for sources at the new housing units.

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 were conservatively assumed to be 0.03 m/s for all modelled sensitive locations.

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 down-washed 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 at the site on the point sources of emissions at the pig farm. The Plume Rise Model Enhancements (PRIME) algorithm is recommended in EPA Guidance for use in dispersion modelling assessments. 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.

The old and new housing units at the pig farm and configuration of the pig housing units included in the PRIME BPIP model for the dispersion modelling assessment are presented in Table 5 for the old housing units and Table 6 for the new housing units.

Table 5 Vertices included and configuration of the old pig housing units in BPIP

Building	Easting	Northing
	UTM (m)	UTM (m)
Old Housing Unit 1	514930	5721710
	514933	5721697
	514843	5721682
	514841	5721695
Old Housing Unit 2	514834	5721694
	514836	5721681
	514759	5721669
	514758	5721682
Old Housing Unit 3	514930	5721725
	514932	5721712
	514757	5721683
	514756	5721695
Old Housing Unit 4	514928	5721740
	514930	5721727
	514810	5721708
	514808	5721720
Old Housing Unit 5	514807	5721721
	514808	5721709
	514778	5721704
	514777	5721716
Old Housing Unit 6	514777	5721703
	514755	5721699
	514754	5721709
	514775	5721713
Old Housing Unit 7	514771	5721718
	514772	5721713

Building	Easting	Northing
	UTM (m)	UTM (m)
	514754	5721709
	514753	5721715
Old Housing Unit 8	514780	5721720
	514752	5721715
	514751	5721728
	514778	5721733
Old Housing Unit 9	514790	5721718
	514781	5721717
	514780	5721732
	514789	5721733
Old Housing Unit 10	514928	5721740
	514794	5721721
	514793	5721732
	514926	5721752
Old Housing Unit 11	514926	5721753
	514791	5721733
	514790	5721747
	514924	5721766
Old Housing Unit 12	514788	5721734
	514775	5721733
	514775	5721746
	514787	5721748
Old Housing Unit 13	514772	5721746
	514774	5721733
	514748	5721729
	514747	5721742
Old Housing Unit 14	514800	5721750
	514746	5721743
	514744	5721756
	514798	5721764
Old Housing Unit 15	514923	5721768
	514809	5721752
	514808	5721764
	514921	5721780
Old Housing Unit 16	514921	5721782
	514850	5721773
	514847	5721793
	514918	5721804

Table 6 Vertices included and configuration of the new pig housing units in BPIP

Building	Easting	Northing
	UTM (m)	UTM (m)
New Housing Unit 1 (Fattening House)	514813	5722010
	514841	5722019
	514800	5722149
	514773	5722140
New Housing Unit 2 (Fattening and Second Stage Weaner House)	514786	5722001
	514813	5722010
	514773	5722140
	514744	5722131
New Housing Unit 3 (Service /S\Farrowing and First Stage Weaner House)	514760	5721992
	514786	5722001
	514744	5722131
	514719	5722121
New Housing Unit 4(Second Stage Weaner Dry Sow + Gilt House)	514729	5722002
	514755	5722009
	514719	5722120
	514695	5722112

6. ASSESSMENT RESULTS

Dispersion modelling has been conducted for five years of meteorological data. The following sections present the highest annual average concentrations of ammonia and nitrogen deposition across the five-year modelled period.

Predicted ground-level concentrations of ammonia at the nearest ecologically sensitive locations due to the pig farm are presented in Table 7. The predicted annual average flux rate of nitrogen deposition at the modelled ecologically sensitive locations due to the pig farm and background sources are presented in Table 8.

Plate 1 is a contour plot that presents the highest annual average ground-level concentrations of ammonia across the model domain during the five-year period.

The results of this assessment can be used to inform the Natura Impact Statement being completed by Dixon Brosnan.

Table 7 Predicted annual average ground-level concentrations of ammonia at the modelled ecologically sensitive locations due to the current pig farm and the proposed development, background concentrations of ammonia and the impact of the current farm and net impact of the proposed development as a percentage of the critical level

Receptor	Concentration of ammonia µg/m³						Critical Level	PC as a percentage of Critical Level - Current Operation	PC as a percentage of Critical Level - Proposed Development	Net Impact of proposed development as a Percentage of the critical level
	Carhue (Current operation - Old housing units)	Carhue (Proposed operation - Old housing units - BAT)	Carhue (Proposed operation - New housing units - BAT)	Carhue (Process contribution - Proposed Development)	SCAIL Background	Total (SCAIL +Additional Impact)	µg/m³			
DR1	0.10	0.07	0.08	0.15	2.74	2.79	3.0	3.3%	5.0%	1.7%
DR2	0.13	0.10	0.10	0.20	2.74	2.81	3.0	4.5%	6.7%	2.2%
DR3	0.15	0.11	0.10	0.21	2.74	2.81	3.0	4.9%	7.1%	2.2%
DR4	0.14	0.11	0.10	0.20	2.68	2.74	3.0	4.7%	6.8%	2.1%
DR5	0.12	0.09	0.08	0.17	2.68	2.73	3.0	4.0%	5.7%	1.7%
DR6	0.13	0.10	0.08	0.18	2.66	2.71	3.0	4.5%	6.0%	1.5%
DR7	0.15	0.11	0.09	0.20	2.66	2.71	3.0	5.0%	6.7%	1.7%
DR8	0.16	0.12	0.10	0.22	2.66	2.72	3.0	5.5%	7.3%	1.8%
DR9	0.15	0.11	0.09	0.20	2.66	2.71	3.0	5.0%	6.6%	1.7%
DR10	0.15	0.11	0.09	0.20	2.66	2.71	3.0	4.9%	6.6%	1.7%
DR11	0.15	0.11	0.09	0.20	2.66	2.71	3.0	5.0%	6.8%	1.8%
DR12	0.13	0.10	0.08	0.18	2.66	2.71	3.0	4.4%	6.0%	1.6%
DR13	0.14	0.11	0.09	0.20	2.66	2.71	3.0	4.8%	6.5%	1.7%
DR14	0.13	0.10	0.08	0.18	2.66	2.71	3.0	4.5%	6.0%	1.5%
DR15	0.14	0.10	0.08	0.18	2.66	2.70	3.0	4.5%	6.0%	1.5%
DR16	0.14	0.10	0.08	0.18	2.66	2.70	3.0	4.7%	6.0%	1.4%
DR17	0.16	0.12	0.08	0.20	2.66	2.70	3.0	5.2%	6.5%	1.3%

Receptor	Concentration of ammonia µg/m³						Critical Level	PC as a percentage of Critical Level - Current Operation	PC as a percentage of Critical Level - Proposed Development	Net Impact of proposed development as a Percentage of the critical level
	Carhue (Current operation - Old housing units)	Carhue (Proposed operation - Old housing units - BAT)	Carhue (Proposed operation - New housing units - BAT)	Carhue (Process contribution - Proposed Development)	SCAIL Background	Total (SCAIL +Additional Impact)	µg/m³			
DR18	0.15	0.11	0.08	0.19	2.66	2.70	3.0	5.1%	6.3%	1.2%
DR19	0.14	0.11	0.07	0.18	2.61	2.65	3.0	4.8%	5.9%	1.2%
DR20	0.13	0.10	0.07	0.17	2.61	2.64	3.0	4.5%	5.5%	1.0%
DR21	0.14	0.10	0.06	0.17	2.61	2.64	3.0	4.7%	5.6%	0.9%
DR22	0.13	0.10	0.06	0.15	2.61	2.63	3.0	4.4%	5.1%	0.7%
DR23	0.12	0.09	0.05	0.14	2.61	2.63	3.0	4.0%	4.7%	0.7%
DR24	0.12	0.09	0.05	0.13	2.61	2.63	3.0	3.9%	4.4%	0.5%
DR25	0.10	0.08	0.04	0.12	2.61	2.63	3.0	3.4%	4.0%	0.5%
DR26	0.10	0.07	0.04	0.11	3.08	3.09	3.0	3.3%	3.8%	0.5%
DR27	0.09	0.07	0.04	0.11	2.61	2.62	3.0	3.1%	3.6%	0.5%
DR28	0.09	0.06	0.04	0.10	3.08	3.10	3.0	2.9%	3.4%	0.5%
DR29	0.07	0.06	0.03	0.09	3.08	3.10	3.0	2.3%	3.0%	0.6%
DR30	0.06	0.05	0.03	0.08	2.87	2.89	3.0	2.1%	2.7%	0.6%
DR31	0.12	0.09	0.07	0.15	2.42	2.46	3.0	3.9%	5.1%	1.2%
DR32	0.02	0.02	0.01	0.03	2.29	2.30	3.0	0.8%	1.1%	0.3%
DR33	0.02	0.02	0.02	0.03	2.29	2.30	3.0	0.8%	1.1%	0.3%
DR34	0.02	0.02	0.02	0.03	2.12	2.13	3.0	0.8%	1.1%	0.3%
DR35	0.02	0.02	0.02	0.03	2.12	2.13	3.0	0.8%	1.1%	0.3%
DR36	0.03	0.02	0.02	0.04	2.12	2.13	3.0	0.9%	1.2%	0.3%
DR37	0.03	0.02	0.02	0.04	2.12	2.13	3.0	0.9%	1.3%	0.4%

Receptor	Concentration of ammonia µg/m³						Critical Level	PC as a percentage of Critical Level - Current Operation	PC as a percentage of Critical Level - Proposed Development	Net Impact of proposed development as a Percentage of the critical level
	Carhue (Current operation - Old housing units)	Carhue (Proposed operation - Old housing units - BAT)	Carhue (Proposed operation - New housing units - BAT)	Carhue (Process contribution - Proposed Development)	SCAIL Background	Total (SCAIL +Additional Impact)	µg/m³			
DR38	0.03	0.03	0.02	0.05	2.08	2.09	3.0	1.2%	1.6%	0.4%
DR39	0.04	0.03	0.02	0.05	2.08	2.09	3.0	1.2%	1.6%	0.5%
DR40	0.04	0.03	0.02	0.05	2.08	2.09	3.0	1.2%	1.6%	0.5%
DR41	0.04	0.03	0.03	0.05	2.08	2.10	3.0	1.3%	1.8%	0.5%
DR42	0.04	0.03	0.03	0.05	2.08	2.10	3.0	1.3%	1.8%	0.5%
DR43	0.04	0.03	0.03	0.05	2.08	2.10	3.0	1.3%	1.8%	0.5%
DR44	0.04	0.03	0.02	0.05	2.08	2.10	3.0	1.3%	1.8%	0.5%
DR45	0.04	0.03	0.03	0.06	2.08	2.10	3.0	1.4%	1.9%	0.6%
DR46	0.04	0.03	0.03	0.06	2.08	2.10	3.0	1.3%	1.9%	0.6%
DR47	0.04	0.03	0.03	0.06	2.08	2.10	3.0	1.3%	1.9%	0.6%
DR48	0.04	0.03	0.03	0.06	2.08	2.10	3.0	1.5%	2.1%	0.6%
DR49	0.05	0.03	0.03	0.06	2.08	2.10	3.0	1.5%	2.1%	0.6%
DR50	0.05	0.04	0.03	0.07	2.08	2.10	3.0	1.6%	2.2%	0.6%
DR51	0.022	0.02	0.01	0.03	2.08	2.09	3.0	0.7%	0.9%	0.2%
DR52	0.030	0.02	0.01	0.03	1.80	1.80	3.0	1.0%	1.0%	0.0%
DR53	0.03	0.02	0.01	0.03	1.80	1.80	1.0	2.9%	2.8%	0.0%
DR54	0.03	0.02	0.01	0.03	1.80	1.80	1.0	3.0%	2.9%	-0.1%
DR55	0.02	0.01	0.01	0.02	1.80	1.80	1.0	1.6%	2.0%	0.4%
DR56	0.00	0.00	0.00	0.01	2.14	2.15	1.0	0.4%	0.9%	0.5%
DR57	0.01	0.01	0.01	0.01	2.04	2.05	1.0	0.9%	1.3%	0.4%

Receptor	Concentration of ammonia µg/m³						Critical Level µg/m³	PC as a percentage of Critical Level - Current Operation	PC as a percentage of Critical Level - Proposed Development	Net Impact of proposed development as a Percentage of the critical level
	Carhue (Current operation - Old housing units)	Carhue (Proposed operation - Old housing units - BAT)	Carhue (Proposed operation - New housing units - BAT)	Carhue (Process contribution - Proposed Development)	SCAIL Background	Total (SCAIL +Additional Impact)				
DR58	0.01	0.00	0.00	0.01	2.15	2.15	3.0	0.2%	0.3%	0.1%
DR59	0.01	0.01	0.00	0.01	2.09	2.10	3.0	0.2%	0.3%	0.1%
DR60	0.02	0.01	0.01	0.02	2.00	2.01	3.0	0.5%	0.7%	0.2%
DR61	0.02	0.01	0.01	0.02	2.00	2.01	3.0	0.5%	0.7%	0.2%
DR62	0.01	0.01	0.01	0.01	1.96	1.97	3.0	0.3%	0.4%	0.1%
DR63	0.01	0.01	0.00	0.01	2.05	2.06	3.0	0.2%	0.3%	0.2%
DR64	0.01	0.01	0.01	0.01	1.90	1.90	3.0	0.3%	0.4%	0.1%
DR65	0.01	0.01	0.01	0.01	1.90	1.90	3.0	0.3%	0.4%	0.1%
DR66	0.01	0.01	0.01	0.01	2.04	2.04	3.0	0.3%	0.4%	0.1%
DR67	0.01	0.01	0.01	0.01	1.90	1.90	3.0	0.3%	0.4%	0.1%
DR68	0.01	0.01	0.01	0.01	1.90	1.90	3.0	0.3%	0.4%	0.1%
DR69	0.01	0.01	0.01	0.01	1.90	1.90	3.0	0.2%	0.4%	0.1%

Table 8 **Predicted annual average flux rate of nitrogen deposition at the modelled ecologically sensitive locations due to the current pig farm and the proposed development, background concentrations of ammonia and the impact of the current farm and net impact of the proposed development as a percentage of the critical level**

Receptor	Deposition of Nitrogen kg/ha/yr					Critical Load
	Carhue (Proposed operation - Old housing units - BAT)	Carhue (Proposed operation - New housing units - BAT)	Carhue (Process contribution - Proposed Development)	SCAIL Background	Total (SCAIL +Additional Impact)	kg/ha/yr
DR1	0.69	0.73	1.42	7.98	9.4	30
DR2	0.95	0.96	1.91	7.98	9.9	30
DR3	1.03	0.99	2.02	7.98	10.0	30
DR4	0.99	0.92	1.91	7.75	9.7	30
DR5	0.84	0.76	1.60	7.75	9.4	30
DR6	0.94	0.76	1.70	7.62	9.3	20
DR7	1.06	0.84	1.90	7.62	9.5	30
DR8	1.16	0.92	2.08	7.62	9.7	30
DR9	1.05	0.83	1.88	7.62	9.5	20
DR10	1.04	0.84	1.87	7.62	9.5	20
DR11	1.05	0.86	1.91	7.62	9.5	20
DR12	0.93	0.77	1.70	7.62	9.3	20
DR13	1.01	0.83	1.84	7.62	9.5	20
DR14	0.94	0.75	1.70	7.62	9.3	20
DR15	0.96	0.74	1.70	7.62	9.3	20
DR16	0.98	0.73	1.71	7.62	9.3	20
DR17	1.10	0.75	1.85	7.62	9.5	30
DR18	1.07	0.72	1.79	7.62	9.4	20

Receptor	Deposition of Nitrogen kg/ha/yr					Critical Load
	Carhue (Proposed operation - Old housing units - BAT)	Carhue (Proposed operation - New housing units - BAT)	Carhue (Process contribution - Proposed Development)	SCAIL Background	Total (SCAIL +Additional Impact)	kg/ha/yr
DR19	1.00	0.68	1.68	7.42	9.1	20
DR20	0.95	0.62	1.56	7.42	9.0	20
DR21	0.99	0.60	1.59	7.42	9.0	30
DR22	0.93	0.53	1.46	7.42	8.9	30
DR23	0.85	0.48	1.33	7.42	8.7	20
DR24	0.81	0.43	1.24	7.42	8.7	20
DR25	0.72	0.40	1.12	7.42	8.5	20
DR26	0.69	0.38	1.07	8.53	9.6	20
DR27	0.65	0.36	1.01	7.42	8.4	20
DR28	0.60	0.35	0.95	8.53	9.5	20
DR29	0.52	0.31	0.84	8.53	9.4	20
DR30	0.46	0.30	0.76	7.82	8.6	20
DR31	0.83	0.62	1.45	7.10	8.6	20
DR32	0.17	0.14	0.31	6.74	7.0	20
DR33	0.17	0.14	0.31	6.74	7.1	20
DR34	0.16	0.15	0.31	6.43	6.7	20
DR35	0.17	0.15	0.32	6.43	6.7	20
DR36	0.18	0.16	0.34	6.43	6.8	20
DR37	0.19	0.17	0.36	6.43	6.8	20
DR38	0.24	0.20	0.45	6.43	6.9	20
DR39	0.25	0.22	0.47	6.43	6.9	20

Receptor	Deposition of Nitrogen kg/ha/yr					Critical Load
	Carhue (Proposed operation - Old housing units - BAT)	Carhue (Proposed operation - New housing units - BAT)	Carhue (Process contribution - Proposed Development)	SCAIL Background	Total (SCAIL +Additional Impact)	kg/ha/yr
DR40	0.25	0.22	0.47	6.43	6.9	8
DR41	0.27	0.24	0.51	6.43	6.9	20
DR42	0.27	0.24	0.50	6.43	6.9	8
DR43	0.27	0.24	0.52	6.43	6.9	8
DR44	0.26	0.23	0.50	6.43	6.9	30
DR45	0.29	0.26	0.55	6.43	7.0	20
DR46	0.28	0.25	0.54	6.43	7.0	8
DR47	0.28	0.25	0.54	6.43	7.0	8
DR48	0.31	0.27	0.58	6.43	7.0	30
DR49	0.32	0.28	0.60	6.43	7.0	30
DR50	0.34	0.28	0.62	6.43	7.1	30
DR51	0.15	0.12	0.27	6.43	6.7	8
DR52	0.16	0.12	0.29	5.91	6.2	8
DR53	0.15	0.11	0.27	5.91	6.2	10
DR54	0.16	0.11	0.27	5.91	6.2	10
DR55	0.11	0.08	0.19	5.91	6.1	10
DR56	0.04	0.04	0.08	6.42	6.5	10
DR57	0.06	0.06	0.12	6.06	6.2	10
DR58	0.04	0.04	0.09	6.43	6.5	30
DR59	0.05	0.04	0.09	6.21	6.3	30
DR60	0.11	0.09	0.20	6.55	6.7	30

Receptor	Deposition of Nitrogen kg/ha/yr					Critical Load
	Carhue (Proposed operation - Old housing units - BAT)	Carhue (Proposed operation - New housing units - BAT)	Carhue (Process contribution - Proposed Development)	SCAIL Background	Total (SCAIL +Additional Impact)	kg/ha/yr
DR61	0.12	0.09	0.21	6.55	6.8	30
DR62	0.05	0.05	0.10	5.85	6.0	30
DR63	0.05	0.05	0.09	6.09	6.2	30
DR64	0.06	0.05	0.11	5.72	5.8	8
DR65	0.06	0.05	0.11	5.72	5.8	8
DR66	0.06	0.05	0.11	6.05	6.2	8
DR67	0.06	0.05	0.11	5.71	5.8	30
DR68	0.06	0.05	0.11	5.71	5.8	30
DR69	0.05	0.05	0.10	5.71	5.8	30

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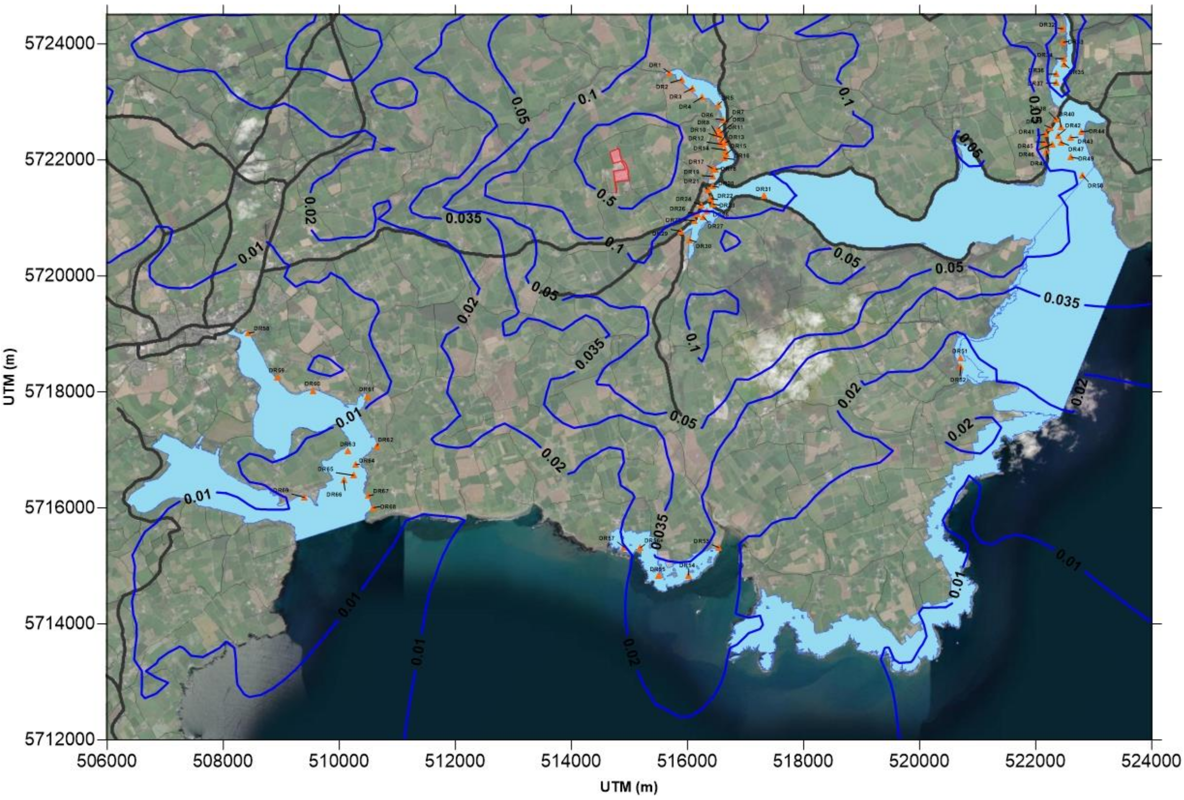

Plate 1	**Highest predicted annual average ground-level concentrations of ammonia of five modelled years due to the pig farm**

Location: Timoleague, Co. Cork and surroundings	**Averaging period:** Annual average	**Data source:** CALPUFF	**Units:** µg/m³
Type: Highest annual average	**Criterion level:** Varies	**Prepared by:** D Gallagher	**Date:** Apr 2022

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:

- 40 x 40 grid point domain with an outer grid resolution of 30 kilometres and nesting grids of 10, 3. 1 and 0.3 kilometres.
- 5 modelled years (1 January 2015 to 31 December 2019)
- Grid centered near the Project site at latitude 52°4’29 and longitude -7°41’
- 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 1km 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 156 x 156 grid cells at 250m spacing
- 5 years modelled (1 January 2015 to 31 December 2019)
- 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 7km
- 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 156 x 156 grid cells at 250m spacing, the same as the CALMET domain
- 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.

APPENDIX B DISPERSION MODELLING ASSESSMENT

B1 MODELLING SOURCE PARAMETERS

Table B.1 Modelled parameters of the sources adopted in the dispersion modelling assessment for the old housing units

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Exhaust Velocity
	km	km	m	m	m	°C	m/s
O_2nd1_1	514773	5721726	112.4	4.5	0.6	25	6.2
O_2nd1_2	514759	5721724	112.6	4.5	0.6	25	6.2
O_2nd1_3	514759	5721722	112.4	4.5	0.6	25	6.2
O_1st2_1	514788	5721723	112.1	4.5	0.5	25	4.5
O_1st2_2	514787	5721727	112.3	4.5	0.5	25	4.5
O_1st2_3	514787	5721731	112.5	4.5	0.5	25	4.5
O_1st2_4	514781	5721719	112.0	4.5	0.6	25	6.2
O_DS4_1	514859	5721735	111.3	4.5	0.6	21	6.2
O_DS4_2	514843	5721733	111.7	4.5	0.6	21	6.2
O_DS4_3	514828	5721731	111.9	4.5	0.6	21	6.2
O_DS4_4	514814	5721729	112.0	4.5	0.6	21	6.2
O_DS4_5	514800	5721727	112.1	4.5	0.6	21	6.2
O_DS4_6	514889	5721740	110.2	4.5	0.6	21	6.2
O_DS4_7	514892	5721740	110.1	4.5	0.6	21	6.2
O_DS4a_1	514917	5721745	109.2	4.5	0.6	21	6.2
O_2nd5_1	514770	5721707	111.5	4.5	0.6	25	6.2
O_2nd5_2	514759	5721704	111.5	4.5	0.6	25	6.2
O_1st6_1	514780	5721711	111.6	4.5	0.5	25	4.5
O_1st6_2	514780	5721709	111.5	4.5	0.5	25	4.5

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Exhaust Velocity
	km	km	m	m	m	°C	m/s
O_1st6_3	514786	5721712	111.6	4.5	0.5	25	4.5
O_1st6_4	514786	5721710	111.5	4.5	0.5	25	4.5
O_1st6_5	514791	5721713	111.6	4.5	0.5	25	4.5
O_1st6_6	514792	5721711	111.5	4.5	0.5	25	4.5
O_1st6_7	514797	5721714	111.5	4.5	0.5	25	4.5
O_1st6_8	514797	5721711	111.4	4.5	0.5	25	4.5
O_1st6_9	514802	5721715	111.5	4.5	0.5	25	4.5
O_1st6_10	514803	5721712	111.4	4.5	0.5	25	4.5
O_Far7a_1	514834	5721718	111.2	4.5	0.4064	25	5.2
O_Far7a_2	514829	5721716	111.2	4.5	0.4064	25	5.2
O_Far7a_3	514822	5721716	111.3	4.5	0.4064	25	5.2
O_Far7a_4	514816	5721715	111.3	4.5	0.4064	25	5.2
O_Far7a_5	514811	5721714	111.4	4.5	0.4064	25	5.2
O_Far7b_1	514870	5721724	110.4	4.5	0.4064	25	5.2
O_Far7b_2	514864	5721723	110.6	4.5	0.4064	25	5.2
O_Far7b_3	514858	5721722	110.8	4.5	0.4064	25	5.2
O_Far7b_4	514852	5721721	111.0	4.5	0.4064	25	5.2
O_Far7b_5	514847	5721720	111.1	4.5	0.4064	25	5.2
O_Far7b_6	514841	5721719	111.2	4.5	0.4064	25	5.2
O_Far7c_1	514895	5721728	109.5	4.5	0.4064	25	5.2
O_Far7c_2	514890	5721727	109.7	4.5	0.4064	25	5.2
O_Far7c_3	514884	5721726	109.9	4.5	0.4064	25	5.2
O_Far7c_4	514878	5721725	110.1	4.5	0.4064	25	5.2
O_f8a_1	514757	5721689	110.8	4.5	0.6	21	5.8
O_f8a_2	514765	5721691	110.8	4.5	0.6	21	5.8
O_f8a_3	514772	5721691	110.7	4.5	0.6	21	5.8

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Exhaust Velocity
	km	km	m	m	m	°C	m/s
O_f8a_4	514779	5721693	110.7	4.5	0.6	21	5.8
O_f8a_5	514787	5721695	110.8	4.5	0.6	21	5.8
O_f8b_1	514800	5721697	110.7	4.5	0.6	21	5.8
O_f8b_2	514809	5721698	110.7	4.5	0.6	21	5.8
O_f8b_3	514819	5721699	110.6	4.5	0.6	21	5.8
O_f8b_4	514827	5721701	110.6	4.5	0.6	21	5.8
O_f8b_5	514842	5721704	110.6	4.5	0.6	21	5.8
O_f8b_6	514851	5721705	110.4	4.5	0.6	21	5.8
O_f8b_7	514861	5721707	110.1	4.5	0.6	21	5.8
O_f8b_8	514869	5721708	109.8	4.5	0.6	21	5.8
O_f8c_1	514881	5721710	109.4	4.5	0.6	21	6.2
O_f8c_2	514897	5721713	108.9	4.5	0.6	21	6.2
O_2nd8d_1	514908	5721710	108.3	4.5	0.6	25	6.2
O_2nd8d_2	514913	5721710	108.1	4.5	0.6	25	6.2
O_2nd8d_3	514918	5721711	108.0	4.5	0.6	25	6.2
O_2nd8d_4	514923	5721712	107.8	4.5	0.6	25	6.2
O_2nd8d_5	514928	5721713	107.6	4.5	0.6	25	6.2
O_F10a_1	514847	5721690	109.9	4.5	0.6	21	6.2
O_F10a_2	514850	5721691	109.9	4.5	0.6	21	6.2
O_F10a_3	514860	5721692	109.6	4.5	0.6	21	6.2
O_F10a_4	514865	5721692	109.4	4.5	0.6	21	6.2
O_F10a_5	514869	5721693	109.3	4.5	0.6	21	6.2
O_F10a_6	514873	5721694	109.1	4.5	0.6	21	6.2
O_F10b_1	514879	5721695	108.9	4.5	0.6	21	5.8
O_F10b_2	514887	5721696	108.7	4.5	0.6	21	5.8
O_F10b_3	514896	5721698	108.4	4.5	0.6	21	5.8

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Exhaust Velocity
	km	km	m	m	m	°C	m/s
O_F10b_4	514903	5721699	108.1	4.5	0.6	21	5.8
O_F10b_5	514911	5721700	107.9	4.5	0.6	21	5.8
O_F10b_6	514918	5721702	107.7	4.5	0.6	21	5.8
O_F10b_7	514926	5721703	107.4	4.5	0.6	21	5.8
O_F9b_1	514828	5721686	110.0	4.5	0.6	21	5.8
O_F9b_2	514821	5721685	110.0	4.5	0.6	21	5.8
O_F9b_3	514812	5721684	110.0	4.5	0.6	21	5.8
O_F9b_4	514803	5721683	110.0	4.5	0.6	21	5.8
O_F9a_1	514793	5721681	110.0	4.5	0.6	21	5.8
O_F9a_2	514784	5721679	110.0	4.5	0.6	21	5.8
O_F9a_3	514776	5721678	110.0	4.5	0.6	21	5.8
O_F9a_4	514768	5721677	110.0	4.5	0.6	21	5.8
O_F11a_1	514915	5721758	109.7	4.5	0.6	21	6.2
O_F11_1	514903	5721756	110.2	4.5	0.6	21	6.2
O_F11_2	514895	5721755	110.5	4.5	0.6	21	6.2
O_F11_3	514887	5721753	110.8	4.5	0.6	21	5.8
O_F11_4	514879	5721752	111.1	4.5	0.6	21	5.8
O_F11_5	514872	5721751	111.3	4.5	0.6	21	5.8
O_F11_6	514864	5721750	111.6	4.5	0.6	21	5.8
O_F11_7	514856	5721749	111.9	4.5	0.6	21	5.8
O_DS12_1	514848	5721748	112.2	4.5	0.6	21	6.2
O_DS12_2	514833	5721746	112.4	4.5	0.6	21	6.2
O_DS12_3	514822	5721745	112.5	4.5	0.6	21	6.2
O_DS12_4	514811	5721743	112.6	4.5	0.6	21	6.2
O_DS12_5	514795	5721740	112.8	4.5	0.6	21	6.2
O_1st13_1	514783	5721743	113.1	4.5	0.6096	25	5.7

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Exhaust Velocity
	km	km	m	m	m	°C	m/s
O_1st13_2	514783	5721741	113.0	4.5	0.6096	25	5.7
O_1st13_3	514783	5721737	112.8	4.5	0.6096	25	5.7
O_1st13_4	514777	5721743	113.2	4.5	0.6096	25	5.7
O_1st13_5	514777	5721740	113.1	4.5	0.6096	25	5.7
O_1st13_6	514777	5721737	112.9	4.5	0.6096	25	5.7
O_2nd14_1	514765	5721738	113.2	4.5	0.6	25	6.2
O_2nd14_2	514753	5721736	113.3	4.5	0.6	25	6.2
O_1st15_1	514766	5721714	111.9	4.5	0.5	25	4.5
O_1st15_2	514757	5721712	112.0	4.5	0.5	25	4.5
O_Far16_2	514901	5721729	109.3	4.5	0.6	25	6.2
O_Far16_1	514915	5721731	108.8	4.5	0.6	25	6.2
O_F17_1	514917	5721773	110.2	4.5	0.6	21	6.2
O_F17_2	514909	5721772	110.5	4.5	0.6	21	6.2
O_F17_3	514901	5721771	110.8	4.5	0.6	21	6.2
O_F17_4	514893	5721770	111.1	4.5	0.6	21	5.8
O_F17_5	514885	5721769	111.4	4.5	0.6	21	5.8
O_F17_6	514878	5721768	111.7	4.5	0.6	21	5.8
O_F17_7	514870	5721766	112.0	4.5	0.6	21	5.8
O_F17_8	514862	5721765	112.3	4.5	0.6	21	5.8
O_F17_9	514849	5721763	112.8	4.5	0.6	21	5.8
O_F17_10	514844	5721762	112.8	4.5	0.6	21	5.8
O_F17_11	514838	5721762	113.0	4.5	0.6	21	5.8
O_F17_12	514826	5721760	113.1	4.5	0.6	21	5.8
O_F17_13	514819	5721759	113.2	4.5	0.6	21	5.8
O_F17_14	514814	5721758	113.3	4.5	0.6	21	5.8
O_1st18_1	514795	5721753	113.4	4.5	0.6096	25	5.7

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Exhaust Velocity
	km	km	m	m	m	°C	m/s
O_1st18_2	514795	5721757	113.6	4.5	0.6096	25	5.7
O_1st18_3	514795	5721761	113.8	4.5	0.6096	25	5.7
O_1st18_4	514789	5721752	113.5	4.5	0.6096	25	5.7
O_1st18_5	514789	5721756	113.6	4.5	0.6096	25	5.7
O_1st18_6	514789	5721759	113.8	4.5	0.6096	25	5.7
O_1st18_7	514783	5721751	113.5	4.5	0.6096	25	5.7
O_1st18_8	514783	5721755	113.7	4.5	0.6096	25	5.7
O_1st18_9	514782	5721758	113.9	4.5	0.6096	25	5.7
O_1st18_10	514777	5721750	113.6	4.5	0.6096	25	5.7
O_1st18_11	514776	5721754	113.8	4.5	0.6096	25	5.7
O_1st18_12	514776	5721758	114.0	4.5	0.6096	25	5.7
O_1st18_13	514771	5721749	113.6	4.5	0.6096	25	5.7
O_1st18_14	514770	5721753	113.9	4.5	0.6096	25	5.7
O_1st18_15	514770	5721757	114.1	4.5	0.6096	25	5.7
O_1st18_16	514758	5721751	114.0	4.5	0.6	25	6.2
O_1st18_17	514751	5721750	114.0	4.5	0.6	25	6.2
O_DS1_1	514912	5721792	111.3	4.5	0.6	21	6.2
O_DS1_2	514907	5721791	111.5	4.5	0.6	21	6.2
O_DS1_3	514902	5721791	111.7	4.5	0.6	21	6.2
O_DS1_4	514896	5721790	111.9	4.5	0.6	21	6.2
O_DS1_5	514891	5721789	112.1	4.5	0.6	21	6.2
O_DS1_6	514886	5721788	112.2	4.5	0.6	21	6.2
O_DS1_7	514880	5721787	112.4	4.5	0.6	21	6.2
O_DS1_8	514868	5721786	112.9	4.5	0.6	21	6.2
O_DS1_9	514863	5721785	113.0	4.5	0.6	21	6.2
O_DS1_10	514858	5721784	113.2	4.5	0.6	21	6.2

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Exhaust Velocity
	km	km	m	m	m	°C	m/s
O_DS1_11	514854	5721784	113.4	4.5	0.6	21	6.2
O_DS1_12	514849	5721783	113.6	4.5	0.6	21	6.2

Table B.2 Modelled parameters of the sources adopted in the dispersion modelling assessment for the new housing units

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Exhaust Velocity
	km	km	m	m	m	°C	m/s
H1_R1_1	514790	5722083	132.1	6.5	0.91	21	5.4
H1_R1_2	514796	5722085	131.9	6.5	0.91	21	5.1
H1_R1_3	514803	5722087	131.7	6.5	0.91	21	5.1
H1_R1_4	514808	5722088	131.5	6.5	0.91	21	5.1
H1_R2_1	514796	5722066	131.6	6.5	0.91	21	5.4
H1_R2_2	514802	5722068	131.4	6.5	0.91	21	5.1
H1_R2_3	514808	5722070	131.2	6.5	0.91	21	5.1
H1_R2_4	514813	5722072	131.1	6.5	0.91	21	5.1
H1_R3_1	514803	5722051	131.0	6.5	0.91	21	5.4
H1_R3_2	514807	5722052	130.9	6.5	0.91	21	5.1
H1_R3_3	514812	5722053	130.8	6.5	0.91	21	5.1
H1_R3_4	514817	5722055	130.6	6.5	0.91	21	5.1
H1_R4_1	514810	5722029	130.4	6.5	0.91	21	5.4
H1_R4_2	514815	5722030	130.2	6.5	0.91	21	5.1
H1_R4_3	514821	5722032	130.1	6.5	0.91	21	5.1
H1_R4_4	514826	5722034	129.9	6.5	0.91	21	5.1
H1_R5_1	514819	5722005	129.6	6.5	0.91	21	5.4
H1_R5_2	514824	5722006	129.5	6.5	0.91	21	5.1
H1_R5_3	514830	5722009	129.3	6.5	0.91	21	5.1

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Exhaust Velocity
	km	km	m	m	m	°C	m/s
H1_R5_4	514835	5722010	129.1	6.5	0.91	21	5.1
H1_R6_1	514827	5721981	128.7	6.5	0.91	21	5.4
H1_R6_2	514832	5721982	128.6	6.5	0.91	21	5.1
H1_R6_3	514838	5721984	128.5	6.5	0.91	21	5.1
H1_R6_4	514843	5721986	128.4	6.5	0.91	21	5.1
H2_R1_1	514762	5722077	132.9	6.5	0.91	21	5.4
H2_R1_2	514768	5722079	132.7	6.5	0.91	21	5.1
H2_R1_3	514775	5722082	132.5	6.5	0.91	21	5.1
H2_R1_4	514779	5722083	132.4	6.5	0.91	21	5.1
H2_R2_1	514768	5722060	132.4	6.5	0.91	21	5.4
H2_R2_2	514774	5722062	132.3	6.5	0.91	21	5.1
H2_R2_3	514782	5722064	132.0	6.5	0.91	21	5.1
H2_R2_4	514787	5722065	131.9	6.5	0.91	21	5.1
H2_R3_1	514774	5722044	132.0	6.5	0.91	21	5.4
H2_R3_2	514780	5722046	131.8	6.5	0.91	21	5.1
H2_R3_3	514788	5722049	131.5	6.5	0.91	21	5.1
H2_R3_4	514792	5722050	131.4	6.5	0.91	21	5.1
H2_R4_1	514782	5722022	131.3	6.5	0.91	21	5.4
H2_R4_2	514788	5722024	131.1	6.5	0.91	21	5.1
H2_R4_3	514795	5722027	130.9	6.5	0.91	21	5.1
H2_R4_4	514800	5722028	130.7	6.5	0.91	21	5.1
H2_W1	514792	5722006	130.7	6.5	0.91	25	5.4
H2_W2	514801	5722009	130.4	6.5	0.91	25	5.1
H2_W3	514797	5721994	130.3	6.5	0.91	25	5.4
H2_W4	514806	5721996	130.0	6.5	0.91	25	5.1
H2_W5	514802	5721982	129.7	6.5	0.91	25	5.4

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Exhaust Velocity
	km	km	m	m	m	°C	m/s
H2_W6	514810	5721985	129.6	6.5	0.91	25	5.1
H2_W7	514806	5721970	128.7	6.5	0.91	25	5.4
H2_W8	514813	5721973	128.6	6.5	0.91	25	5.1
H3_W9	514739	5722067	133.6	6.5	0.91	25	5.4
H3_W10	514748	5722070	133.3	6.5	0.91	25	5.1
H3_W11	514743	5722053	133.2	6.5	0.91	25	5.4
H3_W12	514752	5722057	133.0	6.5	0.91	25	5.1
H3_W13	514749	5722040	132.8	6.5	0.91	25	5.4
H3_W14	514757	5722042	132.5	6.5	0.91	25	5.1
H3_W15	514755	5722025	132.4	6.5	0.91	25	5.4
H3_W16	514763	5722029	132.1	6.5	0.91	25	5.1
H3_1	514761	5722022	132.1	6.5	0.63	25	6.8
H3_2	514762	5722018	132.0	6.5	0.63	25	6.8
H3_3	514763	5722013	131.9	6.5	0.63	25	6.8
H3_4	514765	5722008	131.7	6.5	0.63	25	6.8
H3_5	514767	5722002	131.5	6.5	0.63	25	6.8
H3_6	514769	5721997	131.4	6.5	0.63	25	6.8
H3_7	514771	5721991	131.2	6.5	0.63	25	6.8
H3_8	514773	5721985	131.0	6.5	0.63	25	6.8
H3_9	514776	5721978	130.4	6.5	0.63	25	6.8
H3_10	514778	5721971	129.8	6.5	0.63	25	6.8
H3_11	514780	5721963	129.1	6.5	0.63	25	6.8
H3_12	514783	5721957	128.5	6.5	0.63	25	6.8
H4_1	514721	5722062	134.1	6.5	0.91	21	5.4
H4_2	514725	5722051	133.8	6.5	0.91	21	5.4
H4_3	514728	5722041	133.6	6.5	0.91	21	5.4

Source Number	x-coordinate	y-coordinate	Base Elevation	Stack Height	Diameter	Temperature	Exhaust Velocity
	km	km	m	m	m	°C	m/s
H4_4	514731	5722032	133.3	6.5	0.91	21	5.4
H4_5	514735	5722020	133.0	6.5	0.91	21	5.4
H4_6	514741	5722003	132.5	6.5	0.91	21	5.4
H4_7	514740	5721981	132.0	6.5	0.63	25	6.8
H4_8	514744	5721982	132.0	6.5	0.63	25	6.8
H4_9	514750	5721984	131.9	6.5	0.63	25	6.8
H4_10	514755	5721985	131.7	6.5	0.63	25	6.8
H4_11	514754	5721963	130.1	6.5	0.63	25	6.8